REAL CORP 2023

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LET IT GROW, LET US PLAN, LET IT GROW NATURE-BASED SOLUTIONS FOR SUSTAINABLE RESILIENT SMART GREEN AND BLUE CITIES

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LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

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REAL CORP 2023

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4

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

PREFACE

Manfred SCHRENK,

Conference Director,
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WELCOME to REAL CORP 2023, the
28th International Conference on Urban & Regional Development and Spatial Planning in the Information Society!

A constantly growing world (around 8 billion people now, 9.7 billion to be expected by 2050) with constantly expanding cities and urban agglomerations is facing various challenges such as scarcity of resources, infrastructure provision security, risk of disasters, global warming or ageing of the population. These topics have to be seen as global challenges which are unevenly distributed across the world regarding the dynamics of those phenomena and their geogeaphic location. Are Nature-Based Solutions the key to liveable, sustainable, resilient cities even under the threats of climate change? Is it just about greening the cities and their green and blue infrastructures? What is the context of their technological developments and social innovation?

Nature-Based Solutions are definitely being understood well beyond greenery or only biotic nature. There are strong relations with topics such as liveability, social cohesion and human activities, and urban planning, architecture and design as key disciplines. Thus, beside green and blue (water) infrastructure as currently the most often addressed manifestation of Nature-Based Solutions in cities, REAL CORP 2023 suggests to reflect also on the physical processes and materials (abiotic nature) as inevitable parts of nature. These can bes seen in connection with parameters of urban planning, such as morphology, land use, availability of space for (land) use occupancy etc. These physical world processes are also part of nature, especially as the properties of locations and sites that may well dictate their further development as well as the selection of suitable Nature-Based Solutions for implementation at these specific locations.

Nature-Based Solutions that directly use natural processes (e. g. natural terrain with high vegetation, which in urban areas is most often associated with a park), especially in dense urban patterns, are generally more difficult to implement due to spatial as well as economic constraints. Nature-Based Solutions that may be more appropriate in such situations may come from a set of ideas and proposals that "mimic" nature. Here, it is important to note that nature is made up of both biotic and abiotic components. For example, in terms of reducing the occurrence of heat islands in cities, solutions can be found in the selection of suitable building materials and their appropriate treatment, appropriate physical characteristics of the components of abiotic nature, optimum orientation of buildings and their compositions on the sites, as this can influence the natural ventilation of the rooms (micro scale) or area (macro scale).

Other open questions include ways in which Nature-Based Solutions can be addressed in various spatial planning documents and processes and how can the capabilities of Nature-Based Solutions be used in effective policy making and implementation.

This year we brought together some 200 participants from more than 30 countries worldwide. The main goal of the REAL CORP conference series is to bring together leading experts in the field of spatial planning, geoinformation and related disciplines to exchange their knowledge, share their ideas, discuss current developments and get together for face to face networking leading to the development of new thoughts, partnerships and projects.

The success of the REAL CORP conferences is – clearly without doubt – the result of the efforts of participants, reviewers, and the conference organising team. We would like to acknowledge the Reviewer Team and Programme Committee members for their valueable voluntary help with the review process. Our thanks go to all participants and authors of the submitted papers as well.

The proceedings of this year's conference contain around 110 scientific papers; 92 of them were selected after a double-blind, double-stage (for both abstracts and full papers) peer-review process for publication and presentation at REAL CORP 2023. The non-reviewed papers were accepted by the programme committee after a double-blind abstract review.The conference is held from 18 to 20 September 2023 in Slovenia's capital Ljubljana as well as in virtual space.

Welcome to Ljubljana! Have a great conference!

Manfred SCHRENK, Clemens BEYER & the REAL CORP Team

6

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Table of Contents – Inhaltsverzeichnis:

A Core of Robotics Intelligence. A "Green Button" Idea

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1 ABSTRACT

The report provides an overview of AI methods and tools and of their applicability for creation of robot's intelligence. By a term "robot" we simultaneously refer to a decision support system in a form of an autonomous device (a traditional robot) and to some system presented in the form of special software that implements the functions of an intelligent assistant. The totality of works on AI can be divided into two areas, two types:

- imitation of human intellectual activity;

- decision support, autonomous decision making based on inference (usually first-order predicate algebra), or other tools.

Our company deals exclusively with systems of the second type.

Structure of the paper:

(1) An overview of AI: pattern recognition, machine learning, data meaning, neural networks, singular value decomposition (SVD). Here we discuss the advantages and limitations of the most well-known approaches in the field of applied AI methods today.

(2) Our experience in AI: knowledge base, ontology, inference machine, scenario approach, ontomodeller, Protege 2000. A brief history of the application of AI methods in our company since the late 90s of the last century is presented.

(3) Tactical situation analysis. In our systems, the concept of a tactical situation is the basis for the application of AI in real-time systems and in monitoring systems for various purposes. A tactical situation is a basic concept for determining the reaction to external circumstances and conditions that have arisen for a robot that ensures the fulfilment of a certain mission.

(4) Smart city applications. Developed within the framework of the European CRISALIDE project, an intelligent decision support system in the interests of a smart city, is one of the options for implementing basic AI technologies in the interests of urban governance.

(5) Future work: RIC technology, discussion: a "Green Button" idea. Based on our experience of theoretical and technological research, a technology system is proposed, a technological platform that can be called a core of robotics intelligence (RIC). This platform allows you to form a full cycle of intelligent control of the robot:

- obtaining data on the external environment (robot environment) from various sources, own and external;

- evaluation of options for fulfilling one's own mission and making a decision (close to the optimal solution);

- monitoring the implementation of the decision;

- proofreading of the solution if necessary;

- making a decision on the completion of a mission formed for a robot, or a general system for which a decision is made on automatic control without involving (directly) a person.

Accumulation of experience and self-training based on the analysis of tactical situations and the results of decisions made. We call this idea a "Green Button" idea.

Keywords: robotics, planning, artificial intelligence, smart city, green button idea

2 INTRODUCTION

The history of the practical application of AI methods and tools in our company goes back more than 20 years. During this time, we have formed a system of technologies, including in the field of AI, implemented applications in the interests of marine monitoring systems and Smart City. Among the AI tools used by our company, the following should be noted first of all: ontology system, expert systems (knowledge bases, inference machines), scenario system and singular value decomposition (SVD) method. According to our experience, the application of AI was carried out in two stages: during the development of applications and during their operation. All this allowed us to form a relatively small set of AI technologies in the form of a platform on which you can develop applications of various scale and purpose.

Currently, the entire set of works united by one name — AI, can be divided into two large groups. The first group – which formed this scientific direction – is an attempt to replicate the intellectual functions of the human brain. Despite great efforts in this direction, the progress is very modest. The second group is the endowment of applications or robotic complexes with intellectual functions based on formal logic and other approaches. It is safe to say that all of our AI developments belong to the second group.

During the period of our company's activity, which is since the early 2000s, we have developed a number of hardware and software systems, including tools and methods of artificial intelligence. Based on our experience in the development, production and exploitation of our products, it was concluded that there was a need to create some kind of intellectual core, which could be scaled over a wide range, namely from a micro-robot to large organizational and technical systems. For such a wide range of manufactured systems, we have an invariant representation of our technologies and development tools. Therefore, we can say with confidence that we have some basic core, which is the intellectual basis of all our products. The main motivation and the main idea behind the development and implementation of RIC is the maximum automation of the application of our products in the interests of the end user, a "Green Button" Idea. Let's take a look at the main elements of RIC and some examples of its implementation.

3 AN OVERVIEW OF AI

In the last decade, AI has received a "second wind" after decades of oblivion, when hopes for its widespread use and replacement of people's intellectual activity actually failed (70s of the last century). The revival of AI is due to the following factors: the sharply increased computing capabilities of modern computers and the rapid development of the global Internet. The modern power of computers has made it possible to implement complex algorithms and process large amounts of data. Widespread access to the Internet has dramatically increased the number of users of AI applications, such as voice analysis, pattern recognition, and search for useful information. The whole set of works that is of interest to us can be reduced to the following, fairly well-known, areas in the field of AI: Pattern recognition, machine learning, data meaning, neural networks, singular value decomposition (SVD). It is not possible to analyse the whole variety of works and applications in AI within the framework of this article. We will briefly review only those that we have explored as a platform for practical applications.

3.1 Pattern Recognition

Pattern recognition is the automated recognition of patterns and regularities in data. It has applications in statistical data analysis, signal processing, image analysis, information retrieval, bioinformatics, data compression, computer graphics and machine learning. Pattern recognition has its origins in statistics and engineering; some modern approaches to pattern recognition include the use of machine learning, due to the increased availability of big data and a new abundance of processing power. These activities can be viewed as two facets of the same field of application, and they have undergone substantial development over the past few decades" [Wikipedia]. This idea works well when we have a large statistical sample of initial data. Typically, millions of test images are required. Difficulties arise for rare phenomena when one attempts to use expert, formalized knowledge.

3.2 Machine Learning

Machine learning (ML) is a field of inquiry devoted to understanding and building methods that "learn" – that is, methods that leverage data to improve performance on some set of tasks.[1] It is seen as a part of artificial intelligence. [Wikipedia]. Just like Pattern recognition, this idea works well for cases where we

have a large statistical sample of initial data. The main drawback is the lack of interpretation of the results obtained. The main advantage of this method is that a decision is made that was not predetermined in advance.

3.3 Big Data

"Big data primarily refers to data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many entries (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate.[2] Though used sometimes loosely partly because of a lack of formal definition, the interpretation that seems to best describe big data is the one associated with large body of information that we could not comprehend when used only in smaller amounts" [Wikipedia].

3.4 Neural Networks

"A neural network is a network or circuit of biological neurons, or, in a modern sense, an artificial neural network, composed of artificial neurons or nodes.[1] Thus, a neural network is either a biological neural network, made up of biological neurons, or an artificial neural network, used for solving artificial intelligence (AI) problems" [Wikipedia]. This approach is now very widely used in various subject areas and is very popular. However, we do not use this approach in our applications due to a key drawback – the lack of interpretation of the results obtained. As an alternative, we use the singular value decomposition of matrices.

3.5 Singular Value Decomposition

"In linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix. It generalizes the eigendecomposition of a square normal matrix with an orthonormal eigenbasis to any matrix. It is related to the polar decomposition" [Wikipedia]. This approach allows us to solve the same problems as neural networks, but here we can explicitly control the accuracy of the solution and confidence in adequate results. The use of SVD in our applications has shown its high efficiency. Recognition of tactical situations using SVD gives this method a high degree of versatility.

4   OUR EXPERIENCE IN AI

Knowledge base, ontology, inference machine, scenario approach, onto-modeller, Protege 2000. A brief history of the application of AI methods in our company since the late 90s of the last century is presented.

4.1 System of Ontology

The main motivation for the development of the concept of ontology was an attempt to combine software from different subject areas (domains), and, above all, to form a system of non-intersecting sets of concepts. The first tool for developing ontologies was our OntoModeler software product, Fig. 1, developed in the late 90s of the last century. To describe the logic and business intelligence, a special scripting language with Pascal syntax was developed. These technologies were the basis for the development of knowledge bases and logical scenarios. Also, OntoModeler was integrated into a GIS of its own design, see Fig.2.

The increasing complexity of GIS, the emergence of modern web technologies and technologies of distributed heterogeneous systems have dramatically increased the cost of maintaining and upgrading our key technologies. In the mid-2000s, a decision was made to switch to the JEE platform as the main software development environment and Protege 2000 as the main tool for developing and maintaining ontologies, see Fig.3. A special Plug-in was developed to create scripts based on the Drools language.
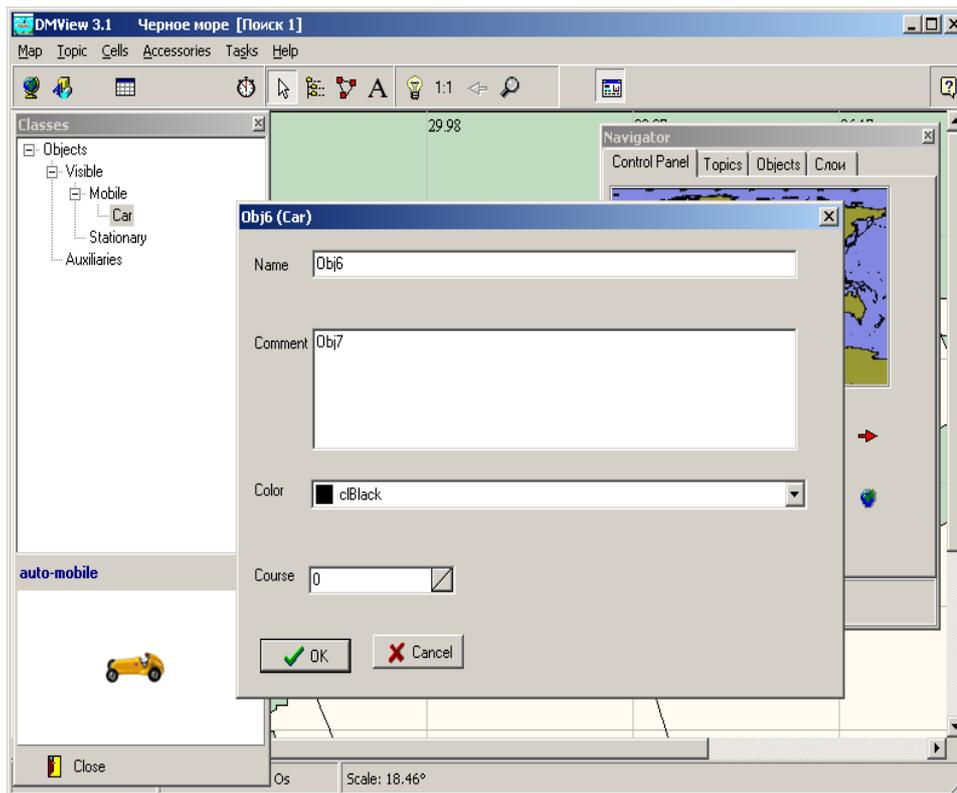
Fig. 1: Ontology editor main window
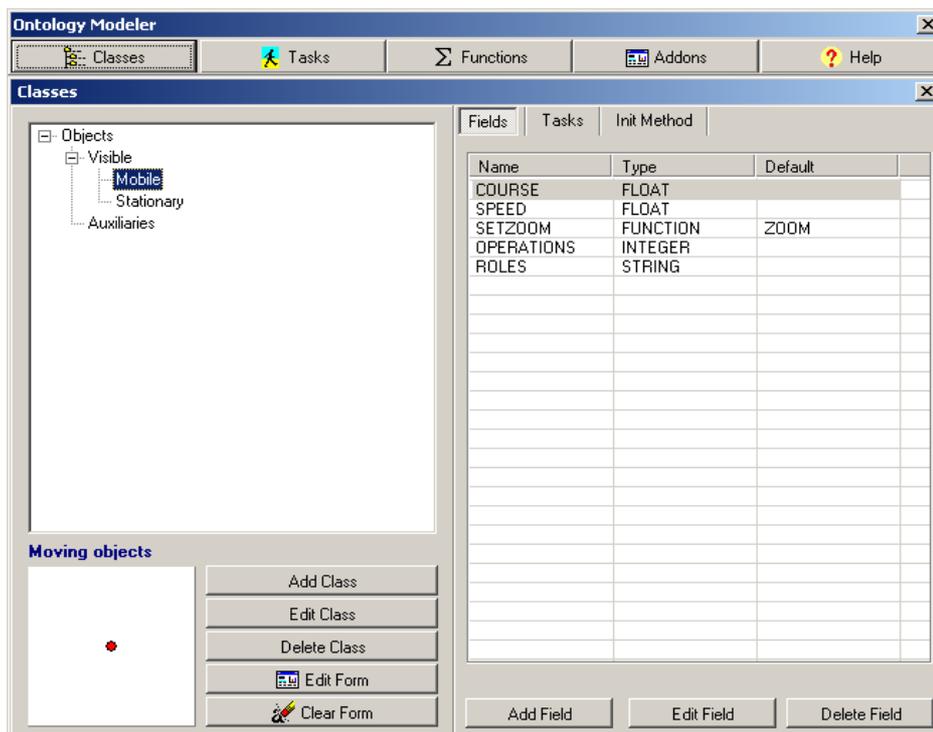
Fig. 2: Integration OntoModeler in to GIS

The application of the Protege 2000 system made it possible to speed up the development of an ontology system and to integrate various software components, such as GIS for various purposes, databases and knowledge bases, to implement a fairly powerful scripting system that allows implementing fairly complex business analytics without involving programmers. This approach made it possible to reduce the application development time, its cost, reliability and maintainability during exploitation by dozens of times.
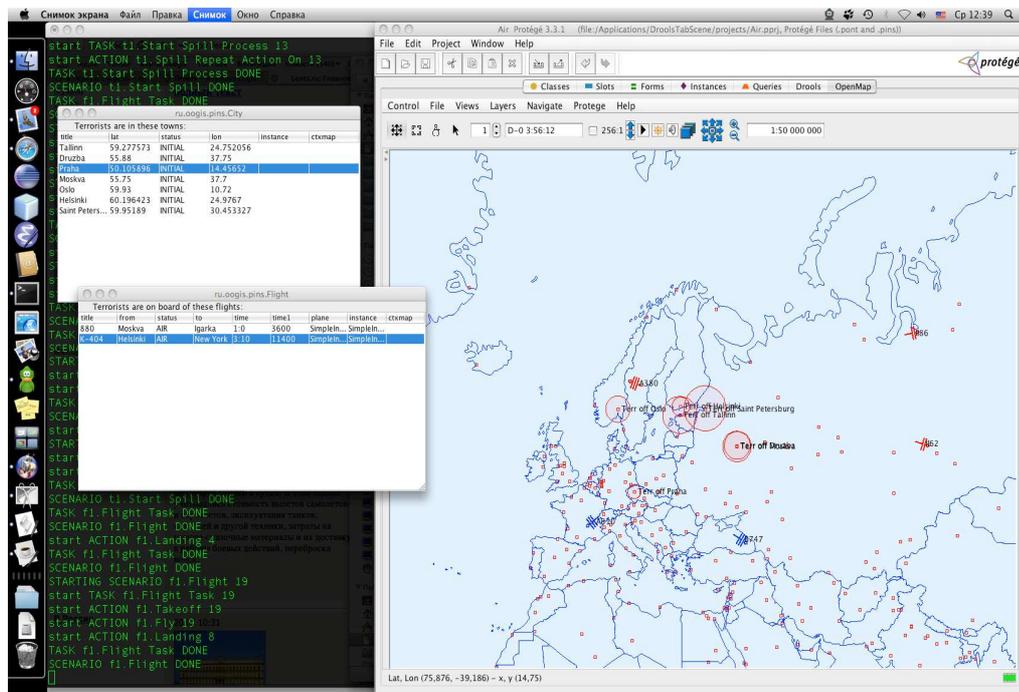
Fig. 3: Protege 2000 Applications

4.2 Scenario Approach

A scenario is the same as algorithm, but with the possibility of executing 2 or more parallel development branches that are executed simultaneously. A fully-fledged scripting system was developed in the Protege 2000 system as a special Plug-in, which implemented a visual script editor that allows you to implement business intelligence in a visual representation, which drastically reduced the time for its implementation, since the work was performed directly by subject matter experts without involving programmers. Note that there are two approaches to visual computer modelling: a scenario approach – when the content and sequence of steps to implement some business intelligence are known, and a rule-based approach for the case when the business intelligence or process is not known in advance. We use both approaches. An example of a simple scenario, its scheme, is shown in Fig. 4.
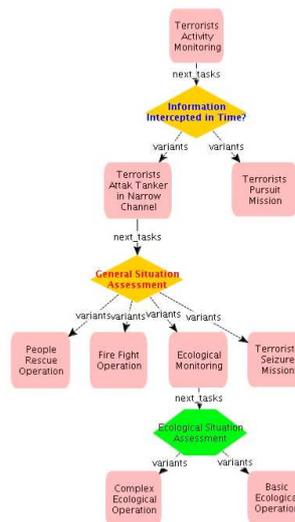
Fig. 4: A simple Scenario

The scenario scheme is a two-dimensional graph, the vertices of which are the stages (phases) of decision making, and the arcs are the transitions from one phase of decision making to another. The difference between a scenario and an algorithm is visually demonstrated, where the stages are performed in strict sequence one after another.

4.3 Micro Service Architecture

The expansion of the scope of our solutions has led to the fact that scaling has fairly wide limits: from smartphone applications to large heterogeneous distributed systems. The technology system that uses Protege as an ontology editor is a rather heavy solution and can not be universally applied. In this regard, we have developed a system of technologies for which a lightweight ontology editor and a scripting system in the Drools language have been created, which allows the user to create flexible and lightweight development tools based on scenario approach in almost any integrated software development environment, for example, in JetBrains products.

5 TACTICAL SITUATION ANALYSIS

In our systems, the concept of a tactical situation is the basis for the application of AI in real-time systems and in monitoring systems for various purposes. A tactical situation is a basic concept for determining the reaction to external circumstances and conditions that have arisen for a robot that ensures the fulfilment of a certain mission.

5.1 JDL Model as a Spiral Processing of Information

In our systems, the concept of a tactical situation is the basis for the application of AI in real-time systems and in monitoring systems for various purposes. A tactical situation is a basic concept for determining the reaction to external circumstances and conditions that have arisen for a robot that ensures the fulfilment of a certain mission. The levels of this model correspond to such fundamental concepts as measurements, data, information, knowledge and understanding. At the same time, these concepts are not absolute, but relative. It all depends on the scale of the model. For example, on micro-robot level, unmanned device, manned vehicle, weather monitoring centre or other purpose.

Measurements, data and information can be interpreted as some attributes of a certain entity (robot), real (physical world), or abstract (digital world). Knowledge is a direct clarification, the work of "artificial consciousness", "intelligence" at the level of such a concept as "phenomenon". This is the level of a "simple" robot that performs a set of embedded business intelligence, its activities are quite well regulated, despite the fact that it can be performed using an inference machine.

"Understanding" is the clarification of the essence of occurring phenomena on the basis of self-learning, i.e. it is the rectification of embedded business intelligence in the form of scenarios based on self-learning or on-the-fly revision by a supervisor.

5.2 Cycle of Control

The control cycle (CC) is the logical basis of any control, artificial or physical entity, including decision support systems. CC is inherent in human nature from the very beginning and, according to the hypothesis of I. Kant [], is pre-established. It is simply not always realized and is often realized fragmentarily and probably not consciously. The control centre is implemented by some system consisting of two parts: Command&Control. This is military terminology, but recently it has been directly applied when considering such concepts as a decision support system (DSS) and the analysis of tactical situations. From the point of view of technical cybernetics, "command" is a given control function, and "control" itself is a technical implementation of the control function, i.e. issuance of a control action and, through feedback, control of its execution.

5.3 Tactical Situation Definition

The basis of the analysis of the tactical situations (TS) is the situation. The situation is not formed arbitrarily, but taking into account a certain class of vehicle. In turn, the TS does not arise without a specific task (tasks), which is solved by the monitoring system, DSS and/or decision maker. That is, TS is closely related to the concept of "task". In human activity, it is quite natural to solve a number of problems almost continuously. DSS is also developed to solve a certain set of problems, and not in general for any problems. Therefore, we can say with confidence that the starting point for starting the analysis of the TS is the formation of a list of tasks that the decision maker solves and the DSS supports their solution. The process of fulfilling (solving) the task takes place against the backdrop of a changing environment and the emergence of new TS. The analysis and evaluation of the TS allows the decision maker to make the following types of decisions:

20

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

(a) continue the task according to the previously developed plan; (b) adjust the plan; (c) make a new decision in connection with such a change in the situation, which led to a change in the TS.

TS analysis is carried out by processing the input stream of measurements, data and information and evaluating the problem being solved. If the performance indicators of the problem being solved do not correspond to the specified (expected), we say that the TS has changed. But this is only for those cases when we can set the criterion and performance indicators. The decision on a "specifically new" vehicle may be done in two ways:

(a) logical, or scenario, based on the logic of first-order predicates; (b) mathematical, or imitative conclusion. Having identified a new vehicle, a new cycle begins.

To clarify, let us give a simple everyday example: various situations can lead to the threat of a car tipping over on the road in motion: – slippery road (rain, snow, ice, etc.); – high speed of movement; – sharp turn; – sharp movements of the steering wheel; – poor pavement of the road surface (clay, sand, gravel), etc. and so on. Therefore, it is advisable to create a list of threats and associate them with possible TS.

6 SMART CITY APPLICATIONS

Developed within the framework of the European CRISALIDE project, an intelligent decision support system in the interests of a smart city, is one of the options for implementing basic AI technologies in the interests of urban governance. In the CRISALIDE project an Innovative Decision-Making Tool has been developed for Contributions on:

- Urban Information Systems;
- Urban Decision Support Systems;
- Geo-Information-Infrastructures, Data availability;
- Urban Planning.

We consider the CRISALIDE as an instrument for end users. Decision making support system (DMSS) can help CRISALIDE users to satisfy human's demand for space. CRISALIDE is a software and hardware complex based on intelligent GIS, which provides the ability to integrate maps of various formats, implement a scenario approach in urban development modelling, 3D modelling, support for 2D + t modelling, support for 3D + t modelling, support for decision-making based on expert knowledge, the ability to monitor changes and assess the possible impact of decisions on the urban environment.

The software and hardware complex provides the consumer with a universal set of technological and functional solutions within the framework of the basic configuration with the possibility of expanding functional tasks in accordance with the requirements of the customer and the subject area, multi-platform and the absence of mandatory additional paid software.

The main end users of the developed CRISALIDE system are state authorities and local self-government, public and private enterprises and organizations directly related to the functioning and development of the urban environment. The introduction of the CRISALIDE system allows us to solve the following tasks: to develop e-government, to improve the quality of public administration through the creation and implementation of modern information technologies. The proposed system of intellectual decision-making support makes it possible to predict the development of urban infrastructure both within the city as a whole and in selected districts and quarters, to identify a deficit or surplus of construction facilities and/or infrastructure, as well as to take into account the socio-economic aspects of the development of municipalities and regions. Main services can be presented by text, graphics and voice forms. A list of services is very big and covers all of city life routines. Most of the services are presented by Internet through different gadgets. But, as was noted by Erich Fromm, today people would like to know and can to do primitive operations, especially how to use gadgets, but do not wish to understand things. It is the biggest demand of our civilization. According to this evidently fact our proposal is to include in to a plan of CRISALIDE project next generation a systems of services, pointed to understanding process. So, understanding should be as a service from Internet. The CRISALIDE project will be consists next main parts as follows:

(1) Knowledge clouds as services for individuals.

(2) Private business analytics for understanding development.

(3) An intelligent social networks development as a platform or environment for knowledge and understanding existences and processes.

7   A "GREEN BUTTON"

In this article, we have presented a far from complete list of technologies that can be used to develop the intelligent core of a robotic complex. A robotic complex can be either completely autonomous or automated, i.e. with human participation. The main feature of RIC is the ability of the installed software to provide decision support, both in stand-alone and automated versions. At the current time, our technologies allow us to form a relatively simple logic of the robot's behaviour, which can act autonomously. But when solving more complex problems, such as, for example, in the CRISALIDE project – the operation of a decision support system for managing the urban environment, the participation of a whole team of people of various specialties is required.

A reasonable question arises: is it possible in automated systems to entrust the formation of proposals for making decisions offline? Theoretically, such a possibility exists, but what about practice? Let's translate these questions into a technological plane. The very first step is confidence in the chosen technological solutions. What does it mean, for example. TS analysis can be considered as a problem of pattern recognition, or simply recognition. Stereotypically suggests the idea of using neural networks. But, the main drawback of neural networks is immediately remembered – the lack of interpretation of recognition results. Believing in such an autonomous decision generation system becomes a matter of faith, which will not fully suit pragmatically minded people who are ultimately responsible for the decision made.
The use of SVD eliminates this drawback, since we can control the accuracy of decision making. Why are we discussing this issue at all? We are discussing, because here, maybe. two extremes: the first is that we do not need an automated DSS, we only need well-trained decision makers. The second extreme is the need to create DSS, which will eventually replace a person in any decision-making process. Our arguments are as follows: even if the decision maker is well prepared and has extensive experience, he is not immune from mistakes. It is a human trait – to make mistakes. DSS, even if it cannot offer the optimal solution, it can protect against making a misguided decision in advance.

At the current level of development of AI technologies, it is impossible to create a DSS that will always make optimal decisions. But you can set up the DSS so that it will not make gross mistakes and make decisions that are close to optimal. We will not consider the concept of "close to optimal" in this article, since this is a separate special topic. The local conclusion that we can draw now is that there is a set of technologies that allows you to automate the DSS as much as possible. We call this hypothesis the "Green Button" idea. The general scenario for implementing the Green Button idea is as follows.

7.1 Access to Environment Data

This is a connection with the outside world in real time. To do this, we have created a whole family of different servers that receive data from a variety of meters and interacting external systems, providing heterogeneity and distribution. The RIC must have access to external information, preferably in real time or near real time. The more channels for obtaining information about the external situation, the better for the adequate behaviour of RIC and, ultimately, the successful completion of the assigned mission. Our experience with real-time systems shows that practically the entire set of information about the external environment can be formed in the form of typical channels, regardless of the type of physical field that needs to be registered. The first and the simplest option is geographic (spatial) coordinates and one physical measurement: temperature, relative humidity, atmospheric pressure, etc. The second option is associated with the processing of data from the analysis of a certain plane or volume, associated with the registration of objects in various environments: the surface of the earth, the air atmosphere, the aquatic environment. For these systems, integrated processing can be reduced to the problem of pattern recognition on a plane or in a volume. As a result, we get an abstract representation of the surrounding world in some functions and arrays of measurements, as well as selected physical objects.

22

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7.2 System of Ontologies

A set of technologies allows you to formalize the subject area and form a number of non-intersecting concepts and relationships between them. Such a system is also called a knowledge base system. The system of ontologies and/or knowledge bases is a way of interpreting the environment (paragraph 6.1) and business intelligence, which ultimately determines the mission of RIC. Thus, a system is obtained that can be interpreted by different logics. As a rule, we use first-order predicate logic and generic tools that support it. The most important property of ontology (in our opinion) is a unified system of concepts for such different entities as decision makers, applications and databases. This significantly reduces the development time of such intelligent systems, their maintenance, scaling and modernization.

7.3 Scenario System

The scenario system allows you to formalize the customer's business analytics, which is the basis of the DSS. Actually, with the help of this idea, the "Green Button" is implemented. Those. automation from an automated system (with human participation) to a fully autonomous system (without human participation). This idea is very productive for cases when, for various reasons, the decision maker cannot make a decision under the circumstances and conditions.

7.4 Tactical Situations Processing

This is the basis of the DSS, which connects a number of fundamental concepts: the tasks (mission) of the object and/or system in whose interests the DSS was developed, the current situation (data, geography and time), the system of restrictions. The technical basis of TSP are: SVD classifier (recognition) and script interpreter. The implementation of TSP allows you to abstract from the elements of what is happening (data, measurements, information) and operate with such concepts as knowledge and understanding. Either the decision maker, or the decision maker + RIC, or RIC evaluates what is happening from the point of view that the mission is feasible, or not, needs to be corrected, or should be replaced by another, or cancelled completely. To understand what we are talking about, very roughly TSP can be interpreted as a pattern recognition process, but! The images here are abstract and have no direct physical interpretation. Plus, many of these "images" refer to cases of "rare events". In this case, a number of well-established AI methods, in particular neural networks, are not applicable. In this regard, we apply the SVD method, which can be applied to large statistics (like neural networks), as well as to "rare events", the abstract images of which are formed by experts.

7.5 Web interface

Interacting RIC system with decision makers and other DSS users. Interaction through touch and through voice communication.

The proposed idea of the "Green Button" has been tested in our systems since the mid-2000s. In the current conditions, a mechanism is being developed to control the degree of automation of the decision support process: from complete autonomy to the participation of the decision maker or the decision maker team in the decision selection process. Our current solutions do not directly evaluate or manage the degree of automation. When solving this issue, we will be guided by the fact that the degree of automation will be determined by the decision maker.

8 CONCLUSION

Development of RIC technology, discussion of it led to a "Green Button" idea. Based on our experience of theoretical and technological research, a system of technology is proposed, a technological platform that can be called a core of robotics intelligence. This platform allows us to form a full cycle of intelligent control of the robot and decision making process for large scale systems:

- obtaining data from the external environment (robot environment) from various sources, own and external;
- evaluation of options for fulfilling one's own mission and making a decision (close to the optimal solution);
- monitoring the implementation of the decision;

- proofreading of the solution if necessary;

- making a decision on the completion of a mission formed for a robot, or a general system for which a decision is made on automatic control without involving (directly) a person.

Accumulation of experience and self-training based on the analysis of tactical situations and the results of decisions has been made. In general we call this idea a "Green Button" idea.

Our next step is to provide a set of real work applications with embedded such system. The firs one will be an extension of CRIALIDE project, maritime monitoring systems, autonomous mobile devices of different types for ground, aerial and maritime purpose.

9 REFERENCES

ERICH, Fromm: Escape from Freedom — Philosophical archive. Nyköping (Sweden), 2016.
PIETRO, Elisei at all: Smart City and Digital Humanities, Real CORP 2022. Vienna, 2022.
VASILY, Popovich at all: Intelligent Decision Making Support System for Smart City Governance and Management. SAECT, Roma, Italy. 27-29 Nov. 2019.
VASILY, Popovich at all: Situational Control. Maritime Radio Eloctronix. №2(76), St. Petersburg, June, 2021.
VASILY, Popovich at all: Knowledge centric approach in information systems. Marine Radio Electronics. #4 (74), pp. 10-16. December, 2020. St. Petersurg (in Russian).
VASILY, Popovich at all: Intelligent Decision Making Support System for Smart City Governance and Management. Proceedings of the ISAECT Conference, Roma, Italy. 27-29 Nov. 2019. Inspect Association Number: 19536136.

24

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Airflow in Urban Environment: an Approach to Improve Egyptian Buildings Regulations

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1 ABSTRACT

Rapid urbanization among many factors contribute to elevate air temperature inside city's urban fabric that causes urban human discomfort. Natural ventilation in urban canyons is one of the measures that can limit that effect and minimize the air temperature of urban areas. Benefits range from pedestrian comfort in the urban environment, to efficiency of natural ventilation systems in urban streets. Studies have covered different urban forms and their impact on pedestrian comfort, others have investigated the role of built-up density on pollutants dispersion, some have studied the role of urban configurations on natural ventilation in buildings, while some studied different physical characteristics which also affect the urban heat island. What is yet to be defined is the effect of those physical characteristics on shaping the building regulations, especially in Egypt, and their efficiency regarding natural ventilation systems in urban canyons to eliminate the raised temperature. Spreading green architecture in Egypt requires reshaping current legislation and codes, starting by revising the existing local building laws and regulations. The aim of this work is to assess and analyse the main building code in Egypt by studying and analysing theories on natural ventilation and its physical characteristics.

Keywords: building regulations, urban canyon, pedestrian comfort, natural ventilation, urbanisation

2 INTRODUCTION

The world is currently experiencing the largest wave of urbanization in history. According to World Urbanization Prospects, by 2050, nearly two out of three of us will live in cities (Santamouris, 1997, Mei et al., 2018, Nazarian and Kleissl, 2016). Global urbanization includes the rapid growth of high-rise buildings, superstructures and increased buildings density. They continue to cause concerns about city breathability by blocking the prevailing wind and are associated with microclimate variations in urban districts. They are causing deterioration of pedestrian thermal comfort, increasing energy consumption and are causing several negative environmental impacts such as urban air pollution and urban warming (Juan et al., 2017, Omrani et al., 2017, Lin et al., 2014). For those reasons, we can easily notice the significant difference in microclimate when we are moving between urban areas and rural areas.

Outdoor urban ventilation is very important for a healthy and liveable urban environment -as it is one of the most effective passive cooling techniques- which is strongly affected by urban morphology (Ramponi et al., 2015, Santamouris, 1997). The interaction between urban morphology and airflows needs to be considered in new urban developments since their effects on human life may be beneficial or detrimental. Such effects do not only depend on the characteristics of the wind as a natural phenomenon – intensity, speed and direction- but also on the features of the obstacles and environments that the wind encounters along its path (Palusci and Cecere, 2022). Baruch Givoni states in (Givoni, 1989), that "Of all the climatic elements the wind conditions are modified to the greatest extent by urbanization". There is a clear need for basic scientific understanding of the airflow process in urban area morphologies for improving outdoor thermal comfort and lowering energy consumption (Mei et al., 2018).

Numerous studies have demonstrated that it is possible to improve urban air ventilation and urban climate by manipulating the building configurations during the early stages of planning and regulations. Countries such as United Kingdom, America, France, Germany and others made energy efficiency strategies a priority in building regulations (Omrani et al., 2017, Juan et al., 2017).

In recent decades, a large number of investigations have been conducted for the assessment of natural ventilation in urban areas. This paper aims to analyse the natural ventilation behaviour and its physical characteristics and assess the Egyptian regulations - Building Law No.119 of year 2008 – regarding natural ventilation aspects.

3 NATURAL VENTILATION

Ventilation generally is the process of delivering fresh air. It could be natural, mechanical or hybrid. Natural ventilation relies on natural forces; it can be described as a process for providing fresh air movement. Natural ventilation can be used basically inside buildings to: improve indoor air quality (IAQ), achieve thermal comfort, reduce energy consumption and reduce pollutants inside spaces. Meanwhile, natural ventilation plays a very important role in the urban environment -as wind flow- to: control the humidity, adjust pedestrian thermal comfort, dilute pollutants and for summer cooling (Arup et al., 2002, Fordham, 2000, Krarti, 2018, Schulze and Eicker, 2013, McConnell, 1926).

3.1 Wind flow

The wind flow in the urban environment is complicated to follow. Small differences in land topographies cause irregular flows; as the wind flow is completely different in rural areas and urban environments (E. Bozonnet, 2006, Azizi and Javanmardi, 2017). Wind flow has many characteristics to be analysed and measured; its direction, velocity and pattern and all those characteristics change significantly from one place to another.

3.1.1 Wind direction

Wind direction is generally defined as where the wind blow or by the direction from which the wind originates (for example, a south wind blows from the south to the north). Any obstacles as buildings or land topography directly affect the wind direction ((NWS, 2021, Kutz, 2016, Serway and Jewett, 2018). Wind direction is usually reported in cardinal directions, or in degrees. A wind rose is a simple way to read wind direction as well as its velocity. For example, as shown below in Alexandria's wind rose (Figure 1), the prevailing wind direction -where the wind blows most often- is North North West (El-Geziry, 2013, (NWS, 2021). Wind direction can be measured by the windsock/wind vane or by ultrasonic Anemometer/thermal Anemometer (more sophisticated) (Hawkins and Sutton, 2009).
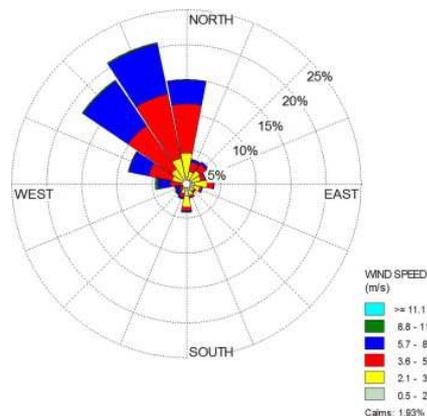
Figure 1: Alexandria's wind rose. (El-Geziry, 2013)

3.1.2 Wind velocity

Wind velocity (wind flow speed) is a fundamental atmospheric quantity caused by movement of the air from high to low pressure (Hogan and Monosson, 2010). Wind velocity is affected by a number of factors and at different scales as the pressure gradient. Where the air pressure differs between two points in the atmosphere or on the surface of the Earth the wind flow become faster or slower to balance out the variation in pressure (Chua et al., 2010, Garrison et al., 2002, Justus et al., 1978). The Beaufort wind force scale was known as the first measurement technique of wind velocity. Nowadays, meters per second (m/s) is the international system unit for velocity (Saucier, 1955, McIlveen, 1991, Hay, 2016). Wind speed could be measured with the same instruments that measure wind direction mentioned in the last section.

3.1.3 Wind flow pattern

Generally we can define wind flow pattern as how wind moves horizontally between different areas. The large global wind pattern is the result of the differential Earth's heating. This difference is created because of the uneven heat by the rays of the sun which happened because of Earth's rotation, its ellipsoid shape and its twenty three and half tilted axis (Dashamlav.com, 2021, Bu and Kato, 2011, Perry, 2004). When it is about

cities and urban areas, wind interacts differently with the surrounding urban areas with different behaviour and characteristics that will be discussed in the next section.

3.2 Urban wind flow

Allard and Ghiaus, (2006) mention that the general aspects of wind patterns in the urban environment - as compared to those of undisturbed wind - are: mean speed due to differences in terrain roughness reduced by 20 to 30%; turbulence increased in intensity by 50 to 100%; and greater incidence (20%) of weak winds. It is also agreed that the mean wind speed above and inside the canopy height is closely related to certain urban dimensions. For roof-top speeds above 4.0m/s, mean velocity decreases by about 33%, while for speeds below 1.5m/s this coupling between the external main and internal secondary flow is considerably reduced or is lost. The centre of a city is warmer than its outlying areas. Daily minimum temperature readings at related urban and rural sites frequently show that the urban site is 6° to 11° C warmer than the rural site. This phenomenon called "urban heat island" (UHI) could be defined as the maximum temperature difference between the city and its surrounding area (Rafferty, 1998).

3.2.1   Urban wind flow pattern

Once the wind flow from the suburban surroundings reaches an urban area it tends to skip over the roofs and sides of buildings and its momentum is transformed into pressure on the windward surfaces of solids, creating several types of effect, such as acceleration, down-flow, flow detachment, low wind speed, high and/ or low pressure zones, sheltered areas and leeward wakes of turbulent vortices (as shown in Figure 2). This unsteady behaviour tends to diminish the flow's momentum due to the drag and viscous forces caused by the friction produced between surfaces and air flow. The Atmospheric Boundary Layer -the lowest 1 or 2 km of the atmosphere which is directly influenced by the presence of the earth's surface and responds to surface forces- is then set by the energy spent in overcoming the shear stress due to the roughness of the terrain, which is determined by the canopy height. Below this height, the free airflow momentum is transformed into wind pressure on vertical surfaces. Above this height the flow tends to stabilize slowly until reaching the gradient speed (Oke, 1978b, Oke, 1988, Cook, 1986, Faria, 2012).
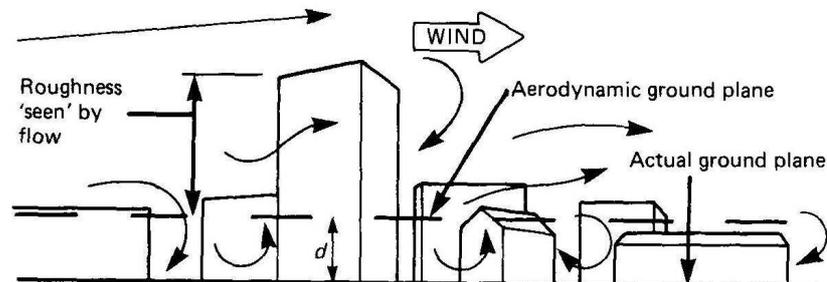
Figure 2: Flow in the interfacial layer (Both canopy layer and surface layer together create the interfacial layer which is extending up to one tenth of the total height of the ABL). (Cook, 1986)

3.2.2   Wind flow pattern around isolated structure

As shown in (Figure 3), when the wind is approaching a structure, it gradually diverges. At the windward facade a stagnation point with maximum pressure is situated at approximately 60–70% of the structure height. From this point, the flow is deviated to the lower pressure zones of the facade: upwards, sidewards and downwards. The upward and sideward flow separate at the upwind facade edges and create a separation bubble or recirculation zone characterized by a low velocity and high turbulence level intensity. Depending on the dimensions of the structure and the turbulence of the oncoming flow, the separated flow can reattach to the side facades and roof (as illustrated by the dotted lines in Figure 3). A considerable amount of air flows downwards from the stagnation point and produces a vortex at ground level. The main flow direction of the standing vortex near ground level is opposite to the direction of the approach flow. Where both flows meet, a stagnation point with low wind speed values exists at ground level, upstream of the structure. The standing vortex stretches out sideways and sweeps around the structure corners creating corner streams with high wind speeds. At the leeward side of the structure, an under pressure zone exists. As a result, backflow or recirculation flow occurs in a cavity zone that consists of vortices with horizontal and vertical axes. The mean cavity reattachment line downstream of the structure marks the end of the cavity zone. After this

structure, the flow resumes its normal direction but wind speed stays low for a considerable distance behind the structure until the wake flow (Bert Blocken 2011).
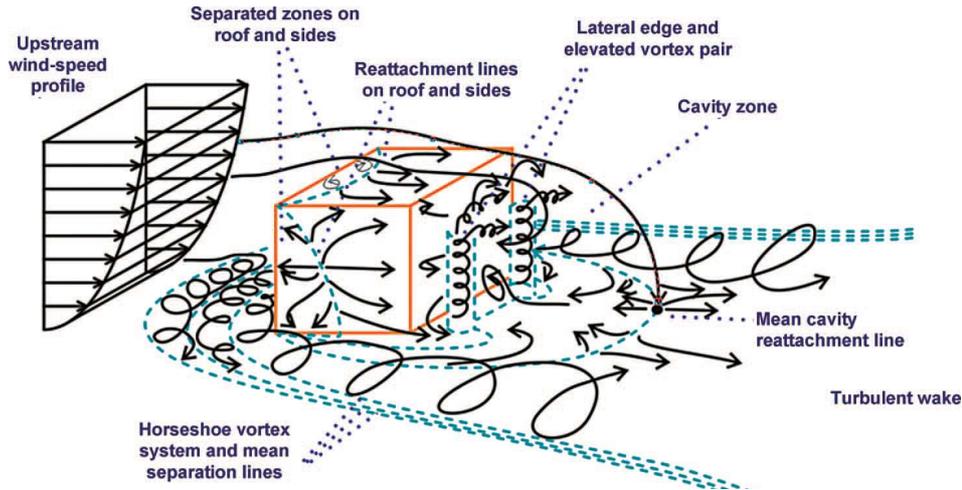
Figure 3: Schematic representation of wind-flow pattern around an isolated structure. (Hosker, 1985)

3.2.3   Wind flow pattern in urban canyons

Urban canyon is the volume lying between buildings, and the urban canyon volume is the volume between road surface and the roof tops of buildings (Figure 4) (Vardoulakis et al., 2003). Urban canyons are characterized by three main parameters: H, the mean height of the buildings in the canyon, W, the canyon width, and L the canyon length. (Georgakis and Santamouris, 2008)
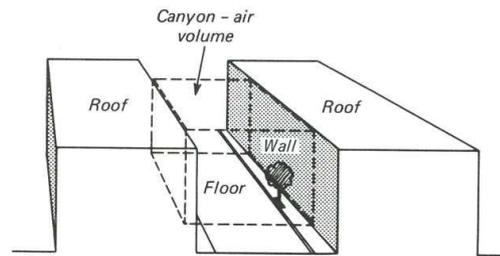
Figure 4: Schematic cross-section of an urban canyon-urban conyon's volume represented with doted line. (Oke, 1978b)

As shown in (Figure 5), Wind flow speed and direction modify as a result of the urban canyon's geometry; parallel, perpendicular or angled.
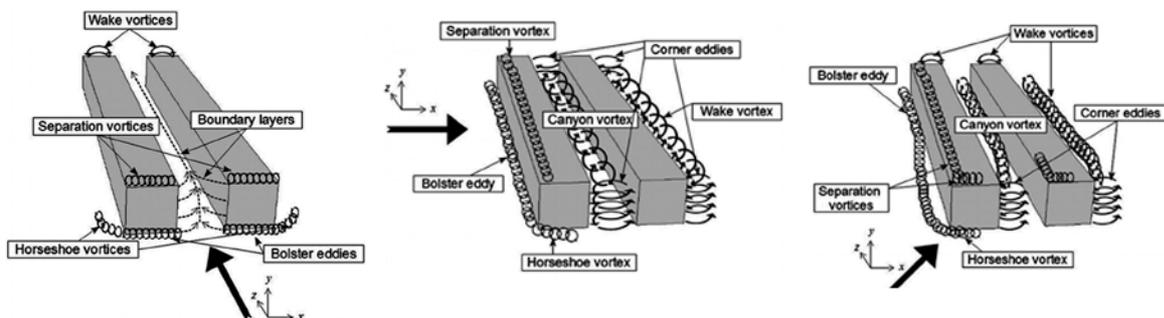
Figure 5: wind flow in different canyon's geometry; parallel (left), perpendicular (middle) and angled (right). (Yazid et al., 2014)

When the wind flow is parallel to the canyon's axis or nearly parallel (deviation of less than thirty degrees), a mean wind component is created along the canyon's axis. The wind speed is reduced due to friction and there is also a possibility of uplifting near the vertical and ground surfaces. In this case the vertical components of velocity tend to be much decreased and in the stream wise direction, if only wind drive forces are applied. Further, the flow inside the canyon is copying the free flow behaviour, but with reduced intensity (Nakamura and Oke, 1988).

28

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An important aspect observed in the perpendicular wind flow is the production of vortices rotating in the mainstream direction below the canopy height and between the two structures shown in (Figure 5). The vortex occurs as a result of pressure differences between the leeward side of the upstream structure and the windward side of the downstream structure. The flow separates at the edge of the leeward surface creating a large wake of low pressure behind the front structure. Then the flow is diverted upwards due to its mass conservation and rises, though with a weaker vertical component. The vortex created in the canyon space therefore presents wind components near the surfaces but little air movement at its centre (Georgakis and Santamouris, 2008, Cook, 1986, Faria, 2012).

Skewed flows usually create a vortex alongside the main axis. The mean flow along the canyon axis presents vertical downwards components causing spiral vortices along the length of the canyon in the upward stream direction but with reduced velocity (Nakamura and Oke, 1988).

4   WIND FLOW PARAMETERS

Many parameters are affecting the urban wind flow. To define those parameters, this study analysed previous studies and the articles published in the field of natural ventilation in the urban environment, whether in individually published articles, or in previous review papers. Thr study investigated relevant publications in related journals regarding natural ventilation and the urban environment, including in particular: Building and Environment, Energy and Building and Journal of Wind Engineering and Industrial Aerodynamics. Among these numerous publications, this paper further focused on studies conducted in the years from 2008 to 2018 with the following keywords: natural ventilation, urban, canyon, airflow and air change rate (ACH). References are analysed according to: relations, methods, type of natural ventilation, wind direction, measurement unit, sensibility analysis, model and limitations of the study. As shown in (Table 1) studies are classified by building typology (high-rise, low-rise, compact, single block or others), scale (urban, canyon or building), measurement unit (Q, ACH, age of air or Cp), type of natural ventilation (pressure or buoyancy) and type of study (coupled or uncoupled). The next five graphs (Figure 6, Figure 7 and Figure 8) show the percentage of studies that discussed each type of classification.

Model					Scale of study			Measurement's unit				Type of NV		Type of study	
high-rise	low-rise	compact	single block	others	urban	Street canyon	Building	Q	ACh	Age of air	Cp	Pressure	Buoyancy	Coupled	Uncoupled

Table 1: previous studies classification. Source: the research

Figure 6: study's model (left) - study's scale (right). Source: the research

Figure 7: measurement unit (left) - type of natural ventilation (right). Source: the research
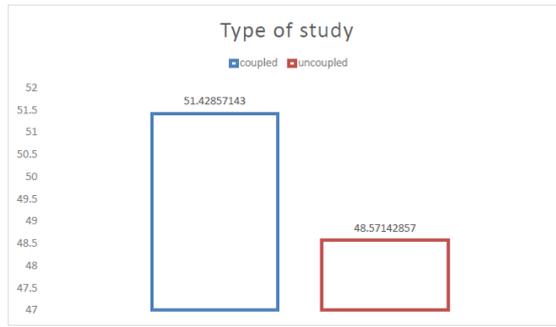
Figure 8: type of study. Source: the research

From previous studies a number of physical parameters were identified that affect the wind flow pattern in urban areas and related phenomena as urban temperature and pollution. The parameters are: Aspect ratio (AR), floor area ration (FAR), packing density (ΛP) and setbacks. The studied ranges of each physical factor are presented in (Table 2). Studied AR ranges vary from 0.5 to 6, FAR ranges vary from 1 to 4, ΛP ranges vary from 0.25 to 0.6 and setbacks were vertical or horizontal and their values depend on road width and buildings height.

Physical factor	Studied ranges
Aspect ratio (AR)	0.5 to 6
Floor area ratio (FAR)	1 to 4
Packing density (Λ_P)	0.25 to 0.6
Setbacks	varied

Table 2: The four physical factors studied ranges. Source: the research

The four parameters and their definitions, importance and relation to urban wind flow will be discussed in next sections.

4.1 Aspect ratio (AR)

Generally as defined in Webster (1907), the aspect ratio is a ratio of one dimension to another. In urban studies, aspect ratios are related mainly to dimensions of urban canyons; they are H/W, L/H and W/L (Figure 9). Those ratios identifies the built aspect ratio and the type of volumetric canyon within it. It is expected that the resultant wind flow speed and direction below the canopy height are connected to variations in these aspect ratios (Hunter et al., 1990, Nakamura and Oke, 1988). A canyon can be considered accoording to the mentioned ratios: for example, uniform or regular when its H/W ratio approximates to 1.0; deep or narrow when this ratio increases to 2.0; and wide or shallow when it drops to 0.5. Also, the L/H ratio is considered short, medium or long for respective ratios of 3.0, 4.5 and 6.0. Regarding the height, a canyon is considered symmetrical when height is relatively constant and asymmetrical when there is large variation in height (Vardoulakis et al., 2003, Nakamura and Oke, 1988, Oke, 1978a).
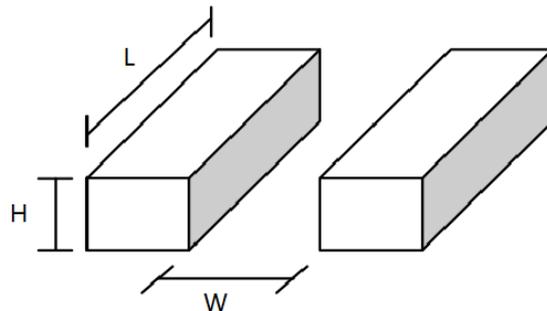
Figure 9: A simple urban canyon. Block's height (H), canyon's width (W) and canyon's length (L).(Afiq et al., 2012)

Comparative analysis of previous AR studies shows that wind speed inside a canyon does not necessarily increase with the increase of canyon AR. Apart from AR, there are other important factors governing the flow field inside a canyon. For example, thermal effects, finite length canyon effects, traffic induced turbulent effects and other physical parameters play important roles in shaping the flow characteristics inside a canyon (Ai and Mak, 2015).

4.2 Floor area ratio (FAR)

Floor area ratio (FAR) is the ratio of a building's total floor area (gross floors areas) to the size of the piece of lot upon which it is built. FAR is sometimes called floor space ratio (FSR), floor space index (FSI), site ratio or plot ratio. The difference between FAR and FSI is that the former is a ratio, while the latter is an index. Index numbers are values expressed as a percentage of a single base figure. Thus a FAR of 1.5 is translated as a FSI of 150% (Birch, 2009, Spikowski, 2006). FAR is often used as one of the regulations in city planning along with the packing density (ʌp) (block covering ratio BCR) as well as zoning to limit urban density. While it directly limits building density, indirectly it also limits the number of people that a building can hold, without controlling a building's external shape. (Figure 10) shows three different plot options with the same FAR (1); by decreasing the lot covering ratio and increasing number of floors. Thus, many authorities have found it unnecessary to include height limitations when using FAR calculations in building regulations. (Birch, 2009, Spikowski, 2006)
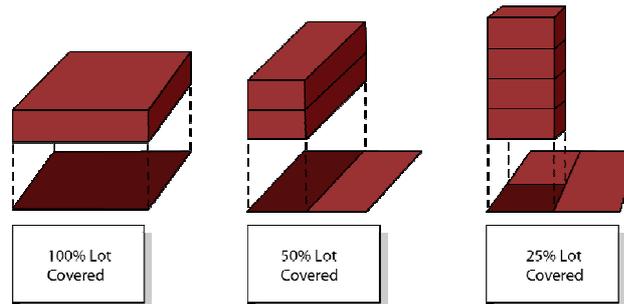
Figure 10: Floor area ratio (FAR=1). (DCOZ, 2022)

Previous FAR studies are wide ranging and vary from effects on environmental aspects such as solar radiation, day lighting. human comfort and natural ventilation, to business studies on land values, city character, regulations and laws.

4.3 Packing density (ʌP)

Packing density (ʌP) is the ratio between the block coverage area (ground floor area) and its total plot area (Hu and Yoshie, 2013). It is also known as; block covering ratio (BCR), plan area density, planar area density, building area density and building to land ratio (SÜMEGHY, 2007). Ramponi et al. (2015) agreed that urban density can be described with geometric parameters like the packing density (ʌP) and the frontal area density (ʌF) (the ratio of the frontal area- front façade that facing the wind - and the total surface area) (Figure 11).
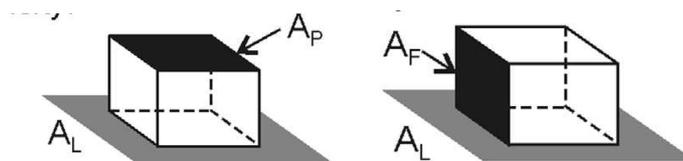
Figure 11: packing density (left) and frontal area density (right). (Ramponi et al., 2015)

Previous studies agreed that building packing density is the key factor to influence the flow adjustment and urban ventilation capacity in the city model; and that lowering the building packing density within a city could reduce the pollutant concentrations at street level and result in higher ventilation efficiency in most cases.

4.4 Setbacks

Setback in architecture, is a step-like recession in the profile of a block. Could be from a wall (other building frontage), a road or a water stream. In regulations, a setback is the minimum distance which a block must be set back from any place which is deemed to need protection (Davis, 1994, Allen, 1995). A setback as a minimum one-bay indent across all stories is called a recessed bay or recess and is the more common exterior form of an alcove. Setbacks were used by people to increase the height of masonry structures by distributing gravity loads produced by building materials. This was achieved by regularly reducing the footprint of each level located successively farther from the ground. The most marked example of a setback technique is the step pyramids of ancient Egypt (Figure 12).

Figure 12: Djoser's Step Pyramid in Saqqara. (egymonuments.gov.eg, 2019)

In previous aforementioned studies setbacks are studied with different parameters to analyze how it could affect the natural ventilation efficiency. Pablo J. Rosado (2017) compared the change in solar flux reflected from the simple narrow (no setbacks) canyon to that of the simple wide (with setbacks) canyon. The simple wide canyon was able to reflect from 2.90 (summer) to 4.52 (fall) times more solar flux than the simple narrow canyon. These multipliers are the scaling factors for adjusting air temperature changes obtained with the simple narrow canyon to the simple wide canyon which directly affect the efficiency of natural ventilation.

5 EGYPTIAN REGULATIONS AND LAW

Law No.119 of 2008 (and its executive regulations) - called unified building law - is the only law used for planning and construction. The Egypt Green Building Council (EGBC) was established by 2009 and introduced a national green building rating system called the green pyramid rating system (GPRS) (Elfiky, 2011). Regarding the law and GPRS, we cannot find obvious planning criteria to be followed to enhance city breathability or outdoor air quality as a result of good natural ventilation penetration through the urban fabric. At present in Egypt, any new constructions are subjected to the proposed planning strategies (for example the proposed strategies of the city of Alexandria 2025, 2032 and 2050) and the unified building law. In the next sections, the unified building law (law No.119 for 2008) will be analysed, based on the four natural ventilation factors mentioned in previous sections.

5.1 Aspect ratio (AR)

In the Law No 119, aspect ratios are not mentioned directly. However, building height is defined as the distance between the surface of the sidewalk (from the centre of the frontal elevation) and the top surface of the concrete slab. Parapets and service rooms at roof level are not considered. The total building height is the distance between the surface of the sidewalk (from the centre of the frontal elevation) and the highest point in the building.

The law states that the building height shall not exceed one and a half times the width of road which means: AR=1.5- with a maximum height of 42 m, The legal rule for the height of the building on two different roads stipulates that: if the building is located at the intersection of two opposite sides with different width, the width of the building height is equal to one and a half times the width of the wider road with a maximum height of 36 meters.(Ministry of Housing, 2009).

5.2 Floor area ratio (FAR)

In the Law No 119 floor area ratio is defined as: the ratio of total built up areas of all floors to the total plot area. According to article 26, FAR is determined by the strategic plan for each part of the city with maximum FAR equal 4 in the case of absence a strategic plan.(Ministry of Housing, 2009).

5.3 Packing density (ʎP)

In the Law No 119 packing density ia defined as: the ratio of the ground floor built up area to the total plot area. According to article 26, ʎP is determined by the strategic plan for each part of the city (Ministry of Housing, 2009).

32

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5.4 Setbacks

In the Law No 119 setbacks are mentioned in different terms and definitions.The Regulation Line is the line that defines the street and creates boundaries between public and private properties; it could be within, wider or narrower than the plot boundaries. The Construction Line is the line within which it is allowed to build on; it could be the street edge, the same as the Regulation Line or recessed from both. Finally, setbacks are mentioned in three other terms: frontal setback, side setback and rear setback which are defined as: the distance between the Property Line and the Construction Line in all directions (Ministry of Housing, 2009). Article 26 states that, in the case of existing streets, the Regulation Line is set back by half the difference between the width of the current road and the proposed width when building or reconstructing the plots (Ministry of Housing, 2009).

6 CONCLUSION

The rapid urbanization we are living nowadays is causing a number of problems, starting from pedestrian discomfort to the blockage of city breathability. Urban ventilation is strongly affected by urban configuration, therefore it is important to be considered as a mandatory element in building regulations and laws.

By comparing the building codes included in the Unified Building Law No.119 of 2008, and its executive regulations released in April 2009 by the Minister of Housing, and the GPRS document released by the HBRC in the same year; there are serious contradictions between both documents, as the Unified Building Law and its executive regulations allow building designs and procedures that do not comply with the GPRS. Moreover, there is no reference in the Unified Building Law to the GPRS or green building in general, nor is there any reference to the Unified Building Law in the GPRS documentation released by the Ministry of Housing, Utilities and Urban Development. Thus, it is clear that the GPRS is an isolated document that does not fit into the current building regulations, nor represent a law on its own (Ayyad and Gabr, 2012, Ammar, 2012). The most important thing - more than the relation between the law and the GPRS - is the existence of natural ventilation as concept, importance and consideration in the law. As studied and mentioned in the last section, when analyzing the law and the GPRS, there is no direct mention to natural ventilation related to the urban environment. Nor do the four main physical aspects affecting the natural ventilation have restricted requirements to enhace urban natural ventilation.

It is important to investigate urban ventilation further, its physical factors and its relation to laws and to specify the requirements in law to be followed to optimize urban natural ventilation and make it obligatory. Now that there are a lot of new developments in the construction field in Egypt, it is a perfect time to regenerate the building regulations to support the concept of natural ventilation in the built environment.

7 REFERENCES

(NWS), T. N. W. S. 2021. Origin of Wind [Online]. National Oceanic and Atmospheric Administration. [Accessed 24-11 2021].

AFIQ, W. M., AZWADI, C. S. N. & SAQR, K. M. 2012. Effects of buildings aspect ratio, wind speed and wind direction on flow structure and pollutant dispersion in symmetric street canyons: a review. International Journal of Mechanical and Materials Engineering, 7, 158-165.

AI, Z. T. & MAK, C. M. 2015. From street canyon microclimate to indoor environmental quality in naturally ventilated urban buildings: Issues and possibilities for improvement. Building and Environment, 94, 489-503.

ALLARD, F. & GHIAUS, C. 2006. Natural ventilation in the urban environment. Building Ventilation: The State of the Art; Santamouris, M., Wouters, P., Eds, 1-35.

ALLEN, I. L. 1995. The city in slang: New York life and popular speech, Oxford University Press.

AMMAR, M. G. 2012. Evaluation of the Green Egyptian Pyramid. Alexandria Engineering Journal, 51, 293-304.

ARUP, O., PARTNERS & DAVIES, E. 2002. Physical considerations in site selection. In: SNOW, D. A. (ed.) Plant Engineer's Reference Book (Second Edition). Oxford: Butterworth-Heinemann.

AYYAD, K. M. & GABR, M. 2012. Greening Building Codes in Egypt. Sustainable Futures: Architecture and Urbanism in the Global South Kampala, Uganda, 27-30.

AZIZI, M. M. & JAVANMARDI, K. 2017. The effects of urban block forms on the patterns of wind and natural ventilation. Procedia Engineering, 180, 541 – 549.

BERT BLOCKEN , T. S., JAN CARMELIET & JAN L.M. HENSEN 2011. Application of computational fluid dynamics in building performance simulation for the outdoor environment: an overview. Journal of Building Performance Simulation, 4:2, 157-184.

BIRCH, E. L. 2009. The urban and regional planning reader, Routledge.

BU, Z. & KATO, S. 2011. Wind-induced ventilation performances and airflow characteristics in an areaway-attached basement with a single-sided opening. Building and Environment, 46, 911-921.

CHUA, T., WASSELL, I. & RAHMAN, T. A. Combined effects of wind speed and wind direction on received signal strength in foliated broadband fixed wireless links. Proceedings of the Fourth European Conference on Antennas and Propagation, 2010. IEEE, 1-5.

COOK, N. J. 1986. Designers guide to wind loading of building structures. Part 1.

DASHAMLAV.COM. 2021. Wind: Meaning, Direction, Speed & Global Wind Pattern & Map [Online]. Available: https://dashamlav.com/wind-meaning-direction-speed-global-wind-pattern/ 13/12/2021].

DAVIS, A. F. 1994. The Landscape of Modernity: Essays on New York City, 1900–1940. JSTOR.

DCOZ. 2022. Zoning Handbook-floor area ratio [Online]. Beaver Builder. 07-06-2022].

E. BOZONNET, R. B. A. F. A. 2006. Modelling air flows around buildings in urban environment. International Workshop on Energy Performance and Environmental 1.

EGYMONUMENTS.GOV.EG. 2019. The Step Pyramid Complex of Djoser [Online]. Ministry of Tourism and Antiquities. Available: https://egymonuments.gov.eg/monuments/step-pyramid-of-djoser/ 21-06-2022].

EL-GEZIRY, T. 2013. General pattern of sea level variation in front of Alexandria (Egypt) and its relationship to the wind pattern. The Egyptian Journal of Aquatic Research, 39.

ELFIKY, U. 2011. Towards a green building law in Egypt: Opportunities and challenges. Energy Procedia, 6, 277-283.

FARIA, L. C. D. 2012. AIRFLOW IN THE URBAN ENVIRONMENT
An evaluation of the relationship between urban aspect ratios and patterns of airflow, wind velocity and direction in urban areas, and coefficient of pressure distribution on building envelopes. PhD, THE CARDIFF UNIVERSITY.

FORDHAM, M. 2000. Natural ventilation. Renewable Energy, 19, 17-37.

GARRISON, J. L., KOMJATHY, A., ZAVOROTNY, V. U. & KATZBERG, S. J. 2002. Wind speed measurement using forward scattered GPS signals. IEEE Transactions on Geoscience and Remote Sensing, 40, 50-65.

GEORGAKIS, C. & SANTAMOURIS, M. 2008. On the estimation of wind speed in urban canyons for ventilation purposes—Part 1: Coupling between the undisturbed wind speed and the canyon wind. Building and Environment, 43, 1404-1410.

GIVONI, B. 1989. Urban Design in Different Climates. World Meteorological Organization, Geneva, Switzerland, .

HAWKINS, E. & SUTTON, R. 2009. The potential to narrow uncertainty in regional climate predictions. Bulletin of the American Meteorological Society, 90, 1095-1108.

HAY, W. W. 2016. Experimenting on a Small Planet: A history of scientific discoveries, a future of climate change and global warming, Springer.

HOGAN, C. M. & MONOSSON, E. 2010. Abiotic factor. Encyclopedia of Earth.

HOSKER, R. 1985. Flow around isolated structures and building clusters: a review. ASHRAE Trans.;(United States), 91.

HU, T. & YOSHIE, R. 2013. Indices to evaluate ventilation efficiency in newly-built urban area at pedestrian level. Journal of Wind Engineering and Industrial Aerodynamics, 112, 39-51.

HUNTER, L. J., WATSON, I. & JOHNSON, G. 1990. Modelling air flow regimes in urban canyons. Energy and Buildings, 15, 315-324.

JUAN, Y.-H., YANG, A.-S., WEN, C.-Y., LEE, Y.-T. & WANG, P.-C. 2017. Optimization procedures for enhancement of city breathability using arcade design in a realistic high-rise urban area. Building and Environment, 121, 247-261.

JUSTUS, C., HARGRAVES, W., MIKHAIL, A. & GRABER, D. 1978. Methods for estimating wind speed frequency distributions. Journal of applied meteorology, 17, 350-353.

KRARTI, M. 2018. Optimal design and retrofit of energy efficient buildings, communities, and urban centers, Butterworth-Heinemann.

KUTZ, M. 2016. Handbook of measurement in science and engineering, John Wiley & Sons.

LIN, M., HANG, J., LI, Y., LUO, Z. & SANDBERG, M. 2014. Quantitative ventilation assessments of idealized urban canopy layers with various urban layouts and the same building packing density. Building and Environment, 79, 152-167.

MCCONNELL, W. J. 1926. Fresh Air and Ventilation. American Public Health Association.

MCILVEEN, R. 1991. Fundamentals of weather and climate, Psychology Press.

MEI, S.-J., HU, J.-T., LIU, D., ZHAO, F.-Y., LI, Y. & WANG, H.-Q. 2018. Thermal buoyancy driven canyon airflows inside the compact urban blocks saturated with very weak synoptic wind: Plume merging mechanism. Building and Environment, 131, 32-43.

MINISTRY OF HOUSING, U. A. U. D. 2009. Executive Regulations of the Building Law اللائحـــة التنفيذيـــــــة لقـــانون 144. ((البنـــــاء. 82 A ed. Egypt: Alamiria press.

NAKAMURA, Y. & OKE, T. R. 1988. Wind, temperature and stability conditions in an east-west oriented urban canyon. Atmospheric Environment (1967), 22, 2691-2700.

NAZARIAN, N. & KLEISSL, J. 2016. Realistic solar heating in urban areas: Air exchange and street-canyon ventilation. Building and Environment, 95, 75-93.

OKE, T. 1978a. Boundary layer climates, London, Methuen and Co., Halsted Press.

OKE, T. R. 1978b. Boundary layer climates, Routledge.

OKE, T. R. 1988. Street design and urban canopy layer climate. Energy and buildings, 11, 103-113.

OMRANI, S., GARCIA-HANSEN, V., CAPRA, B. & DROGEMULLER, R. 2017. Natural ventilation in multi-storey buildings: Design process and review of evaluation tools. Building and Environment, 116, 182-194.

PABLO J. ROSADO, G. B.-W., ARASH MOHEGH, RONNEN M. LEVINSON 2017. Influence of street setbacks on solar reflection and air cooling by reflective streets in urban canyons. solar energy, 144.

PALUSCI, O. & CECERE, C. 2022. Urban Ventilation in the Compact City: A Critical Review and a Multidisciplinary Methodology for Improving Sustainability and Resilience in Urban Areas. Sustainability, 14, 3948.

PERRY, S. 2004. Wind tunnel simulation of flow and pollutant dispersal around the World Trade Center site. Environmental Manger, February, 2004.

RAFFERTY, J. P. 1998. urban climate [Online]. Available: https://www.britannica.com/science/urban-climate 07-03-2022].

RAMPONI, R., BLOCKEN, B., DE COO, L. B. & JANSSEN, W. D. 2015. CFD simulation of outdoor ventilation of generic urban configurations with different urban densities and equal and unequal street widths. Building and Environment, 92, 152-166.

SANTAMOURIS, M. 1997. Passive Cooling of Buildings. James and James.

34

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

SANTAMOURIS, M. 2004. Natural Ventilation in Urban Areas. Air Infiltration and Ventilation Centre, 3.

SAUCIER, W. J. 1955. Principles of meteorological analysis, University of Chicago Press Chicago, Ill.

SCHULZE, T. & EICKER, U. 2013. Controlled natural ventilation for energy efficient buildings. Energy and buildings, 56, 221-232.

SERWAY, R. A. & JEWETT, J. W. 2018. Physics for scientists and engineers, Cengage learning.

SPIKOWSKI, W. M. 2006. The complete guide to zoning: How real estate owners and developers can create and preserve property value. American Planning Association. Journal of the American Planning Association, 72, 376.

SÜMEGHY, T. G. A. Z. 2007. MAPPING THE ROUGHNESS PARAMETERS IN A LARGE URBAN AREA FOR URBAN CLIMATE APPLICATIONS. ACTA CLIMATOLOGICA ET CHOROLOGICA.

VARDOULAKIS, S., FISHER, B. E., PERICLEOUS, K. & GONZALEZ-FLESCA, N. 2003. Modelling air quality in street canyons: a review. Atmospheric environment, 37, 155-182.

WEBSTER, M. 1907. Aspect ratio [Online]. Britannica Company. Available: https://www.merriam-webster.com/ 24-05-2022].

YAZID, A. W. M., SIDIK, N. A. C., SALIM, S. M. & SAQR, K. M. 2014. A review on the flow structure and pollutant dispersion in urban street canyons for urban planning strategies. Simulation, 90, 892-916.

An Assessment of Urban Decay in Rural Towns: a Case of Building Dilapidation in Thohoyandou Town, South Africa

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1 ABSTRACT

Urban decay is a global dilemma that can severely weaken the image, livability, and productivity of most cities due to its negative impacts on the built environment. Building dilapidation is one form of urban decay which can pose a risk to public health, safety or well-being . The impact of urban decay cannot be overemphasized particularly in South Africa's historically disadvantaged rural towns such as Thohoyandou. The aim of this study was to assess the status of building dilapidation in Thohoyandou Central Business District (CBD) in Limpopo province of South Africa. The objectives of the study were to map building dilapidation in Thohoyandou CBD; to investigate the causes of building dilapidation in Thohoyandou CBD and to suggest recommendations towards addressing persisting building dilapidation. This study adopted a qualitative research approach through conducting 20 key informant interviews and field observations. The study revealed that building dilapidation in Thohoyandou CBD is caused by factors such as lack of municipal by-laws to deal with derelict buildings, irregular planning procedures in the construction of buildings; lack of building maintenance, illegal occupation of buildings; negligence of buildings by property owners, incapacity of the municipality to render services to overpopulated buildings as well as lack of enforcing building occupant capacity by-laws. These findings highlight the complexity of the issue and the need for a holistic approach to address urban decay. Based on the research findings, the study puts forth several recommendations to mitigate building dilapidation in rural towns like Thohoyandou. The study suggested recommendations which include formulating municipal by-laws to deal with derelict buildings, stricter enforcement of regular planning procedures in construction projects; establishing a dedicated CBD building maintenance plan, conducting Thohoyandou CBD building audits, and regulation of building occupants' capacities. Collaboration among stakeholders, including the municipality, property owners, and the community, is essential for the successful implementation of these strategies. The study contributes to the existing knowledge on urban decay and revitalization. The research findings have significant implications for policy and decision-making in Thohoyandou CBD and other similar contexts, aiming to promote sustainable urban development and improve the overall quality of life.

Keywords: central business district, building dilapidation, urban decay, rural towns, spatial planning

2 INTRODUCTION

Urban decay and building dilapidation pose significant challenges to the sustainable development and revitalization of cities and towns worldwide (Ndlebe, 2017). In the context of developing countries, rural towns often face unique circumstances and complexities in combating urban decay (Phillips, 2017). Thohoyandou CBD, a rural town in South Africa, exemplifies these challenges, where the deterioration of buildings has become a pressing issue, negatively impacting the town's overall aesthetics, economy, and residents' quality of life.

This research aimed to investigate the causes and implications of building dilapidation in Thohoyandou CBD and to propose strategies for addressing this issue. By examining this specific case, the study contributed to the broader understanding of urban decay and provides valuable insights for similar rural contexts facing similar challenges.

According to Saranya and Mewa (2017), building dilapidation refers to the progressive deterioration and decay of structures, resulting from neglect, inadequate maintenance, or other contributing factors. In Thohoyandou CBD, the phenomenon of building dilapidation has been escalating, with a growing number of abandoned or rundown buildings becoming a common sight (Thulamela Municipality IDP, 2019). The consequences are multi-fold, including reduced property values, increased crime rates, decreased economic activities, and a decline in community morale (Phillips, 2017).

While the literature on urban decay and building dilapidation predominantly focuses on urban centers in developed countries, there is a dearth of research examining this issue in rural towns, especially in the context of developing countries. Thohoyandou CBD provided an ideal case study due to its unique characteristics, including a predominantly rural setting, limited resources, and a history of inadequate urban planning and management.

This study adopted a qualitative research approach, utilizing a case study research design to explore the causes and implications of building dilapidation in Thohoyandou CBD. By employing key informant interviews, field observations, and secondary sources, the research sought to uncover the underlying factors contributing to building dilapidation and understand their interconnectedness. Thematic content analysis was employed to analyze the collected data, identify recurring patterns and themes, and draw meaningful conclusions.

The findings of this study offered valuable insights into the complexities of building dilapidation in rural towns like Thohoyandou and inform the development of strategies and interventions to mitigate urban decay. Ultimately, the research aimed to contribute to the existing knowledge base on urban revitalization efforts in developing countries and promote sustainable urban development for the betterment of Thohoyandou CBD and similar contexts.

3 LITERATURE REVIEW

3.1 Introduction

Urban decay is a significant issue that affects cities worldwide, leading to numerous social, economic, and environmental challenges (Saranya and Mewa, 2017). Understanding the causes and consequences of urban decay is crucial for policymakers, urban planners, and researchers to develop effective strategies for revitalization and sustainable urban development (Phillips, 2017). This literature review aims to explore the various dimensions of urban decay, analyze its underlying causes, and highlight the importance of comprehensive interventions.

Urban decay encompasses a range of interconnected problems, including physical deterioration, social disintegration, economic decline, and inadequate infrastructure (Mireku, 2021). Dilapidated buildings, high crime rates, unemployment, poverty, and spatial inequalities are common manifestations of urban decay (Aubakari, 2021). According to Martinez (2021), the consequences of urban decay are far-reaching, affecting the quality of life for residents, hindering economic growth, and exacerbating social inequalities.

This literature review serves as a critical component of a broader thesis focusing on urban decay and its remediation. By examining existing research, theories, and practical interventions, the review aims to provide a comprehensive understanding of urban decay, its causes, and potential solutions. The review draws upon a range of scholarly works, including academic articles, books, and policy reports, to ensure a comprehensive analysis of the topic. By synthesizing the existing literature, this review seeks to identify common themes, knowledge gaps, and emerging trends in the field of urban decay. It also aims to highlight the significance of urban planning, policy interventions, and community engagement in addressing urban decay and promoting sustainable urban development. The findings of this literature review will contribute to the broader thesis by providing a solid theoretical foundation and informing the subsequent empirical research and analysis.

Overall, this literature review will play a vital role in understanding the complexities of urban decay and formulating effective strategies for its mitigation. By examining the existing body of knowledge, it will provide insights into the causes and consequences of urban decay and offer recommendations for policymakers, urban planners, and community stakeholders to foster vibrant and sustainable cities.

3.2 Urban Decay: Definition and Causes

Urban decay refers to the progressive deterioration of urban areas, characterized by physical, social, and economic decline (Martinez, 2021). It encompasses a wide range of manifestations that collectively contribute to the degradation of cities and communities. Physical decay is often visible through dilapidated buildings, crumbling infrastructure, and abandoned spaces (Suite, 2023). Social disintegration involves the breakdown of social networks, increased crime rates, poverty, and social inequalities (Lombardo, 2017).

Economic decline manifests as unemployment, decreased investment, and a shrinking tax base (Ndlebe, 2017).

Urban decay is the result of a complex interplay of various factors, including economic, social, and planning-related aspects (Philip, 2017). Economic factors play a significant role in the deterioration of urban areas. The decline of traditional industries, such as manufacturing, can lead to high unemployment rates and poverty, creating a cycle of disinvestment and decline (Letlape, 2019). Global economic forces, such as deindustrialization and globalization, have also contributed to the decay of certain cities and neighborhoods (Suite, 2023).

According to Glaeser and Gyourko (2005), social issues, including crime, social inequality, and social dislocation, are intertwined with urban decay. High crime rates, often associated with urban decay, create an atmosphere of fear and insecurity, discouraging investment and economic activity (Attwood, 2013). Social inequalities, such as unequal access to quality education, healthcare, and housing, further perpetuate urban decay (Davis, 2018). Social dislocation, caused by factors such as migration, racial segregation, and gentrification, can disrupt social cohesion and exacerbate urban decay (Fahey, 2017).

Inadequate urban planning and governance contribute significantly to urban decay. Poor land-use planning, zoning regulations, and lack of comprehensive urban development strategies can result in mismatched land uses, uncontrolled sprawl, and neglect of certain neighborhoods (Kandžija et al., 2017). Insufficient investment in infrastructure maintenance and renewal leads to the physical deterioration of buildings and public spaces (Lewis, 2013). Additionally, inadequate community participation and lack of accountability in decision-making processes can hinder the revitalization of decaying areas (Nassaji, 2015).

The impacts of urban decay are detrimental to both communities and cities as a whole. Decaying neighborhoods often experience a decline in property values, making it difficult for residents to sell their homes and move elsewhere (Onuoha, 2014). This exacerbates residential segregation and hinders social mobility. Urban decay can also lead to decreased tax revenues for local governments, limiting their capacity to provide essential services and invest in infrastructure (Vera, 2015).

Furthermore, the negative impacts of urban decay extend beyond economic and social realms. Deteriorating physical environments contribute to poor health outcomes, as decaying buildings may contain health hazards such as lead, asbestos, or mold (Zack, 2015). The lack of green spaces and the degradation of the natural environment further exacerbate health disparities in decaying neighborhoods (Kweon et al., 2017). Urban decay also perpetuates a negative cycle, as it discourages private investment and perpetuates a sense of hopelessness and disengagement among residents (Bess, 2008).

In conclusion, urban decay is a multifaceted phenomenon with profound impacts on communities and cities. Its manifestations encompass physical, social, and economic decline. Economic factors, social issues, and inadequate urban planning all contribute to the emergence and persistence of urban decay. The negative impacts of urban decay include reduced property values, diminished tax revenues, health hazards, and social disintegration. Understanding the causes and impacts of urban decay is essential for formulating effective strategies for revitalization and sustainable urban development.

3.3 Importance of Addressing Urban Decay

Addressing urban decay is of utmost importance for achieving sustainable urban development and ensuring the well-being of communities (Bess, 2008). Neglecting urban decay can have severe consequences that extend beyond the physical deterioration of neighborhoods (Awumbila, Owusu, and Teye, 2014). By understanding the significance of addressing urban decay, policymakers, urban planners, and community stakeholders can work towards implementing comprehensive strategies to revitalize declining areas (Branas et al., 2011).

One of the potential consequences of neglecting urban decay is the increase in crime rates. Decaying neighborhoods often experience higher levels of criminal activities due to the lack of social control, disinvestment, and limited economic opportunities (Crentsil and George, 2018). The presence of vacant and abandoned properties creates a breeding ground for criminal behavior and contributes to a sense of insecurity among residents (Galeser, 2011).

Environmental degradation is another consequence of urban decay. Neglected areas are more likely to suffer from poor environmental management, including inadequate waste disposal, pollution, and the loss of green

spaces (Harrison, 2002). This not only negatively impacts the quality of life for residents but also contributes to health hazards and the degradation of ecosystems (Phillips, 2017).

Furthermore, neglecting urban decay can result in declining property values, exacerbating economic inequalities and hindering economic growth. Deteriorating neighborhoods face challenges in attracting investments and businesses, leading to a downward spiral of disinvestment and limited job opportunities (Taipale, 2011). The decline in property values also affects homeowners and can lead to financial instability and limited mobility for residents (Ndlebe, 2017).

To effectively address urban decay, comprehensive strategies are required. Piecemeal approaches are often insufficient and fail to tackle the root causes of decay (Okrent, 2009). Comprehensive strategies should encompass physical, social, economic, and environmental dimensions of urban development (Onuoha, 2014). This may involve targeted investments in infrastructure, affordable housing, and community facilities, as well as promoting community engagement and participation in decision-making processes (Parab et al., 2020).

In summary, addressing urban decay is crucial for sustainable urban development. Neglecting urban decay can have detrimental consequences, including increased crime rates, environmental degradation, and declining property values. It is imperative to adopt comprehensive strategies that address the underlying causes of urban decay and foster revitalization. By doing so, cities can promote social equity, environmental sustainability, and economic growth, ensuring vibrant and inclusive communities for the future.

3.4 Approaches to Urban Decay Remediation

Urban decay remediation requires a multifaceted approach that encompasses urban renewal programs, community development initiatives, and effective land use management frameworks (Smith and Sarah, 2008). This section explores these approaches and their role in addressing urban decay.

3.4.1 Urban Renewal Programs

Urban renewal, a concept rooted in the post-World War II era, aims to revitalize deteriorating urban areas through comprehensive redevelopment strategies (Squires and Kubrin, 2005). These programs emerged in response to the challenges of blight, substandard housing, and social dislocation (Bess, 2008). Urban renewal initiatives have been implemented worldwide, such as the regeneration efforts in London's Docklands and the revitalization of New York City's Times Square (Vera, 2015). However, the effectiveness of urban renewal strategies has been a topic of debate. While they can rejuvenate declining areas and attract investment, they often face criticism for causing displacement, eroding local cultures, and neglecting social inclusivity (Zach, 2015).

3.4.2 Community Development Initiatives

Community-based approaches play a vital role in addressing urban decay by empowering residents and fostering social cohesion. Such initiatives involve active participation from community members, grassroots organizations, and local authorities (Wilkerson et al., 2014). Successful examples of community-led efforts can be found worldwide, including the establishment of community land trusts in the United States and the creation of self-help housing projects in Brazil (Squires and Kubrin, 2005). These initiatives not only address physical decay but also promote social capital and empowerment. However, challenges exist, including limited resources, unequal power dynamics, and the need for sustained community engagement (Parab et al., 2020).

3.4.3 Land Use Management Frameworks

Land use management systems (LUMS) are essential tools for regulating land use and preventing frictional blight. LUMS encompass various mechanisms, such as land use policies, framework plans, and land use schemes, which guide decision-making processes and promote harmonious land development (Okrent, 2009). The Thulamela district in South Africa provides an example of a comprehensive LUMS. In this district, the Land Use Management System (LUMS) plays a crucial role in managing land use and development, aligning with the Integrated Development Plan's policy and strategic-based decisions (Mavhunga et al., 2019). Such frameworks help mitigate conflicts between incompatible land uses, ensuring sustainable urban development and avoiding the detrimental effects of urban decay (Onouha, 2014).

40

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3.4.4   Spatial Planning and Land Use Management Act (SPLUMA)

The Spatial Planning and Land Use Management Act (SPLUMA) serves as a comprehensive framework for spatial planning and land use management in South Africa. It requires the preparation of Spatial Development Frameworks (SDFs), which lay out a clear vision for long-term development goals (Vera, 2015). SPLUMA addresses the causes of urban decay by providing regulations for spatial planning, land use schemes, and urban management. It aims to promote spatial sustainability and efficiency. For instance, SPLUMA emphasizes sustainable land use, limits urban sprawl, and encourages the redevelopment of existing structures (Taipale, 2011). By adopting SPLUMA and adhering to its goals, municipalities can effectively tackle urban decay and promote sustainable urban development (Nassaji, 2015).

In conclusion, addressing urban decay requires a comprehensive approach that includes urban renewal programs, community development initiatives, effective land use management frameworks, and adherence to relevant legislation such as SPLUMA. Urban renewal programs can rejuvenate deteriorating areas, but they must consider social inclusivity and avoid displacement. Community development initiatives empower residents and promote social capital, although challenges of resource constraints and power dynamics exist.

3.5 Integrated Development Planning

Integrated Development Planning (IDP) is a crucial concept in addressing urban decay as it provides a comprehensive framework for coordinating various planning processes and promoting sustainable development (Zach, 2015). The municipality of Thulamela's IDP plays a significant role in addressing urban decay within its jurisdiction.

IDP refers to a strategic planning process that integrates various sectors and stakeholders to guide the development of a municipality or district (Vera, 2015). It serves as a primary instrument for informing planning, management, and decision-making processes (Smith and Sarah, 2008). The IDP recognizes the interconnectedness of social, economic, and environmental factors, aiming to create inclusive and sustainable communities (Bess, 2008).

The municipality of Thulamela's IDP is crucial in addressing urban decay within its region. It provides a framework for aligning national and provincial legislation with local planning requirements (Kandžija et al., 2017). The IDP identifies the plans and planning requirements that are binding on the municipality and outlines the principles and procedures for consultation and coordination with local municipalities (Republic of South Africa, 2000). By integrating various planning processes, the IDP ensures a holistic approach to urban development and helps overcome the challenges associated with urban decay (Branas et al., 2011).

The Thulamela municipality's IDP encompasses both rural and urban issues, addressing the declining built form and physical environment in the region. Urban decay often results in a lack of coherence and functionality in cities, hindering their overall development (Crentsil and George, 2018). The integration of various activities, guided by the IDP, enables the municipality to address urban decay by promoting effective land use, infrastructure development, and social inclusion (Thulamela Local Municipality, 2018).

The IDP's strategic planning approach ensures that all decisions related to planning, management, and development are informed by a shared vision and goals (Republic of South Africa, 2000). It enables the municipality to prioritize interventions and allocate resources effectively, taking into account the specific challenges associated with urban decay (Awumbila Owusu, and Teye, 2014). By integrating spatial development frameworks, land use management systems, and community-driven initiatives, the IDP contributes to a coordinated and comprehensive response to urban decay (Craig and Dougla, 2005).

In summary, integrated development planning plays a vital role in addressing urban decay by providing a holistic and coordinated approach to urban development. The municipality of Thulamela's IDP serves as a strategic planning instrument, aligning national and provincial legislation with local planning requirements. Through the integration of various planning processes, the IDP enables the municipality to address urban decay challenges and promote sustainable and inclusive development in both rural and urban areas.

3.6 Conclusion

This literature review has examined the concept of urban decay, its causes, impacts, and the approaches to remediation. The review highlighted the significance of addressing urban decay for sustainable urban development and emphasized the need for comprehensive strategies.

Urban renewal programs have been identified as a key approach to revitalizing deteriorating urban areas. However, it is crucial to consider their effectiveness and limitations, as well as the importance of community development initiatives. Community-based approaches play a vital role in empowering local communities and fostering sustainable change. Additionally, the review explored the role of land use management frameworks, such as the LUMS in the Thulamela district, and the Spatial Planning and Land Use Management Act (SPLUMA) in guiding land use and development. These frameworks provide regulatory mechanisms to prevent frictional blight and promote harmonious land use.

Moreover, the municipality of Thulamela's integrated development plan (IDP) emerged as a significant tool for addressing urban decay by integrating various planning processes and promoting sustainable development. To combat urban decay effectively, future research should focus on evaluating the outcomes of urban renewal programs, analyzing the long-term impacts of community development initiatives, and exploring innovative approaches within land use management frameworks. Additionally, interventions should prioritize the implementation of comprehensive strategies that integrate multiple approaches, including urban renewal, community development, land use management, and integrated development planning.

4 RESEARCH METHODOLOGY

4.1 Introduction

This section provides an overview of the research methodology, highlighting its significance in addressing the research objectives. The research design, approach, and key components are briefly discussed, setting the stage for the subsequent sections. The chosen qualitative research approach is justified based on its ability to capture human expressions, experiences, and observations. The case study research approach is explained as suitable for conducting a thorough and in-depth study of urban decay. The section also establishes the context for the research methodology and its importance in generating genuine and authentic results.

4.2 Research Approach

A qualitative research approach was chosen to capture the nuances and insights of the human mind in relation to urban decay. Qualitative research allows for open and transparent expression of opinions, experiences, and observations. It enables a deeper understanding of how individuals make sense of their urban environment (Neumen, 2013). By adopting a case study research approach, the study aims to conduct a comprehensive and in-depth examination of urban decay, narrowing down complex issues into manageable and investigable problems. This approach is particularly suitable for qualitative research and facilitates the application of theories or models to real-world phenomena (McLeod, 2014). It also addresses the need for researchers to gain insights into urban collapse and its implications.

4.3 Study Population

The study population consists of key stakeholders involved in the building dilapidation of Thohoyandou CBD. This includes municipal officials, property owners, and tenants within the CBD. Selecting the right participants is crucial for the accuracy and relevance of the study. Understanding the characteristics and preferences of the target audience helps in obtaining precise and meaningful research outcomes (Murphy, 2016)

4.4 Sampling Procedure

The sampling procedure for this study involved the selection of a sample group to be studied instead of attempting to study the entire population (Creswell, 2013). Non-probability sampling methods were adopted due to the qualitative nature of the research. Purposive sampling was used to select municipal officials involved in spatial planning issues within Thohoyandou CBD, while convenience sampling was employed to identify property owners and tenants within the CBD. The choice of sampling techniques aimed to gather information from relevant individuals who had knowledge and experience related to the research topic. By using a combination of purposive and convenience sampling, the study ensured the inclusion of key stakeholders who could provide valuable insights into the building dilapidation in Thohoyandou CBD (Reddy, 2017).

4.5 Data Collection

The data collection process for this study involved both primary and secondary data sources. Primary data collection methods included key informant interviews and field observations. Key informant interviews were conducted with 13 municipal officials, 2 property owners, 4 tenants, and 1 informal trader within the Thohoyandou CBD. These interviews provided valuable insights into the perspectives and experiences of key stakeholders involved in the building dilapidation issue. Field observations were carried out to map dilapidated buildings within the CBD using an observation checklist and capture photographs of the buildings.

Secondary data collection involved gathering information from various sources such as local government documents including the Thulamela Vision 2030 document, the Thulamela Integrated Development Plan (IDP) 2021/2022, and the Thulamela Spatial Development Framework (SDF). Additionally, previous studies such as journal articles and papers were reviewed to gain a better understanding of the research problem and explore existing knowledge on urban decay and revitalization efforts.

The collected data, both primary and secondary, served as the basis for the analysis and interpretation of the research findings. Thematic content analysis was applied as the method of data analysis, which involved identifying patterns and common themes in the interview data (Braun and Clarke, 2006). This analysis approach allowed for a comprehensive exploration of the data and facilitated the achievement of the research objectives.

4.6 Qualitative Data Analysis

Qualitative data analysis plays a crucial role in uncovering patterns, themes, and meanings within the collected data, providing valuable insights into the research topic. In this study, thematic content analysis was chosen as the method for data analysis (Creswell, 2013). Thematic content analysis is a systematic approach that involves identifying, organizing, and interpreting patterns or themes in qualitative data (Braun & Clarke, 2006).

Thematic content analysis was selected due to its suitability for analyzing rich textual data and its ability to uncover common themes and patterns across the interviews and observations (Reddy, 2017). By using this method, the research team aimed to identify recurring ideas, concepts, and perspectives related to building dilapidation in Thohoyandou CBD.

The process of analyzing the raw data involved several steps. First, the transcripts and field notes were read and re-read to gain a comprehensive understanding of the data (Shareia, 2016). Then, meaningful units of information were coded, assigning labels to segments of data that captured important concepts or themes. These codes were then grouped together to form broader categories or themes. Through an iterative process, the research team refined and revised the themes until a coherent and comprehensive set of themes emerged (Robson and McCartan, 2016).

Rigor and reliability were maintained throughout the analysis process by employing strategies such as intercoder agreement, member checking, and peer debriefing (McMillan and Schumacher, 2014). Intercoder agreement involved multiple researchers independently coding a subset of the data to ensure consistency and agreement in the coding process (Hadi and Closs, 2016). Member checking allowed participants to review and validate the interpreted findings, ensuring their perspectives were accurately represented ((Theofanidis and Fountouki, 2018). Peer debriefing involved seeking feedback from other researchers to enhance the credibility and trustworthiness of the analysis.

By employing thematic content analysis and maintaining rigor in the analysis process, this study aimed to provide a robust and comprehensive understanding of the causes and recommendations for building dilapidation in Thohoyandou CBD.

4.7 Ethical Considerations

The study adhered to a set of ethical considerations to ensure the rights and well-being of the participants. Approval was obtained from the university's research and innovation policy committee, ensuring that the study met ethical standards. Voluntary participation was emphasized, allowing participants to choose whether or not to take part in the study without coercion. Informed consent was obtained from participants, ensuring they were fully informed about the purpose, procedures, and potential risks involved. Anonymity

and confidentiality were maintained to protect participants' identities and ensure their responses remained confidential. Potential for harm was minimized by conducting the study in a sensitive manner and providing support resources if needed. Finally, results communication involved sharing findings with participants and the wider research community, ensuring transparency and accountability.

The ethical considerations followed in this study align with established guidelines and principles for conducting ethical research (Polit and Beck, 2017). By upholding these ethical standards, the study aimed to protect the rights and well-being of the participants and ensure the integrity and trustworthiness of the research process.

4.8 Conclusion

This research methodology section has discussed the key elements of the study's research design, data collection methods, and data analysis techniques. The emphasis has been placed on the adherence to ethical considerations, including voluntary participation, informed consent, anonymity, confidentiality, and potential for harm. Rigorous data collection and analysis methods, such as key informant interviews, field observations, and thematic content analysis, were employed to ensure the reliability and validity of the study's findings. The relevance of the research methodology in achieving the research objectives has been highlighted, as it provides a robust framework for understanding and addressing the issues related to urban decay. By following ethical guidelines and employing rigorous research methods, this study aims to contribute valuable insights and recommendations for addressing urban decay effectively.

5   RESULTS AND DISCUSSION

5.1 Introduction

This section aims to present and interpret the findings of the study. This chapter begins by summarizing the research questions or hypotheses addressed and providing a concise overview of the collected or analyzed data. The presentation of results focuses on the key findings, organized in a logical manner from the most important or significant to the least. The discussion of findings involves interpreting and analyzing the results in relation to the research questions or hypotheses. Throughout the discussion, reference is made to existing literature to compare and contrast the current study's findings with previous research. Emphasis is placed on identifying patterns, trends, and relationships observed in the data, while offering explanations or potential reasons for the observed results.

5.2 Research objective 1: Which buildings have dilapidated in Thohoyandou CBD?

Name of dilapidated building	Privately owned/ Owned by the municipality
Noorani complex	Privately owned
Gole complex	Privately owned
Thohoyandou inter-modal taxi rank	Owned by municipality
Matidza complex	Privately owned
NTK Thohoyandou	Privately owned
Post office	Owned by Municipality
Jjays Bottle store	Privately owned
Mutsindo mall	Owned by municipality
Luvhengo Complex	Privately owned

Table 1 Dilapidated buildings in Thohoyandou CBD.

The study found that that there are dilapidated buildings around Thohoyandou CBD. Some of these buildings include Noorani complex, Matidza complex, Mutsindo mall, Gole complex, NTK, Post Office, Luvhengo complex and are presented in table 4.1. above. Observation of the Noorani complex showed that the ceiling was decaying, the wall were peeling off and there were some electrical cables hanging on the balcony steels which are rusting. Findings of the study suggested that this was a result of a lack of maintenance in this building. The findings show that the building is dilapidating and may be contributing to urban decay in Thohoyandou CBD. Observation of the Thohoyandou intermodal taxi rank showed a razor wire abandoned on the stairs of the structure to show that the place is not in use. Further observation of the NTK and Thohoyandou Post office building showed that the buildings were in very poor condition, most windows of the buildings were broken and their roofing was rusting and striping off along with the interior wall of the buildings.

5.3 Research question 2: What are the causes of building dilapidation in Thohoyandou CBD?

Through interviews with key informants, the study identified various factors contributing to building dilapidation, including the lack of bylaws, irregular planning procedures, inadequate building maintenance, illegal occupation of buildings, neglect by property owners, the municipality's incapacity to render services, non-regulation of building capacities, and overcrowding. This following highlights the key findings:

Lack of Bylaws: One significant cause of building dilapidation in Thohoyandou CBD is the absence of bylaws to deal with derelict buildings. According to Key Informant A, "The absence of bylaws to deal with derelict buildings is a major challenge. We lack regulatory instruments to enforce compliance and ensure building maintenance." Bylaws serve as crucial regulatory instruments for creating inclusive, accessible, and safe cities (Ndlebe, 2017). According to Van dijk (2007), they enforce compliance and have the potential to bring positive change to the city's safety profile over time. However, the lack of effective bylaws hinders the municipality's ability to control human and corporate behavior, contributing to the deterioration of buildings (Luyt, 2008).

Irregular Planning Procedures: The irregular planning procedures in the construction of buildings, such as the intermodal taxi rank, have also played a role in building dilapidation. Key Informant B stated that, "Poor planning and budgeting, coupled with inadequate monitoring, have led to structural issues and improper provision of housing." Poor planning and budgeting, coupled with inadequate monitoring by local municipalities, lead to structural issues and improper provision of housing (Boraine, 2010). These factors negatively impact the condition of buildings, resulting in urban blight and aesthetic degradation (Wakely, 2014).

Lack of Building Maintenance: The lack of building maintenance exacerbates the problem of dilapidation. Key Informant C emphasized the following, "Building owners often display ignorance and a delayed response to maintenance issues." Building owners often display ignorance and a delayed response to maintenance issues, leading to the worsening of problems such as sanitation, electricity, and water (Ndlebe, 2017). Additionally, the absence of bylaws regulating derelict buildings allows mismanagement by landlords, affecting both revenue and the overall city aesthetics (Andile, 2018).

Illegal Occupation of Buildings: The illegal occupation of buildings, particularly by foreign business owners seeking better living standards, contributes to overcrowding and strain on municipal services. Key Informant D pointed out the following, "The illegal occupation of buildings by foreign business owners seeking better living standards has led to overcrowding and strain on municipal services." The influx of people increases the demand for services, including water, electricity, and solid waste disposal, which the municipality struggles to provide (Chen et al, 2014). According to Graham (2020), this influx further leads to the deterioration of buildings in the CBD.

Neglect by Property Owners: A significant issue in Thohoyandou CBD is the neglect of buildings by absentee property owners who prioritize rent collection over property maintenance. Key Informant E highlighted the following, "Absentee property owners prioritize rent collection over property maintenance." As absentee owners often reside elsewhere, they disregard the condition of the buildings, leading to decay and a decline in the aesthetic appeal of the CBD (Mantzaris, 2014).. According to Murimoga and Musingafi (2014), the lack of control over tenants and a disregard for building upkeep contributes to neighbourhood decline and blight.

Municipal Incapacity to Render Services: The municipality's inability to effectively deliver services, such as water, electricity, and sanitation, exacerbates building dilapidation. Key Informant F stated the following, "The municipality's inability to effectively deliver services exacerbates building dilapidation." Overcrowding caused by illegal occupants puts pressure on these utilities, leading to inadequate service provision (Andole, 2016). Poor leadership, governance, and financial mismanagement further contribute to the ineffective delivery of services (Routhe, 2018).

Non-regulation of Building Capacities: Thohoyandou CBD faces the challenge of large buildings with limited maintenance and insufficient space. According to Key Informant G, "The lack of regulation regarding building capacities affects the cleanliness, health, and overall functionality of the CBD." Overcrowding, especially due to the presence of illegal traders, obstructs proper infrastructure development and service provision (Phillips, 2017). The lack of regulation regarding building capacities affects the cleanliness, health, and overall functionality of the CBD (Graham, 2020).

Overcrowding: The rapid population growth in Thohoyandou CBD, driven by people seeking access to services, intensifies the pressure on buildings. Key Informant H explained the following, "Rapid population growth in Thohoyandou CBD intensifies the pressure on buildings." Small offices in rental buildings accommodate more people than the municipality's targeted capacity for service provision. Overpopulation leads to inadequate maintenance, strain on utilities, and ultimately, the dilapidation of buildings.

The causes of building dilapidation in Thohoyandou CBD are multi-faceted and interconnected. The absence of bylaws, irregular planning procedures, inadequate building maintenance, illegal occupation, neglect by property owners, municipal incapacity, non-regulation of building capacities, and overcrowding all contribute to the deteriorating state of the buildings. Addressing these issues requires a holistic approach, including the implementation of effective bylaws, improved planning processes, increased maintenance efforts, and better service provision. It is imperative for stakeholders, including the municipality, property owners, and the community, to work collaboratively towards revitalizing the CBD and ensuring its long-term sustainability.

5.4 Research question 3: Which recommendations can be suggested to address building dilapidation in rural towns such as Thohoyandou?

This section focuses on several key strategies to address the challenges related to derelict buildings and urban decay. These strategies include formulating bylaws, enforcing planning procedures, establishing a dedicated CBD building maintenance plan, evicting illegal occupants, conducting building audits, and regulating building capacities.

One crucial strategy identified is the formulation of bylaws to deal with derelict buildings. The responsible person or persons who violate these bylaws would be held liable for damages and costs incurred by the local authority to address the issue (Bess, 2008). By developing and enforcing these bylaws, Thulamela municipality can ensure accountability and promote the proper maintenance of buildings (Thulamela Municipality, 2023). To ensure compliance with the bylaws, authorized officials would be appointed by the municipal manager or relevant authority. These officials would have the right to enter any building or property at any time to assess compliance and issue notices as necessary. This approach aims to prevent hindrances to the authorized officials' authority and enable effective enforcement of the bylaws (Thulamela Municipality, 2023).

Another strategy involves stricter enforcement of planning procedures in the construction of buildings. Clients would be required to prepare baseline risk assessments for construction projects, and the municipality would enforce planning procedures based on these assessments (Phillip, 2017). This would ensure that health and safety specifications are incorporated into the design phase and that contractors comply with regulations. The goal is to enhance the longevity and sustainability of buildings while prioritizing safety (Karrin, 2011).

Establishing a dedicated CBD building maintenance plan is also crucial for overcoming building depreciation (Taipeli, 2011). This plan would focus on energy-efficient and adaptable buildings that have long-term value and longevity. By implementing technical systems and services that are easily replaceable and maximizing passive methods, buildings can become more sustainable (Lambardo, 2017). Additionally, water collection, purification, and energy generation should be integrated into building designs. Retrofitting public buildings can serve as examples of sustainable practices (Karrin, 2011).

The eviction of illegal occupants from buildings is another key strategy to address urban decay. The municipality would take action against illegal land occupiers with the property owner's permission (Zack, 2015). This includes submitting charges of trespassing, issuing eviction notices, and demolishing unfinished or unoccupied structures (Vera, 2015). Agreements with significant landowners would also be pursued to enable swift response to land invasions (Thulamela Municipality, 2023).

Conducting building audits in the Thohoyandou CBD is essential to ensure that buildings are used in accordance with their intended purpose. Many buildings in the area are occupied by businesses that may not align with their original designation (Bess, 2008). Conducting audits and comparing the information in land use applications with actual usage can help identify discrepancies and enforce appropriate zoning regulations (Thulamela Municipality, 2023). Lastly, the regulation of building capacities is crucial for efficient and effective building regulation (Vera, 2015). Thulamela municipality can implement a building regulatory capacity assessment strategy to gather essential information, identify gaps, and establish a baseline for

improvement (Andole, 2016). This assessment can aid in streamlining product certification, design, construction, and approval processes, ultimately enhancing the market's efficiency (Thulamela Municipality, 2023).

In summary, the strategies presented above offer a comprehensive approach to addressing derelict buildings and urban decay. By formulating bylaws, enforcing planning procedures, establishing maintenance plans, evicting illegal occupants, conducting building audits, and regulating building capacities, Thulamela municipality can promote accountability, sustainability, and revitalization in urban areas. These strategies emphasize the importance of compliance, safety, adaptability, and efficient building management to achieve long-term improvements in urban environments (Thulamela Municipality, 2023; Karrin, 2011).

6 CONCLUSION

This research shed light on the challenges posed by building dilapidation in Thohoyandou CBD, a rural town in South Africa. The study explored the causes and implications of this issue and proposed strategies for addressing urban decay in similar contexts. Through a qualitative research approach and a case study design, the research uncovered the underlying factors contributing to building dilapidation and highlighted their interconnectedness.

The findings of this study have significant implications for urban revitalization efforts in developing countries, particularly in rural towns facing similar challenges. By understanding the causes of building dilapidation and its consequences, policymakers, urban planners, and community stakeholders can devise targeted interventions to reverse the decay and promote sustainable development. Moreover, this research contributed to the existing knowledge base on urban decay by providing insights from a rural perspective, which has been largely overlooked in previous literature. The study emphasized the need for tailored strategies that address the unique circumstances of rural towns, such as Thohoyandou CBD, including limited resources and inadequate urban planning and management.

By implementing the proposed strategies, such as community engagement, capacity building, and strategic partnerships, Thohoyandou CBD can reclaim its vibrancy and become a model for sustainable urban development. Additionally, the lessons learned from this study can be applied to similar contexts worldwide, fostering inclusive and resilient communities.

7 REFERENCES

Accordino, J., and G. Johnson (2000). "Addressing the Vacant and Abandoned Property Problem." Journal of Urban Affairs 22(3): 301–315.
Awumbila M. G. Owusu, and J. K. Teye (2014) Can Rural-urban Migration into Slums Reduce Poverty? Evidence from Ghana, Migrating Out of Poverty Working Paper 13 (Brighton: University of Sussex).
Bashir, M., Afzal, M.T. and Azeem, M., (2008). Reliability and validity of qualitative and operational research paradigm. Pakistan journal of statistics and operation research, pp.35-45.
Bess, M. (2008). "Assessing the Impact of Home Foreclosures in Charlotte Neighbourhoods." Geography & Public Safety 1(3): 2–5.
Branas, C., R. Cheney, J. MacDonald, V. Tam, T. Jackson, and T. Ten Have (2011). "A Difference-in-Difference Analysis of Health, Safety and Greening Vacant Urban Space." American Journal of Epidemiology 174(11): 1296–1306.
Craig, C.S. and Douglas, S.P., (2005). International marketing research. Chichester: John Wiley & Sons.
Crentsil, O and George O., (2018) "Accra's Decongestion Policy: Another Face of Urban Clearance or Bulldozing Approach?", International Development Policy | Revue international de politique de development
Creswell, J. 2007. Qualitative Inquiry and Research Design: Choosing among Five Approaches, 2nded., Sage, Thousand Oaks, CA.
Denzin, N. and Lincoln, Y. 2005. "Introduction: the discipline and practice of qualitative research", in Denzin, N.K. and Lincoln, Y.S. (Eds), The Sage Handbook of Qualitative Research, Thousand Oaks, CA, Sage Publications Ltd., pp. 1-32.
Ethridge, D. E. (2004). Research Methodology in Applied Economics (2nd ed.). N.p.: Wiley-Blackwell.
Fahey, C., (2017). Urban or moral decay?: the case of twentieth century Detroit. Journal of Architecture and Urbanism, 41(3), pp.170-183.
Glaeser, Edward (2011). Detroit's Decline and the Folly of Light Rail. Retrieved from: http://online.wsj.com/article/SB10001424052748704050204576218884253373312.htmlSanyaolu, P and Sanyaolu C., (2018). Urbanization, 1.10.13140/RG.2.2.23495.96161.
Hadi, M.A. and José Closs, S., 2016. Ensuring rigour and trustworthiness of qualitative research in clinical pharmacy. International journal of clinical pharmacy, 38(3), pp.641-646.
Kaarin Taipale, (2011). CKIR, Aalto University School of Economics, under the supervision of David Le Blanc (UN-DESA).
Kandžija, V., Tomljanović, M. and Huđek, I., (2017). Deindustrialization as a process in the EU. Ekonomski vjesnik: Review of Contemporary Entrepreneurship, Business, and Economic Issues, 30(2), pp.399-41Dr.
Kothari, C.R., 2004. Research methodology: Methods and techniques. New Age International.
Lewis D. (2013). Subjects Politics & International Relations, New York. Edition1st Edition Imprint Routledge. DOIhttps://doi.org/10.4324/9780203793374, Pages172
McMillan, J.H. and Schumacher, S., (2010). Research in Education: Evidence-Based Inquiry, My Education Lab Series. Pearson.

McMillan, J.H. and Schumacher, S., 2014. Research in Education: Evidence-Based Inquiry, MyEducationLab Series. Pearson.

Murphy, M., 2016. Population definitions for comparative surveys in education.

Nassaji, H., (2015). Qualitative and descriptive research: Data type versus data analysis.

Ndlebe, AN. (2017). Assessing the impacts of urban decay on the residential land uses. Master's degree in Town and Regional planning, The case of Durban south beach, South Africa.

Okrent, D. (2009). Detroit: The Death- and Possible Life- of a Great City. Retrieved from: http://www.time.com/time/magazine/article/0,9171,1926017-1,00.html

Onuoha, D. (2014) 'Decongesting Accra', Johannesburg Salon, 7(1), pp. 123-130, http://jwtc.org.za/resources/docs/salon-volume-7/TheSalon_Vol7.pdf (accessed on 30 August 2017).

Parab, A.A., Mehta, P., Vattikola, A., Denney, C.K., Cherry, M., Maniar, R.M. and Kjaer, J., (2020). Accelerating the adoption of eSource in clinical research: a transcelerate point of view. Therapeutic innovation & regulatory science, 54(5), pp.1141-1151.

Polit, D.F. and Hungler, B.P. (1999) Nursing Research; Principles and Methods. Sixth Edition, Lippincott Williams & Wilkins, Philadelphia.

Smith, F and Sarah A. (2008). "Urban Decline (and Success), US". EH.Net Encyclopedia, edited by Robert Whaples. June 5, 2008. URL http://eh.net/encyclopedia/urban-decline-and-success-in-the-united-states/

Squires, G.D. and Kubrin, C.E., (2005). Privileged places: Race, uneven development and the geography of opportunity in urban America. Urban Studies, 42(1), pp.47-68.

Vera, M. (2015), St. Revitalization of Historic Buildings as an Approach to Preserve Cultural and Historical Heritage, Petersburg State Polytechnical University, Politekhnicheskaya, 29, Saint-Petersburg, 195251, Russia.

Wilkerson, J.M., Iantaffi, A., Grey, J.A., Bockting, W.O. and Rosser, B.S., (2014). Recommendations for internet-based qualitative health research with hard-to-reach populations. Qualitative health research, 24(4), pp.561-574.

Zack, T., (2015). Making an area hot: Interrupting trade in an ethnic enclave in Johannesburg's inner city. Mean streets: Migration, xenophobia and informality in South Africa, Cape Town: Southern African Migration Programme, pp.60-77.

Application of the Persona Concept to Convey Socially Sustainable and Responsible Transport System Planning to Children and Juveniles Considering Autonomous Vehicles: Work Report on the Project AM4Kids – Future Workshop

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1 ABSTRACT

The automation in the transportation and mobility sector, particularly the use of autonomous systems in public transportation, presents novel challenges for various user groups despite offering numerous positive aspects. Autonomous vehicles, particularly in the domains of micro-public transportation and car sharing, have the potential to serve as a flexible mobility solution for individuals without a driver's license or those who are physically or mentally incapable of operating a vehicle. To ensure equitable access to this potential of independent and flexible mobility for all individuals, the design of autonomous transportation modes must be inclusive.

The Austrian "AM4Kids" project (August 2020 to October 2023) imparts knowledge on mobility and transport system planning to children and juveniles in the context of the progressive automation of transportation and mobility modes, focusing on the principles of inclusive mobility offerings. Children and juveniles have attended several workshops on mobility and inclusion for over three years. In the final stage of the workshop series, the children and juveniles develop their visions and ideas for automated mobility, discussing the opportunities, risks, and consequences for themselves and other groups.

One way to better understand and visualise the wide range of everyday lives of people with disabilities, their mobility patterns, and mobility options is to use the persona concept. This method aims at packaging real users' motivations, needs, wishes and ambitions in a model to better integrate future research and technology development of automated mobility with the wants and needs of users. Personas do not represent the whole range of user diversity. However, they enable planners and developers to deal realistically with the situations and mobility needs of the relevant groups of people and allow specific analyses to implement user-oriented transport solutions.

This paper outlines the methodology applied and the results achieved to make them accessible to a broad professional audience. The project demonstrates that knowledgeably selected personas provide added value in developing technologies. They can also be employed in the further education and sensitisation of children and juveniles.

Keywords: awareness, persona, inclusion, automated mobility, children

2 INITIAL SITUATION

This paper is a follow-up to the 2022 paper entitled "Automated Mobility and Inclusion as Educational Topics for Children and Juveniles and as Tasks and Responsibilities of Mobility Planning: Work-Report on the Project AM4Kids" (Hohenecker et al. 2022).

The project assumes that people with disabilities do not have some "special needs" which would set them apart from non disabled transport participants. Instead, and in line with the social model of disabilities, the design of environments, infrastructures and vehicles neglects them as potential and actual users. They need awarness to be represented in the mindsets of traffic planners, traffic engineers and decision-makers. Exclusion, therefore, is not a consequence of bodily impairments but of failing to upgrade and to generalise chances of participation, e.g. in terms of universal design or design for all principles. The project aims to broaden the scope of reflection on how traffic systems, including infrastructures, vehicles and environments, are planned, designed and built and how human creativity can intervene and change these human-made structures. Contemporary (interface) design approaches must address these issues on a general and abstract level. They emphasise the diversity of road user groups by constructing "personas" (Cooper et al. 2007),

which are fictional but realistic characters with concrete situations and specific aims in their daily lives as well as broader biographical perspectives (see Chapter 3 in this paper). Personas are a fruitful starting point for pedagogical work as they are a dialogue partner in developing ideas for a future mobility system. They help children and juveniles in educational settings to develop forward-looking responsibility when they imagine future traffic systems and transport modes.

The focus is on children and juveniles who gain insight into transportation planning and the associated research fields and research processes within the framework of the project. The guiding statement is "Today's children and juveniles will be tomorrow's users and decision makers of automated mobility" (Hohenecker, Knoll et al. 2022). Children and juveniles shall learn about the wants and needs of diverse traffic participant groups, to deal in particular with the prospects for the development of automated mobility, and to develop and reflect their visions of the future in the subject area of mobility.

The project consortium of AM4Kids[1] is composed of sociologists, transportation planners, landscape architects, civil engineers and legal experts focusing on the needs of people with disabilities. Six different schools with fourteen overall classes participated in the project. Age groups from primary school to secondary school level 2 are represented. The classes vary in terms of school levels and in terms of pupils with disabilities involved as well as educational specialisation. Table 1 gives a brief overview of the numbers of participating school classes. For example, one school has some children with visual impairments and another school focuses on technical and engineering education.

school level	school classes and timeline	summarising unique characteristics
primary school (age group 6-10 years)	eight classes: in three different schools from 08-2020 until 10-2023	inclusive school and all-day school, volatile school, classes with special educational needs (integrative class)
secondary school level 1 (age group 10-14 years)	two classes: one school since 08-2020 until 10-2023 and two classes: one school from 01-2023 until 10-2023	school for children with visual impairment, classes with special educational needs (integrative class)
secondary school level 2 (age group 14-20 years)	two classes: one school from 08-2020 until 10-2023	vocational college, juveniles with technical & engineering education

Table 1: Overview of participating school classes per school level

The AM4Kids project comprises three phases. Children and juveniles went through all phases using age-appropriate teaching materials developed in the corse of the project.

Phase one focused on knowledge building about mobility and inclusion. Workshops conducted in phase 2 aimed at reflecting on their own mobility behaviour and learn about the needs of diverse traffic participant groups. In phase three, the children and juveniles develop their vision of the future of mobility.

The current paper refers to the project´s third phase and presents workshop materials and the results of this phase. Chapter 2.1 gives a summary of the project activities to date.

2.1 Previous project activities

The children and juveniles receive insight into mobility research within the project. They learn to observe mobility from different perspectives and reflect on their mobility patterns. The aim is to learn about mobility demands, needs and situational requirements of various traffic participant groups.

2.1.1   Phase 1 - Building knowledge

Phase one consists of expert lectures (task 1), sensitisation workshops about inclusion (task 2) and a time travel into the history of mobility (task 3). The expert lectures and workshops aim at explaining mobility and traffic system planning, give insight into our daily work and shall trigger curiosity about transport planning and inclusion in general. Moreover, the key figures and indicators of mobility and their meaning in practice are explained. In the sensitisation workshops, the needs and demands of visually impaired and blind people are addressed. The workshop started with a theoretical introduction to assistive devices and accessibility. The second part of the workshop was practical training where different kinds of visual impairments were

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simulated, such as blindfolds or special glasses. Task three includes time travel, in which the children reflect on the film "Towards the year 2000 - a preview of Tomorrow's World", produced about 50 years ago. It shows how the producers at this time thought the world could look like 30 years later. The film should stimulate creativity of thinking about future scenarios. Past visions of future mobilities are reflected and analysed by asking what was predicted, discussed, implemented, and established back then for today.

2.1.2 Phase 2 – Reflection on mobility behaviour

In phase two, the reflection on mobility behaviour (task 4) took place. The children acted as transportation system planners, and they worked with age-appropriate mobility logbooks. We organised walks and spatial explorations in the course of which we analysed their school environment together and conducted transport planning methods such as surveying, counting, mapping and measuring. In task five, we developed three logbooks depending on the participating school and the age of the children and juveniles.

Tasks within the mobility logbooks were: documenting trips on three consecutive days, elaborating on the development of different modes of transport in the last decades and conducting interviews with familiar grown-ups about their mobility behaviour. Further, there was a task to design an imagined mode of future transport and to visualise their way to school in a drawing.

2.2 Autonomous driving and its impacts on people with disabilities

Accessibility is an essential prerequisite for the equality of people with disabilities. The unrestricted, barrier-free use of services, facilities and objects determines the radius of action and enables self-determined participation in society. To shape a sustainable and inclusive development of automated mobility, discussing this complex and multi-layered topic with children and young people today is essential. With a focus on inclusion, the aim is to understand how automation and digitisation enable or restrict the mobility of people with disabilities.

To develop inclusive mobility solutions a Design for All approach as an analytical lense. Following this basic idea for the planning and design of products, services and infrastructures, it should be possible for all people to use products, services and infrastructures without individual adaptation or special assistance. Design for All describes a design process that aims to achieve accessibility, usability and experienceability for as many people as possible.

With a focus on inclusion and automated mobility, the AM4Kids project deals with tomorrow´s traffic planning and mobility research. Automated mobility has much potential to increase independent mobility of people with disabilities, if various offerings address the needs and situations of people with disabilities. The following issues have to be adressed:

- The preparatory activities for a trip (pre-trip), such as obtaining information about the AM offer, the ordering, booking and payment process, the reservation of assistance services, etc., are to be carried out as far as possible on the person's own responsibility.

- All stages of the journey (on-trip) are barrier-free for people with disabilities. This starts when leaving the house door and concerns the access to the AM offer, the wait or stop, the change of inter- and multimodal means of transport, equipment, information on and around the route, stage or vehicle, the stay in the AM means of transport, stay qualities and equipment in the vehicle and ends when getting off near the destination as well as the departure to the destination address to the house door.

- The appropriate provision of information during the journey, as problems might occur during the journey. This involves a reflection of the experience (post-trip), any payment as well as any complaints to the operating company or the provision of services for the vehicle (e.g. charging the battery, luggage collection, etc.).

A central question is to what extent AM or a concrete AM offer is able to meet the specific requirements of people with disabilities to enable their independent mobility? For one, this is a question of technological development, but also of the socially acceptable costs of automated mobility for the different groups of people with disabilities. It is important that these groups can actively participate in the development of automated mobility to meet their needs sufficiently. The current situation is still way behind this requirment.

3 PERSONA CONCEPT IN THE AM4KIDS PROJECT

Personas are fictional characters that represent the target audience of a product or service. They help designers and developers understand the needs, goals, and behaviours of their (potential) users and provide a „human face" to the data and insights gathered during research. Personas are a valuable tool in user-centred design. (Cooper et al. 2007). However, the creation of personas can be influenced, e.g, by gender bias, leading to inaccurate or stereotypical representations of users. For example, a persona based on gender stereotypes may not accurately represent the needs and behaviours of the imagined target group, leading to a product that is not inclusive or accessible to all. (Marsden et al. 2015).

To create effective personas, designers and developers must be aware of their biases and strive to create inclusive and diverse representations of their target audience. With reference to gender, they have to address a range of gender identities and other factors such as age, ethnicity, and socioeconomic status. In the context of mobility, personas can be used to understand the diverse needs of different users, such as people with disabilities, older adults, commuters, tourists, and families with children.

For example, a persona for a person with a disability may include information about their mobility limitations, such as the need for accessible transportation and priority seating. They may also have specific needs for information, such as real-time updates on service disruptions or accessible route planning tools. A persona for a commuter may include information about their daily routine, such as the need for reliable and efficient transportation options. They may also have preferences for specific modes of transportation, such as biking or public transit, and may prioritise cost, convenience, and environmental impact.

Ten personas were developed in the R&D project "AM inclusive!" (Knoll et al. 2021). The goal of the personas is to package the motivations, needs, desires, and usage goals of real users into a model that decision-makers, responsible parties, developers, etc., can use to empathise with people with disabilities and develop user-centred decisions or technology developments accordingly. With the support of project partner Austrian Disability Council (ÖBR), feedback from people with disabilities was incorporated into the persona descriptions. The personas were constructed carefully to be typical and credible and contain as few gender stereotypes as possible. In the context of the project theme, Automated Mobility, the following information was used for the description of the personas:

- Name
- Sociodemographic information and background
- Mobility behaviour (regular routes, professional routes, etc.)
- Requirements for the mobility system (information, vehicle, accessibility, etc.)
- Technology and automation in everyday life today
- Wishes, needs, barriers

In the following, we present an example of a blind person using a guide dog:

Example of a persona: Michael - Blind person with a guide dog

Michael, now 30 years old, lost his vision at age 20 due to retinopathy pigmentosa, an inherited retinal degeneration. He relies on a guide dog for safety and assistance when navigating public spaces, particularly for using public transportation. While he has learned Braille, Michael finds standard tactile print with raised letters more accessible for reading. His guide dog accompanies him to work in an office, providing the support he needs to be spontaneous and independent during his daily commutes. When taking the bus, the dog helps Michael locate the entrances and exits, as the bus stops at different points within the bus stop. Michael requires a priority seat on the bus to accommodate himself and his guide dog, but the need for a quiet space for the dog is often overlooked in planning. He appreciates loudspeaker announcements, although they can be challenging to understand. Michael benefits from having an annual pass for public transportation, eliminating the need to worry about finding suitable tickets. However, he faces difficulties with the validation machines, which can be tricky to locate and insert the ticket correctly, especially as the bus wobbles during the journey.

Technology and automation in everyday life today: At home, Michael relies on a smartphone app to search for mobility information. The app helps him find the best time and connections for his commute using public

transportation. There are certain barriers that Michael encounters in public spaces and when using public transportation. When faced with new and unfamiliar routes, Michael usually looks for a companion to accompany him and his guide dog. While using his navigation app, Michael sometimes needs clarification for directions like left or right, and announcements may come too late. Accurate descriptions are crucial in these situations. Having his guide dog by his side would have helped Michael avoid obstacles caused by incorrect announcements. In Vienna's 22nd district, Seestadt Aspern, there has been a self-driving bus operated by Wiener Linien in test operation for some time now. Michael believes that automation will have a similar impact on him as long as he travels with his guide dog. The dog assists him in boarding and exiting the bus and helps him find a vacant seat that allows space for both himself and the guide dog without blocking others' way. Michael doesn't foresee significant changes due to self-driving vehicles. It's crucial for Michael that his guide dog is recognized as an assistance dog so that he cannot be denied entry to hospitals, doctor's offices, or stores with the animal. One significant concern for Michael is electric cars, as he has difficulty hearing them. He shares this concern with his colleagues who also have visual impairments.

This example demonstrates that, overall, individuals with disabilities have similar end goals and life aspirations as those without disabilities. However, the means and conditions to achieve these goals must be adapted to accommodate different sensory and motor abilities.

4 METHODOLOGY

The design of project phase three aims to sensitise children and juveniles to the topic of mobility in the context of current technical developments and inclusion. Hohenecker et al. (2022) described that the AM4Kids workshops promote creative and networked thinking among children. In phase three, the focus is on examining automated mobility from different perspectives. For this purpose, the project consortium developed Future Council workshops in an age-appropriate manner, depending on the participating school classes. Using personas, children and juveniles learn about the importance of developing mobility offers in a future-oriented and socially sustainable manner. The acquired knowledge enables the pupils to experience mobility from different perspectives and allows them to understand the implication of scientific concepts. It shows that in the course of childrens´ participation processes, the age-appropriate and step-by-step development of knowledge is indispensable for sustainable learning experiences.

The idea of Future Councils is based on the following goals:

- To impart knowledge about the automation of transportation system elements: Lectures, the lecturers explain the stages of automation and the term transport system. It is essential to convey the interaction of people, means of transport and the associated infrastructure. The diversity and heterogeneity of the users of a transport system are addressed, and the children and juveniles are sensitised to the different needs and demands. In an interactive exchange, the children and juveniles elaborate on which tasks in a transport system or means of transport have been automated throughout time and reflect on the advantages and disadvantages of these developments. Finally, driverless autonomous vehicles are presented, and their current and future application areas are discussed.

- Changing perspectives with the persona concept: After a short theoretical introduction to the persona concept, the children and juveniles read the description of their assigned persona in small groups. They learn about the persona's transport needs and requirements and identify barriers and difficulties. They reflect on the mobility system affordances to be entirely usable by the persona.

- Develop future scenarios and solutions for the persona: Pupils develop visions of the future and scenarios for automated mobility and discuss where the opportunities, risks and consequences lie for themselves and other groups of people and the environment. They work independently in small groups to develop means of transportation and elements of a transportation system that they believe will improve the persona's mobility situation.

- Reality Check of our Future Scenarios: Finally, a dialogue happens on eye level with researchers about their elaborated ideas within the workshop. The experts of the project consortium give feedback and discuss the relevance of their project ideas using the categories of society, politics, industry and users (results see chapter 5).

4.1 Change of perspectives with the persona concept

The personas created within the project "AM Inklusive!" (Knoll et al. 2021) and used in the current project "AM4Kids" promote a change in perspective within the working groups. Personas help pupils understanding the needs of others, as well as provide insight into the everyday challenges of persons with disabilities in the transport system. The goal is to encourage pupils to develop mobility solutions for personas from an inclusive design perspective, followed by discussing visions and ideas in a Future Council. Scientists and planners accompany the children and juveniles in this process, offer feedback and insight into the interdisciplinary, multi-level exchange between disciplines. In the following, the used personas are outlined:

4.1.1   Michael – blind person with a guide dog

Michael is a blind person who uses a guide dog for safety and support in public spaces. Michael finds reading the standard tactile script with raised letters easier than Braille. He works in an office and usually takes the bus, with his guide dog showing him the next entry and exit points. Michael uses an app on his smartphone to find the best time and connection for his public transportation routes. He often seeks a companion to walk new and unfamiliar routes with him and his guide dog. Michael emphasises the importance of recognising his guide dog as an assistance animal, allowing him to enter hospitals, doctor's offices, or shops. He finds electric cars dangerous as he cannot hear them, which is also challenging for his visually impaired colleagues.

4.1.2   Amina – a person who is blind from birth

Amina is a 47-year-old blind woman who lives with her partner and works in an office. She uses public transportation to get to work and relies on an assistant to help her with tasks. Amina faces challenges when using public transportation, such as needing help to see which line or end station the vehicle is heading to. She uses a long cane to navigate and prefers to orient herself to linear structures. Amina uses apps on her smartphone to find the best connections when travelling alone and asks for help when buying tickets. She uses a Braille display and a screen reader to work on her computer at home. Amina wishes for more automated communication and announcements in public transportation and at stops to help her navigate.

4.1.3   Aleksandar – blind person with an affinity for technology

Aleksandar is a 28-year-old blind man who lives in a city with his wife and two children. He is interested in technology and has tried many different products. He discovered a new technology at a fair - shoes with sensors that warn him of obstacles through vibrations on his smartphone. Despite the sensor, he still needs to be attentive as it cannot detect downward stairs or obstacles at chest or head height. Aleksandar always carries a long cane with him. He is now a representative for the manufacturer of the sensor technology. He travels to work alone and uses a screen reader to navigate new routes. In his free time, he travels with his family using public transportation. Aleksandar wishes for better communication with vehicles and for electric vehicles to make more noise. He has tried a self-driving bus but found it challenging to locate the entrance and exit. He also uses a navigation app on his smartphone and wishes for better communication with traffic lights. He uses an acoustic signal at intersections to know when the light turns green. He is happy that future traffic lights will be operated by pressing a button instead of using a Euro-Key.

4.1.4   Maria – a person with visual impairment

Maria is a 67-year-old retired woman living alone in the countryside with a visual impairment. She needs help recognising contrasts, doing reading and locating bus stops difficult. While urban areas support the visually impaired, the countryside needs such infrastructure. Maria uses call-and-collect taxis to travel and recently acquired a smartphone to help with navigation and reading. However, she needs help with GPS accuracy and the need for large font sizes. Improving and expanding support systems for people with visual impairments is crucial to make their daily lives easier.

4.1.5   Justin – a person who uses an electric wheelchair

Justin is a 19-year-old who lives with his parents in the countryside and has had problems feeling and moving his legs and arms since birth. Over time, his mobility has decreased, and he now uses an electric wheelchair. While his home has been modified to accommodate his wheelchair, Justin faces challenges when using public transportation. Bus and train ramps can be difficult to access, and he often needs assistance from

54

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other passengers or transportation staff. Justin wishes for more accessibility in vehicles, including easier-to-use ramps and better communication systems for signalling entry and exit. He also hopes for technological advancements in electric wheelchairs to make them more lightweight and suitable for off-road use. Despite these challenges, Justin remains optimistic and looks forward to finding employment and continuing to explore the world around him.

4.1.6   Jana – a person using a mechanical wheelchair

Jana is a 38-year-old woman who has been using a manual wheelchair for 23 years since an accident left her unable to walk. She is skilled with her wheelchair and uses public transportation, including the subway, tram, bus, and rapid transit systems. However, she faces limitations in many buildings and needs help to cross the streets. Jana uses an app on her smartphone to find traffic information and the fastest connections for her routes. She also buys her tickets through the app. Jana has not been able to try the self-driving bus yet, but she is interested in how the ramp works and where the emergency button and wheelchair space are located.

4.1.7   Franz – a person with a phobia

Franz has claustrophobia and experiences anxiety and panic in crowded and enclosed spaces. This fear affects his mobility, and he prefers to drive his car instead of public transportation. Franz's employer does not have a company parking lot, so he must pay for parking. He avoids rush hour and schedules his work freely to avoid crowds. Franz would like to use public transportation more often, but he needs to catch up on information about the occupancy of the vehicles. He prefers a driver who can intervene and support in certain situations rather than relying solely on technology.

4.1.8   Cecilia, a deaf person

Cecilia relies on lip-reading and sign language to communicate. She prefers to be accompanied by an interpreter when dealing with authorities or doctors. Cecilia uses a video conferencing service to communicate with her sister and has downloaded several smartphone apps to help her stay informed and communicate better. Public transportation has improved for people with disabilities, but important information may still be announced over the loudspeaker before appearing on the display. Cecilia and her partner own a car but mainly use it to shop or get to the nearest train station.

4.1.9   Ali, a person with hearing impairment

Ali relies on hearing aids and induction loop systems to communicate. Ali avoids speaking to people or asking for directions in public places due to his difficulty in hearing. He uses an app on his smartphone to find the fastest route for public transportation and is grateful for digital screens displaying information about public transportation disruptions. Ali also uses a car-sharing service to borrow a car and prefers to walk instead of using e-scooters, which he finds too dangerous.

4.1.10   Sarah, a person with learning difficulties

Sarah lives in a supervised shared apartment and works in a supervised workshop. Sarah finds it challenging to understand information and prefers to be accompanied by a friend or caregiver when travelling on new routes. She records spoken words to remember things and asks for help when buying tickets or navigating her smartphone. Sarah finds it overwhelming to use transportation apps and prefers to ask other people for directions. She wishes there was only one app for public transportation with information in easy language.

4.2 Future Council in secondary levels 1 and 2

The tasks of the Future Council differ between secondary level 1 (A) and 2 (B) in complexity and scope. The persona's characteristics are first collected in a profile in both workshop versions. Version A asks about the persona's challenges in public transport, whereas version B generally asks about mobility behaviour. This builds on knowledge about mobility and transport generated in the previous project phases.

In version A, the pupils collect ideas for a means of transport or elements of a future transport system, which could be helpful for the persona. From these, implementation possibilities are derived and recorded in writing and graphically.

In version B, they think about how the persona would feel when travelling in a public transport system with autonomous buses a) with an operator and b) without an operator. The task here refers to the requirements of

the public transport system so that the persona can travel confidently in the given scenarios. From this, solution strategies are derived and discussed in plenary, commented by the project consortium. The children and juveniles document their process step by step on prepared Flipcharts as shown in Figure 1.
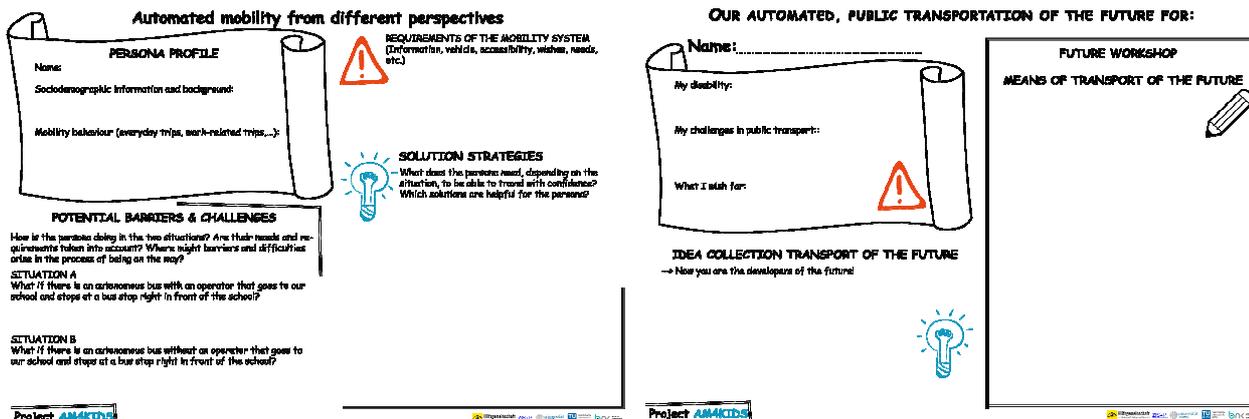
Fig. 1: Flipcharts with the Future Council's assignment for elaborating the content in small groups. Version A secondary level 1 (left), Version B secondary level 2 (right)

4.3 Future Council in primary school

The Future Council workshops have also been adapted to the needs and capabilities of children in primary school. Pupils had the opportunity to develop their ideas for means of transport for the future in a very creative and open setting. After the expert´s input, means of transport, the related developments in the course of history, automated and autonomous mobility as well as inclusion – adapted to the age group and prepared for easy understanding – the children were enabled to take researcher roles. Their work output was drawings and collages for fantasy-based ideas for future mobility modes. As the persona concept is too complex for this age group, it was not used explicitly in this context. As an alternative, the expert team prepared the following questions to give some instructions and to reflect the ideas and inventions together with the students:

- For WHOM did you develop the means of transport of the future?
- WHAT should your means of transport be able to do? What should be better than the means of transport you already know?
- HOW are your means of transport controlled? Is it automated?
- WHO can use your means of transport? Is it suitable for blind people? Is it suitable for people who cannot see/hear/walk well? Are there any helping tools?

In this way, the persona concept – in terms of putting oneself in the position of someone else and create solutions that help the needs of a particular user group – was integrated into the workshop format to sensitise the pupils accordingly.

5   RESULTS

The children of secondary level 1 presented their ideas mainly graphically with short notes for the explanation on their flipcharts. Figure 2 shows the persona "Michael" as an example of the result of one of the working groups. Michael has a visual impairment, and his assistance dog accompanies him. The children recognise some challenges, such as the need of sufficient space for Michael and his dog in public transport. Therefore, one focus of their reflections is that public transportation should also include space reserved exclusively for assistance dogs. In addition, they suggest that securities help with the ticket machines and that these are also provided with tactile Braille. It is important to them that a contact person is always available for the passengers. In addition, information about the current location and the route should be available for people with visual impairments in public transport, e.g. in the form of maps with Braille.
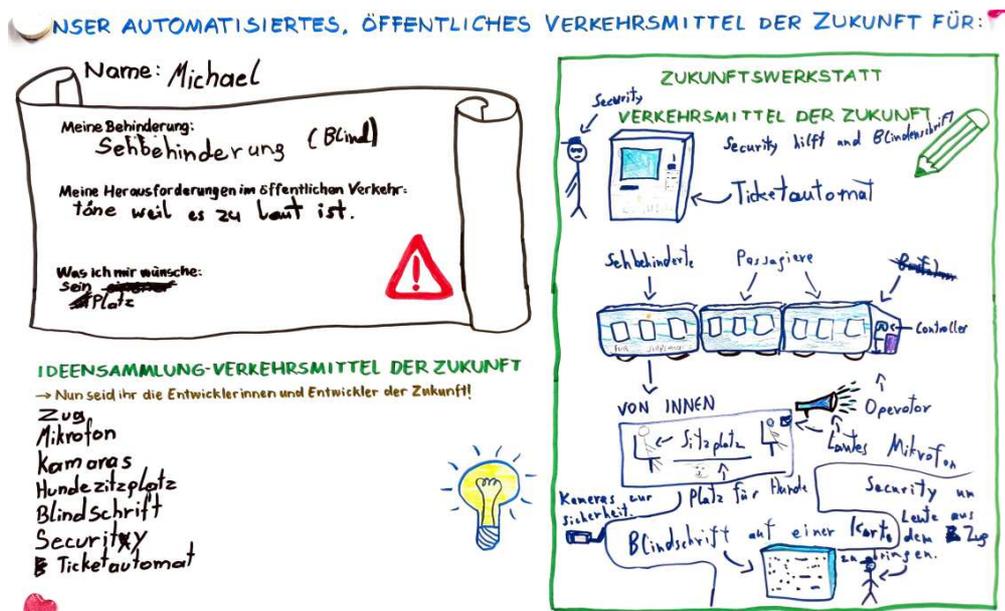
Fig. 2: Example of a flipchart about the persona Michael - created by secondary level 1 students

The task for the students of secondary level 2 is linked to a given process, which refers to the scenario of the autonomous bus in the surrounding area of the school as a mobility offer. The students initially identify barriers and challenges, derive requirements for the mobility system, and develop solution strategies. For example, they used the perspective of the persona "Ali," (impaired hearing). The group suggests that warnings at bus stops (especially platforms) are given via light signals on the ground. Using vibration to alert people to events or last-minute changes in public transportation is also part of the solution strategy. These additional information channels would be beneficial for all passengers, not only for people with hearing impairments. In the workshop, the secondary level 2 students focus on actual technical implementations and discuss them intensively in groups. They propose various apps for the different personas, tailored to their needs. The persona "Franz" avoids public transportation because he is claustrophobic and feels uncomfortable when too many people are in the vehicle. The students follow the solution strategy to equip public transport with weight sensors and light barriers to estimate occupancy in real-time. The resulting information will be stored in the routing apps of the public transport. The persona "Franz" would thus be able to plan his routes better even in new routes about which he has no experience. Figure 3 below shows an example of the flipcharts about the persona "Jana" and a section about the persona "Ali".

Fig. 3: Example of flipcharts about the personas "Jana" (left) and "Ali" (right) - created by secondary level 2 students

Personas helped pupils to consider the practical problems of traffic participants with disabilities and to develop practical solutions. In the case of Michael, for example, they found the following elements to be included in a more inclusive traffic system:

- Louder and clearer announcements
- Recognition of the dog

- Improvement of the navigation app
- Tactile standard font.

The solutions developed by pupils in the workshops crystallised around two basic ideas. The first idea addressed realistic ways of adapting environmental conditions to the situation of persons with disabilities. Technical devices replaced or worked around the sensory impairments and broadened accessibility to traffic situations. On the other hand, pupils in technical schools integrated realistic design ideas with the technical devices they knew from their education. Blind persons need non-visual communication channels; wheelchair users need broader entrance and exit areas to access vehicles, etc. The second strategy used by younger pupils was developing less realistic (science fiction) vehicles and infrastructures like flying wheelchairs or highways for wheelchairs. These solutions projected known solutions of traffic participation for non-disabled people on people with disabilities and created a specific traffic system around their situation. From a pedagogical point of view, both strategies are meaningful and relevant and help pupils see the complexities of design problems regarding traffic participation.

6 DISCUSSION

The aim of an inclusive mobility system is to enable all people to move around on an equal footing and to participate fully in society. To this end, it is necessary to ensure a seamless, inclusive mobility chain from door to door.

- A mobility chain is schematically composed of the following elements:
- Pre-mobility: information + information + planning + implementation/ticket purchase.
- First mile: from the starting point to the 1st station or parking lot.
- First station: arrival to boarding + interactions on the spot/ such as ticket purchase, replacement transport, etc.
- In transit
- Intermediate/final station: exit mode of transport 1 to board mode of transport 2 or leave station
- Last mile: Final station to the actual destination
- Follow-up: Report problems encountered, reclaim, save the route for later trips, etc.

In between, waiting times and waiting places occur. Every mobility chain must meet the requirement of complemteness and inclusion. In reality, however, a large number of different and incomplete mobility chains occur. Therefore, the involvement of people with disabilities in planning mobility chains is essential. These considerations have to be taken into account in the context of the development of an inclusive offer for Automated Mobility and one should:

- Subject existing traffic information services to an inclusion usability check.
- Consistent implementation of the multi-sense principle: Reliable information transfer (pre-/post-trip) for passengers through analogue and digital functional diversity so that a transparent exchange of information between (automated) vehicle and passenger can be enabled.
- In developing applications for traffic information, pay attention to the needs of various people with disabilities.
- Barrier-free design of the road infrastructure, for example, utilising the comprehensive installation of tactile guidance systems, so that safe orientation to and from the (automated) vehicle is possible.
- Optimise physical design of (automated) vehicles; this refers to the need to design a vehicle that enables people with disabilities to get in and out independently
- Conduct regular usability tests and field checks with different groups of people with disabilities in public spaces and along the entire mobility chain

7 CONCLUSION

To conclude: Beyond its use in a design context, the personas concept is also a valuable device in pedagogical settings. Instead of reflecting on the situation of people with disabilities on an abstract level,

pupils learn to understand the situations of concrete traffic participants with their abilities and restrictions, their aims and demands. These aims and demands are not different from non-disabled traffic participants. Instead, the means and conditions must be adapted to meet their situations. To be sure, the solutions developed by the pupils, depend on their developmental and educational levels. Solutions developed by pupils from technical schools are much more realistic and geared towards working around sensory or bodily restrictions. Younger pupils tend to develop imaginary vehicles and infrastructures and create traffic systems for people with disabilities. While the first strategy adds communication channels and situational modifications to increase accessibility, the second strategy emphasises visions of mobility systems from the standpoint of other types of traffic participants (e.g. a highway seen from the perspective of wheelchair users). Both strategies bring design problems to the fore which can be further discussed and developed. Personas promote the attention of future mobility planners (more precisely: of pupils in the role of mobility planners of future traffic systems) to the diversity of user groups and the awareness of accessibility. Nevertheless, inclusive personas must not be misused as a substitute for the involvement of people with disabilities. The creed of participatory traffic planning says: "Nothing about us without us" and in this vein, traffic planning has to be done by people with and without disabilities together. Personas are an excellent educational tool to develop an inclusive mindset as it orients imagination to specific problems that open more ways to develop viable and sustainable solutions.

8 ACKNOWLEDGEMENT

9 REFERENCES

Cooper, Alan; Reimann, Robert; Cronin, David (2007): About Face. The Essentials of Interaction Design 3: Wiley Publishing, Inc

Hohenecker, Nina and Knoll, Bente and Schlembach, Christopher and Hauger, Georg and Sammer, Gabriela and Schiesser, Beatrix (2022): Automated Mobility and Inclusion as Educational Topics for Children and Juveniles and as Tasks and Responsibilities of Mobility Planning: Work-Report on the Project AM4Kids. Mobility, Knowledge and Innovation Hubs in Urban and Regional Development. Proceedings of REAL CORP 2022, 27th International Conference on Urban Development, Regional Planning and Information Society. pp. 101-109. ISSN 2521-3938

Knoll, Bente; Hofleitner, Birgit; Feßler, Anne Katrin; Hauger, Georg; Fian, Tabea; Adensam, Nadine; Hohenecker, Nina; Schlembach, Christopher; Lehmann, Tobias; Sammer, Gerd; Neuhold, Robert; Benesch, Emil (2021): Automatisierte Mobilität inklusive! Hg. v. Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK). Online available: https://www.b-nk.at/projekte/mobilitaet/bericht-automatisierte-mobilitaet-inklusive/; last check 15.06.2023

Marsden, Nicola; Link, Jasmin, Büllesfeld, Elisabeth (2015): Geschlechterstereotype in Persona-Beschreibungen. In: Sarah Diefenbach, Niels Henze und Martin Pielot (Hg.): Mensch und Computer 2015 Tagungsband. Stuttgart: OLDENBOURG WISSENSCHAFTSVERLAG, S. 113–122.

Bäume im Bild: Wie ein transdisziplinärer Ansatz und KI zur Verbesserung der Datenqualität eines städtischen digitalen Baumkatasters beitragen können

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1 ABSTRACT

Städtische Baumkataster werden aus vielfältigen Gründen erstellt und gepflegt: Die Standorte und Arten der Bäume auf öffentlichem Grund spielen bei der Pflegeplanung - vor allem mit Blick auf die zu erwartenden Effekte durch den Klimawandel - eine zunehmende Rolle. Insbesondere der Zustand ist relevant für die Kommune, um ihrer Verkehrssicherungspflicht nachzukommen. Des Weiteren sind Bäume in der Bauplanung wesentlich und nicht zuletzt auch im Naturschutz von hoher Relevanz.

Die Digitalisierung städtischer Baumkataster hat in den letzten Jahrzehnten weitere Vorteile mit sich gebracht: Der Prozess der Datenerfassung und -bearbeitung kann einfacher und effizienter gestaltet werden. Durch die leichtere Zugänglichkeit ist eine bessere Planung, deren Koordination und eine Weitergabe relevanter Daten schneller realisierbar. Dies trägt auch zu einer transparenteren Kommunikation bei. Der Export von Daten ermöglicht zudem Analysen und automatisierte Anwendungen.

Allerdings stellt es die Kommunen vor eine große Herausforderung, das Baumkataster aktuell, vollständig und fehlerfrei zu halten, da es sich um eine sehr große Datenbasis handelt, die sich regelmäßig ändert.

Verschiedene (meist proprietäre) Anwendungen unterstützen die Mitarbeitenden von Kommunen durch intuitiv nutzbare Eingabemasken, um das städtische Baumkataster zu bearbeiten. Es bleibt jedoch immer die Herausforderung, dass die verschiedenen Merkmale einzelner Bäume oder Baumgruppen händisch angelegt oder bearbeitet werden müssen. Dies ist umso aufwändiger je mehr Merkmale ein Baumkataster enthält und birgt die Gefahr, dass durch mitunter mangelhafte fachliche Kenntnisse fehlerhafte Einträge vorgenommen werden. Es gibt zwar technische Hilfsmittel wie Bestimmungs-Apps, die bei nicht-trivialen Merkmalen wie bspw. Höhe herangezogen werden können, aber manche Eigenschaften, wie z.B. das Alter, können oft nur geschätzt werden.

Alle diese Gründe führen dazu, dass die Datenqualität städtischer Baumkataster oft unbefriedigend ist und die Daten nicht ohne Bedenken genutzt werden können. Im Rahmen des Klimawandels werden überdies Merkmale relevant, die bisher nicht erfasst wurden. Beispielsweise können ergänzende Angaben zum Standort (bspw. Baumscheibe oder Park) dazu dienen, einen potenziellen Trockenstress besser vorauszusagen. Eine Klassifizierung des Allergenpotenzials kann darüber hinaus Menschen mit Allergien eine adäquate raumrelevante Information zu „Allergen-Belastungsgebieten" zur Verfügung stellen.

Um den großen personellen und zeitlichen Aufwand der Pflege des städtischen Baumkatasters in Zukunft zu minimieren und weitere für die Planung und Wissenschaft relevante Merkmale großflächig integrieren zu können, wird in Kaiserslautern ein transdiszplinärer Ansatz erprobt, der auf Grundlage verschiedener Datenbasen und mit Einbezug unterschiedlichster Akteursgruppen arbeitet.

Ausgangslage sind das vorhandene Baumkataster der Stadt, das lückenhaft ist und nur wenige Merkmale enthält, allerdings wegen der präzisen GPS-Standorte eine gute Datenbasis bildet. In Kombination mit Luftbildern kann ein Deep-Learning-Modell trainiert werden, das die fehlenden Bäume erkennt. Ein weiteres KI-Modell, das mit Panoramabildern und LiDAR-Daten aus Straßenbefahrungen arbeitet, soll zudem eine Artenbestimmung ermöglichen. Die Ergebnisse werden von Fachkundigen stichprobenartig evaluiert, sodass eine Feedback-Schleife entsteht, mit der die Modelle sukzessive verbessert werden.

Gleichzeitig wird eine Web-Anwendung entwickelt, die eine nutzerfreundliche Oberfläche bereitstellt, auf der Forschende und interessierte Bürgerinnen und Bürgern weitere Merkmale ergänzen können - auf diesen

Daten können weitere Modelle trainiert werden. Andere Merkmale, wie etwa Höhe des Baumes, können automatisiert aus den vorhandenen Datensätzen extrahiert werden. Im Rahmen des Prozesses sollen unterschiedliche Datenbasen unter Berücksichtigung der rechtlichen Rahmenbedingungen, der Kosten und der Verfügbarkeit als Trainingsdaten dienen und eine Aussage über die Qualität der jeweiligen Ergebnisse getroffen werden. Des Weiteren ist es ein erklärtes Ziel, die KI-Modelle übertragbar zu gestalten, so, dass sie in Regionen mit ähnlichem Baumbestand direkt angewendet werden können. Eine weitere Anwendung kann die Aktualisierung des Baumkatasters und das Monitoring der Datenqualität desselben sein, sobald neue Daten zur Verfügung stehen.

Keywords: artificial intelligence, machine learning, künstliche Intelligenz, Datenqualität, Baumkataster

2 EINLEITUNG

Bäume sind für die Aufenthaltsqualität im öffentlichen sowie privaten Raum sehr wichtig. Sie beeinflussen das lokale Klima und die Luftqualität, werten Straßen, Plätze und Parks optisch auf und bieten zudem einen Lebensraum für Tiere.

Im Zuge der Verkehrssicherungspflicht, aber auch im Hinblick auf die Baumkontrollen, die Bauplanung und den Naturschutz, ist es für Kommunen von hoher Relevanz, die Lage und den Zustand der städtischen Bäume auf öffentlichem Grund zu kennen und zu erfassen. Hierbei spielen Baumkataster eine große Rolle. Dort werden Informationen zu den Bäumen gesammelt und gespeichert. Dazu gehören neben der Position des jeweiligen Baumes die Art und/oder die Gattung, die Höhe, der Kronendurchmesser, der Stammumfang sowie, falls bekannt, das Pflanzjahr und das Alter. Das Baumkataster stellt somit ein Hilfsmittel für die Baum- und Grünflächenpflege dar. Jedoch ist der Aufbau, die Ergänzung weiterer Merkmale und die Pflege eines solchen Katasters eine aufwändige Aufgabe, die viele Ressourcen beansprucht. Die Digitalisierung städtischer Baumkataster hat in den letzten Jahrzehnten vielerlei Veränderungen mit sich gebracht: Der Prozess der Datenerfassung und -bearbeitung kann einfacher und effizienter gestaltet werden. Durch die leichtere Zugänglichkeit ist eine bessere Planung, deren Koordination und eine Weitergabe relevanter Daten schneller realisierbar. Dies trägt auch zu einer transparenteren Kommunikation bei. Der Export von Daten ermöglicht zudem Analysen und automatisierte Anwendungen.

Jedoch haben nicht alle Kommunen digitale Baumkataster beziehungsweise sind diese oft unvollständig oder nicht aktuell. Weiterhin sind in den kommunalen Baumkatastern häufig nur die Bäume erfasst, die im öffentlichen oder halböffentlichen Raum stehen und in die Sorgfaltspflicht der Kommune fallen. Allerdings sind auch private Bäume für Aussagen über die Lufthygiene relevant und sollten für Anwendungsfälle in diesem Bereich aufgeführt sein [vgl. Albert et al. 2022]. Im Rahmen des Klimawandels werden überdies Merkmale von Bedeutung, die bisher nicht dokumentiert wurden. Unter anderem können ergänzende Angaben zum Standort (z.B. Baumscheibe oder Park) dazu dienen, einen potenziellen Trockenstress besser vorauszusagen. Eine Klassifizierung des Allergenpotenzials kann darüber hinaus Personen mit Allergien eine adäquate raumrelevante Information zu „Allergen-Belastungsgebieten" zur Verfügung stellen.

Anhand dieser Problemfelder entstand die Idee, die Datenqualität städtischer Baumkataster zu verbessern. Um den großen personellen und zeitlichen Aufwand der Pflege des städtischen Baumkatasters in Zukunft zu minimieren und weitere, für die Planung und Wissenschaft relevante Merkmale, großflächig integrieren zu können, wird in Kaiserslautern ein transdisziplinärer Ansatz erprobt, der auf Grundlage verschiedener Datenbasen und mit Einbezug unterschiedlicher Akteursgruppen arbeitet. So soll es ermöglicht werden, dass die vorhandenen, aber unvollständigen Daten ergänzt und weitere Merkmale wie Baumart, Höhe und Kronendurchmesser sukzessive hinzugefügt werden.

Im Rahmen des Prozesses sollen unterschiedliche Datenbasen unter Berücksichtigung der rechtlichen Rahmenbedingungen, der Kosten und der Verfügbarkeit als Trainingsdaten dienen und eine Aussage über die Qualität der jeweiligen Ergebnisse getroffen werden. Des Weiteren ist es ein erklärtes Ziel, die KI-Modelle übertragbar zu gestalten, sodass sie in Regionen mit ähnlichem Baumbestand direkt angewendet werden können. Interessierten Bürgerinnen und Bürgern soll es durch die Entwicklung einer nutzerfreundlichen Web-Anwendung ermöglicht werden sich an der Evaluation der Ergebnisse zu beteiligen und ergänzende Merkmale zu erfassen. Sobald neue Daten zur Verfügung stehen, kann ein weiterer Einsatz darin bestehen, das Baumkatasters regelmäßig zu aktualisieren und die Qualität der Daten zu überwachen.

Die Vorteile eines solchen Vorgehens sind vielfältig. Durch Nutzung von Luftbildern können auch private Bäume erfasst werden, die für die Öffentlichkeit nicht ohne Weiteres zu sehen und häufig nicht kartiert sind. Dies ist u.a. für die potenzielle Bewertung von Bereichen mit hohen Allergiepotenzialen durch (Baum-)Pollen sowie das Ozonbildungspotenzial durch biogene Kohlenwasserstoffemissionen von Interesse [Albert et al. 2022].

Es gibt einige Initiativen in deutschen Städten und Regionen, die sich bereits für eine Verbesserung des Baumkatasters einsetzen. Unter anderem in der Metropole Ruhr werden Baumstandorte auf Grundlage ähnlicher Daten und unter Anwendung von KI detektiert [Metz et al. 2023]. Da die Modelle Open-Source zur Verfügung gestellt werden sollen, könnten diese in den hier verfolgten Ansatz integriert werden. Es gibt des Weiteren bereits Deep-Learning-Modelle, die Bäume detektieren, bspw. Ventura et al. [2022] und Weinstein et al. [2019], auf die im nächsten Abschnitt näher eingegangen wird.

Ein erfolgreicher Anwendungsfall eines gut gepflegten Baumkatasters, kann der Einbezug der Bevölkerung bei der Bewässerung sein. Unter anderem in Berlin [Technologiestiftung Berlin] und Leipzig [OKF 2023] werden Plattformen genutzt, um das Gießen von Stadtbäumen zu koordinieren und nachzuvollziehen. In Magdeburg [Winter 2023] finden sich darüber hinaus noch Informationen zu gefällten Bäumen.

Im Folgenden werden zunächst der Projektkontext und die beteiligten Akteurinnen und Akteure vorgestellt. Die Vorgehensweise wird im Allgemeinen erklärt und die vorhandenen Datengrundlagen erklärt und evaluiert. Es wird Bezug auf bereits existierende KI-Modelle zur Positionsbestimmung und Eignung in diesem Anwendungsfall genommen. Zusätzliche mögliche Merkmale werden priorisiert und Möglichkeiten bzw. Grenzen ihrer Bestimmung aufgezeigt. Zuletzt werden die Maßnahmen zur Einbeziehung der Zivilbevölkerung dargelegt.

3 ANSATZ UND PROJEKTKONTEXT

Um das Vorhaben erfolgreich umzusetzen, bedarf es einer Zusammenarbeit verschiedener Akteursgruppen, die ihre jeweilige Expertise zur Verfügung stellen: es ist ein breites Fachwissen zu den Themengebieten Umwelt und Klima, Stadtplanung, Datenverarbeitung, Web-Design und KI gefragt, das durch die Forschenden abgedeckt wird. Mitarbeitende der öffentlichen Verwaltung kennen die vorhandenen Daten, stellen diese bereit und liefern Use-Cases aus der Praxis. Des Weiteren bestehen dort bereits Kommunikationskanäle, um mit der Zivilbevölkerung in Kontakt zu treten und diese für Crowdsourcing-Aktionen zu gewinnen. Hierbei sollen an Aktionstagen interessierte Bürgerinnen und Bürger mit Unterstützung der Forschenden Merkmale von Bäumen möglichst großflächig digital erfassen bzw. die Ergebnisse aus den KI-Modellen validieren.

Das Forschungsvorhaben ist aus dem durch die Carl-Zeiss-Stiftung geförderten Verbundprojekt „Ageing Smart – Räume intelligent gestalten" entstanden. Im Fokus des Gesamtprojektes stehen die Babyboomer, also die geburtenstarken Jahrgänge von 1955 bis 1969, durch deren Eintritt in das Rentenalter Kommunen vor Herausforderungen gestellt werden. So sind diese oftmals damit konfrontiert, neben altersgerechten Wohnstandorten auch passende Versorgungs- und Freizeitstrukturen zu schaffen. Das Gesamtprojekt hat sich als Ziel gesetzt, ein datengestütztes Entscheidungsunterstützungssystem (Decision Support System) zu entwickeln, das Mitarbeitenden der öffentlichen Verwaltungen in ebendiesen Planungsprozessen unterstützt. Insgesamt zehn Teilprojekte aus den Fachbereichen Raum- und Umweltplanung, Informatik und Mathematik der RPTU am Standort Kaiserslautern bearbeiten interdisziplinär diese Fragestellung. Ebenso involviert ist das Fraunhofer-Institut für Experimentelles Software Engineering (IESE) sowie das Deutsche Forschungszentrum für Künstliche Intelligenz (DFKI) GmbH (siehe dazu Abb.1).

Das Teilprojekt der Physischen Geographie untersucht bestehende, lokale, öffentliche Grünflächen im Hinblick auf die Frage, ob diese relevanten Rückzugsräume von allen Personengruppen gleichermaßen nutzbar sind. Ein besonderer Blick liegt hierbei auf den meteorologischen Rahmenbedingungen sowie lokalklimatischen und lufthygienischen Fragestellungen. Im Rahmen der Weiterentwicklung des Baumkatasters liefert das Teilgebiet mögliche Use-Cases und bietet die fachliche Expertise. Im weiteren Verlauf des Teilprojektes soll das methodische Vorgehen, das bereits im Jahr 2022 von Albert et al. vorgestellt wurde, auf Siedlungsräume übertragen werden. Hierbei ist ein (nahezu) vollständiges digitales Baumkataster erforderlich.

Das Team des SmartCity Living Lab des DFKI befasst sich im Rahmen des Forschungsprojekts, dessen Erkenntnisse und Umsetzungen auf vielfältigen Datenquellen fußt, mit der Data Governance und dem Daten-Management, um eine ausreichende Datenqualität zu gewährleisten. Diese ist ausschlaggebend für die Güte automatisierter Anwendungen und Methoden der Künstlichen Intelligenz. KI kann umgekehrt aber auch wie in diesem Fall genutzt werden, um eine gewünschte Datengrundlage zu schaffen oder zu verbessern.

Die Stadt Kaiserslautern wurde als eine von sieben Modellkommunen im Projekt ausgewählt und arbeitet zudem im Rahmen der MPSC-Förderung (Modellprojekte Smart Cities) des BMWSB schon seit einigen Jahren eng mit Forschenden des DFKI und der RPTU zusammen. Sie stellt Daten zur Verfügung und nutzt ihre Kommunikationskanäle mit der Zivilbevölkerung, um diese aktiv miteinzubeziehen.
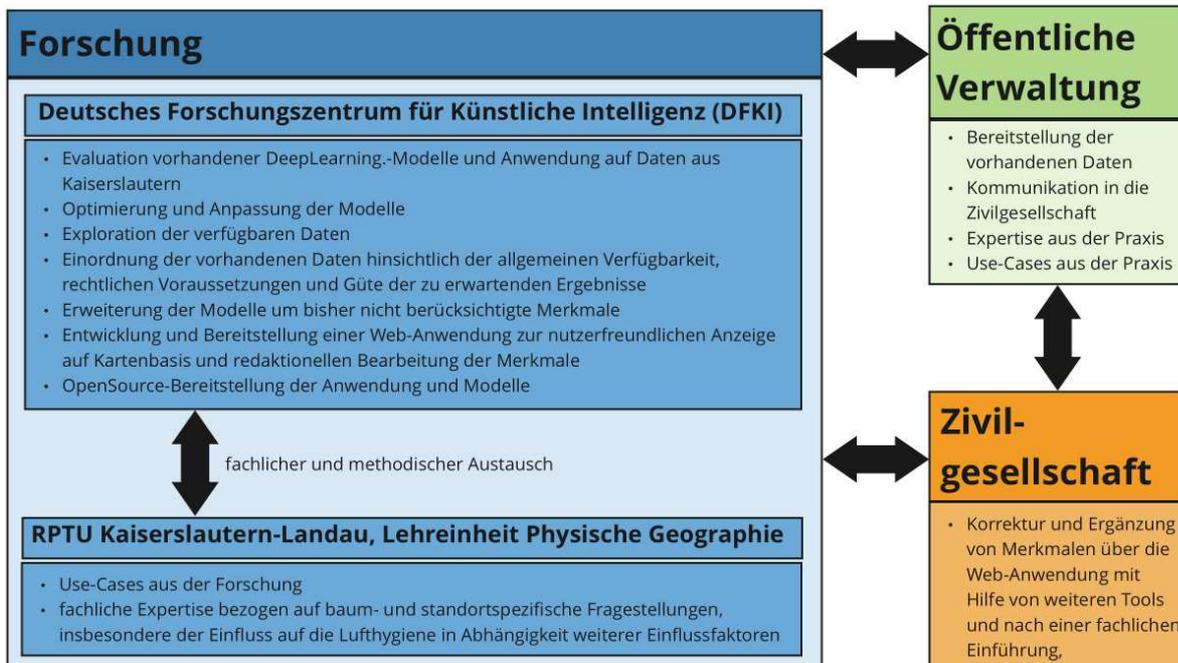
Abb. 1: Kooperationsnetzwerk zum Verbessern, Ergänzen und Nutzen des städtischen Baumkatasters

4 VORGEHENSWEISE

Zunächst werden die verfügbaren Daten auf ihre Qualität und Nutzbarkeit in diesem Anwendungsfall hin untersucht. Sie dienen als Grundlage, um das aktuelle Baumkataster mit den Merkmalen Position und Spezies unter Anwendung von vorhandenen und ggf. angepassten Deep-Learning-Modellen, um fehlende Positionen von Bäumen zu ergänzen. In einem weiteren Schritt wird ein weiteres Modell angewendet oder ggf. selbst trainiert, das die Gattung der neu detektierten Bäume ergänzen soll. Um die Qualität der Ergebnisse einordnen zu können, ist hier eine Kontrolle von fachkundigen Personen nötig. So können die Modelle sukzessive verbessert werden.
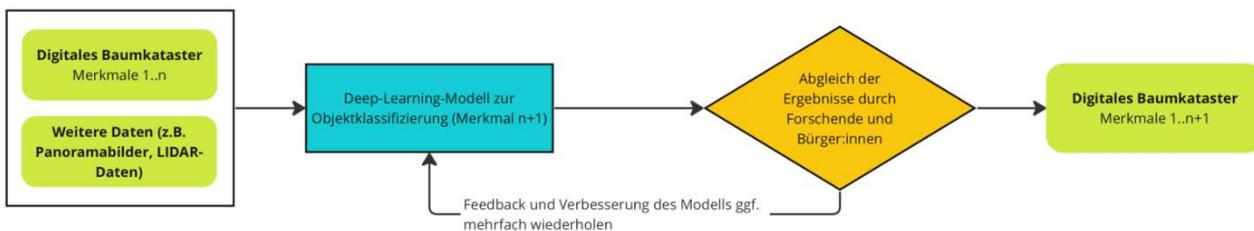
Abb. 2: Generalisierte Vorgehensweise zur Ergänzung des Digitalen Baumkatasters unter Einbezug der Bevölkerung

Des Weiteren soll das Baumkataster um weitere Merkmale, wie bspw. Höhe, Stammdurchmesser oder Standort ergänzt werden. Hierzu werden drei Ansätze verfolgt: Zum Ersten können vorhandene Deep-Learning-Modelle auf verfügbare Daten angewendet werden und wiederum durch eine Feedback-Schleife optimiert werden (vgl. Abb.2). Zum Zweiten können automatisierte Anwendungen (auch ohne Nutzung von KI) bestimmte Merkmale großflächig ergänzen. Zum Dritten gibt es die Option, ein eigenes Modell zu

64

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trainieren. Hierfür werden ausreichend Trainingsdaten benötigt, die in einem Crowdsourcing-Ansatz gesammelt werden sollen. Interessierte Bürgerinnen und Bürger erfassen mit Unterstützung von Fachkundigen und unter Benutzung einer anwenderfreundlichen und intuitiven Software neue Merkmale von einigen Bäumen. So soll der Datensatz im Ganzen um die jeweiligen Attribute ergänzt werden.

4.1 Einordnung der Datengrundlagen

Es gibt einige Datenquellen, die Informationen zu den städtischen Bäumen in Kaiserslautern bereithalten. Diese müssen zunächst auf ihre Qualität geprüft werden. Dabei werden die verschiedenen Kriterien je nach Anwendungsfall unterschiedlich gewichtet und bewertet. In diesem Fall spielen insbesondere die Fehlerfreiheit, die Zugänglichkeit und die Verfügbarkeit der Daten eine übergerodnete Rolle. Unvollständige, aber verlässliche Daten können genutzt werden, um den Datensatz mithilfe von automatisierten Anwendungen zu vervollständigen.

Um Datenquellen als Trainingsdaten für KI-Methoden nutzen zu können, sollten diese möglichst fehlerfrei sein, da das Modell sonst eventuell diese Fehler reproduziert. Des Weiteren ist es sinnvoll, Datensätze zu nutzen, die den Kommunen ohnehin vorliegen oder ohne großen Aufwand zu beschaffen oder erzeugen sind, um ein Modell perspektivisch auch auf andere Kommunen anwenden zu können.

Die Aktualität der Daten ist in diesem Use-Case zunächst untergeordnet, da im Verhältnis zur Gesamtanzahl der Bäume nur ein kleiner Anteil gefällt bzw. neu gepflanzt wird. Andere Merkmale, wie die Höhe, ändern sich kontinuierlich. Hier muss generell mit Ungenauigkeiten gerechnet werden und diese mit angemessenen Methoden quantifiziert werden. Dies ist insbesondere in Use-Cases, die ebenjene Merkmale verwenden, zu berücksichtigen.

4.1.1 Das Baumkataster der Stadt Kaiserslautern

Das Baumkataster der Stadt Kaiserslautern enthält sehr präzise GPS-Koordinaten von ca. 16.600 Bäumen und der jeweiligen Bezeichnung der Gattung bzw. Art. Eine stichprobenartige Überprüfung der Daten durch Ortsbegehungen hat jedoch ergeben, dass viele Bäume hier noch nicht erfasst sind (s. Abb. 3). Es ist zudem entweder die Gattung oder die Art angegeben, wobei erstere aus letzterer hergeleitet werden könnte, umgekehrt aber nicht. Für die meisten Anwendungsfälle ist die Gattung als Information allerdings ausreichend.
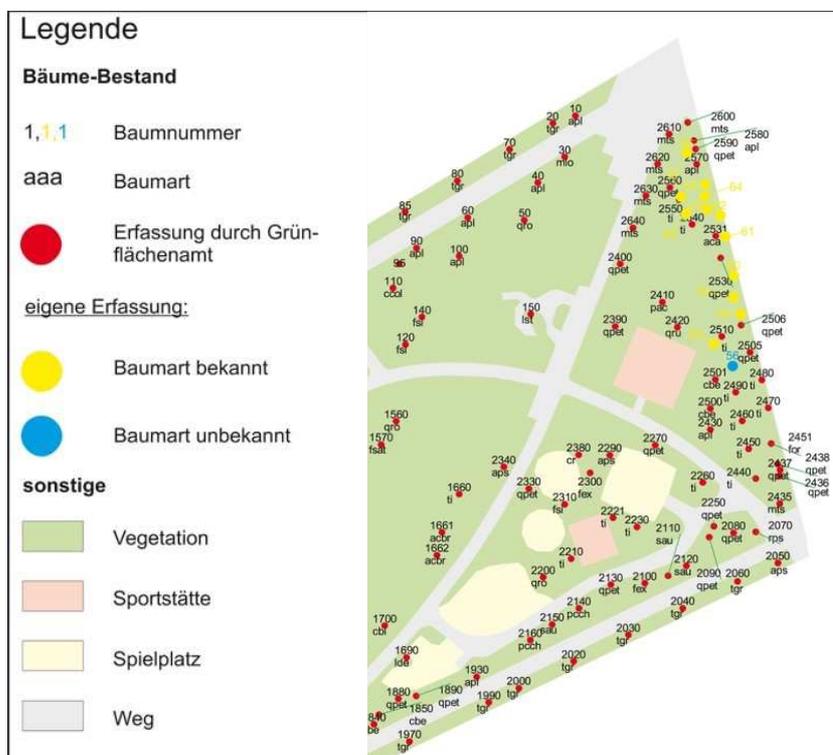
Abb. 3: Karte mit vorhandenen und fehlenden Bäumen im Stadtpark von Kaiserslautern (rot=durch Grünflächenamt erfasst, gelb & blau = eigene Erfassung) [Henninger 2014]

4.1.2 OpenStreetMap

In der OpenStreetMap-Community gibt es das Bestreben, auch Bäume und Baumflächen mit diversen Merkmalen zu kartieren. Allerdings sind zumindest in der Stadt Kaiserslautern bisher wenige Eintragungen (nur rund 1000) vorhanden. Dazu kommt, dass mit dem Smartphone erfasste GPS-Standorte für bestimmte Anwendungsfälle zu ungenau sein können. Es ist darüber hinaus unklar, wie gut die Daten sind, die bisher erfasst wurden. In OpenStreetMap (OSM) sind einige Attribute vorgesehen, an denen man sich orientieren kann, um perspektivisch die neu generierten Daten in die Plattform zu integrieren. Erwähnenswert ist darüber hinaus jedoch, dass Merkmale enthalten sind, die ein anderes implizieren. Beispielsweise kann man durch Angabe der Gattung herleiten, ob es sich um einen Laub- oder Nadelbaum handelt. Umgekehrt ist das nicht möglich. Allerdings ist dieses Merkmal leicht von Personen zu erfassen, die weder Wissen über Baumarten noch technische Hilfsmittel zu deren Bestimmung haben. Es gibt auch eine Unterscheidung der Attribute height (Höhe) und est_height (geschätzte Höhe), die verhindern kann, dass falsch oder zu grob geschätzte Angaben als korrekt interpretiert werden [OSM Contributors 2023].

4.1.3 Luftbilder

Der Stadtverwaltung Kaiserslautern liegen Luftbilder aus Befliegungen zu unterschiedlichen Jahreszeiten und mit verschiedenen Auflösungen vor. Hier wird zunächst mit den Bildern der Frühjahrsbefliegung aus dem Jahr 2018 gearbeitet. Diese sind in einer Auflösung von 40cm frei über das Geoportal RLP [GDI-RP] verfügbar. Höher aufgelöste Luftbilder mit einer Bodenauflösung von 8cm sind aus Gründen des Datenschutzes nicht frei verfügbar, werden aber von der Stadtverwaltung zu Forschungszwecken zur Verfügung gestellt. Es soll überprüft werden, ob eine bessere Auflösung zwangsläufig auch eine bessere Kategorisierung nach sich zieht. Falls die Vorteile einer höheren Auflösung nicht signifikant sind, kann man die datenschutzrechtlich unbedenklichen und frei verfügbaren Daten nutzen. Dies macht eine Übertragung der Ergebnisse auf andere Kommunen und die Anwendung der Modelle auf neuere Luftbilder wesentlich unkomplizierter.

Des Weiteren wird auch ein Abgleich zu Befliegungen aus anderen Jahreszeiten und daher mit anderer Belaubung stattfinden. Es ist zu erwarten, dass je nach Use-Case unterschiedliche Jahreszeiten zu bevorzugen sind. Soll der Standort (Baumscheibe, Baumreihe oder Grünfläche) bestimmt werden, liefern die Luftbilder aus Jahreszeiten ohne Belaubung mutmaßlich bessere Ergebnisse.

4.1.4 Daten aus Straßenbefahrungen

Im Herbst 2021 hat die Stadt Kaiserslautern Befahrungen im gesamten Stadtgebiet ausführen lassen, bei der Panoramabilder und LiDaR-Daten erfasst wurden. Unter deren Nutzung können präzise Messungen (Höhe, Kronendurchmesser und Stammdurchmesser) am PC durchgeführt werden.
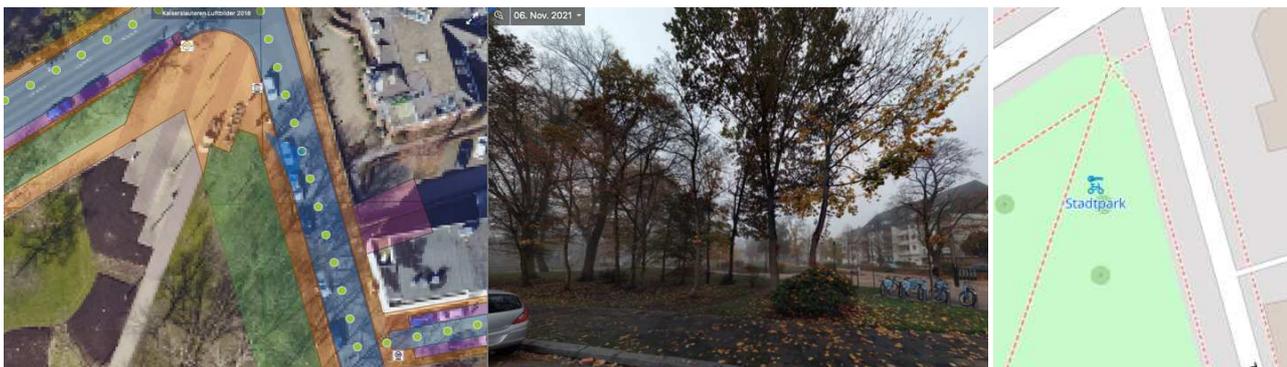
Abb. 4: Screenshots aus Cyclomedia (links) und OSM (rechts) auf denselben Bereich des Stadtparks von Kaiserslautern in Abb. 3

Ein direkter Vergleich der Bäume, die in OSM dargestellt werden, mit dem Bildausschnitt der Straßenbefahrung auf den entsprechenden Teil des Stadtparks, zeigt sofort, dass in OSM bisher nur ein Bruchteil der Bäume verzeichnet ist (vgl. Abb. 4).

4.2 Auswahl, Anwendung und Anpassung von KI-Methoden zur Bestimmung von Position und Spezies

Es gibt bereits einige Ansätze, die sich mit dem Kategorisieren von Bäumen beschäftigen. Es ist also nahe liegend, diese zu nutzen und darauf aufzubauen. Die Übertragbarkeit auf Kaiserslautern hängt unter anderem davon ab, mit welchen Daten die bestehenden Modelle trainiert wurden. Wurden Traningsdaten aus Erdteilen mit einer im Vergleich sehr abweichenden Vegetation genutzt, ist es fraglich, ob das entsprechende Modell mit den hiesigen Bildern sinnvolle Ergebnisse liefert. Zudem muss die Jahreszeit berücksichtigt werden.

4.2.1   Vorhandene Modelle zur Positionsbestimmung von Bäumen

Es gibt bereits Modelle, die Bäume detektieren. Erste Anwendungen auf Kaiserslautern haben ergeben, dass die Ergebnisse noch nicht zufrieden stellend bzw. nutzbar sind. Im Rahmen eines Masterprojekts mit dem Titel „Improving the Tree Cadastre of KL using Object Classification (Python)" wird eines der Modelle angepasst und verbessert.

Ein Convolutional Neural Network (CNN) wurde auf Luftbildern aus Kalifornien trainiert und liefert so genannte Bounding Boxes, in denen Bäume stehen. Es detektierte in den Testdaten 73,3% der vorhandenen Bäume und 73,6% der detektierten Bäume waren tatsächlich existent [Ventura et al. 2022]. Diese Genauigkeit ist jedoch nicht ausreichend. Hinzu kommt, dass dem Modell vier Kanäle (RGBN) zur Verfügung standen, bei den Luftbildern in Kaiserslautern aber nur drei (RGB) vorliegen.

Ein weiteres vielversprechendes Modell wurde auf Bäume außerhalb von Städten trainiert [Weinstein et al. 2019] und dann mit Stadtbäumen in München feintrainiert.

Abb. 5: Ergebnisse der Modelle von Ventura et al. [2022] und Weinstein et al. [2019] angewendet auf die Luftbilder aus Kaiserslautern

4.2.2   Herausforderungen bei der Positionsbestimmung

Das Ziel der KI-Methoden besteht darin, eine hohe Präzision und Abdeckung zu erreichen. Das bedeutet, dass eine möglichst große Anzahl von Bäumen korrekt erkannt werden soll und dabei gleichzeitig möglichst wenige Fehler gemacht werden sollten. Es sollten also keine Bäume an Stellen gefunden werden, an denen tatsächlich keine stehen (False Positives, FP). Dies kann durch fehlerhafte Klassifizierung eines anderen Objekts oder durch ein Rauschen in den Daten verursacht werden. Umgekehrt sollten keine Bäume übersehen werden. Solche False Negatives (FN) treten auf, wenn die Bildqualität schlecht ist oder ungünstige Umgebungsbedingungen herrschen.

Da im städtischen Baumkataster schon viele Bäume fehlen, ist der Fokus auf einen hohe Abdeckung wünschenswert. Fälschlicherweise erkannte Bäume lassen sich schnell aus dem Datensatz entfernen, wohingegen nicht erkannte Bäume in Anbetracht der Angabe präziser GPS-Koordinaten etwas aufwändiger hinzuzufügen sind.

Da die vorhandenen Modelle Schwierigkeiten mit Baumflächen haben und es bereits Ansätze gibt, für Wälder auf Grundlage von Luftbildern das Verhältnis unterschiedlicher Baumarten zu bestimmen, wird diese Thematik zunächst hintenangestellt. Dennoch werden bei einigen Use-Cases die Baumgruppen und deren

Arten eine zentrale Rolle spielen. Daher muss langfristig auch für Baumgruppen eine Lösung gefunden werden.

In städtischen Baumkatastern sind häufig aus pragmatischen Gründen nur Bäume auf öffentlichem Grund verzeichnet, für die die Kommune auch eine Sicherungspflicht inne hat. Unter Anwendung von KI werden jedoch alle Bäume auf den gegebenen Bildern erkannt, also auch die auf halböffentlichem und privatem Grund. Diese sind insbesondere relevant für Anwendungsfälle, die sich mit Lufthygiene beschäftigen [vgl. Albert et al. 2022].

4.2.3 Artbestimmung von Städtbäumen mit KI

Wesentlich komplexer ist die Bestimmung der Spezies der Bäume, die neu im Kataster ergänzt wurden. Hierfür werden zwei Ansätze verfolgt, die auf Grundlage des usprünglichen Katasters fußen. Es soll erprobt werden, wie gut ein Modell mit hochaufgelösten Luftbildern die Gattung kategorisieren kann. Da hierfür erwartungsgemäß zu wenige Trainingsdaten vorliegen, wird ein zweiter Ansatz verfolgt, der die Panoramabilder nutzt. Diese und bereits existierende Modelle zur Baumbestimmung werden genutzt, um die fehlenden Angaben zur Spezies zu ergänzen.

4.3 Ergänzung weiterer Merkmale

Zusätzlich zu den Merkmalen Spezies und Position sind weitere Merkmale relevant, die soweit möglich, großflächig ergänzt werden sollen. Eine Priorisierung erfolgt in Abhängigkeit von den spezifischen Anwendungsfällen. Im Projektkontext haben Standort und Höhe eine hohe Priorität (vgl. Tabelle 1). Eine Orientierung geben unter anderen die in OSM verwendeten Merkmale.

Es ist unbedingt zu beachten, dass alle Attribute veränderlich sind. Die Höhe ändert sich stetig und es kommt bisweilen auch vor, dass ein Baum gefällt und an derselben Stelle ein Baum einer anderen Art gepflanzt wird. Das Baumkataster muss also regelmäßig aktualisiert oder mit entsprechenden Hinweisen versehen werden.

In OSM wird zusätzlich die Bedeutung eines Baumes erfasst. Diese umfasst zusätzliche Informationen z.B. ob ein Baum ein Naturdenkmal ist, eine besondere Landmarke darstellt oder historische Relevanz besitzt. Solche Attribute werden hier nicht berücksichtigt, da sie im lokalklimatischen Kontext keine Rolle spielen.

4.4 Automatisierte Ergänzungen

Messbare Merkmale wie Höhe, Stammdurchmesser und Kronendurchmesser können für Bäume, deren Position verfügbar ist, automatisiert aus den LiDaR-Daten errechnet werden (vgl. Abb. 6), die bei Straßenbefahrungen im Herbst 2021 erfasst wurden.
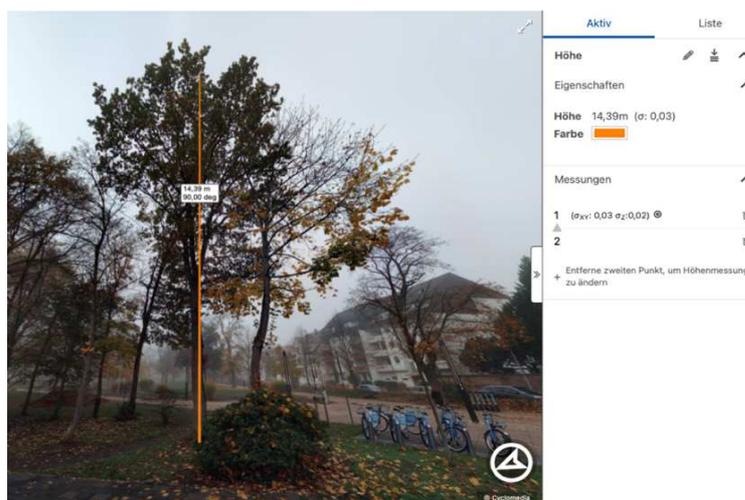
Abb. 6: Screenshot aus Cyclomedia mit der beispielhaften Messung der Höhe eines beliebigen Baumes

4.5 Bilden weiterer Deep-Learning-Modelle

Es sollen weitere Deep-Learning-Modelle gebildet werden, die eine Aussage über den Standort des Baumes treffen können: Steht dieser in einer Baumscheibe, einem Grünstreifen oder einer Grünanlage? Dies hat erheblichen Einfluss auf den Wasserbedarf des jeweiligen Baumes. In Baumscheiben sind arttypische

Wurzelausprägungen bis in die feuchteren Erdschichten hinein kaum möglich und werden durch Schutt im Untergrund sowie Medienträgern wie Rohre, Kabel und Leitungen zusätzlich erschwert.

		Merkmal	Beschreibung	Bemerkung	Priorität
In OSM	1	position	gegeben durch GPS-Koordinaten (Latitude, Longitude); in OSM auch Punkt oder Knoten	Die Präzision der Koordinaten ist für die Anwendung von KI relevant.	sehr hoch
	2	genus	Art; Sammelbegriff	kann aus (3) hergeleitet werden; in den meisten Use-Cases ausreichend	sehr hoch
	3	species	Gattung; Wissenschaftlicher Name	präziser, aber schwieriger zu bestimmen als (2)	mittel
	4	leaf_type	Laubbaum oder Nadelbaum	kann aus (2) hergeleitet werden	niedrig
	5	leaf_cycle	Beschreibt die Eigenschaft das Blattwerk abzuwerfen	kann aus (2) hergeleitet werden	niedrig
	6	est_height	geschätzte Höhe in Metern	falls keine genaue Angabe möglich	niedrig
	7	height	Höhe in Metern	relevant für Verschattung	hoch
	8	diameter_crown	Kronendurchmesser in Metern	relevant für Verschattung	mittel
	9	circumference	Stammumfang in Metern	kann aus (10) berechnet werden	niedrig
Weitere	10	diameter_trunk	Stammdurchmesser in Metern	kann aus (9) berechnet werden	niedrig
	11	standort	Umgebung des Baumes (Baumscheibe, Baumstreifen, Grünanlage)	relevant für Aussage über möglichen Trockenstress	hoch
	12	zustand	Gesundheitszustand des Baumes	kann nicht großflächig berechnet werden, da Trainingsdaten fehlen	keine
	13	sicherungsbedarf	Notwendigkeit Vorkehrungen zu treffen	kann nicht großflächig berechnet werden, da Trainingsdaten fehlen; unklare Rechtslage im Anwendungsfall	keine
	14	alter	Alter des Baumes	kann ggf. durch (2) und (7) geschätzt werden	niedrig
	15	standalter	Zeitpunkt der Pflanzung des Baumes am jetzigen Standort	zusätzliche Datenquellen sind nötig	keine
	16	besitz	Privatbesitz oder im Besitz der öffentlichen Hand	eine Verschneidung mit dem Liegenschaftskataster ist notwendig; relevant für die Sicherungspflicht	keine

Tabelle 1: Überblick Merkmale und ihre Priorisierung im Projektkontext

Die Erfassung dieses Merkmals kann also genutzt werden, um möglichen Trockenstress vorauszusagen und somit helfen, Priorisierungen beim Gießen von Stadtbäumen festzulegen.

Es gibt Merkmale, die in gut gepflegten Baumkatastern auftauchen und nicht leicht automatisiert auf Grundlage der bisher vorhandenen Datenquellen zu ergänzen sind. Dazu gehören Baumalter und Pflanzzeitpunkt. Ersteres könnte man anhand der Höhe und der Gattung grob abschätzen oder ein Intervall angeben. Zum Pflanzzeitpunkt könnten zusätzliche Datenquellen (z.B. Bebauungspläne) weitere Informationen bieten, wobei hierbei nur abgeschätzt werden kann, wann ein Baum frühestens gepflanzt wurde. Daher wird dieses Merkmal nicht berücksichtigt.

4.6 Einbezug der Zivilbevölkerung

Parallel zu den ersten Erprobungen und Verbesserungen der KI-Methoden wird eine nutzerfreundliche und intuitive Web-Anwendung entwickelt, die einen Einbeziehung interessierter Bürgerinnen und Bürger ermöglichen soll. Hierfür sollen diese unkompliziert weitere Merkmale ergänzen oder vorhandene editieren können. Das Nutzen weiterer Hilfsmittel wie Baumarten-Bestimmungsapps oder Messwerkzeuge bietet sich an. Fachkundige Personen sollen regelmäßig zur Einführung und Beratung zur Verfügung stehen.

In der Web-Anwendung werden ähnlich wie im Gieß-den-Kiez-Portal [Technologiestiftung Berlin] in einer Kartenansicht die vorhandenen Bäume angezeigt. Bei Auswahl einer dieser Punkte durch Anklicken öffnet sich ein Fenster mit zusätzlichen Informationen. Zudem soll es die Möglichkeit einer Registrierung geben, sodass nach einer Anmeldung die Möglichkeit besteht, Merkmale zu editieren oder zu ergänzen und Hinweise zu fehlenden oder gefällten Bäumen zu geben.

Initiiert und angeleitet von den Forschenden mit Unterstützung von Studierenden und Mitarbeitenden der Stadt, soll es regelmäßige Aktionstage geben, beispielsweise im Rahmen des bundesweiten Digitaltages, bei denen entweder vorhandene Merkmale kontrolliert oder neue Merkmale in der Web-Anwendung erfasst werden können. Jene könnten als Traininsggrundlage für weitere KI-Modelle dienen.

4.7 Übertragbarkeit, Evaluation und Pflege

Der Programmcode der Deep-Learning-Modelle und auch die trainierten Weights der Modelle sollen offen zur Verfügung gestellt werden, sodass andere Kommunen unter Nutzung der benötigten Datenquellen mit erheblich weniger Aufwand in der Lage sind, eigene digitale Baumkataster zu erstellen oder zu verbessern.

Des Weiteren kann durch Nutzung der Modelle mit zukünftig erfassten Daten ein Monitoring stattfinden, bei dem abgeglichen wird, welche Bäume ohne Vermerk im Baumkataster gefällt, gepflanzt oder ersetzt wurden.

Langfristig soll auch eine Evaluation der genutzten Methoden stattfinden: Wenn eine Aktualisierung der Baumhöhen anhand von Gattung, Ursprungshöhe und vergangener Zeit seit dem Erfassen der Höhe stattgefunden hat, soll ein Abgleich mit der tatsächlichen neuen Höhe stattfinden, so dass auch hier wiederum eine Verbesserung der Vorgehensweise vorgenommen werden kann.

5 ZUSAMMENFASSUNG UND AUSBLICK

Zusammenfassend ist festzustellen, dass sowohl die Erstellung als auch die Pflege eines qualitativ guten Baumkatasters eine aufwändige Arbeit ist, die jedoch vor allem im Angesicht des Klimawandels immer dringlicher und bedeutsamer wird. Ein digitales Baumkataster kann Mitarbeitenden von Kommunen helfen, Umwelt- und Klimaaspekte effektiver zu berücksichtigen und nachhaltigere Entscheidungen in der Stadtplanung zu treffen, indem z.B. geeignete Baumarten für entsprechende Standorte gewählt werden. Darüber hinaus bietet es Unterstützung bei der Voraussage von potentiellem Trockenstress, Verschattung und möglichen lufthygienischen Einflüssen bei bestimmten Wetterlagen. Durch die Einbeziehung von privaten Bäumen und die Ergänzung weiterer Merkmale wird das Baumkataster umfassender und nutzbarer für weiter reichende Anwendungsfälle aus der Wissenschaft.

Die (Weiter-)Entwicklung von Deep-Learning-Modellen erlaubt nicht nur eine Übertragung auf andere Kommunen, sondern auch eine regelmäßige Aktualisierung unter Anwendung von erneut erfassten Luft- und Panoramabildern. Dies ermöglicht überdies ein Monitoring der Datenpflege. Unter Verwendung geeigneter Schnittstellen, Portale und Web-Anwendungen sollen die Daten öffentlich zugänglich und editierbar sein.

Die Zusammenarbeit verschiedener Akteursgruppen aus der Forschung, der Verwaltung und der Bevölkerung ist zugleich herausfordernd und entscheidend für den Erfolg des Projekts. Eine transparente Kommunikation, die einfache Erklärungen und nachvollziehbare Gründe für eine Mitwirkung beinhaltet, ist hier unabdingbar.

Es ist überdies empfehlenswert, dass nach der Erprobung verschiedener KI-Modelle unter Anwendung auf unterschiedliche Datenbasen eine Evaluierung stattfindet, bei der Kriterien festgelegt werden, nach denen die zu verwendenden Daten und Modelle auszuwählen sind. Des Weiteren sollen einheitliche und vereinfachte Prozesse erstellt werden, wie eine Erfassung bzw. wiederkehrende Aktualisierung des Baumkatasters ablaufen kann und insbesondere wie mit fehlerhaften Ergebnissen aus den KI-Anwendungen umgegangen wird, die sich nie gänzlich vermeiden lassen. Eine weiterer großer Schritt, der noch umzusetzen und zu integrieren ist, wird der Umgang mit Baumgruppen sein.

6 LITERATUR

ALBERT, L.; FRÖHLICH, N.; HAUSBRAND, N.; HENNINGER, S.; MAURER, T.; RUZIKA, S.: Human-biometeorologisch angepasste Routenführungen durch mathematische Optimierung. In: Mobility, Knowledge and Innovation Hubs in Urban and Regional Development. Proceedings of REAL CORP 2022, 27th International Conference on Urban Development, Regional Planning and Information Society. pp. 427-435. DOI: 10.48494/REALCORP2022.7061

BRUNS, L.; DITTWALD, B.; Meiners, F.: Leitfaden für qualitativ hochwertige Daten und Metadaten, https://www.nqdm-projekt.de/de/downloads/leitfaden, abgerufen am: 1.06.2023.

HENNINGER, S. (2014): The Impact of Biogenic Isoprene in Dependence on Meteorological Conditions within Urban Green. In: Rauch, S., Morrison, G., Norra, S. und N. Schleicher [Hrsg.]: Urban Environment - Proceedings of the 11th Urban Environment Symposium, Springer Verlag, pp. 153-162.

LENKUNGSAUSSCHUSS GEODATENINFRASTRUKTUR RP IM MINISTERIUM DES INNERN FÜR SPORT DES LANDES RHEINLAND-PFALZ, GDI-RP, https://www.geoportal.rlp.de, abgerufen am: 01.05.2023.

METZ, M; WEINMANN, A.; KRISZTIAN, L: Automatisierte Detektion von Baumstandorten in der Metropole Ruhr. In: FOSSGIS e.V. (2023). Tagungsband FOSSGIS-Konferenz 2023. p. 161. DOI: https://doi.org/10.5281/zenodo.7573277

OPEN KNOWLEDGE FOUNDATION DEUTSCHLAND E.V., https://codeforleipzig.github.io/giessdeibohm/, abgerufen am:14.06.2023.

OPEN STREET MAP WIKI CONTRIBUTORS, OpenStreetMap Wiki "DE:Tag:natural=tree" https://wiki.openstreetmap.org/w/index.php?title=DE:Tag:natural%3Dtree&oldid=2446549, abgerufen am 02.06.2023.

TECHNOLOGIESTIFTUNG BERLIN, https://www.giessdenkiez.de, abgerufen am: 14.06.2023.

VENTURA, J; PAWLAK, C.; HONSBERGER, M.; GONSALVES, C.; RICE,J.; LOVE, N.L.R.; HAN, S.; NGUYEN, V.; SUGANO, K; DOREMUS, J.; FRICKER, G.A.; YOST, J.; RITTER, M.: "Individual Tree Detection in Large-Scale Urban Environments using High-Resolution Multispectral Imagery." arXiv:2208.10606 [cs], Oct. 2022.

WEINSTEIN, B.G.; MARCONI, S.; BOHLMAN, S.; ZARE, A.; WHITE, E.: Individual Tree-Crown Detection in RGB Imagery Using Semi-Supervised Deep Learning Neural Networks. Remote Sens. 2019, 11, 1309.

WINTER, J: Baumfreunde Magdeburg, https://www.baumfreunde-md.de/home, abgerufen am: 14.06.2023.

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Brownfield Regeneration in Sarajevo – Sustainable Growth Towards a Polycentric City

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1 ABSTRACT

Urban planning and design processes generally follow standardised procedures that have been tried and tested by generations of experts. However, due to the local context and changing framework conditions in each city and project site, processes always need to be adapted and result in unique planning histories that take into account the specific political, spatial, social, cultural and economic conditions of a place. Adverse circumstances might challenge ambitious process designs and lead to slimmed-down planning processes and unsatisfactory results, while an enabling environment can enrich the process and inspire the outcome. The reality, however, is not always black or white. There are multiple influential factors and it is the task of the planners not to lose sight of the goal and to use the circumstances in the best possible way to achieve high-quality design results. Urban design may be defined as "the process of providing quality contextual places for people" (Black & Sonbli 2019, 21). This indicates the contextuality of place and process and highlights the need to adapt to the local context in order to achieve an adequate result.

Within the framework of a consultancy for the European Bank for Reconstruction and Development (EBRD), an international and interdisciplinary planning team composed of architects, spatial planners, economists, and sustainable resource managers, made the effort to implement an integrated and participatory urban design process for two brownfield sites in Sarajevo. This paper explores the manifold challenges and obstacles that the team was confronted with and the creative approaches to overcome these hurdles. It takes a critical look at the adjustments in the process and the results, and gives an outlook and recommendations for the next steps towards implementation and development.

Keywords: Land Consolidation, Sustainable Design, Integrated Urban Design, Brownfield Regeneration, Microclimate Simulation

2 A CITY OF CONTRADICTIONS: SARAJEVO AND BEYOND

2.1 Political and administrative context and the lack of trust

The City of Sarajevo is the capital and largest city in Bosnia and Herzegovina (BiH) with a population estimated at 276,000 inhabitants, according to the latest census (Statistika, 2013). The area of the city is 141.5 km2 and it consists of four municipalities: Stari Grad, Centar Sarajevo, Novo Sarajevo, and Novi Grad. The city is represented by the Mayor of the City of Sarajevo and the City Assembly. Along with five other municipalities, it is part of Sarajevo Canton, which has its own legislative, executive and judiciary powers. It is governed by the Assembly of the Canton and the Prime Minister. Moreover, every municipality has its own Municipal Mayor and Municipal Assembly. The complex hierarchy of this governance system is reflected in all spatial processes and jurisdiction is often (mis)used in the planning of the city's development and urban growth.

The complex political-administrative structure of the Canton of Sarajevo, which is reflected in the management of the city itself, resonates at all levels of government, and complicates the management of the city, its territories and resources (Zupcevic & Causevic 2009). The frequent overlapping of responsibilities and the exclusion of certain levels from responsibilities, often supported by unclear or conflicting legal regulations, reduces public confidence in the abilities and intentions of those involved in management processes. The spatial planning authorities are particularly challenged, since private capital has been driving construction activities rapidly since the political system change, while strategic planning can hardly keep up with the definition of the necessary framework conditions.

Under these circumstances, and in view of the post-war reconstruction of the city, non-transparent developments of large spatial reserves were carried out, mostly at the sites of former industrial areas, but also in the central urban fabric, which shook trust in both political and professional goodwill of the actors involved (Tzifakis & Tsardanidis 2006). In many cases, planning documents were changed on investors' requests without the participation of the public. This was facilitated by the law on spatial planning at the time, which gave Municipal Mayors the opportunity to change existing planning documents through abbreviated procedures and for individual locations without holding a public hearing and presentation (Spatial Planning Act, Canton Sarajevo Gazette, 7/05, Article 46). Real estate developments without a legal basis or contrary to valid planning documents were not uncommon either.

Over the past two decades, the development of Sarajevo has led to the creation of large shopping centres and monofunctional residential areas. Unfortunately, many of these projects failed to comply with basic urban planning parameters, neglecting important factors such as fire safety standards, road width, and lighting. Private investments dominated the real estate sector, as public institutions lacked the capacity to actively participate in real estate development. Limited public budgets, the need to invest in socio-economic measures, and the absence of a resident-focused development strategy have profoundly influenced urban development in Sarajevo. Furthermore, the city's urban planning has been characterised by a lack of vision and strategy, driven by the imitation of global and regional trends, such as the separation of functions and a car-centric approach. Planning regulations often prioritised these trends rather than considering local potentials and the overall quality of life for Sarajevo's residents.

The wider public and planning professionals had limited influence on urban development in Sarajevo due to prevailing circumstances. Following the war, private ownership took precedence over public ownership, with land becoming a valuable asset for obtaining investment benefits. Consequently, private investors wield significant influence, sometimes overshadowing the concerns of the wider public and planning experts. This has led to a loss of faith in effective spatial planning, as responsible institutions often prioritise meeting the desires of investors over improving residents' quality of life (Botic 2013). Although current urban planning legislation recognizes public involvement, participation typically occurs towards the end of design processes, and public hearings often serve as justification for changes that have already been decided upon.

2.2 Environmental challenges and the new urban plan

At the same time, the Sarajevo urban area faces pressing challenges amidst multiple crises like climate change and social division. The quality of housing has declined and although the number of units its steadily growing, there is a lack of affordable housing for middle- and low-income groups. Public spaces and social infrastructure are lacking in existing and new settlements. Environmental problems, such as air pollution, worsen due to high private car usage and reliance on wood and coal for heating. Authorities' efforts to address these issues are slowly entering public discourse, but time and initiatives are needed for noticeable changes in daily life (Hewlett & Gallego-Lopez 2020).

Sarajevo's location in the valley allows only limited air flow, leading to frequent smog, particularly during winter months. Within the urban fabric, specific areas are more susceptible to pollution, causing significant impacts on the surrounding regions. Historical urban planning documents, spanning from the 1960s to the 1980s, acknowledged the importance of mitigating winter smog by implementing measures such as city gasification, promoting sustainable public transportation, and imposing height limitations in the central area where the valley is narrowest. However, as urban growth intensified in the 2000s, these policies proved insufficient to accommodate the pressures of urban growth. Irregular developments on vacant lots and abandoned industrial sites further exacerbated the environmental conditions in Sarajevo. Buildings of unfavourable height and position further impair the already problematic state of Sarajevo's air pollution.

The change in perspective and new understanding of social, economic and ecological urban needs are reflected in some important documents that have been developed over the last few years and are also used in preparation for the new Urban Plan. The Study on Ventilation Corridors was developed along with the Green Cantonal Action Plan for Sarajevo in 2020 (Hewlett & Gallego-Lopez 2020). The document proposes regulations for the positioning and height of the buildings along the main ventilation corridors in the city and has been adopted by the Government. The planning and construction needs of the Canton and the City of Sarajevo are subject of a new Urban Plan, which is currently being drafted. The last Urban Plan was created in 1986 and has long become inadequate and ineffective to address contemporary urban challenges. The lack

74

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of a high-quality urban strategy was consequently reflected in the detailed planning documents (regulatory plans, urban projects), which were supposed to be based on the overall Urban Plan. However, the ongoing process of developing a new Urban Plan is leading to a number of problems as several major development projects in the city are halted awaiting its adoption. In such a stalemate, all efforts to activate and improve the urban space depend on the willingness of decision-makers to act and advocate for the incorporation of new solutions into the Urban Plan and their subsequent elaboration within the detailed planning documents. At this point of time, planning is a matter of building trust between the profession, the public, decision makers and investors, which requires a great deal of skill and time, as well as a change in the mindset of all stakeholders involved.

2.3 Brownfields as a potential for polycentric development

During the after-war period, large areas of former industrial complexes were abandoned. The regeneration of these brownfield sites holds great potential for future urban development and the emergence of new qualities in Sarajevo. In times of high land use and rapid soil sealing in the urban peripheries, brownfields represent an attractive opportunity to enable urban growth in a more sustainable way. Additionally, most brownfield sites already have access to basic infrastructure such as water, electricity and sewer connections. Due to the city's expansion over time, many brownfields in Sarajevo are located in high-density environments and in central positions within the city area today. The regeneration of these sites and a general focus of urban development activities on urban voids are significant in order to prevent urban sprawl and to generate a city of adequate density.

The development of brownfield sites in Sarajevo also offers the potential to create new mixed-use centralities in a largely monofunctional urban fabric that evolved along the valley and has its main administrative centre and business hub around the old town in the east. As a growing city, it is time for Sarajevo to develop new urban centres that fulfil multiple functions, offer job opportunities as well as recreational spaces, educational and cultural institutions. In a polycentric vision of the city, the numerous brownfield sites across the urban tissue are anchor points and incubators for such developments. The elaboration of a clear vision for Sarajevo's brownfield sites is crucial in order to induce the release of these high-potential land and encourage investments in their development.

The task of developing two brownfield sites in Sarajevo was at the beginning of the planning team's intense interaction with the city. Against the background of a complex political and administrative situation and a general lack of trust in urban planning processes, it was crucial to apply a professional approach, a transparent planning process and comprehensible, fact-based decision making.

3 CREATING TRUST THROUGH COMPREHENSIBLE PLANNING

3.1 Application of a good practice urban design process

Although each urban design process is unique in its procedure and outcomes, there is a broad consensus in scholarship and practice as to what basic stages should be followed (cf. Black & Sonbli 2019, Carmona 2013, Lloyd-Jones 2001). In order to create "quality contextual places for people", the design process should start with a multi-layer analysis that includes the urban context on different spatial scales as well as the policy framework and socio-demographic aspects. Based on the findings, a strategic design framework is developed. It informs the development of the design through concepts and scenarios before acting as an evaluation matrix for the outcomes. The design phase as such is circular rather than linear as it reverts to the concept through several evaluation loops and should be tested by local stakeholders. The stage of delivery and implementation adds another layer to the design that needs to remain flexible and adapt to the various demands that arise during realisation (Black & Sonbli 2019). The design process is rational and experimental, it works through a process of deduction, where a design solution is an early hypothesis to be tested, drawing on pre-existing models and exposing it to multiple realities (Lloyd-Jones 2001). It is important to stress that the designers do not act in isolation but are exposed to power relations that shape the process and its outcomes through agency and political structures. The history of place and the contemporary political situation influence the process along with numerous stakeholders ranging from policy makers, investors, space users, etc (Carmona 2013). Acknowledging the importance of all these actors is the first step towards enabling participatory design processes. The inclusion of local stakeholders in planning processes

has steadily increased in recent decades and numerous tools for co-creation and participatory design have been developed that can be integrated into tried and tested processes (cf. Krebs & Mayr 2023, 550ff.).
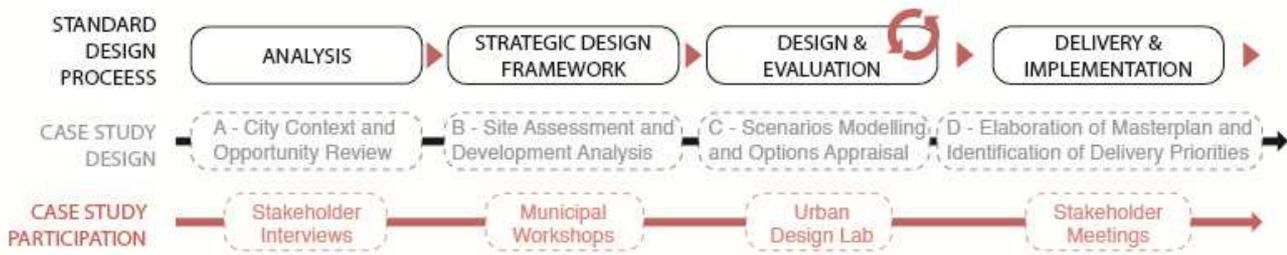
Fig. 1: Stages of a standard urban design process as compared to the case study in Sarajevo. Source: Author's own figure based on Black & Sonbli 2019.

In Sarajevo, the work process was organised in four main phases. The first task was to understand the urban context of Sarajevo and review the many opportunities for brownfield development that the city had to offer. The result of a multi-criteria analysis of 24 brownfield sites was the selection of two target sites for further analysis and development: Kvadrant B in Marijn Dvor and the former Central Railway Workshop Vaso Miskin Crni (VMC) in Novo Sarajevo.

Kvadrant B is an eight hectare central location in the city of Sarajevo. The area is partially developed with new shopping malls, business buildings and services and is part of the city's new business and public centre, with old heritage buildings from the Austro-Hungarian period which are currently in private ownership. The rest of the site, near the Miljacka River, is used as a parking space, owned by the Canton of Sarajevo. The connection to the public transport system and the road network is excellent and high density surroundings are a good precondition for the implementation of mixed uses in the area. The redevelopment of the site has been subject of discussion for over 20 years and has evolved to a controversial topic.

The former Central Railway Workshop Vaso Miskin Crni was partially and poorly transformed into shopping malls after the 90s. The twelve hectare site is centrally located, with good connection to all the main traffic lines and the tram line in walking distance. It consists of both newly built facilities as well as old warehouses, which are currently abandoned. The central location and the high-density surrounding form an ideal condition for the implementation of a mixed-use neighbourhood. The high number of involved owners, among which there are both private and public entities, is a challenge to the development of the site.

The selected brownfield sites were assessed and a spatial analysis was carried out. In parallel, a Real Estate Demand Study was prepared to inform the planning process and decision-making. In order to test development opportunities, different spatial and mixed-use scenarios were drafted for both sites. They were discussed with the Working Group comprising representatives from all involved administrative levels to agree on the way forward. In parallel, the Sarajevo Urban Design Lab was conducted. The program included a series of academic workshops, public events, and stakeholder meetings that enabled a broader discussion about brownfield development in Sarajevo. At the same time, the different mixed-use scenarios for both project sites were evaluated, and their financial viability assessed against the backdrop of the previously conducted market analysis. A microclimate simulation analysed the impact of the design on the immediate environment in terms of heat and wind effects. Finally, clear design visions were developed for Vaso Miskin Crni and Kvadrant B, including a detailed design strategy, technical information, infrastructure plans, as well as environmental and social impact appraisals. The final design also made a strong case for the benefits of the proposed projects from the perspectives of urban regeneration and sustainable 'green' development.

The process was carried out by an interdisciplinary team of architects and urbanists, environmental and financial experts, as well as trained participation specialists. The clear process designed on the onset of the project increased transparency and provided a flexible and holistic approach where each stage informed the other. The clear structure was the basis for the involvement of public and private stakeholders throughout the process and promoted the trust and accountability needed in the Sarajevo context.

The following sections go into more detail on some of the components of the design process that were particularly important in order to respond to the diverse challenges we encountered in Sarajevo: public participation, market demand, sustainable urban design, microclimate simulations and land consolidation.

76

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3.2 Public participation in a complex environment

The concept of public participation is often explained along Sherry Arnstein's ladder of participation (1969). The model describes eight levels of participation ranging from manipulation to information and partnership all the way up to citizen control which is presented as the ultimate form of participation. This conception of citizen involvement, however, has also been criticised. Collins and Ison suggest that "[T]he linear conceptualization of participation does little to emphasise the importance of either the process or the existence of feedback loops, which shape understandings of the situation" (2009, 362). While a high level of public involvement is generally desirable, it is questioned to what extent power should be shifted from elected decision makers to small groups of people who have the capacity to engage. Moreover, the possibilities and range of participation vary according to the design question, scale of the problem, and local context. Therefore, the level, range and tools of public participation must be adapted to the specific parameters of each project.

In the case of Sarajevo, public participation in planning processes is usually limited to the legally required public hearings prior to adoption of a planning document. Involvement of local stakeholders throughout a design process is rare or virtually non-existent. There is, however, an emerging public interest in the spatial development of the city. Driven by the professional and academic community a public discourse on urban development is developing, which criticises the undesirable developments of the past and calls for a new style in urban planning. The focus is on issues such as quality of life, public space and social participation, while issues of sustainability and resilience are less present. Both selected brownfield sites have been in the focus of public attention for a while due to specific developments and expectations related to them. At the same time, there is limited experience with public participation processes and a lack of trust in the system of political decision making. This challenging situation is further complicated through the powerful position of private landowners and investors who try to influence the public discourse to their advantage.

In the midst of this complex situation, the planning team for the development of Kvadrant B and Vaso Miskin Crni endeavoured to involve decision makers, experts and the public in the planning process. In a first step, and in order to take account of the multilayered administrative and political situation, a Working Group was set up. Members of this group included representatives and decision makers of all administrative levels included in the planning process: Catnon, City and the Municipalities. Regular meetings with this group formed the basis for transparent communication across administrative boundaries and hierarchies and aimed to achieve broad political support for the developed design proposals.

In a stakeholder analysis, the planning team identified key players in the professional and academic field of planners and architects in Sarajevo who should be involved in the process in order to contribute their expertise and act as multipliers to make the discussion accessible to a broader public. The Stakeholder Core Group comprised experts and academics, representatives of the Association of Architects in BiH (AABH), and local practitioners. They were invited to planning workshops to discuss ideas for urban design, functions and possibilities for implementation. Additionally, interviews were conducted with selected stakeholders from different fields of expertise related to the economic, spatial, and socio-cultural development of the city.

The centre piece of participation and exchange was the four-day Urban Design Lab (UDL), which was carried out in cooperation with the University of Sarajevo. It included an urban design workshop with local students on both project sites, professional workshops with municipal staff and the Stakeholder Core Group, as well as public events like a movie night, panel discussion, and final presentation of the academic workshop. Since the urban design process was on a mere conceptual stage, the idea was to reach out to a wider public while staying in a professional context. The events were advertised through the networks of the University, AABH and Days of Architecture, a local architecture festival. The professional exchange during the UDL was very valuable for the design process and supported the development of robust masterplans that would respond to the urban context and local needs. The participation process also revealed broad support for the work of an 'external' planning team that would bring in new ideas and possible solutions to the development of two sites that have been much discussed and disputed in the past.

The entire planning process was thoroughly documented and the results were submitted for the National Architecture Award (Collegium Artisticum). It was selected as winner in the category urbanism and presented in a public exhibition. Moreover, the project report was published by the University of Sarajevo with a clear presentation of the design process and full disclosure of all plans and development proposals

(Krebs & Pavlović 2023). The planning team has thus guaranteed a maximum degree of transparency on the process and its results. It is now up to the political decision makers to initiate implementation and involve the public in a continued discourse on the design and its realisation in the urban context.

3.3 Market demand study and financial analysis

The aim of the market demand study and financial analysis was to understand the current situation of the real estate market in Sarajevo in order to base the design proposal on actual needs and respond to adverse trends. The approach was chosen in response to the uncoordinated real estate development of the last decades that has led to monofunctional housing estates on the urban fringes and underused spaces across the urban fabric.

As a first step, a detailed market demand analysis was prepared to understand the investment and development activity and trends in each real estate segment (residential, office, hotel and retail market) in Sarajevo and BiH. One of the key findings was that due to the unavailability of large lands for development within the urban fabric, most new development is on the suburban, greenfield land. The migration of residents to the outskirts resulted in the need for expansion of the city's infrastructure (communal infrastructure such as roads, sewerage, pedestrian paths etc.). In addition, the remote location of the new suburban neighbourhoods leads to long commutes to the downtown business district every day, mostly by car. This has a negative impact on the quality of air due to high CO_2 emissions. Furthermore, the distance of the new residential neighbourhoods to main public facilities (e.g. hospitals, schools, elderly homes etc.) and lack of mixed uses exacerbates social exclusion. The market demand study supported the case for regeneration of central dormant brownfield sites such as Vaso Miskin Crni and Kvadrant B. The two selected sites have access to the communal infrastructure (roads, public transportation – tram and bus lines, access to sewerage, electricity, water, telecommunication etc.) and they are close to the central business district and public institutions. In case of a reuse of the brownfield sites the greenfields might remain undeveloped and pollution could be decreased and social inclusion ensured. Moreover, given the sites' central location and connectivity, the utilisation of the existing urban infrastructure would be improved (more users and direct and indirect financial benefits).

Based on a detailed market research and analysis of the location of the two selected sites and their characteristics, a highest and best use analysis was conducted. The key conclusions of the analysis supported the elaboration of mixed-use concepts and project phasing schemes. Due to the vast size of the Vaso Miskin Crni site, one of the key recommendations was to keep an element of flexibility in the future planning documents to create the opportunity for a sustainable economic development rather than prescribing the long-term redevelopment according to short-term market projections (Bacon et al. 2008).

Finally, a financial case using a discounted cash flow method was prepared based on the development ratios and vision from the proposed masterplan. The financial case assessed financial feasibility and viability of the proposed concept. The quantification went beyond the typical investment return ratios. An estimation of the favourable environmental implications for the proposed development was also conducted. Some of the analysed implications were obtained by assuming the surface of public greenery per inhabitant and employee, estimating the reduced commute time and quantity of fewer CO_2 emissions.

3.4 Sustainable urban design and smart city innovation

Based on the spatial analysis, inputs from participation, financial considerations and other relevant factors, a robust urban design was developed for both sites as a first proposal for further elaboration.

The site of Kvadrant B is envisioned to be developed as a new business centre that incorporates mixed uses to create a lively and attractive neighbourhood. Ground floor areas will host shops, services, cafes, and restaurants, reviving the streets and public spaces of the area. The inclusion of a variety of new central functions will further support the implementation of business and retail uses. The concert hall which has been anticipated for the past 20 years will be taken into account with a designated plot that is temporarily used as a public park. Moreover, a significant percentage of high-quality housing should be present on site to counteract the decreasing number of residents in the central area of the city. The new urban structure responds to the Austro-Hungarian urban pattern in the east of the site and continues the typical block perimeter system. Existing heritage buildings shall be preserved and restored while the structure of new buildings will gradually transition towards the modernist buildings in the west, organically filling the gap in the urban fabric. Building heights develop with the typology, rising from east to west with a high point next

to the existing tower of the Sarajevo City Center. The area along the river will be transformed into a linear park providing a high-quality green space. The centre of the neighbourhood will be a new green square with multifunctional urban surfaces but many trees to provide shade and cool down the environment during hot summer months.
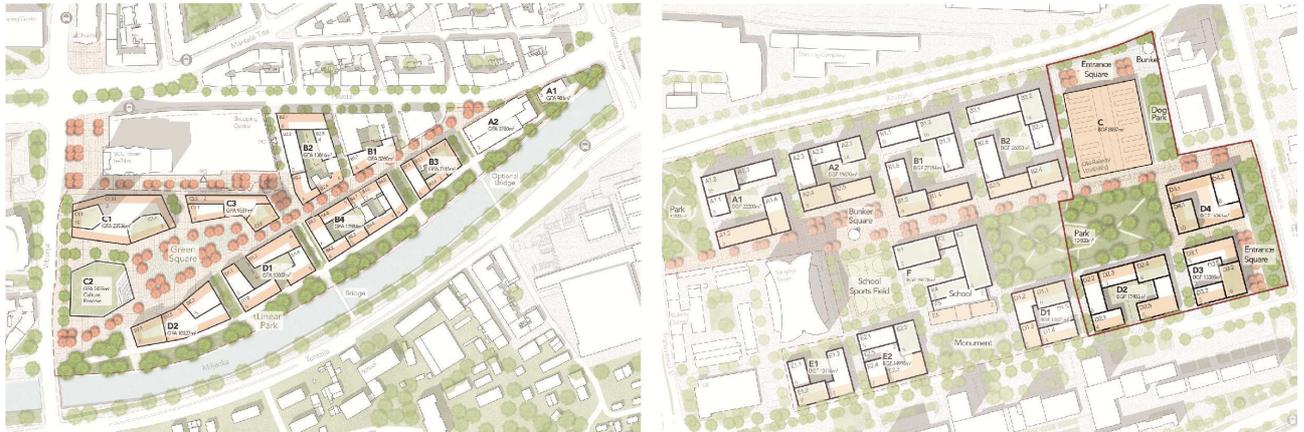
Fig. 2: Development propositions for Kvadrant B (left) and Vaso Miskin Crni (right). Author's own figure.

Vaso Miskin Crni could be redeveloped as a new centrality of Novo Sarajevo that integrates central functions which are currently missing. The development of a mixed-use neighbourhood will include offices, retail, housing, and social infrastructure in a balanced ratio that responds to market demands and establishes an urban business centre. Integrating active uses, like restaurants, cafes, and shops, in the ground floor zones of the buildings will be crucial in order to create a lively centrality that meets the demands of people working, living and seeking leisure in the area. The new urban fabric respects the industrial heritage of the site while responding to surrounding structures. It is recommended to keep two buildings of the old Railway Workshop as valuable assets that preserve the identity of the site. The form of the old production hall was picked up and replicated to shape the urban grid along the east-west axis. The predominant typology is a modern block development with green courtyards. The denser blocks in the southeast of the site have continuous plinths that provide larger spaces for retail and urban workshops. The general building height is five floors with selected high points of up to 16 floors. The main public space is the one-hectare park in the centre of the neighbourhood. It will be designed to fulfil the diverse needs of the new inhabitants and people working or studying in the area. The main east-west axis will be another important public space. Designed as a pedestrian boulevard with shops, cafés, and restaurants along the building fronts, it will be the vibrant spine of the neighbourhood.

With the development of the two brownfields, Sarajevo has the opportunity to implement flagship projects for smart and environmentally friendly urban development. However, sustainable urban development is a long-term transformation process that adds an extra layer of complexity to already complex urban design processes (Thompson 2016). In order to establish an innovative ecosystem in a smart city, numerous stakeholders need to be coordinated. Sophisticated governance with a long-term planning horizon is required, where tasks include management, decision-making and implementation, but also communication and creating transparency and opportunities for participation (Appio et al. 2019). In 2018, the City of Sarajevo launched a Smart City Initiative, developing a vision for Smart Sarajevo 2030. Initial projects have been implemented since, however, a legally binding and comprehensive Smart City Strategy has not been established yet. Measures against air pollution are a top priority in Sarajevo. Hence, reducing road traffic and promoting renewable energy provision and green spaces are the fields to be tackled in any urban development project. Considering the local challenges, the lack of a holistic strategy, insufficient sustainability standards in the building sector and limited public budgets, the recommended Smart City measures for the two brownfield developments focus on affordable innovations in the fields of renewable energy and energy efficiency, sustainable mobility solutions and green city.

The introduction of sustainable building standards in both development areas could be a lever to reduce the high energy demand for heating and cooling and is a prerequisite for shifting energy supply to local renewable energy sources such as district heating, geothermal and photovoltaic energy. Since green building certifications are not yet standard in BiH, the brownfields could be presented as lighthouse projects to be

scaled up in the future. The use of state-of-the-art building rating systems could also become mandatory in quality assurance and create transparency, which in turn supports the trustmaking process. Regarding the costs, which are an obstacle in the implementation of sustainable building standards, investors have to expect an additional 100 euros per square metre of net floor area or a total additional investment cost of 7 percent (Schöfmann et al. 2020; Hu & Skibniewski 2021) . On the other hand, the operating costs over the life cycle of a building can be reduced by up to 85 percent (Architektur Online 2020).

Sarajevo's path towards becoming a pedestrian and bicycle-friendly city requires the reduction of motorised vehicles and the promotion of active mobility with attractive public transport and supplementary micro-mobility offers (Appio et al. 2019). The establishment of car-free neighbourhoods with neighbourhood garages at the edge of the area with e-charging infrastructure and a general reduction of parking obligations for project developers have been recommended. Adequate bicycle infrastructure inside and outside the buildings (lockable bicycle parking, etc.) should be implemented. Sharing systems (bicycles, e-cars) can be a valuable complement to the use of public transport, but should be implemented on a city-wide level. Public transport remains by far the most energy-efficient mode of transport for daily use.

Air quality is a top priority in Sarajevo, so developers should prioritise green city solutions and create resilient urban spaces. Landscape planning should be integrated early and throughout the development process to be cost-effective. Greening and shading of public spaces are the most effective measures to avoid urban heat islands in the long term. Intensive planting (trees, façade greening) also has positive effects on the microclimate. Trees with a high crown density can reduce the perceived temperature by up to 18°C during the summertime (Stangl et al. 2019). In addition to heat, heavy rainfall is also one of the noticeable effects of climate change, so the implementation of comprehensive rainwater management is strongly recommended.

3.5 Microclimate analysis

The impact of wind and its relationship to temperature is crucial in a topographical valley like Sarajevo due to the high probability of the Inversion Weather Phenomenon (Walczak 2023). In order to understand and quantify the current urban situation and potential future projects, different simulation frameworks can be applied. "Rhinoceros 3D" with the algorithmic modelling extension of "Grasshopper 3D" allows a real-time bridge between qualitative 3D modelling (architecture and urban design) and quantitative simulation frameworks.

On the one hand, these tools were used to simulate temperature during a period representing the hottest week of the typical meteorological year. As input, historic weather files from the years 2007 to 2021 were used from the location of the International Airport in Sarajevo (Climate OneBuilding 2023). On the other hand Computational Fluid Dynamics (CFD) wind simulations were run through "OpenFOAM" cases. "OpenFOAM" is an open-source CFD software and has an extensive range of features to solve, among others, complex fluid flows and turbulences, which has been made accessible through the "blueCFD-Core" project (Walczak 2023). The simulation results have been calibrated and validated in Sarajevo through on-site 3D wind measurements using a mobile Galion LIDAR system "windRoverII" (Walczak 2023), as part of the 4D Digital Twin for Sarajevo developed within the "Urban Transformation Project Sarajevo - UTPS" (Walczak & Pagani 2022). Additionally, both frameworks required information on building volumes, facade materials, roofs and public spaces, as well as the location of vegetation.

Through an iterative process and fast visual feedback mechanisms, multiple scenarios were gradually tested and translated into the architecture and urban design of both brownfield sites. Challenges and opportunities included strategies in larger open spaces regarding urban heat islands and their mitigation through vegetation and non-sealed surfaces. Related specifically to wind, urban design features such as porosity in building volumes, the linear orientation following the wind direction and heterogenous building heights support urban ventilation and natural cooling. Also, the incorporation of water bodies and river streams is benefitting cold air streams.

As an outlook, conclusion and policy recommendation, for resilient planning and implementation, each regulatory plan would require such an analysis since the climatic boundary conditions are changing with every intervention (Pelja-Tabori 2021) .

80

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3.6 Towards implementation: ideas for land consolidation

Early phases of analysis have revealed complex ownership structures at both sites. Plot sizes range from very small to very large parcels with a diverse mix of more than twenty different landowners on each site. The largest shares are owned by private companies, followed by different public institutions and individual private landowners. In both cases, the complex ownership situation has been the main reason why a coordinated overall development has not taken place in the past. While large private owners have shown their interest and were willing to buy the parcels of smaller owners, the latter are hoping for higher returns and better opportunities at a later point. Public owners and the local administrations have not yet developed the necessary tools to facilitate and lead the development either.

The study of good practice cases from Vienna, however, offered solutions that could also be feasible for Sarajevo. The central tool for land consolidation would be a cooperation agreement in the form of an Urban Development Contract between all private and public owners that is based on a consensus about the masterplan for development and future cadastre plan of the area. The new cadastre plan redistributes the land according to their value after development. Landowners would own the same share of net gross floor area compared to the percentage of land that they own now. This ensures an equal distribution of the profit that arises from development. At the same time, selected land parcels would be transferred to public ownership to provide access roads, public parks, social infrastructures, etc. These assets are an added value to other landowners who can sell their properties for higher prices due to enhanced amenities in the surroundings. At the same time, they guarantee basic services and improve quality of life also for the people living around the site. The cooperation agreement also includes the founding of a joint Development Corporation that leads the development process from this point on, coordinating all stakeholders and implementing the masterplan as agreed.

The Vienna model of land consolidation has been presented to the local public authorities who showed interest in the approach. Major landowners were contacted to assess their willingness to cooperate in such a process. Overall there have been positive reactions but there were also concerns in relation to the transparency of such processes. The need to create and maintain public trust and to include the wider public in decision making processes related to both brownfield sites that represent key locations in the urban fabric was emphasised. However, the coordination of such a process through international and independent experts was seen as a potential to overcome such obstacles and to move towards implementation of sustainable, mixed-use neighbourhoods in Vaso Miskin Crni and Kvadrant B.

4 CONCLUSION

The elaboration of development proposals for Kvadrant B and Vaso Miskin Crni took place in the field of tension between the interests of different political and administrative levels, landowners and the public, as well as the contemporary demands on modern urban planning, which result from the climate and biodiversity crisis, social inequality and economic development requirements. The textbook approach to urban design was adapted and enhanced to meet the specific challenges that the City of Sarajevo presented to the planning team.

The complex political and administrative system and the lack of trust in public authorities were addressed through a transparent and comprehensible planning process where each step was a logical consequence of previous analysis and which was fully disclosed through a publication that covers the entire design process and final results. Local experts, academia and the professional public were included through the Stakeholder Core Group and open event formats reached out to a wider public for the discussion of concepts and design principles. The many layers of administration were involved in the process through the Working Group that was regularly informed and invited to participate in the design process through co-creative workshops.

The predominant role of developers in urban development in Sarajevo and complex ownership structures on the selected brownfield sites were tackled through the empowerment of the local administration in the Working Group that enhanced their internal cooperation and influence on the design process. At the same time, a comprehensive real estate demand study ensured that the recommended mix of uses was based on empirical facts rather than on personal financial interests or public misconceptions of the situation. The proposed land consolidation approach represents a possible solution for the problem of implementation and the possibility of further independent consultation by the international team has been offered.

Environmental and social challenges can be met through innovative design ideas and smart city approaches that were adopted to the local circumstances and potentials. The microclimate analysis is a new tool to refine urban design that has been used for the first time in Sarajevo and has proven the compatibility of the urban design proposal with the demands of the ventilation corridors. Some suggestions from this work could also find their way into the new urban plan currently being developed.

Overall, the aim of the design process was to elaborate sustainable, resilient and climate-fit development proposals for brownfield sites in Sarajevo and to showcase a design and possible implementation process that could be replicated in other urban voids throughout the city in order to create a polycentric city of short distances. Of course, the team's efforts cannot cease at this point and it will take much more work with a specific focus on stakeholder engagement, public consultation and transparent cooperation with landowners to move these projects towards implementation and "quality contextual places for people".

5 REFERENCES

APPIO, Francesco P., LIMA, Marcos and PAROUTIS, Sotirios: Understanding Smart Cities: Innovation Ecosystems, Technological Advancements, and Societal Challenges. In: Technological Forecasting and Social Change, Vol. 142, Issue C, pp. 1-14. Paris, 2019.

ARCHITEKTUR ONLINE: Lebenszykluskosten: Gebäude ganzheitlich planen und bewerten. Vösendorf, 2012. Available at: https://www.architektur-online.com/kolumnen/edv/lebenszykluskosten-gebaeude-ganzheitlich-planen-und-bewerten [Accessed 09.06.2023].

ARNSTEIN, Sherry R.: A Ladder of Citizen Participation. In: Journal of the American Planning Association, Vol. 35, No. 4, pp. 216-224. Chicago, 1969.

BACON, L. Kevin, DAGENHART, Richard, GREEN LEIGH, Nancey and SKACH, John: The Economic Development - Urban Design Link in Brownfield Redevelopment. In Economic: Development Journal, Vol. 7, Issue 2. Washington, 2008.

BLACK, Philip and SONBLI, Taki Eddin: The urban design process. London, 2019.

BOTIC, Jurica: Spatial and National Distribution of Foreign Direct Investments in Bosnia and Herzegovina. In: Hrvatski Geografski Glasnik, Vol. 75, Issue 1. Zagreb, 2013.

CARMONA, Matthew: The place-shaping continuum: a theory of urban design process. In: Journal of Urban Design, Vol. 19, Issue 1, pp. 2-36. London, 2013.

CLIMATE ONEBUILDING: Climate Data Files. Available at: https://climate.onebuilding.org/WMO_Region_6_Europe/BIH_Bosnia_and_Herzegovina/index.html [Accessed 07.06.2023].

COLLINS, Kevin and ISON, Ray: Jumping off Arnstein's Ladder: Social Learning as a New Policy Paradigm for Climate Change Adaptation. In: Environmental Policy and Governance, Vol. 19, Issue 6, pp. 358–373. New Jersey, 2009.

HEWLETT, Mark and GALLEGO-LOPEZ, Catalina: Green Cantonal Action Plan for Sarajevo. London, 2020.

HU, Ming and SKIBNIEWSKI, Miroslaw: Green Building Construction Cost Surcharge: An Overview. In: Journal of Architectural Engineering, Vol. 27, Issue 4. Maryland, 2021.

KREBS, Roland and MAYR, Stefan (eds.): Future public spaces. Urban design in times of crisis. Berlin, 2023.

KREBS, Roland and PAVLOVIĆ, Andrea (eds.): Brownfield Development in Sarajevo. Sarajevo Brownfield Urban Regeneration Project. Sarajevo, 2023.

LLOYD-JONES, Tony (2001) The design process. In: Marion ROBERTS and Clara GREED (eds.) Approaching urban design. The design process. New York, 2001, pp. 51-56.

PELJA-TABORI, Nataša: Sarajevo: The Post-war City in Transition Future Scenarios for the Post-Pandemic City. In: Annual Review of Territorial Governance in the Western Balkans, Vol. III, pp. 75-89. Tirana, 2021.

SCHÖFMANN, Petra, ZELGER, Thomas, BARTLMÄ, Nadja, SCHNEIDER, Simon, LEIBOLD, Jens, BELL, Daniel: Zukunftsquartier. Weg zum Plus-Energie-Quartier in Wien. In: Berichte aus Energie- und Umweltforschung. Vienna, 2020.

STANGL, Rosemarie, MEDL, Alexandra, SCHARF, Bernhard and PITHA, Ulrike: Wirkungen der grünen Stadt. Studie zur Abbildung des aktuellen Wissenstands im Bereich städtischer Begrünungsmaßnahmen. In: Berichte aus Energie- und Umweltforschung. Vienna, 2019.

STATISTIKA (2013) National Census of Bosnia and Herzegovina 2013. Available at: http://www.statistika.ba/ [Accessed 14.06.2023]

THOMPSON, Emine Mine: Smart City: Adding to the Complexity of Cities - A Critical Reflection. In: Complexity & Simplicity - Proceedings of the 34th eCAADe Conference, Vol. 1, pp. 651-660. Oulu, 2016.

TZIFAKIS, Nikolaos and TSARDANIDIS, Charalambos: Economic Reconstruction of Bosnia and Herzegovina: The Lost Decade. In: Ethnopolitics, Vol. 5, Issue 1. London, 2006.

WALCZAK, Michael: Impact of Urban Planning on Air Quality: The Consequences of the Mismatch Between Natural Wind Flows and Building Typologies. In: SDG 11, Transitioning to Sustainable Cities and Communities, Ed. Hubert Klumpner, Klearjos Eduardo Papanicolaou and Georgeen Theodore, Forthcoming, 2023.

WALCZAK, Michael and PAGANI, Marco: An Agent-based Digital Twin for Sarajevo. In: ETH Zurich NSL, Newsletter 54, June 2022: Artificial Intelligence / Machine Learning. Zurich, 2022. Available at: https://www.nsl.ethz.ch/urban-transformation-project-sarajevo/ [Accessed 07.06.2023].

ZUPCEVIC, Merima and CAUSEVIC, Fikret: Case study: Bosnia and Herzegovina. Sarajevo, 2009

82

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Building According to Climate Change

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1 ABSTRACT

Urban heat islands are a frequent phenomenon that significantly impacts liveability and human well-being. The ongoing research aims to provide an updated map of Tessin Canton's critical spatial and thematic areas in Switzerland. Furthermore, the objective is to investigate the level of performance of the current guidelines and provide indications to ensure a greater level of sustainability in the urban planning of cities.

In adapting to climate change, the Swiss Confederation established an action plan for 2020-2025 comprising 75 measures. This intersectoral coordination document provides the cantons and municipalities with practical actions for tackling climate change.

The research stems from a holistic view of the south of the Alps heat island phenomenon through an interdisciplinary and multiscalar approach. Therefore, the attention is on the trend of summer temperatures, particularly on days of heatwave. Furthermore, the study verifies the effects of the nature-based solutions adopted in the territory. In this way, it evaluates the impact of the measures in the action plan and the variables that most affect human well-being.

The study is developed in three consecutive phases based on the literature and the work carried out by the Federal Office for the Environment (UFAM). First, the available satellite images calculated the Land Surface Temperature (LST) and the perceived temperature (PET). Integrating these results with geospatial, demographic and settlement data has made it possible to identify the most sensitive areas of Tessin Canton.

In the next phase, the liveability in the heat islands was investigated. Various instruments (sensors, Climametro and thermal imaging camera) were used to analyse the climatic data and the data on the built environment in the urban area of Mendrisio, a city in the south.

In the third phase, the main aim was to verify the urban microclimate and provide valuable indications for the definition of a sustainable city. Therefore, the relationships between land use, urban typologies and abiotic nature were investigated.

The results of the ongoing research concern extending the heat islands of the Tessin Canton and evaluating the effects of the measures promoted by the UFAM. The next phase will allow for an in-depth study of the role of surface and groundwater in urban areas and valley floors. The aim is to provide further indications for implementing the sponge-city concept.

The ongoing study is possible thanks to the synergies between the University of Applied Sciences and Arts of Southern Switzerland and the Republic of Tessin Canton. The results obtained greatly help provide guidelines for sustainable territorial planning that is attentive to human well-being.

Keywords: climate change, abiotic natures, urban microclimate, heat islands, Tessin canton

2 ADAPTATION TO CLIMATE CHANGE IN SWITZERLAND

In Switzerland, the Confederation has a coordinated role in climate change adaptation. The action plan for 2020-2025[1] currently in force consists of 75 interdisciplinary measures, which are in continuity with the 2012 strategy and the 2014-2019 action plan. The goal is to coordinate the actions put in place and prepare the necessary to face the challenges of climate change.

Based on the work carried out by the UFAM[2] and the literature on heat islands, the ongoing project started in 2020. The objectives were defined by an interdisciplinary team of SUPSI and the Department of the Territory of Tessin Canton.

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[1] "Adattamento ai cambiamenti climatici in Svizzera. Piano d'azione 2020–2025".
[2] Federal Office for the Environment.

The project aims to map heat islands in Tessin Canton. In 2022, IPCC[3] defined the UHI[4] as "The relative warmth of a city compared with surrounding rural areas, associated with heat-trapping due to land use, the configuration and design of the built environment, including street layout and building size, the heat-absorbing properties of urban building materials, reduced ventilation, reduced greenery and water features, and domestic and industrial heat emissions generated directly from human activities".

The second objective is to investigate the perception of temperature within urban typologies. This aim allowed the study to obtain two other results. First, analyze the abiotic measures of the federal action plan in terms of performance. Furthermore, the study provided indications to improve the urban microclimate and gain greater sustainability in the urban planning of cities.

3 IDENTIFY HEAT ISLANDS

The research stems from a holistic view of heat island phenomenon through an interdisciplinary and multiscalar approach. Therefore, the attention is on the trend of summer temperatures, particularly on days of the heatwave.

The study is developed in three consecutive phases. During the first phase, the most problematic areas of the Tessin Canton were identified through the analysis of satellite data of the surface temperature. In addition to the impact of heat on the cantonal territory, it was essential to have information on the territory. Therefore, the study required information about the conformation of the territory to understand how it can absorb, reflect or reduce heat. At last, Canton's available territorial and demographic variables were needed to choose the relevant ones to identify the areas where the heat can produce the most significant impact on the territory and among the population.

3.1 The surface temperature and the perceived temperature

The first data analyzed were satellite data of the earth's surface temperature. The LST[5] is the temperature measured at the level of the earth's surface. According to Anderson et al., the LST is one of the most important parameters in the physical processes of surface energy and water balance at local through global scales.[6] Simplifying, it is not equivalent to the air temperature but to the temperature perceptible by touching a given surface.

The first step used an indicator that associates other variables with temperature to understand how environmental conditions affect people's well-being. It is the Physiologically Equivalent Temperature. According to Höppe, PET[7] is defined as the air temperature at which, in a typical indoor setting (without wind and solar radiation), the heat budget of the human body is balanced with the same core and skin temperature as under the complex outdoor conditions to be assessed.[8]

From a human bioclimatological point of view, it indicates the feeling of aphasia. The point was that people's thermal perception changes more rapidly than changes in air temperature. Matzarakis et al.[9] confirmed that the PET, expressed in °C, is a suitable indicator for the human-biometeorological evaluation of the thermal component of different climates.

After acquiring the LST values from satellite measurements[10], the maps of the perceived temperature were drawn up using a mathematical model based on the formula developed for the city of Dresden.[11] An initial check was carried out to validate the calculated PET. The case study was the Mendrisiotto Region, with the temperatures measured and the data acquired using the Climameter (see chapter 4.3).

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[3] Intergovernmental Panel on Climate Change.

[4] Urban heat islands.

[5] Land Surface Temperature.

[6] "A thermal-based remote sensing technique for routine mapping of land-surface carbon, water and energy fluxes from field to regional scales".

[7] Physiologically Equivalent Temperature.

[8] "The physiological equivalent temperature - a universal index for the biometeorological assessment of the thermal environment".

[9] "Applications of a universal thermal index: physiological equivalent temperature".

[10] ECOSTRESS and Landsat 07.

[11] "Risiken beherrschen, Chancen nutzen. Die Region Dresden stellt sich dem Klimawandel".

Based on the available data, it was possible to produce three representations of the heat islands extension in Tessin Canton. The first map concerns the average extension of the heat islands on heat days with an average temperature above 25°. The second map identified the extent of heat islands during extreme weather events, such as in the summer of 2022, when the temperature exceeded 25° for two weeks. The maps underline that in addition to the more inhabited areas, there is an increase in temperature also on the valley sides.
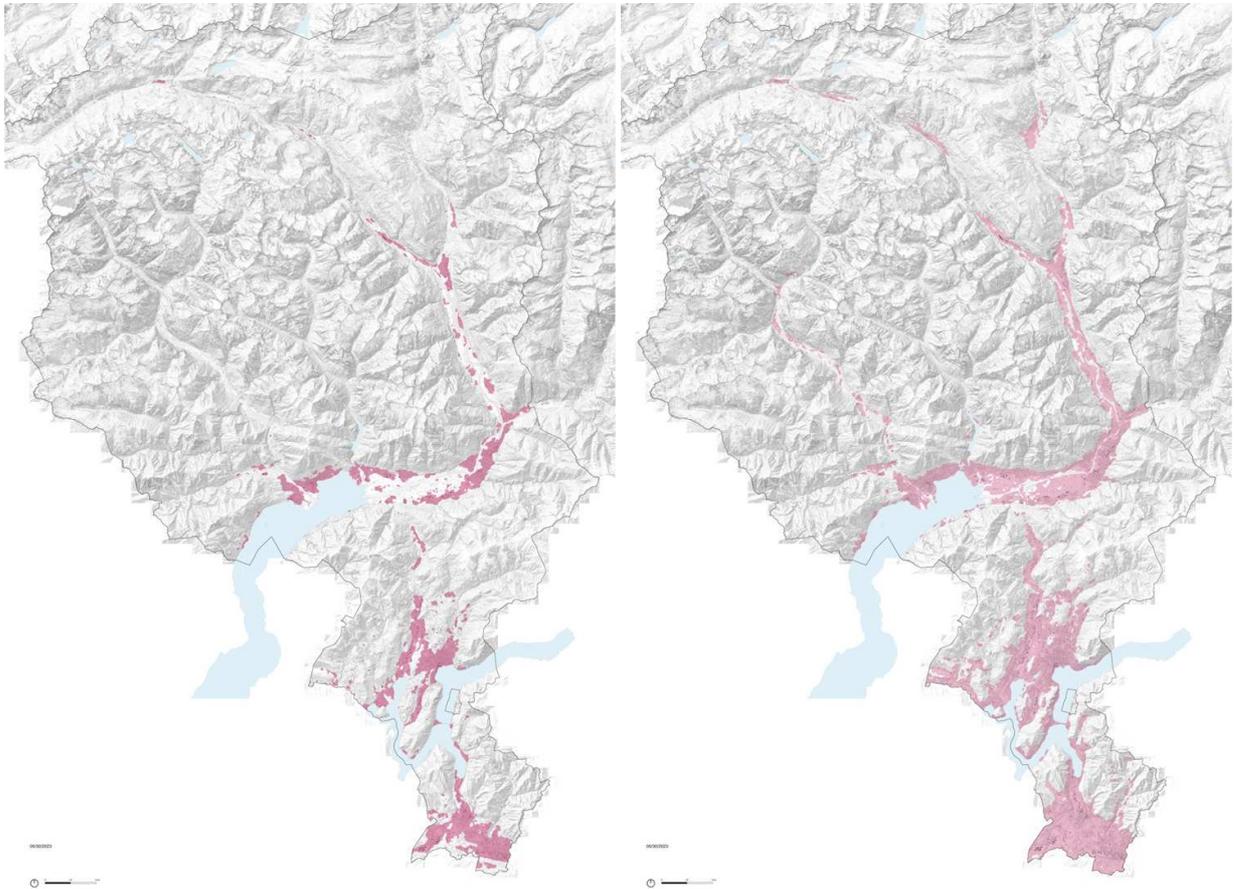
Fig. 1 (left): the average size of the heat islands. Elaborations by the authors (2023). Fig. 2 (right): the extension of the heat islands. Elaborations by the authors (2023).
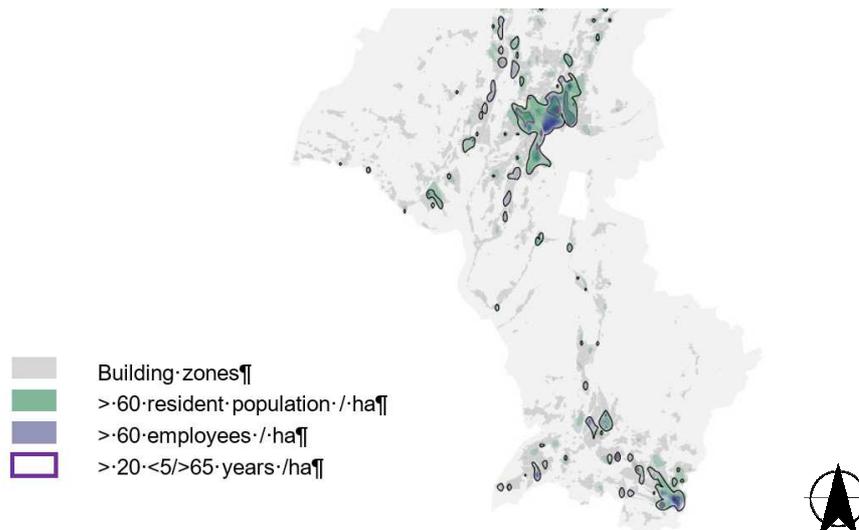
Fig. 3: example of the sensitive and vulnerable areas of Tessin Canton. Elaborations by the authors (2023).

3.2 The sensitive and vulnerable areas

In addition to the maps already introduced, a further study was made to understand where high temperatures are a problem for the population of Tessin Canton. Sensitive areas are areas where the density of the resident

population and workers exceeds 60 units/ha. This value is approximately equivalent to a utilization index[12] 0.5 that separates the typology of single-family houses with gardens from denser typologies. In addition, the study identified vulnerable areas where the density of children under five or people over 65 exceeds 20 inhabitants/ha. The analysis showed that heat islands often coincide with a high resident population density or employees.

4 LIVING IN URBAN HEAT ISLANDS

The elaborations in the first phase provided essential maps for understanding the urban heat island extension. Despite this, it took much work to indicate the abiotic nature measures to make urban microclimate more livable.

Therefore, three measurements examined the urban typologies and climatic elements determining well-being. The measurements concerned:

- the trend of the temperature and humidity of the air during 24h;
- the measurement of the surface temperatures with the thermal imaging camera;
- the evaluation of all the relevant data of the user in the space thanks to the Climameter.

The analyses were conducted in the Mendrisiotto region (focusing on Mendrisio, Stabio and Chiasso) during the summer of 2021.

4.1 Check the air temperature throughout the day

The first campaign verified different types of urban spaces on air temperature. The work aimed to compare spaces with similar characteristics in terms of construction and use but with different architectural and abiotic nature elements.

Bluetooth Data Loggers were installed in Mendrisio to record temperature and humidity trends. The loggers (Temperature range: -20° - +60°; Temperature accuracy: ± 0.5 ℃; Humidity range: 0-99% RH; Humidity accuracy: ± 5% RH) were capable of registering data every 10 minutes and of archiving data for 100 days. The data were exported in CSV format via Bluetooth from up to 50m. A total of 24 sensors have been installed.

The comparison between measurements in the urban and rural areas was easy. The interpretation of the differences within the different urban typologies took more work. The analysis identifies that an irrigation system lowers the temperature by approx. 1° and that the shade lowers the area's temperatures by approx. 2°. However, these variations cannot describe the differences in terms of perception. The air temperature shows an average value that does not quantify the thermal stress a person is exposed to. Therefore, different measurement methods must be used to analyze other factors relevant to well-being within urban spaces.
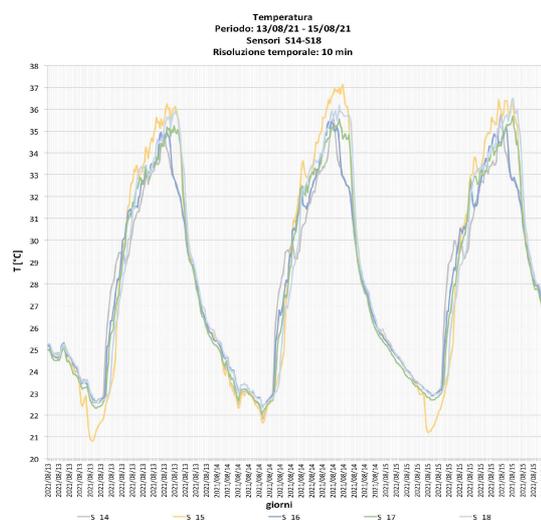
Fig. 4: the measurement campaign in Mendriso (CH) with Data Logger Bluetooth. Elaborations by the authors (2023).

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[12] Relationship between the gross useful area built on a land and the area of the land.

4.2 Measure and display surface temperatures

A thermal imaging camera was used during the second survey. "In a limited sense thermal imiging is basically concerned wih converting images produced by the longer-wavelength thermal radiation emitte by these cooler bodies to visual wavelength images that we can see. In a broader sense the term thermal imaging can also apply to systems where no visual image is generated, but a thermal image is captured and processed entirely electronically to measure some specified parameter or detect the presence of some object."[13]

The survey used the FLIR Lepton® camera with radiometric-capable solution that is smaller than a dime, fits inside a smartphone, and is one tenth the cost of traditional IR cameras. Using focal plane arrays of 80x60 active pixels, Lepton easily integrates into native mobile-devices and other electronics as an IR sensor or thermal imager. The radiometric Lepton captures accurate, calibrated, and noncontact temperature data in every image pixel.[14]

The following figure is an example of photos taken in the summer of 2021 in Mendrisio (CH).
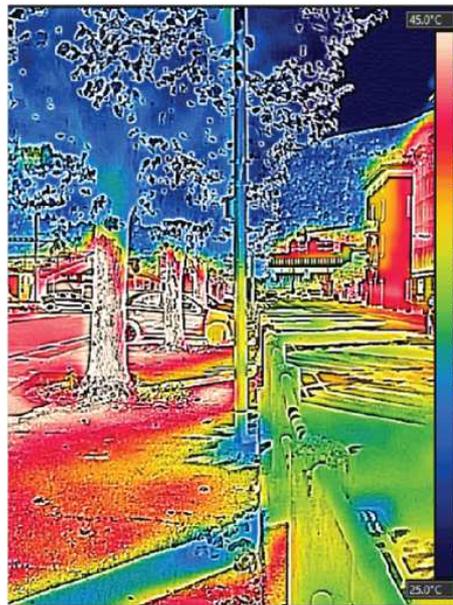
Fig. 5: the measurement campaign in Mendriso (CH) with FLIR Lepton® camera. Elaborations by the authors (2023).

4.3 Detecting and calculating perceived temperature

For the third campaign, the study applied the CityFeel method. It is developed by HEPIA[15] and includes a measurement protocol and the Climameter instrument. CityFeel measures the human perception of the immediate environment in terms of response to hygrothermics and air quality.[16]

The Climameter is a light and compact backpack that can be used on climatic trips anywhere in the city. It is composed of several sensors for ambient and radiant temperature in vertical and lateral directions, humidity and air movement (wind), solar radiation, and hemispherical visual environment (sight) from which some urban indicators are extracted (view of the sky). It records other parameters related to the composition of the air (CO_2, NO_x, Ozone, PM 2.5-10) and the acoustic situation. It also includes a platform, a GPS and a data logging system.

The data collected by the sensors feed a model of the thermal equilibrium of the human body to evaluate PET. Other common indicators of comfort or stress are also calculated, such as PMV - Predicted Mean Vote, UTCI – Universal Thermal Climate Index, HUMIDEX - Humidity Index, and WBGT – Wet Bulb Globe Temperature.

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[13] "Thermal Imaging Cameras: Characteristics and Performance."

[14] https://www.flir.com/products/lepton/

[15] Haute École du Paysage, d'ingénierie et D'architecture De Genève.

[16] "CityFeel – micro climate monitoring for climate mitigation and urban design".

The μCM-Viewer facilitates the observation and interpretation of the collected data using a graphical interface, making it possible to reproduce and analyze ex post the climatic paths performed in an almost immersive way.

The instrument was used for surveys in Mendrisio, Stabio and Chiasso during the summer of 2021. Around 20 routes were carried out at different times (morning, afternoon, and evening), each relief from one to two and a half hours. The planned routes were close to the 24 Bluetooth Data Loggers, close to the Meteoswiss measuring stations[17] in Stabio and close to the OASI[18] measuring stations in Mendrisio to compare the data. Furthermore, the main points of interest for the population were considered, such as hospitals, retirement homes, universities, railway stations, historical centres, industrial areas and open squares.

This campaign combined the factors mentioned in the first two campaigns and was crucial to represent the human experience.

Fig. 6: the measurement campaign in Mendrisio (CH) with the HEPIA Climameter. Elaborations by the authors (2023).

5 RECOGNIZING THE POTENTIAL OF URBAN TYPOLOGIES

The third phase aimed to verify the effects of the natural solutions adopted in the territory according to the analyses developed by Kleerekoper[19] about urban design and the indications in "Reducing Urban Heat Islands: Compendium of Strategies"[20] regarding the importance of trees on streets and parking lots. Specifically, the present study evaluated the impact of measures, including the federal action plan and the variables that most impact human well-being. Therefore, the relationships between land use, urban typologies and abiotic nature were investigated.

5.1 The retention and reflection of materials

Construction materials with different heat retention or heat reflection were considered. Analyzes have underlined that the most pleasant place in Mendrisio in the summer is still the historic centre. Even on hot summer afternoons, temperatures remain below the stress limit. The combination of shade with surface materials that balance the temperature throughout the day allows the cool of the night to be transported into the day.

Regarding the colours of the facades, light colours reflect the light better and heat up less. Therefore, making surfaces lighter usually reduces heat build-up. Nevertheless, light colours can increase PET if the reflective effect of white makes the situation in front of the facades less pleasant.

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[17] The automatic network SwissMetNet from MeteoSwiss.

[18] The network of monitoring stations of the Tessin Canton Environmental Observatory.

[19] "Urban measures for hot weather conditions in a temperate climate condition: A review study"

[20] "Reducing Urban Heat Islands: Compendium of Strategies"

88

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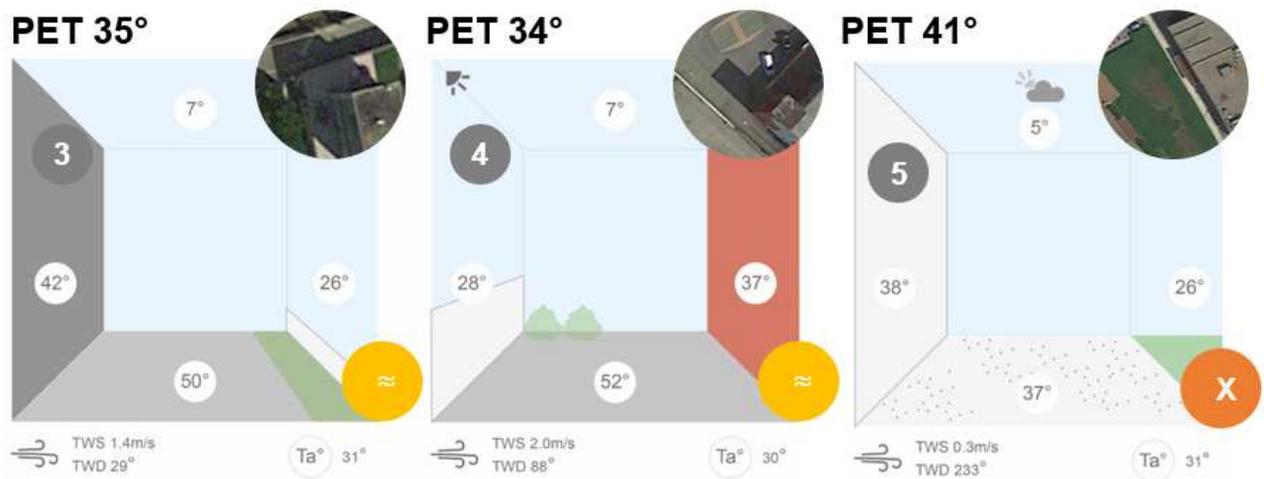
Fig. 7: elaborations to investigate the effect of the materials and colors of the facades. Elaborations by the authors (2023).

5.2 The waterproof or vegetable flooring

Different ground, such as asphalt, gravel, grass or reinforced grass for parking, are typical of the study area.

In the industrial area of Stabio, the difference between partially impermeable surfaces with tree-lined streets and asphalted streets or an impermeable street situation without elements giving shade was analyzed. The comparison of the collected data underlines that the introduction of single green elements contributes little to urban microclimate for people's well-being.
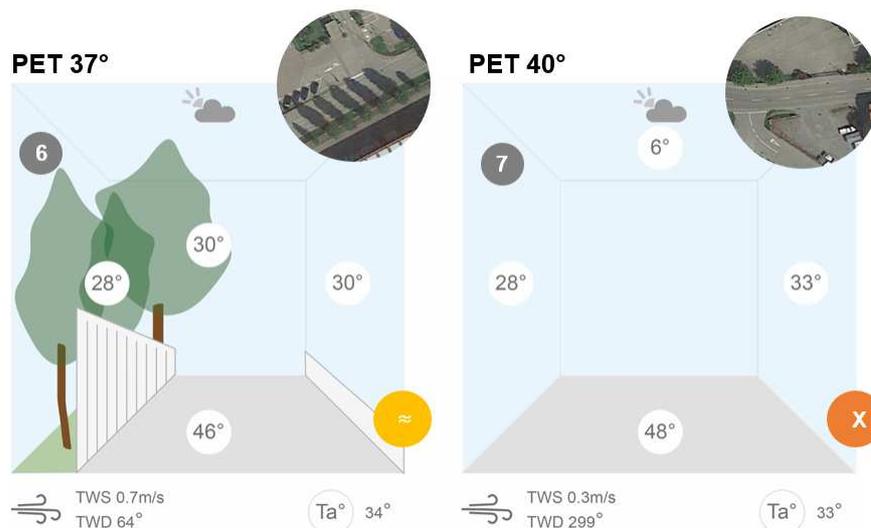
Fig. 8: elaborations to investigate the introduction of individual green elements. Elaborations by the authors (2023).

Combining the measures improves the situation for the user. Mendrisio's case study, for example, compared two car parks. The first combines trees with a permeable floor. The second case is entirely paved without mitigation measures. Data analysis of a summer heat day PET differs by almost 10 degrees between these two situations.

At last, a combination of elements is needed to improve the situation. Furthermore, the attention should certainly be paid to water retention. Vegetated soil conserves humidity and contributes to a pleasant climate, so ideally, the city becomes a Sponge City. According to the World Future Council, Sponge City indicates a particular type of city that does not act like an impermeable system not allowing any water to filter through the ground, but, more like a sponge, actually absorbs the rain water, which is then naturally filtered by the soil and allowed to reach into the urban aquifers. This allows for the extraction of water from the ground through urban or peri-urban wells. This water can be easily treated and used for the city water supply.[21]

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[21] "Sponge Cities: What is it all about?"

5.3 The shade or exposure to solar and reflected radiation

The sky is usually pleasantly cool, and its surface temperature is between 5-7 degrees, higher with cloud cover. Thus, even in summer, people feel the cooling effect of the sky when they are outside. The sun's radiation compensates for this effect wherever shade is not.

Exposure to high temperatures is also influenced by the buildings' shade. For example, the situation between the sun and shade of the new SUPSI building in Mendrisio is lowered by over 10° PET despite the same external arrangement. This means it is comfortable during sunny days in the winter but becomes almost unlivable in the summer.

Finally, the data has shown that the temperature of gravel squares or dry green areas does not differ much from asphalted squares. The introduction of trees brings PET closer to air temperature. Therefore, the data is below the heat stress limit.
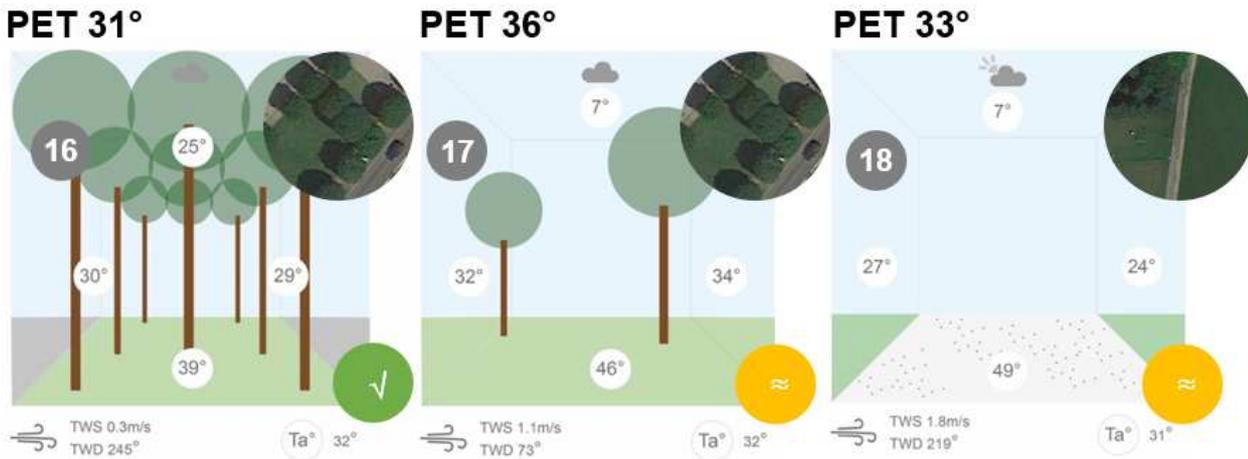
Fig. 9: elaborations to investigate the effect of shadow in public spaces. Elaborations by the authors (2023).

5.4 The design or not of the vegetation on the walls

Greening roofs and walls can mitigate the overheating effect. Plants cool the air by evaporating water and radiating less heat. A green facade or an intensive green roof thus also contributes to an acceptable climate in the public space.

Fig. 10: elaborations to investigate the effect of the greening of the walls. Elaborations by the authors (2023).

From these considerations, three situations in Mendrisio were analyzed during an August day with a clear sky and 31-32° degrees. The first case is a 20th-century street with buildings alternating with tree-lined gardens in front of a large park with centenary trees. Along the same road, the gardens are either converted to waterproof outdoor parking or occupied by a semi-underground garage bordering the road. The third case considered green walls. The analyzed data showed that greening private gardens without measures in the

road space lowers the temperature, but not below the necessary value. The green roof does not bring significant benefits to the public space. A similar effect is the case of green walls: the data analyzed do not show a significant contribution to well-being. Therefore, single greening interventions in a predominantly impermeable and built space exposed to the sun do not significantly contribute.

6   A NEW ATTENTION TO THE QUALITY OF PUBLIC SPACES

The ongoing study shows that in many localities in Tessin when an air temperature of 30° is reached or exceeded, people are already exposed to severe heat stress of over 38° PET. Therefore, reductions in the perceived temperature of approximately 10° are necessary to bring the situation back within tolerable limits. As described in the paper, applying single measures has limited effectiveness. In the best cases, they reduce a few degrees to a maximum of 5°. Only public spaces that combine several measures to reduce heat islands manage to achieve the goal. These reflections will be fundamental for envisaging measures and interventions in the cities of the valley floor but also for small or medium-sized urban centres, located in the valleys or in the mountains. Planners need to pay more attention to thermal comfort conditions in urban typologies, and interventions are also needed to limit overheating phenomena through ventilation or natural cooling measures of the external spaces. Therefore, more than a cosmetic greening of the existing city is required. A new approach to the design of urban spaces will be necessary so that they are also pleasant to live in as a function of climate change.

The research is still in progress. The deadline is expected in 2025. During 2023 the focus is on identifying the contribution of night cooling, on the open-source dissemination of the maps created and on the involvement of the municipalities to introduce the study results. At the moment, the phenomenon of heat islands must be addressed according to a holistic vision that includes the processing and interpretation of different types of data at different scales of intervention.

The importance of involving the population and local authorities is undeniable for the future. The focus of reflection must be the well-being of citizens in adapting to climate change.

7   ACKNOWLEDGEMENT

8   REFERENCES

Anderson M.C., Norman J.M., Kustas W.P., Houborg R., Starks P.J., Agam N.: A thermal-based remote sensing technique for routine mapping of land-surface carbon, water and energy fluxes from field to regional scales. In: Remote Sensing of Environment, 2008.
Camponovo R., Gallinelli P., Guillot V.: CityFeel - An innovative protocol and instrument to better understand urban microclimate. Zürich, 2018.
Johnson D.P., Wilson J.S., Luber G.C.: Socioeconomic indicators of heat-related health risk supplemented with remotely sensed data. In: International Journal of Health Geographics, 2009.
Hicham B., Hicham M., Hassan R.: Review of methods for retrieving urban heat islands. Ben Guerir, 2020.
Höppe, P.: The physiological equivalent temperature - a universal index for the biometeorological assessment of the thermal environment. In: International Journal of Biometeorology, Volume 43, pp 71–75, 1999.
Kleerekoper, L.: Urban measures for hot weather conditions in a temperate climate condition: A review study. Amsterdam, 2016.
Matzarakis A., Mayer H., Iziomon M.G.: Applications of a universal thermal index: physiological equivalent temperature, 1999.
Möller V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A.: IPCC - Climate Change 2022: Impacts, Adaptation and Vulnerability. Annex II, 2022.
Morabito M., Messeri A.: Benessere, disagio termico e temperatura percepita all'aperto. Toscana Medica, Vol.2, 2018.
Müller B.: Risiken beherrschen, Chancen nutzen. Die Region Dresden stellt sich dem Klimawandel, 2011.
Repubblica e Tessin Canton: Piano Energetico Climatico Cantonale - Strategia 2022. Bellinzona, 2023.
Repubblica e Tessin Canton, Ufficio di statistica (Ustat): Il clima in Tessin. Bellinzona, 2021.
Szajewska, A.: Development of the Thermal Imaging Camera (TIC) Technology. Warsaw, 2016.
Ufficio federale dell'ambiente (UFAM): Adattamento ai cambiamenti climatici in Svizzera. Piano d'azione 2020–2025. Bern, 2020.
Ufficio federale di meteorologia e climatologia MeteoSvizzera: Il cambiamento climatico nel Tessin Canton. Bern, 2021.
U.S. Environmental Protection Agency. Heat Island Reduction Activities. In: Reducing Urban Heat Islands: Compendium of Strategies, 2008.
Williams T.: Thermal Imaging Cameras: Characteristics and Performance, 2009.
World Future Council: Sponge Cities: What is it all about? 2016.
Adattamento ai cambiamenti climatici – strumento online per i comuni: https://www.onlinetool-klimaanpassung.ch/

Copernicus: https://scihub.copernicus.eu/dhus/#/home
ECOSTRESS: https://ecostress.jpl.nasa.gov/
Landsat 7: https://www.usgs.gov/search?keywords=Landsat%207
MeteoSvizzera: https://www.meteosvizzera.admin.ch/
National Centre for Climate Services NCCS: www.nccs.ch
Osservatorio Ambientale della Svizzera Italiana (OASI): https://www.oasi.ti.ch/web/dati/meteo.html
Scenari climatici CH2018: www.scenari-climatici.ch [Web site, accessed on June 2023]

92

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Challenges for Implementing Blue-Green Measures in the Transformation of Peri-Urban Streets

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1 ABSTRACT

The PeriSponge project is a three-year research project with an implemented prototype in Feldbach, a small town in the south of Austria. PeriSponge aims to improve potential hydrological retention areas and flood capacities along transport areas through well-designed, multifunctional and multicoded open spaces, while providing water management and quality of life solutions to improve climatic, ecological and social functions for quality sustainable peri-urban areas. The analytically applied research is being evaluated and will be made transferable to other cities. At this point, the project is at the end of the first project year.

Keywords: toolbox, blue-green measures, mobility open space, peri-urban, spatial planning

2 STATE OF KNOWLEDGE

Resilient urban areas need integrated planning and an frugal use of resources and land, while at the same time being liveable and of high urban quality (Degros & Bendiks, 2021). The idea of using resources and land as efficiently as possible is reflected in the context of urban sustainability, especially in the approach of multifunctionality (Jabareen, 2006). This applies even more to open spaces, which have to fulfil a multitude of requirements, from leisure and biodiversity to mobility and infrastructure, and which have to accommodate an ever-greater diversity of user groups (Becker, 2020) as well as climate change adaption measures. In order for such efficient use to succeed, urban planning and the design of open spaces must take on an important moderating role between the different sectoral plans in order to turn monofunctional and/or sealed infrastructure buildings, traffic areas, residual spaces, etc. into green-blue infrastructures for more quality of life and to be able to meet the overall demand for more green and open spaces (cf. Umweltbundesamt, 2021).

The impacts of already increased water-related events such as floods, droughts, water pollution, scarcity of biodiversity and pressure on high-quality open spaces in urban settlements, among others (Zandonella et al, 2013)are intensified by the steady growth of cities (Trenberth, 2011; O'Donnel and Thorne, 2020). Beyond the general focus on central places of the Urban, the 2005 UN Habitat report shows not only that 61% of the world's 5 billion population will live in urban areas by 2025, but more importantly that about 85% of this development process will take place in the urban hinterland, widely referred to as "peri-urban", "suburban", "outskirt" or "urban sprawl" (Prakash et al., 2011).

These peri-urban areas, which are largely car-dependent and lack urban infrastructure, are areas that have been created by economic, social and legal frameworks in recent decades. With the growth of sealed areas - especially on the periphery - a decoupling of spatial, hydrological, ecological and social needs and an increasing socio-ecological fragmentation of open space can be observed (Hecke, 2020).

This shows that these areas deserve more attention than they currently receive in general discourses on resilience, sustainability in urban planning and design.

3 TOOLBOXES FOR THE REDESIGN OF PUBLIC SPACE

In order to facilitate a systematic redesign of public space, a number of toolboxes, i.e. application-oriented planning aids focusing on the redesign of existing urban streets, have been developed (cf. BlueGreenStreets, 2022). The spatial focus of these planning aids is mainly concentrated on central urban areas such as inBerlin, Vienna, Hamburg, Zurich, Kassel, etc. (Stadtentwicklung Wien, 2011; Stadt Zürich, 2019; Umweltbundesamt, 2019).

These toolboxes were developed for the conditions of wide urban street spaces. The parameters of wide street spaces, such as historical, spatial local characteristics, allow a systematisation of redesign concepts. Above all, military, hygienic and representational purposes as well as the number of inhabitants were important factors why streetscapes were significantly widened. From the mid-19th century onwards, entire

districts and neighbourhoods were altered to create wide streets and boulevards in the urban structure, which are now subject of redesign measures to blue-green streets (cf. Degros et al., 2021). A second round of widening urban streets started with car-oriented urban planning schemes in the mid-20th century. In the search for space to implement blue-green elements for climate adaption, the research project Bluegreenstreets found that many streets in the urban study areas in different German cities had wider profiles than the nationally recommended minimum width. This additional space offers room for action in the transformation process to integrate blue-green infrastructure and recreational spaces, once the traffic shift is implemented.

Our study in small to medium sized towns in Austria, and there, on the outskirts of the cities, display on the contrary that many road widths mapped are even narrower than nationally suggested guidelines (ÖsterreichischeForschungsgesellschaftStraße-Schiene-Verkehr 2020) for sufficient dimensioning of road lanes and sidewalks. The historic road network were connections for agricultural and trading purposes and served as a national network for military operations in case of war. For these transport only uses, such roads were implemented with minimum widths. From the industrial age onwards, different functions and trades have settled along the historic road network. In the second half of the 20th century, these small trade and agriculturally driven cities saw more housing developments and commercial areas growing along the existing road networks while the narrow road widths remained. Agricultural or green areas were converted into sealed surfaces or parcelled out for single-family housing developments. With all the infrastructure created in parallel for this purpose, such as car parks, small garden settlements, agricultural land, cemeteries, etc., a mix of sealed, private and public and partly fallow land was created. Urban sprawl as well as such peri-urban sprawl puts high pressure on environmental resources, the developments "eat up" valuable natural habitats in the surrounding landscape (OECD 1990). However, this phenomenon affects not only ecological networks, but also publicly usable space. As the pressure for open space may not be comparable to dense centres, the heterogeneous character includes industries and commercial uses with workers and employees as well as units with apartment buildings and single family houses which all have a certain need for public space, may it be for recreation or socializing. On the other hand, urban and peri-urban sprawl also leads to interstitial and leftover spaces that are often private and socially underused (Mariani& Barron, 2014), This is particularly the case along the circulation areas of peri-urban spaces (Bendiks & Degros, 2019). Urban sprawl also reinforces the current dominant use of motorised transport of roads (cf. Umweltbundesamt).

Therefore, peri-urban spaces are particularly affected by a lack of quality publicly usable open spaces and a lack of valorisation of the few publicly usable spaces. They are also affected by heat stress caused by large sealed surfaces such as shopping centres and car parks (ÖROK, 2019).

These structural differences and challenges between urban and peri-urban space can only be addressed to a limited extent with the existing planning recommendations focused on inner urban streets and make the need for a toolbox for the peri-urban space all the more obvious. Literature is largely lacking, although peri-urban spaces are growing four times faster than inner-city spaces (cf. Piorr et al., 2011) and thus can and must make a significant contribution to climate change adaptation and mitigation.

4 THE PERISPONGE PROJECT – WATER, CITY, PEOPLE

The research project PeriSponge explores which potential streetscapes may have to contribute to a blue-green transformation of peri-urban areas. As public spaces are rather sparse outside central areas, infrastructures of mobility represent an important spatial resource for the implementation of blue-green elements. A blue-green transformation comes along with multifunctional benefits when aiming to make settlement areas more resilient for future challenges. Blue-green transformation means in the first place to introduce design principles for a decentralised local water management oriented towards sustainable local water cycles. Well-designed, multifunctional and multicoded (Becker, 2020) elements for water management in streets can contribute to provide rainwater retention for flood prevention, to keep rainwater for irrigation and vital urban greenery, to refill groundwater levels and last but not least to secure climate comfort for those using urban space by shading and cooling effects of trees and other vegetation (evapotranspiration) also in times of intensifying heat waves. The applicability and practicability of blue-green multifunctional designs for peri-urban streets will be tested and evaluated by means of a "prototype" implemented in Feldbach, Austria.

94

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The choice of the implementation site of the prototype is derived from an analysis in three thematic levels: Water, City and People. The hydrological analysis defines danger spots where flood events and floods have occurred in the past and may occur in the future. Among other aspects, flow paths and slope waters are taken into account and possible areas for retention volumes are identified in order to store or retain rainwater. At the urban planning level, mobility, urban activities, green and open spaces, amenity qualities and sealed surfaces are analyzed. Gaps and missing spatial and ecological connections in the urban structure locate future areas for action. The hydrological and urban planning analysis are overlaid in the next step with local knowledge and show results for combined action needs in possible locations to integrate multicodedstreetscapes.
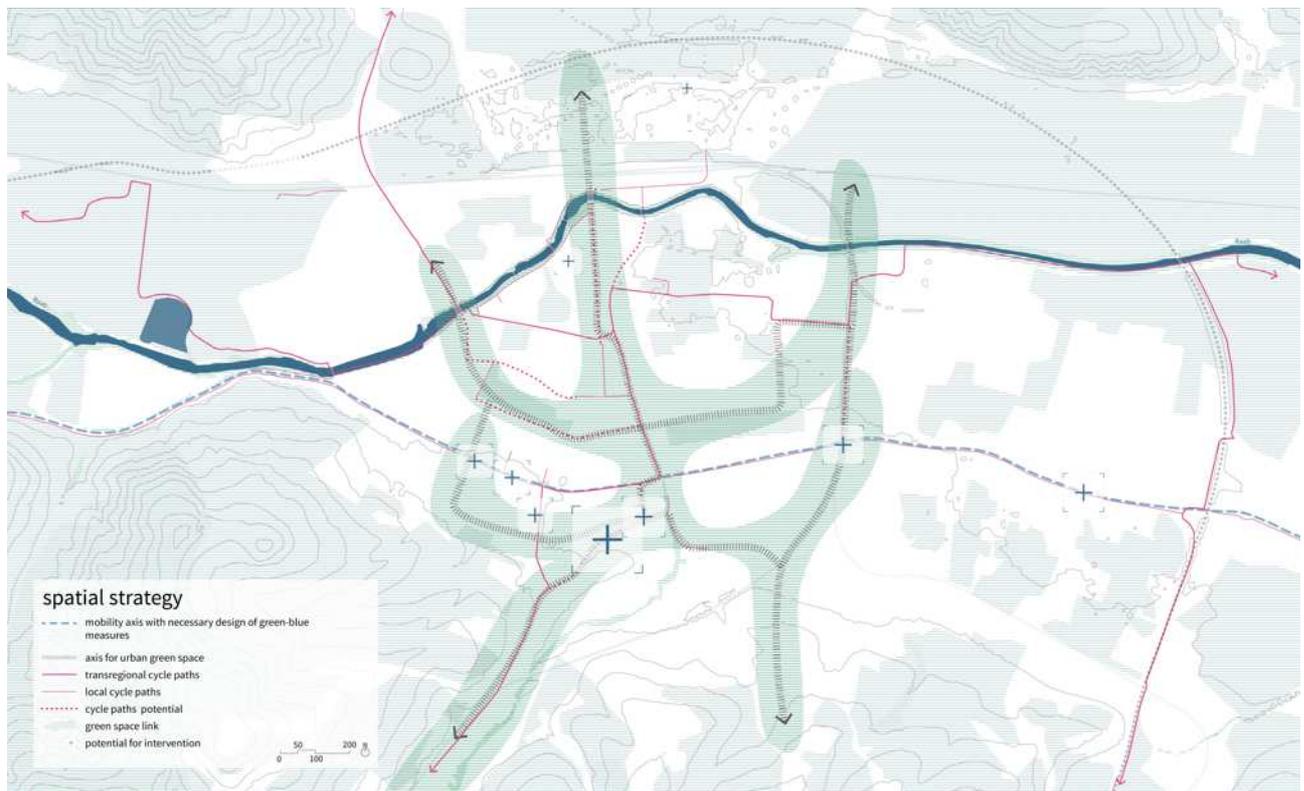
Fig. 1: Spatial Strategy Feldbach - overlaps for needs for action: potential project locations

The third level consists of the people, residents and interested parties, who are involved in the entire process. This serves to create awareness, a transparent design process in which wishes and suggestions are taken into account, and a resulting increase in acceptance among the population. Multicodedstreetscapes create additional spaces for people to stay. The scarce public space in the peri-urban area can thus be integrated along the streetscape. Naturally cooled and shaded areas can thus contribute not only to staying but also to pleasant movement with active mobility. This type of implementation supports the needs of adjacent residents and people moving in the peri-urban space.

In the design and implementation process, several events are offered in the project phases for further participation in order to communicate different design approaches and legal contents. After implementation, the prototype and its effectiveness will be analysed and evaluated.

From a hydrological perspective, the retention volume, the effectiveness of retardation/storage and the before/after effect of the microclimate will be evaluated, among other things. In addition, the degree to which rainfall events can be mitigated will be determined. From an urban planning perspective, the appropriation and acceptance of the new public spaces and their design will be evaluated. (Fig.2)

The project results will be used to develop transferable and scalable instruments, such as a practice-oriented toolbox and action guidelines for other peri-urban areas.

Fig. 2: Participation process on project site in Feldbach (June 21, 2023) (c) Philipp Flachhuber, Institute of Urbanism
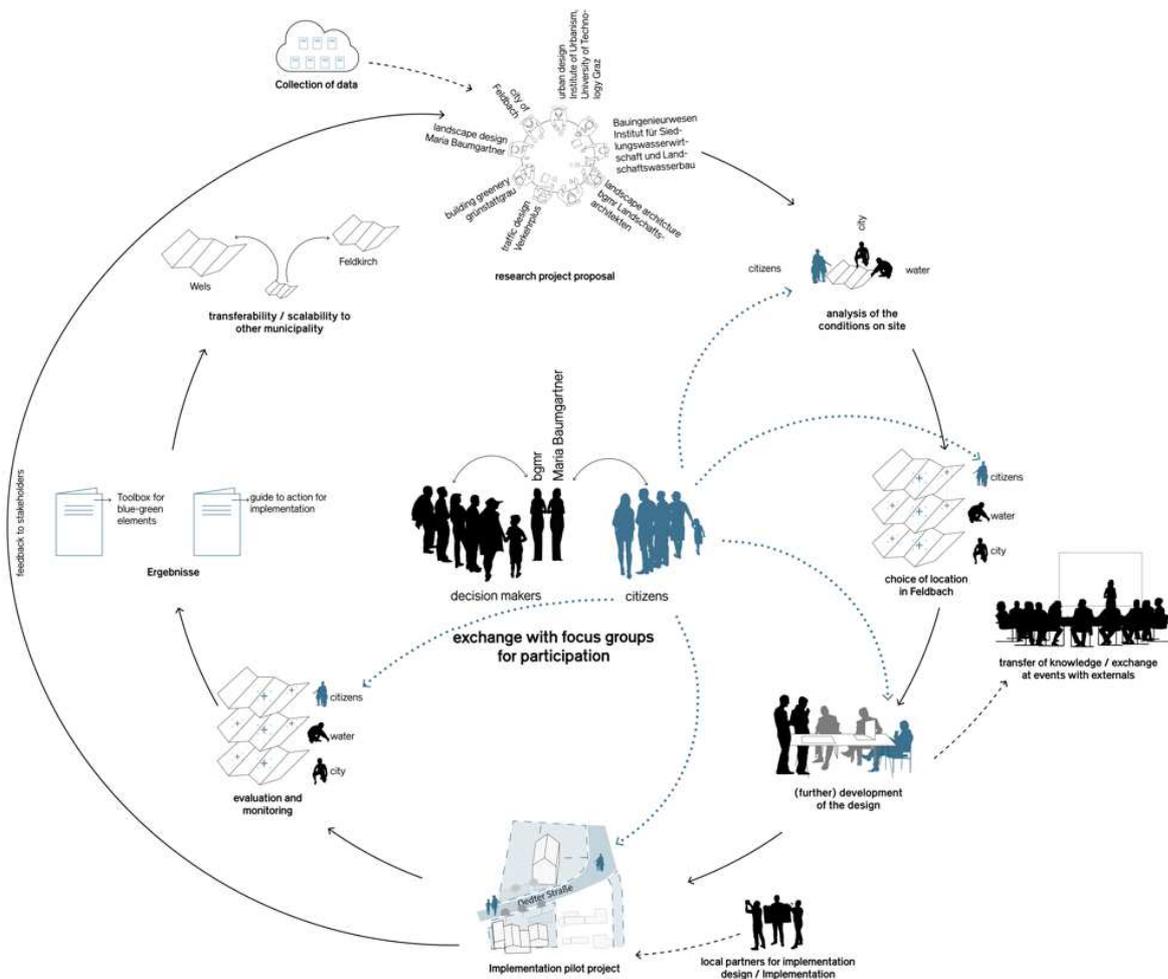
Fig. 3: Implementation Project PeriSponge Methodology

96

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5 IMPLEMENTATION SITE FELDBACH, AUSTRIA

Feldbach is the fifth largest city in Styria with 13,371 inhabitants and is growing, especially on the outskirts (LandesstatisitkSteiermark, 2019). Pressure can be observed especially on the outskirts of the city, which is mainly due to the expansion of infrastructure and led to demographic change and increased immigration

Situated in a valley, Feldbach is located on an axis between south-eastern Styria and Graz and embodies a medium-sized and regional centre. Topographically, Feldbach is bordered by elevations from the north and south. The main river runs north of the old town. The geographical valley location of Feldbachfavours floods during heavy rainfall events, especially slope water from the elevations in the south enters the urban area along flow paths from the. south. The heavy rainfall events in the summers of 2017 and 2021 in particular caused major damage to settlement areas along the streams.

The long-established and the newly built streets in Feldbachhave different characteristics, but can be described as peri-urban. Long-established peri-urban streets have heterogeneous use and declining density, while new peri-urban streets have strong monofunctional commercial or residential use. Both types are seen as peripheral streetscapes that are subject to faster transformation than urban streetscapes.

In direct comparison, the streets around the old town of Feldbach can be described with urban parameters. This is mainly reflected in the denser development, closed building lines and heterogeneous adjacent functions. Likewise, some integrated cycle paths indicate a more urban structure. If Feldbach is considered as a whole, the peripheral streets cancategorised as peri-urban. However, if Feldbach is put in relation to large cities and urban centres, the majority of streets in Feldbachcan be seen as peri-urban.

Fig. 4: Implementation site Oedter Straße, long-established street on the outskirts of the city

In the rapid development of the predominant development type single-family house over the urban fringe areas in Feldbach, the creation of inner-city, multifunctional green spaces was neglected. The development of blue-green infrastructures and green spaces was mostly limited to aesthetic elements (as the design of the main square shows) or not pursued at all, as in the redesign of the roadside greenery on the main streets. As a result, progressive soil sealing, the decline of open spaces and extreme precipitation events repeatedly lead to hydrological problems such as flooding, but also to a drastic increase in temperatures and changes in the city's microclimate (Gangl, 2020). The streets in Feldbach fulfil the already mentioned characteristics of

peri-urban streets, such as the too small or minimal street width, the high degree of sealing and too little green and public spaces.

6 INITIAL FINDINGS FOR A PERI-URBAN TOOLBOX

For the development of a peri-urban toolbox and a systematic redesign of existing streets, the first step was to categorize and analyse existing street network to show characteristics, usage patterns and spatial potential for transformation The findings are looked at from a systemic thinking to generate transferable knowledge and solutions.

The documented streets are analysed for the implementation of multicoded measures. Accordingly, not only potentials against flooding but also for natural cooling and quality of public space measures are examined. The latter are most likely to be integrated where most people flows take place. Schillerstraße functions as a transition between the old town and the peri-urban space of Feldbach. The total of 78 documented streets is located north and south of it. Peri-urban space per se has different functions, monofunctional residential streets are thus excluded from the documentation.

The 78 streets were photo-documented and categorised according to FRC (Functional Road Class). The number of lanes and directions of travel, number of adjacent pavements, bicycle lanes, vehicle parking areas and adjacent ground and upper floor uses were documented. Most of the streets are classified in the sixth category, that of collector streets. Most of these streets have only one lane, which can be used in both directions. Some of these streets have parking areas for motor vehicles, and rarely have pavements on both sides.

This category has the most roads and therefore has the largest surface area. Most collector roads have very small cross-sections and therefore a correspondingly low spatial potential for redesign, if traffic change is not considered.
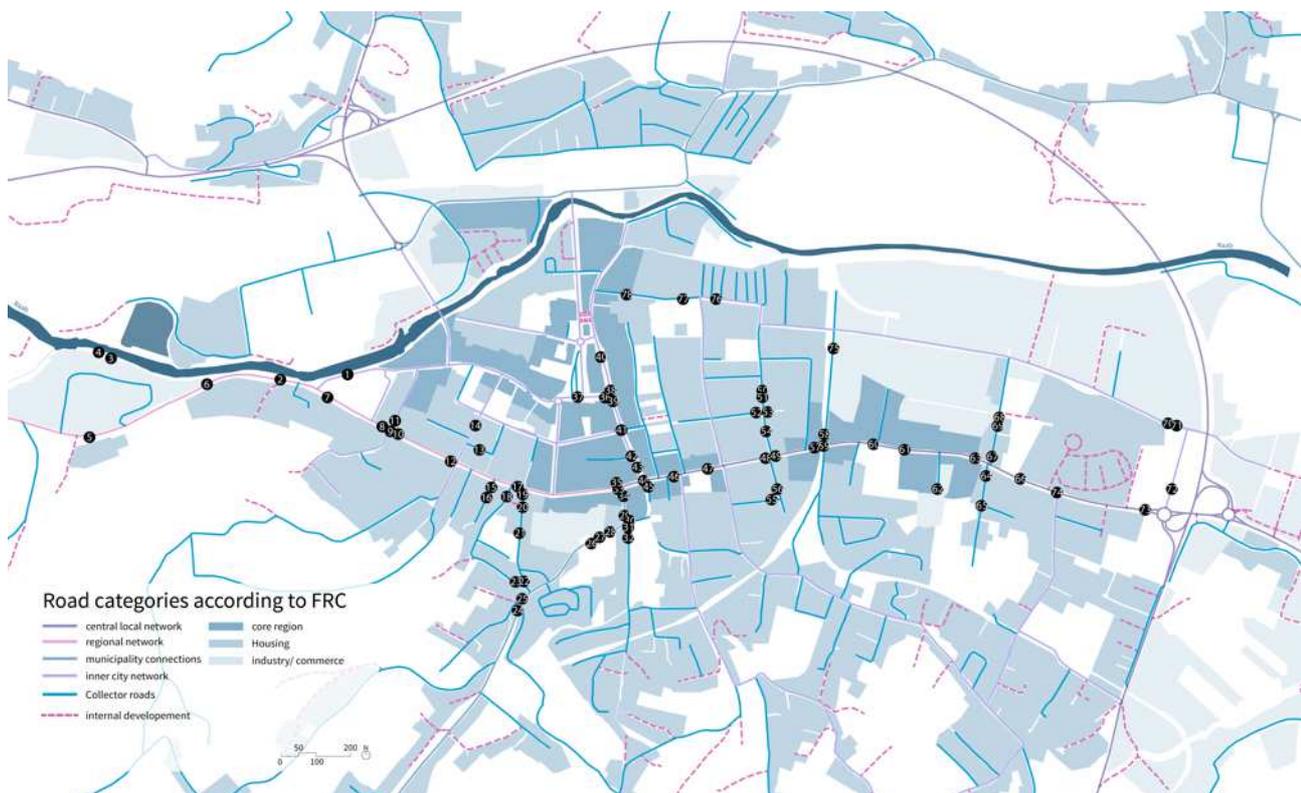
Fig. 5: Road documentation in Feldbach
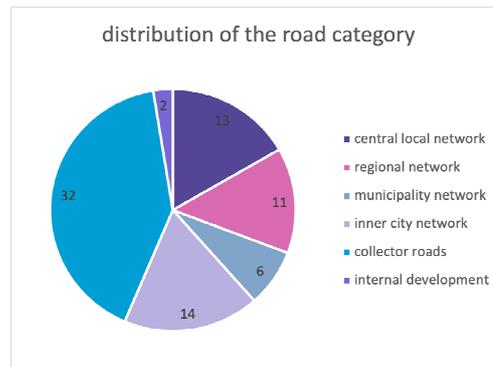
Fig. 6: distribution of the road categories in Feldbach according to FRC

(1) Central local network: Supraregional connections between district capitals or from district capitals to the provincial capital. Connections from district capitals to other employment, supply and tourism centres (13 documented streets)

(2) Regional network: Regional connections of municipalities or parts of municipalities to district capitals. Regional connections of municipalities or parts of municipalities to other centres of employment, supply and tourism (11 documented streets)

(3) Municipality connections: Small-scale and local connections between municipalities or parts of municipalities.(6 documentedstreets)

(4) Inner city network: Other local connection functions (14 documented streets)

(5) Collector roads: Connects service roads in residential or commercial areas to a main road (32 documented streets)

(6) Internal development: Connection to a building plot (2 documented streets)
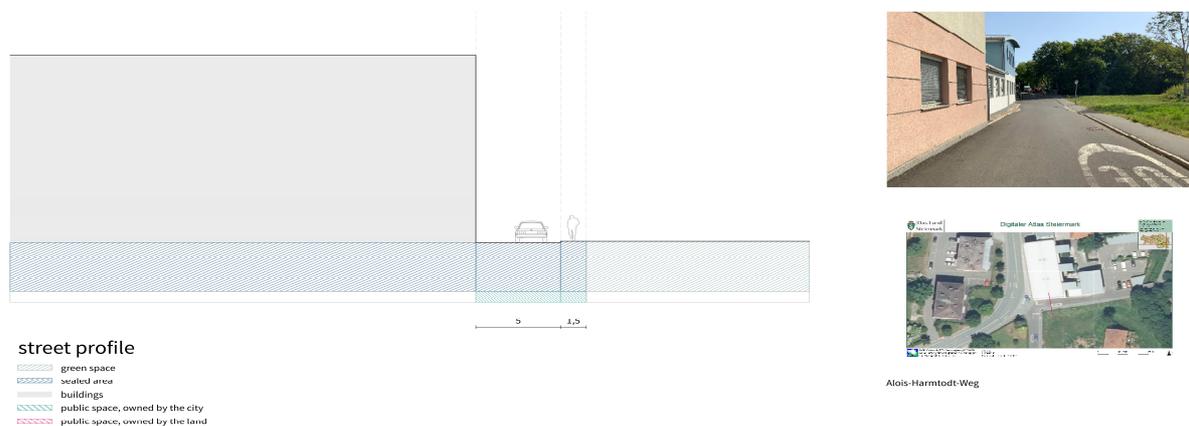
Fig. 7: Example of collector street: nr30 – Alois-Harmtodt-Weg
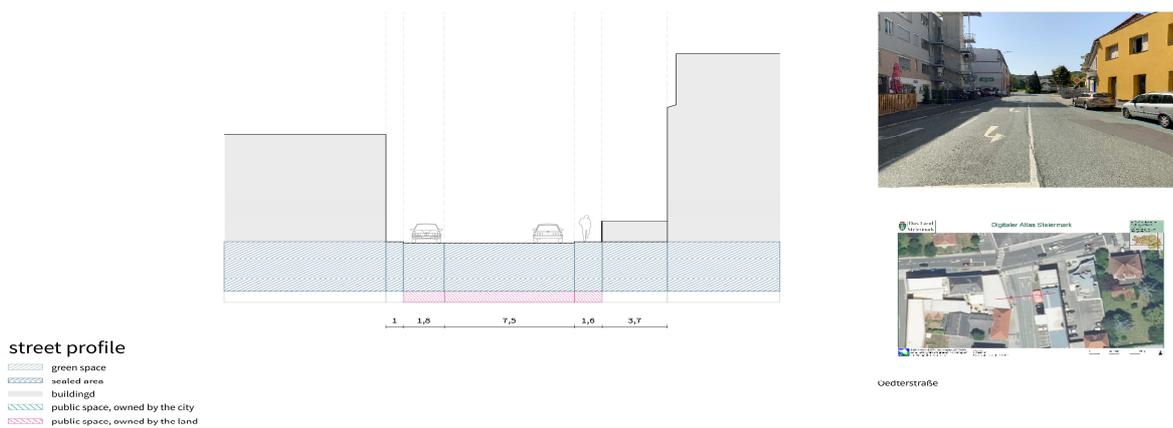
Fig. 8: Example of municipality connection: nr34 – Oedter Straße

6.1 Need for changes in mobility policy

The prioritisation of motorised traffic on the narrow cross-sections results in a monofunctional design of the street space. A spatial separation between active mobility, such as walking and cycling, and passive mobility, motorised traffic such as public and individual transport, for example, often only find space in current practice where the cross-section allows for implementation. In order to achieve an implementation of the design of multicoded mobility open spaces, the transformation process has to be linked with the mobility turnaround. This is the only way to defuse the prioritisation of motorised traffic and activate sufficient areas for the implementation of blue-green infrastructures.

6.2 Planning beyond property borders

In the development process of the demonstration project in Feldbach it became apparent that the limited public street space at the implementation site of a peri-urban street cannot fulfil sufficient retention tasks in terms of area. In order to solve the existing heavy rain problems and to achieve a large retention effect, planning beyond the street boundary is inevitable. The limited public street space alone cannot bear the demands of rainwater management. For the greatest possible positive effect, you need cooperation and coordination with the adjacent neighbours. As in the demonstration project, this implies cooperation with many private actors, like a large commercial enterprise with large sealed areas, the cemetery, a large area with little green space quality, a municipal housing development, a social facility for young people and private property owners. In the coordination process, current projects or wishes of different agents must be included in order to be able to implement a project beyond property boarders. For the communication process with and between the agents, the local knowledge, which in small towns is bundled directly in the administration, must be used. From previous experience, it can be assumed that it is similar in comparably sized municipalities, as the administrative structures are the same. Our role as scientists and planners is mainly to guide which actors need to be brought to the table in order to implement blue green infrastructures. In this specific case, an attempt is being made to transform a road, which is administered by the province of Styria, but is located in the municipal area of Feldbach, which adds another administrative level that requires additional effort in terms of financial coordination, responsibility and approval.
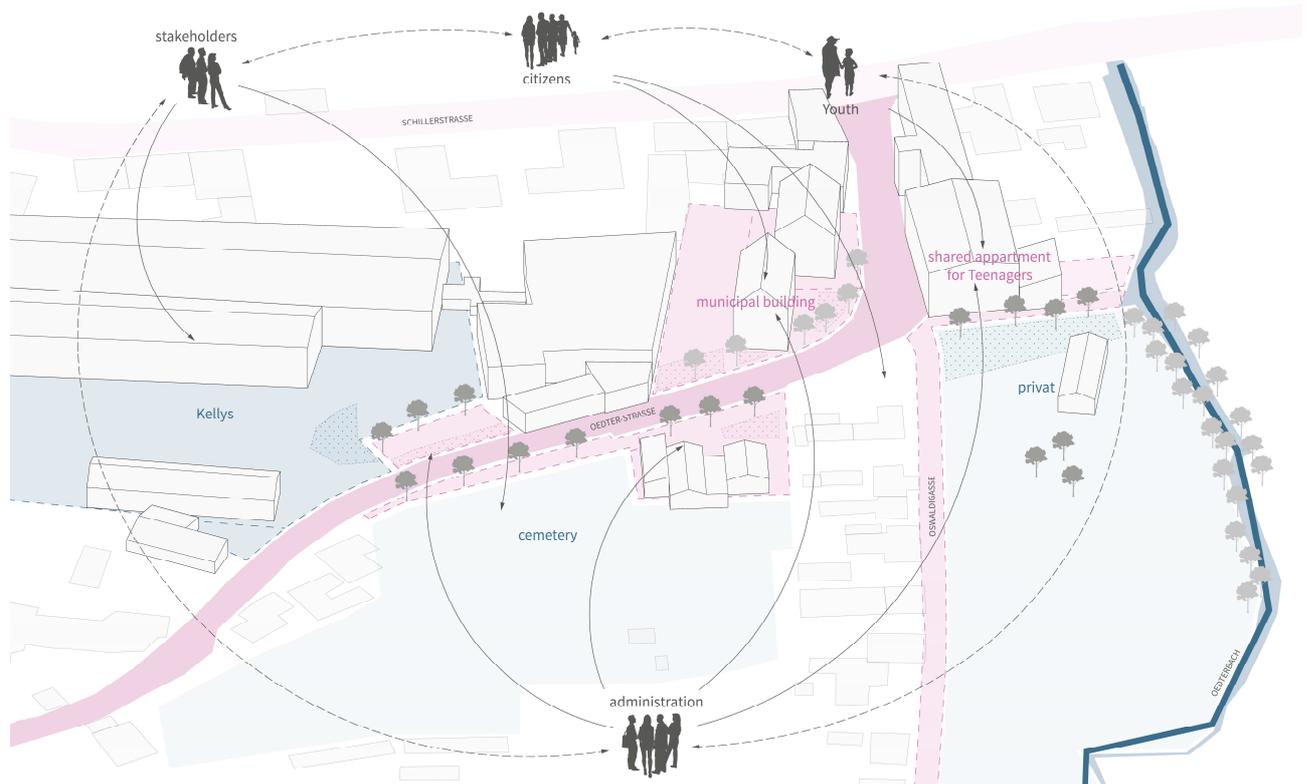
Fig. 9: planning beyond property boarders at the Feldbach implementation site

6.3 Administrative challenges

The administration in small and medium-sized towns is often limited in terms of staff and faces additional challenges due to the complex, multidisciplinary tasks and the large number of actors. Another issue is that specific data is often not captured or older data is not yet digitised, which can slow down the work process if not planned for. Administrative tasks are often handled by only a few people in small towns. When important decisions hangon a single person, they can quickly be put off by more urgent tasks, for example when heavy rainfall events and consequent flooding occur. In the disaster phase, the importance of new projects thus quickly recedes into the background. The quality of the implemented projects is thereforenot only dependent on the way the administration works, but also on the local implementing companies. The novelty of the topic of creating multicoded spaces in the peri-urban space and the interdisciplinary work in the scientific context of a research project result in new ways of working for the municipality and local companies, which are to a large extent outside their previous practice and can thus cause uncertainties about the results.

Nevertheless, an advantage of municipalities is that the administrations know the local conditions well, can process orders quickly and react more flexibly than in the administratively complicated apparatus of big cities.

6.4 Thinking in strategies

In case of the pilot onOedterStraße, the research project defined five climate adaptation strategies. These strategies were derived from the local conditions. Nonetheless, due to the representative peri-urban mix of functions and road typologies in the project area, the strategies hint towards transferable solutions for peri-urban streets in general:

- Road repartition to gain space for blue-green climate-adaptive elements: through traffic calming, reduction of roadway widths according to goals for transformation of mibility patterns, to gain green and retention space determine

- Decoupling of public and or private parking lots along the street from the storm water channnels: through decentralized infiltration measures on side to relieve the pressure on the canal networks

- Decoupling of buildings or ensembles along the street from the storm water channnels: through decentralized infiltration measures on side to relieve the pressure on the canal networks

- Adjustment of road slopes for emergency waterways targeted drainage of slope water: through modification of road profiles

- Wetlands and/or rainwater retention areas: through identification of suitable propably underused adjacent spaces along the streets such as brownfields, underused parking lots, undeveloped land, gaps or other, preferably in public property or in chance for purchase

These strategies highlight the need to plan beyond property borders in often narrow peri-urban streets. This first strategies developed within the pilot project will be extend through a set of micro strategies for more central urban streets, that already have got some green elements like road trees. In many cases, such existing elements can be transformed into small elements for a climate-adaptive road network through relatively small interventions. These interventions could be to remove edgings of tree beds and create flat depressions in order to uptake rainwater. These two approaches for small scale and easy interventions together with bigger transformative measures hint towards a comprehensive goal for the blue-green adjustment of the wholeperi-urban road network on the long run, starting now.

6.5 Multifunctionalityand urban quality

The technical rain water solutions always need to be thought and planned along integrative goals for usable and comfortable public space. Streets and their ancillary spaces make up a significant part of the public realm especially in peri-urban areas. The major challenge of climate-adapted transformation of streetscapes therefore goes beyond purely functional tasks. Even though retention and infiltration areas are engineering facilities for water management objectives, it is necessary to consider them in the context of the public space in terms of design and to integrate social and aesthetic aspects. They should contribute to the spatial quality of the place. This means applying multifunctional planning principles. A retention basin can be designed as a park at the same time, a planted infiltration bed can enhance the green and open space, a row of trees the streetscape.

7   CONCLUSION

These points are of decisive importance for a transformation of mobility spaces in the peri-urban space. At the same time, the turnaround in mobility policy and the transformation of the public space in which it takes place must be thought about and developed together. The transformation must be integrated in the holistic system and cannot be part of an individual single solution.

With the prototype in Feldbach, we are testing how such a transformation can be implemented. The project already shows that new constellations of actors are needed. The approach of thinking beyond the plots creates an extremely local solution. Is it at all possible to make these approaches transferable to other cities or transferable at all?

How can the approaches developed be made scalable? What would a project look like that envisages transforming Feldbach's 10 most important gateways, also in terms of coordination with the province of Styria, budget, personnel, etc.?

The current issues and requirements for the project and the planned implementation show that it is essential to work together on approaches to solutions that are becoming increasingly relevant in the current challenges of spatial transformations (cf. Armengaud, Degros et al. 2023).

8   REFERENCES

ARMENGAUD, M., DEGROS, A., RADULOVA-STAHMER, R.: Towards Territorial Transition. Zurich, 2023.
BALAS, M., FELDERER, A., VÖLLER, S., ZEITZ, F., & MARGELIK, E.: Zweiter Forschrittsbericht zur österreichischen Strategie zur Anpassung an den Klimawandel. Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, Abteilung VI/1,
BECKER, C. (2020). Zehn Jahre Multicodierung. Garten+Landschaft, 20–23. 2021.
BENDIKS, S., DEGROS, A.: Traffic space = public space: a handbook for transformation. Zürich, 2019.
BLUEGREENSTREETS (ED.): BlueGreenStreets als multicodierte Strategie zur Klimafolgenanpassung – Wissenstand 2020. Statusbericht im Rahmen der BMBF- Fördermaßnahme „Ressourceneffiziente Stadtquartiere für die Zukunft". 2020.
UMWELTBUNDESAMT (HRSG.), BÖHME, C., FRANKE, T., PREUß, T.: Umsetzung einer integrierten Strategie zu Umweltgerechtigkeit – Pilotprojekt in deutschen Kommunen. Dessau-Roßlau, in Reihe: Umwelt & Gesundheit 02/2019. 2019.
DEGROS, A., BAGARIC, A., BAUER, S., RADULOVA-STAHMER, R., STEFAN, M., SCHWAB, E. (2021). Basics Of Urbanism. 12 Notions of Territorial Transformation. Zurich, 2021.

102

REAL CORP 2023: *LET IT GROW, LET US PLAN, LET IT GROW*
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

DEGROS, A., BENDIKS, S.: Interstitial Justice. Topos, Right to the City (115), 54–58. 2021.

GANGL, V.: Feldbach Die SPÖ fordert durchgehendes Konzept für den Hochwasserschutz, in: Kleine Zeitung. 2020, October 28. https://www.kleinezeitung.at/steiermark/suedostsued/5888905/Feldbach_Die-SPOe-fordert- durchgehendes-Konzept-fuer-den

HECKE, B.: Aktivbürger fordern Bausperren in Graz, in: Kleine Zeitung. 2020, August 11. www.kleinezeitung.at/steiermark/graz/

HÖRMANN, H.-J.: Leitfaden für die Eröffnungsbilanz nach der VRV 2015. Amt der Steiermärkischen Landesregierung. 2019. https://gemeindebund.at/website2020/wp- content/uploads/2020/07/rfg_1-2_2019_web_gesamt.pdf

LAND STEIERMARK: „Querspange Gnas" bald frei für den Verkehr, Presseinformation von: Land Steiermark. 2009, July 24. https://www.politik.steiermark.at/cms/beitrag/11147415/2494255/

O'DONNELL, E., THORNE, C.: „Drivers of future urban flood risk". Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 378. 2020. https://doi.org/10.1098/rsta.2019.0216.

Österreichische Forschungsgesellschaft Straße-Schiene-Verkehr: Planung und Entwurf von Innerortsstraßen. RVS 03.04.12. 2020.

PRAKASH, A., SIGNH, S., NARAIN, V.: Changing waterscape in the periphery. In IDFC Report, 162- 172. 2011.

PIORR, A., RAVETZ, J., TOSICS, I.: Peri-Urbanisation in Europe. Forest & Landscape, 2011.

STADT ZURICH: Das Grünbuch der Stadt Zürich. Ziele und Massnahmen zur Entwicklung der Grün- und Freiräume. Zurich, 2019

STADTENTWICKLUNG WIEN, MA 18: Projektierungshandbuch Öffentlicher Raum. Wien, 2011

TRENBERTH, K.: Changes in Precipitation with Climate Change. Climate Research47 (1): 123–38. 2011. https://doi.org/10.3354/cr00953.

UMWELTBUNDESAMT: https://www.umweltbundesamt.de/umweltatlas/bauen-wohnen/wirkungen-bauen/zersiedelung-verkehr/was-sind-die-gruende-fuer-die-zersiedelung-wie-ist, 14.06.2023

ÖSTERREICHISCHE RAUMORDNUNGSKONFERENZ (ÖROK), UMWELTBUNDESAMT (HRSG.): Update gewidmetes, nicht bebautes Bauland Auswertung von Baulandreserven 2014 und 2017 in Österreich. Wien, 2019.

ZANDONELLA, A., BARUFFI, F., CAPPELLETTO, M., PASINI, S., GALLI, A., MARSALA, V., SCARINCI, A., PANELLI, C., GUALDI, S., & BISAGLIA, M.: Groundwater storage in adaptation to climate change. Proceedings of the Institution of Civil Engineers - Water Management, 166(9), 488–500. https://doi.org/10.1680/wama.11.00096. 2013.

Climate Havens of Egypt: Facing Extreme Weather Events

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1 ABSTRACT

Climate change is expected to impact the habitability of many places around the world which will displace millions of individuals. According to the IPCC Fourth Assessment Report, the Nile Delta is one of the world's most vulnerable areas when it comes to sea-level rise, extreme weather conditions, and other factors worsened by climate change, which will lead to a significant population shift. Despite the evidence of this population shift in Egypt there is no obvious framework or strategies for dealing with such migration trends. Little research has been done to assess the number of people that may actually be displaced and where they will choose to go.

So, in this paper the effect of Sea Level Rise (SLR) on migration as an extreme weather event will be examined among governorates of Egypt especially the Nile Delta zone, predicting migration pathways between them. Secondly, the paper analyses and aggregate destination governorates of the Nile Delta zone to spot climate havens. Finally, a map will be concluded for vulnerable areas to SLR and probable destination areas in Nile Delta of Egypt which can help -in addition to the other climate factor- to navigate the challenges of planning for future climate-migration to plan for more sustainable, inclusive, and equitable cities for all.

Keywords: Sea Level Rise, climate migration, climate change, Egypt, Climate havens

2 INTRODUCTION

2.1 Climate vulnerability of Egypt
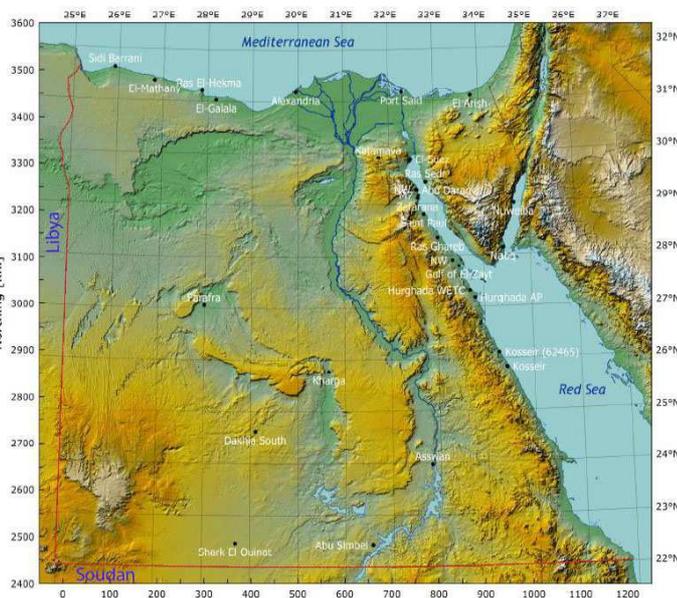
Figure 1: Egypt, its border with Libya from west and Soudan from south is highlighted (EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change, March 2016)

Egypt is located in northern Africa surrounded by Libya from the west, Gaza from the east and Soudan from the south, with a coastal strip extending for about 3,500 kilometers, overlooking the Mediterranean Sea in the north, and the Red Sea in the east. The River Nile extends from the south to the north forming the low laying Delta of the river with large cities and agriculture. The delta and its narrow valley are about 5.5% of Egypt's area and accommodates more than 95% of its population and agriculture (EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change, March 2016). As mentioned by the climate change knowledge portal, Egypt's climate is dry, hot, and dominated by desert.

It has a mild winter season with rain falling along coastal areas, and a hot and dry summer season. Egypt is a highly arid country and receives very little annual precipitation (Climate change knowledge portal , 2021).

According to the ND-GAIN matrix which illustrates the comparative resilience of countries (Dame, n.d.), Egypt is in the upper left quadrant which indicates a high vulnerability to climate change with a low level of readiness to face it. That make Egypt in need of an adaptation plan for climate change, as well as investments and innovation to improve readiness Figure 2.
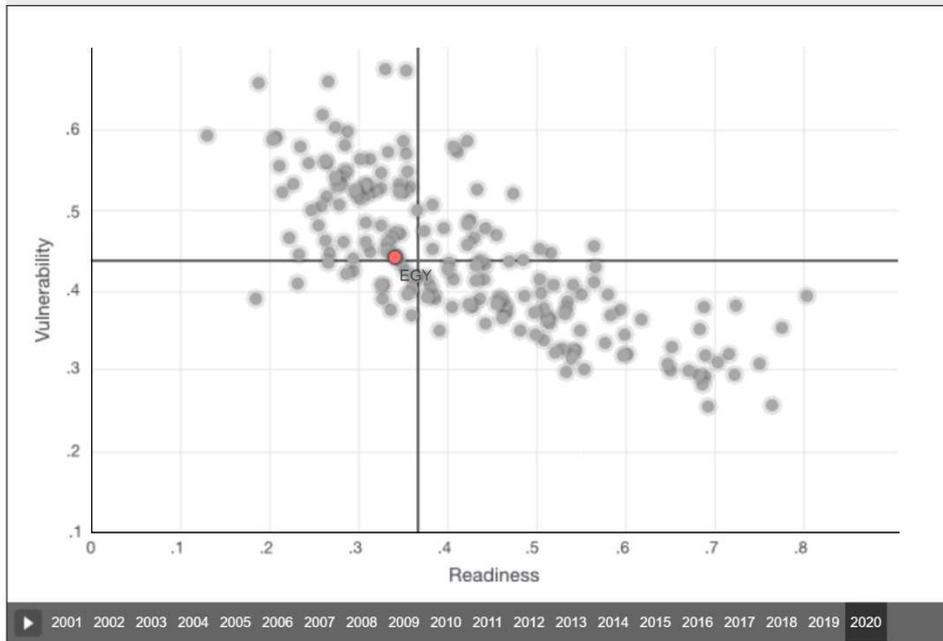
Figure 2: The ND-GAIN Matrix illustrates the comparative resilience of Egypt, in which the vertical axis shows the score of vulnerability to climate change and the horizontal axis shows the readiness score, source: Notre Dame global university (Dame, n.d.).

2.2 What is expected for Egypt?

A number of climate change studies considering Egypt (EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change, March 2016) (Perez, et al., 2021) (Mohamed Arouri, may 2017) stated that mean annual temperatures are increasing and expected to increase by 1.64°C and 2.33°C degree by the next 50 years (Figure 4). Precipitation, flooding and rainfall projections are uncertain, but they indicate slight reductions in precipitation for most months by mid-century (Figure 3). This increase in temperature and reduction of precipitation besides urban encroachment, pollution, depletion of soil fertility, water and soil salinity, sand dunes, soil erosion, and other indirect reasons leading to land degradation formed the desertification phenomenon in Egypt.

Moreover, there is uncertainty regarding the magnitude to which flood season discharge into the Nile River could be affected by climate change, but according to climate change knowledge portal south, Cairo may experience flash flooding due to sudden extreme rains. Variability in Nile flows is moderated by the High Aswan Dam. The dam has one year's worth of storage capacity, to help in handling periodic droughts, although Egypt remains vulnerable to multiyear droughts.
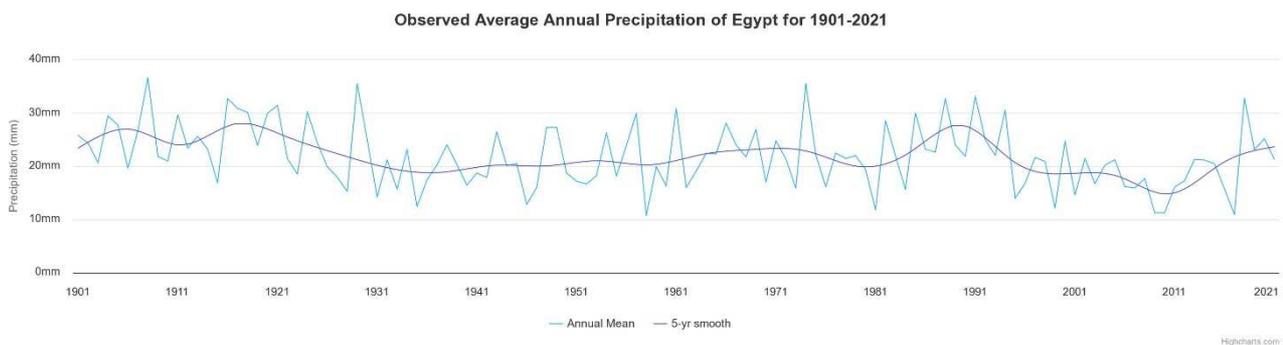
Figure 3: Average annual precipitation of Egypt for 1901-2021, source (Climate change knowledge portal , 2021)

106

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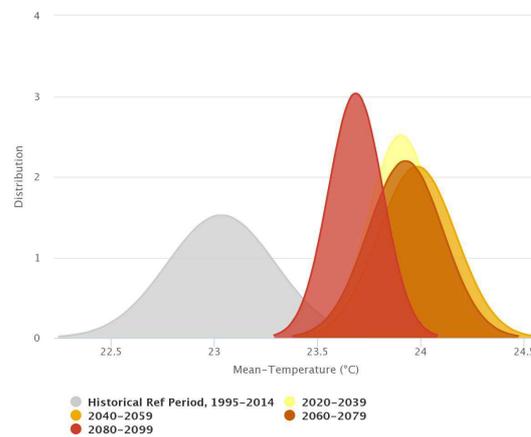
Figure 4: Projected change in distribution, mean-temperature, Egypt. Source (Climate change knowledge portal , 2021).

On the other hand, the sea level is continuously rising at a rate of 1.8 and 4.9 mm/year with an average of 3 mm/year, it is expected to rise between 3 and 61 cm this century, depending upon local heat and salinity levels of the Mediterranean (Figure 5). Risk areas in the Alexandria region are: Mandara and El Tarh (east of the city), and risk areas in the Nile Delta region are Al Manzala Lagoon barrier, east and west of the Rosetta City, Gamil, and the Tineh plain. Finally, Increased severity and frequency of sandstorms and haze have been documented (USAID, September 2015).
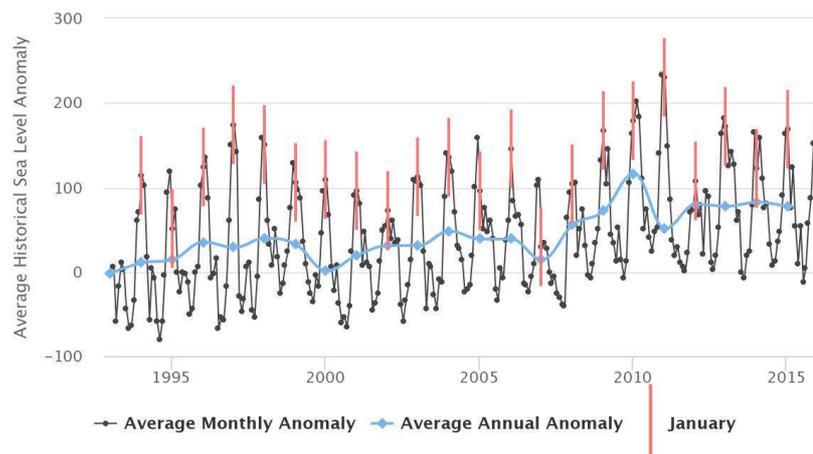
Figure 5: historical sea level for costal Egypt, source (Climate change knowledge portal , 2021).

2.3 Challenges

According to the climate change knowledge portal, the primary challenges are centred around water resource availability, changing precipitation patterns, and increasing population demands. Having high evaporation rate with the virtual absence of permanent surface water over large parts of the country results in water as a highly scarce resource. Moreover, the rising of the sea level which is not only threatening the physical coastline but also the costal ecosystem, can contaminate freshwater aquifers affecting agriculture and natural ecosystems, especially the densely populated Nile delta. Dr. Khaled Kazem in his report states that if the sea level rose by 0.5 m only, 67% of residents, 65.9% of the industrial sector, and 75.9% of the services sector would be submerged. Therefore, 1.5 million persons would better be displaced, which will result in social and economic repercussions in addition to security threats (Kazem, 2021).

The UNDP added that the most vulnerable areas in Egypt to climate change are: agriculture, coastal zones, aqua-culture and fisheries, water resources, human habitat and settlements, and human health. More than 95% of fresh water consumed in Egypt is generated outside its territory from the Nile River flowing through nine countries and its use is controlled by international agreement. Although the impact of climate change on the Nile basin is not clear yet, there are indications that we will witness a significant impact (EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change,

March 2016), especially the sea level rise due to its low elevation like all world deltas (Marzouk & Abo-ElHassan, May 2014). Egypt depends mainly on the agriculture and the Nile is the main source of water which will be greatly affected by climate change, and accordingly people who work in the agricultural field. The Nile Delta is already receding by 3-5 mm per year. This will lead to internal migration. On the other hand, East Africa and South Desert are one of the threatened areas in Africa, and because of Egypt's location it will be a desirable land for international refugees (Mohamed Arouri, may 2017).

So, among all the challenges the sea level rise phenomena will have a direct impact on the vulnerable spots in Egypt; from agriculture to coastal zones, water resources, and specially human habitats. In addition to the lack of accurate data to other consequences of climate change on Egypt this research will focus on the SLR phenomena from the climate change consequences, not only because of direct inundation, but also because of the potential impact on saltwater intrusion, extreme events, loss of biodiversity, socioeconomic and health implications (El Raey, El-Askary, El-Hattab, & Kafatos, December 2009). In particular, this research will focus on the Nile Delta area from the coastal zone as it is the lowest in elevation and most vulnerable to inundation due to SLR (EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change, March 2016). Besides it is the main agricultural land of Egypt and hosts over one-third of the population and nearly half of all crops, also hosts most of the industrial activities and commercial centers, and is highly vulnerable to various impacts of climate change (El Raey, El-Askary, El-Hattab, & Kafatos, December 2009).

3 DATA SETS AND DESCRIPTIVE ANALYSIS

To achieve the research goals, three main data sets are used to fulfil a three parts methodology to create the final results:

First, mapping and examining the sea level rise scenarios of the Nile delta Coastline, using SLR scenarios from different sources: The Intergovernmental panel on climate change IPCC, the scenario of the costal research institute CORI, the World Bank reports, and different researches and publications.

Second, examining the push and pull effects of the sea level rise phenomena on migration internally in the Nile Delta region to determine the movement of migrants. Data sets for migration variables is the Population and Housing Census of Egypt held by the Central Agency for Mobilization and Statistics (CAPMAS) in 1996 and 2006.

Finally, generating the finale results of the vulnerable and proposed destination zones.

4 CASE STUDY

4.1 Study area

The study area includes the Nile Delta region in Egypt and its coastline extending from Alexandria in the west to Port Said in the east with a total length of about 240 km. It extends from the seacoast in the north to the borders of Greater Cairo in the south, it is bordered on the east by the Suez Canal region and the eastern desert extends westward to Alexandria and the Western Sahara.

The coastline has two promontories, Rosetta and Damietta. There are three lakes connected to the sea: Idku, Al-Burullus, and Al- Manzalla. In addition, there are five harbors located on the coast: Idku fishing harbor, New Burullus fishing harbor, Damietta commercial harbor, El Gamil fishing harbor, and Port Said commercial harbor.

It is the most fertile land of the country and hosts most of the agricultural productivity with high density of population. Agricultural land use accounting for 75% of the total area of the region, followed by the urban uses by 17.9%, then the fallow land by 6.3% of the total area of the region. It is highly vulnerable to potential impacts of climate change due to its relatively low elevation (El Raey, El-Askary, El-Hattab, & Kafatos, December 2009) (Marzouk & Abo-ElHassan, May 2014) (Figure 6).
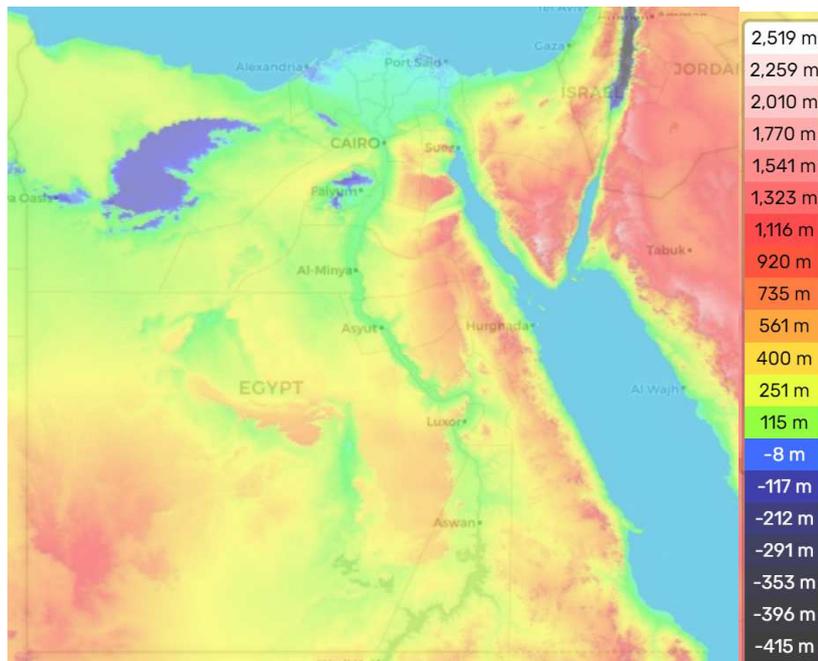
Figure 6: Egypt's elevations map, The Nile Delta with low elevation is highlighted, source: topographic maps (map, n.d.).

4.2 Vulnerability Assessment

By analysing the different expected scenarios of sea level rise, they can be summarised in two common scenarios: first, the scenario of the Intergovernmental panel on climate change IPCC which assumes that sea level will rise by only 0.5m in coming by 2050 (Figure 7). Second, the scenario of the costal research institute CORI which depended on areal surveying maps to develop the digital elevation model (DEM) for the Nile Delta coastal zones if sea level rises by one meter (Figure 8).

Figure 7:Inundation according to the Intergovernmental Panel on climate change IPCC (SLR 0.5m) (Dawod & Mohamed, October 2015) (Marzouk & Abo-ElHassan, May 2014), source: author.

Figure 8: Inundation according to the Intergovernmental Panel on climate change IPCC (SLR 1m) (Dawod & Mohamed, October 2015) (Marzouk & Abo-ElHassan, May 2014), source: author.

SLR	Affected population	Affected cropland km2
0.5m	3800000	1800
1m	6100000	4500

Table 1: estimated population and cropland affected by SLR (Marzouk & Abo-ElHassan, May 2014).

From examining the different Sea level Rise scenarios, the total number of affected population and cropland is estimated in Table 1 (Marzouk & Abo-ElHassan, May 2014) (EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change, March 2016).

The Nile Delta consists of 11 governorates: Qalyobia, Gharbia, Monofiya, Sharkia, Port Said, Ismailia, Dakahliea, Damietta, Kafr El-Sheikh, El-Bohaira and Alexandria (Figure 9). According to FAO organization Nile Delta governorates comprise about 60% of the land cultivated with cereals, and 50% of sugar crops and many other products, besides its high population. According to the Central Agency for Public Mobilization and Statistics, Egypt's population the Nile delta region is nearly half Egypt's population (Table 2). In addition, as shown in Figure 6, the lower region of Egypt which make it highly vulnerable to inundation due to sea level rise and its other consequences.
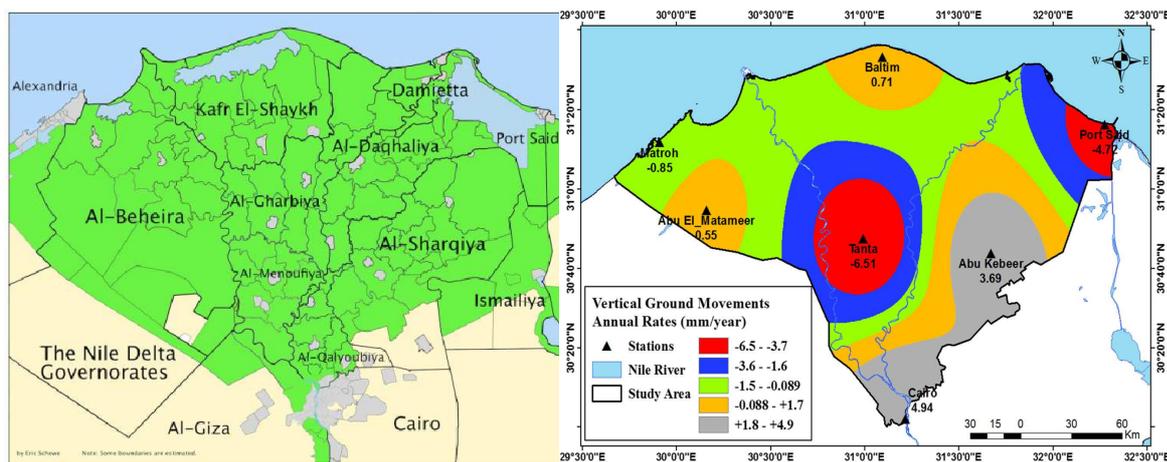
Figure 9: Nile Delta governorates (Al-Agha, Closas, & Molle, 2015). Figure 10: Vertical Ground Movements Annual Rates in mm/year (El-Quilish, El-Ashquer, Dawod, El feki , 2022).

Governorates	%	Total population	
Total Egypt	100	102 878 749	
Cairo	9.8	10 100 166	
Giza	9.1	9 323 196	
Nile Delta governorates			
Total	48.9	50318343	
Sharkia	7.5	7 744 815	
Dakahliea	6.7	6 930 797	Costal governorates
El-Bohaira	6.5	6 723 269	
Qalyobia	5.9	6 024 438	
Alexandria	5.3	5 469 480	
Gharbia	5.2	5 343 756	
Monofiya	4.5	4 640 003	
Kafr El-Sheikh	3.5	3 645 111	
Ismailia	1.5	1 419 631	
Damietta	1.5	1 593 610	
Port Said	0.8	783 433	

Table 2: estimated population and their percentage, source: CAPMAS Egypt.

Taking into consideration land subsidence (Figure 10) according to (Dawod & Mohamed, October 2015) (El-Quilish, El-Ashquer, Dawod, & El feki , 2022) the subsidence is maximum in Port Said and Tanta followed by Damietta and Matrouh. By comparing the map of land subsidence and the SLR map it is concluded that the coastal zone will be affected by the Sea Level Rise in different time stages. By applying the worst scenario (SLR by 1m) and land subsidence it is found that about 19 urban agglomerations will be affected with approximate six million residents (Marzouk & Abo-ElHassan, May 2014).

4.3 Migration in Egypt

There are a lot of studies related to migration in Egypt but few are examining how it is linked to climate change. One of them is a working paper which found that temperature and precipitation does not affect migration among governorates but the weather of the destination areas (Mohamed Arouri, may 2017). But according to the expected climate changes in Egypt there will be a significant impact that may cause

migration between Egypt's governorates, especially coastal and delta governorates which is the study area of this research.

Illustrating internal migration rates in Egypt, the 2017 census found that the Red Sea and the Sinai governorates have the highest in-migration rates because of the touristic project, thus job opportunities. The Giza and Qaliobia governorates follow for being near to the Cairo governorates, while Suez has the highest out-migration followed by Port Said and Cairo (sector, September 2019). According to Table 4 the cause of migration is mainly work, followed by study and marriage. However, by time when Egypt's governorates witness a significant climate change consequence specially sea level raise those statistics should be affected and the motivations of the migrants and their choices for their future location will be affected.

Governorate	In-migration rate	Out-migration rate	Net migration rate
Cairo	1.8	4.5	-2.7
Alexandria	1.2	1.5	-0.3
Port Said	1.1	5.8	-4.7
Suez	1.2	7.8	-6.6
Damietta	0.5	3.3	-2.8
Daqahlia	0.4	0.4	0.0
Sharqia	0.6	0.8	-0.2
Qalioubia	3.5	0.4	3.1
Kafr Sheikh	0.4	0.8	-0.4
Gharbia	0.4	0.4	0.0
Menoufia	0.5	0.6	-0.1
Behaira	0.4	0.5	-0.1
Ismailia	1.9	0.7	+1.2
Giza	4.0	0.3	+3.7
Bany Swaif	0.3	0.7	-0.4
Fayoum	0.3	0.8	-0.5
Menya	0.2	0.6	-0.4
Asiout	0.3	0.7	-0.4
Sohag	0.3	0.7	-0.4
Qena	0.2	0.7	-0.5
Aswan	0.5	0.6	-0.1
Luxor	0.3	0.4	-0.1
Red Sea	8.2	0.6	+7.6
New Valley	3.2	0.4	+2.8
Matrouh	1.7	0.5	1.2+
North Sinai	1.9	1.5	0.4+
South Sinai	6.0	1.3	4.7+
Total	1.2	1.2	-

Table 3: internal migration in Egypt, source: CAPMAS Egypt

Causes of Migration	Urban			Rural			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Work	44.0	13.3	28.2	36.0	10.6	21.3	42.3	12.6	26.6
Study	8.3	5.4	6.9	7.4	4.6	5.8	8.3	5.3	6.6
Marriage	16.6	45.3	31.3	15.9	52.1	36.8	16.4	47.0	32.7
Divorce/Widowhood	0.5	1.7	1.1	0.5	1.8	1.3	0.5	1.7	1.1
Accompanying Others	24.0	29.3	26.7	27.1	22.8	24.6	24.6	27.6	26.2
Other	6.6	5.0	5.8	13.1	8.1	10.2	7.9	5.8	6.8
Total	100	100	100	100	100	100	100	100	100
Number (in thousands)	413	439	851	109	150	260	522	589	1111

Source: Population Census in 2017.

Table 4: Causes of Migration, source: CAPMAS Egypt

4.4 Migration due to Sea Level Rise

By illustrating the worst scenario of sea level rise in the Nile delta and the land subsidence of the study area, it is predicted that costal zones of Port Said, Damietta, Kafr El-Sheykh, and Alexandria will witness an obvious out-migration movement due to the sea level raise. Among these, Alexandria and Kafr el-Sheykh have a higher population density, while Damietta and Port Said have a lower density. On the other hand, Al Daqahliya, Al Gharbiya, Al Menoufiya, Al Sharqya, and Al Qalyoubiya are expected to witness in-migration due to the sea level rise to be a destination governorate.

In a previous study Mohamed Arouri (2017) examined the effect of extreme weather events on migration among governorates of Egypt. He used the gravity model in order to draw the flow of migration between governorates of Egypt. The Gravity model is inspired by Newton's law of universal gravity. It states that any two objects attract each other with a force that is proportional to their masses and inversely proportional to the squared distance between them. In other words, the migration flow between two distinct geographic locations is positively associated with their population size, geographic area, or GDP, and negatively associated with the distance between them. On the other hand, Davis, Bhattachan, PaoloD'Odorico, & Suweis (2018) used a radiation model to simulate migrations among districts of Bangladesh that were affected differently by SLR. Both agreed that - regardless of the climate factor- firstly, the distance between governorates negatively affects the migration flows. If the distance between two governorates increases by 1 percent, the probability of migration happening between them decreases by 0.2 percent. Secondly, people move from governorates with low population to those with high population. Finally, highly educated people tend to have better information and employment opportunities and they are more likely to migrate than low educated people.

According to Figure 9 Al Menoufiya, and Al Qalyoubiya are the remotest in distance from the costal governorates while Al Gharbiya, Al Sharqya, and Al Daqhaliya are less in distance; and according to Table 2, Al Sharqya and Al Daqhaliya are the most populated, followed by Al Qalyoubiya, Al Gharbiya, then Al Menoufiya. Applying the findings of the models described above, the five expected destination governorates Al Sharqya, and Al Daqhaliya may witness the biggest share of migrants.

5   RESULTS AND DISCUSSION

In order to determine which of the previous governorates are the most liable for the expected migration due to the predicted consequences of sea level rise in the Nile Delta of Egypt, we need first to define the climate havens. According to (Marandi & Main, 2021) climate havens are countries or governorates or any regions which are ready to welcome climate migrants, they are characterized by: climate resilience, not prone to sea level rise or wildfires and prolonged heat waves, with ready access to fresh water supply, high vacancy rates or abundance of affordable housing, high infrastructural capacity designed to support more residents than currently live there, an expressed desire to grow, history of or interest in improving adaptive capacity through sustainability or resilience efforts. There are several sources that provide information on climate havens. One such source is a website named Lucid Home which provides a list of cities that are considered climate havens in the United States (Lucidhome, n.d.). Another website is Climate Refugees which provides a map of potential climate havens in North America and some parts of Africa (Refugia Research Coalition, n.d.). Unfortunately, there are no similar applications or websites that can detect or help find climate havens in Egypt.

By illustrating the use of buildings in the previous possible destination governorates (Table 5), it is found that Al Sharqia has the highest number of buildings, including unoccupied buildings and under construction buildings, followed by Al Dakahlia and Al Qalyubia, with Al Gharbia and Al Minoufia having fewer buildings .

Governorate	No. of buildings	Housing	Work	Housing & work	Unoccupied	Closed	Under construction
Al Sharqia	1304132	862288	76333	66420	192140	30312	44605
Al Dakahlia	1094653	763740	53502	84142	98466	11931	38455
Al Qalyubia	843226	507149	44198	87465	133690	10404	37267
Al Gharbia	806850	572927	41736	61291	71103	10680	29466
Al Minoufia	746272	507091	30432	48483	107964	15053	25119

Table 5: Current use of regular buildings, source: CAPMAS Egypt.

The water supplies in those governorates were also analyzed (Figure 11) and it was found that Al Minoufia and Al Gharbia have the highest number of water stations for pure water. followed by Al Sharqia and Al Dakahlia, and then Al Qalyubia.

Figure 11: purified water stations, source: CAPMAS Egypt.

Based on the land subsidence data of Nile Delta governorates shown in Figure 10 and the definition of climate havens, the research concluded that the east of the Nile delta, especially Al Sharqia is considered a climate havens and is the most reliable governorate which is ready to host migrants due to its demographic and geographic characteristics.

On the other hand, this conclusion differs from the findings of the previous study (Marzouk & Abo-ElHassan, May 2014) which proposed that the direction of the expansions and mitigation in the Nile Delta have to be towards the west as shown in Figure 12. However, this research proposes that the expansion and mitigation is better directed towards the east of the Nile Delta, as shown in Figure 13.

In order to have the most accurate conclusion more factors must be taken in the consideration. Factors considering more consequences of climate change besides the sea level raise, in addition to taking in the consideration more factors that lead migrants other than the climate change.
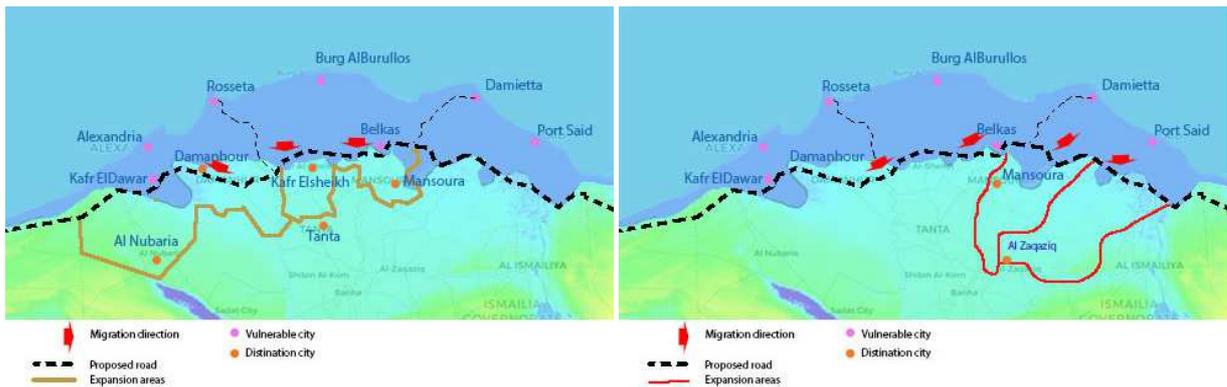
Figure 12: migration direction and mitigation areas, inspired by (Marzouk & Abo-ElHassan, May 2014). Figure 13: proposed migration direction and mitigation areas, source: author

6 CONCLUSION

This research focuses on assessing the vulnerability of the Nile Delta coast to sea level rise SLR caused by climate change, and the subsequent migration flow. Understanding these factors is crucial for adapting to the effects of a changing climate, especially sea level rise. Yet many aspects of human migration in response to climate change remain poorly understood. The Nile Delta region of Egypt with its highly populated governorates and vulnerability to the potential impacts of SLR and inundation was examined.

The research projects that by 2050, under various scenarios of sea level rise and its impacts, as many as six million people in the coastal area of the Nile Delta may be forced to migrate due to direct inundation. To assess the relocation of these migrants and where the best destinations are, models from existing literature have been applied to determine migration flow, and the destination of the migrants have been predicted accordingly. In addition to evaluating those destinations it is found that the most reliable destination is the east of the Nile Delta, especially the Al Sharqia governorate. The study also highlights the need for further research in understanding the complexities of human migration in response to climate change.

7 RECOMMENDATION

Further studies on the coastal zones of the Nile Delta and other Deltas worldwide should cover aspects such as groundwater salinity, infrastructure, and the natural resources of the coastal zone, in addition to the emphasis on coastal flooding due to expected sea-level rise. It is also recommended that vulnerable areas prone to inundation in the coastal zone of the Nile Delta should have additional protective construction to prevent inundation and subsequent migration.

To be fully aware of the migration flow due to climate change more data about climate change consequences other than the sea level rise must be studied and to be available for researchers so that climate havens can be spotted properly.

To prepare for the expected migration trend due to climate change, the government must develop policies and regulations that prioritise safety and equity. In addition, further research could come up with applications or sources that would help migrants to find the perfect spot.

8 REFERENCES

Al-Agha, D., Closas, A., & Molle, F. (2015). Survey of groundwater use in the central part of the Nile Delta. Australian center for international agricultural research.

Climate change knowledge portal . (2021). (The World Bank Group) Retrieved january 5, 2023, from https://climateknowledgeportal.worldbank.org/country/egypt

Dame, U. o. (n.d.). University of Notre Dame: Notre Dame Glopal adaptation initiative. Retrieved January 5, 2023, from https://gain.nd.edu/our-work/country-index/matrix/

Davis, K. F., Bhattachan, A., PaoloD'Odorico, & Suweis, S. (June 2018). A universal model for predicting human migration under climate change: examining future sea level rise in Bangladesh. Environmental research letter .

Dawod , G., & Mohamed, H. (October 2015). High-Precision GPS Monitoring of the Land Subsidence in the Nile Delta:Status and Preliminary Results. Regional Conference on Surveying & Development. Egypt .

(March 2016). EGYPT THIRD NATIONAL COMMUNICATION: Under the United Nations Framework Convention on Climate Change. Egypt: Egyptian Environmental Affairs Agency (EEAA).

El Raey, M., El-Askary, H., El-Hattab, M., & Kafatos, M. (December 2009). Impact of Sea Level Rise on the Low Land Area South East of Alexandria, Egypt. Egypt : University of Alexandria and Regional Center for Disaster Risk Reduction.

El-Quilish, M., El-Ashquer, M., Dawod, G., & El feki , G. (2022). Development of an Inundation Model for the Northern Coastal Zone. Arabian Journal for Science and Engineering(48), 601–614.

Jan C. Semenza, K. L. (2019). Climate change impact on migration, travel, travel destinations and the tourism industry. Journal of Travel Medicine, 1-13.

Kazem, K. (2021, March 22). Egyptian cabinet information and decision support center . Retrieved october 1, 2022, from https://www.idsc.gov.eg/DocumentLibrary/View/4573

Lucidhome. (n.d.). Retrieved May 1, 2023, from https://www.lucidhome.co/?ref=blog.lucidhome.co

map, W. t. (n.d.). topographic-map.com. Retrieved may 6, 2023, from https://en-gb.topographic-map.com/map-cbdnx/Egypt/?center=53.17312%2C31.9043&zoom=2

Marandi, A., & Main, K. L. (2021). Vulnerable City, recipient city, or climate destination? Towards a typology of domestic climate migration impacts in US cities. Journal of Environmental Studies and Sciences volume, 11, 465–480.

Marzouk, A., & Abo-ElHassan, M. (May 2014). الـــدلتاوات علـى وتأثيرهـــا المناخيـــة التغيـــــارت. The International Conferance about the consequences of the climate change on Africa . Egypt.

Mohamed Arouri, A. B. (may 2017). IS INTERNAL MIGRATION A WAY TO COPE WITH CLIMATE CHANGE? EVIDENCE FROM EGYPT. Egypt: The Economic Research Forum (ERF).

Perez, I., Kassim, Y., Ringler, C., Thomas, T., Eldidi, H., & Breisinger, C. (2021). CLIMATE-RESILIENCE POLICIES AND INVESTMENTS FOR EGYPT'S AGRICULTURE SECTOR. Egypt: International Food Policy Research Institute.

Refugia Research Coalition. (n.d.). Retrieved May 1, 2023, from https://www.climaterefugia.org/

sector, P. S. (September 2019). Migration Booklet in Egypt 2018. Egypt: Central Agency for Public Mobilization and Statistics (CAPMAS).

USAID. (September 2015). Climate change information fact sheet, Egypt.

Co-Creating Inclusive Public Spaces: Engaging Underrepresented and Marginalized Communities in the Planning Process

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1 ABSTRACT

Demographic data show that life expectancy is increasing, due to medical developments, higher living standards, healthier diets, etc. But longer life expectancy also means a higher proportion of the elderly population with various functional handicaps. The concept of functionally disabled people is broad and can include persons with disabilities, the elderly, pregnant women, young children and anyone who is permanently or temporarily handicapped in some way. This paper reviews the academic research in the field of architecture in relation to the accessibility of public spaces for persons with disabilities, with a focus on co-creation and community engagement.

For all people, independent movement and mobility are essential. A requirement for ensuring the independent movement of persons with disabilities and their integration into society is the physical accessibility of urban areas and buildings. The technical foundations for accessibility design have been established by universal design's principles and guidelines, but they still require aesthetic value to be added. Allowing disabled people access to public spaces increases their visibility, which strengthens their sense of independence and autonomy and promotes a more positive perception of society. Persons with disabilities are less stigmatized as a result of their inclusion in society, and the general public and professionals are more aware of the need to modify environments and services so that everyone can use them. Inclusion of persons with disabilities in society leads to destigmatization and increased awareness among professionals and the general public about the importance of adapting the environment and services so that all users can use them on equal terms.

However, more than technical solutions are required to achieve accessibility and inclusion. Co-creation and community involvement are essential components of creating accessible and inclusive public places. Co-creation is a design approach that involves end users and designers working together to jointly develop solutions that are tailored to their needs (Prahalad & Ramaswamy, 2004). Community participation means actively integrating people of the community in the design and planning processes, particularly those who are underrepresented or marginalized, to ensure that their viewpoints are taken into consideration.

Architects frequently associate disability with accessibility and compliance with spatial legislation, but they overlook the social aspect of disability and the added value it can bring. Individuals with sensory and physical limitations view spaces differently, giving them a distinct perspective on and experience with the built world. By incorporating underrepresented and marginalized people in the design process, architects can acquire a more diversified perspective on accessibility and inclusivity, leading to more effective and meaningful design solutions.

This paper proceeds by saying that community involvement and co-creation are critical for developing inclusive and accessible public spaces. To accomplish accessibility and inclusion, more than simply technological improvements are required; a societal and cultural shift in favour of respecting diversity and strengthening underrepresented and marginalised people is also required. Involving persons with disabilities in the design and planning process may result in a more inclusive and equitable society.

Keywords: built environment, inclusion, urban space, disabled people, accessibility

2 INTRODUCTION

According to statistics provided by the World Health Organization (WHO, 2022), approximately 1.3 billion individuals, constituting 16% of the global population, are estimated to experience some form of disability. Furthermore, demographic data indicate noticeable growth within the ageing segment of the population, consequently leading to an increase in the number of individuals with disabilities. It is important to acknowledge that the definition of functionally disabled people encompasses a wide range of individuals, including those with disabilities, the elderly, pregnant women, young children, and anyone facing permanent or temporary limitations owing to various impairments.

The Convention on the Rights of Persons with Disabilities, the first international human rights treaty of the United Nations (UN) concerning the protection of the rights of persons with disabilities and the prevention of discrimination against them, introduces a social perspective into its definition. In contrast to the past, when individuals with disabilities were often perceived as recipients of medical treatment, the Convention recognized them as bearers of human rights. As per the Convention's definition, a person with a disability is „a person who has long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others" (UN General Assembly, 2007). Disability is defined as „an evolving concept, and results from the interaction between persons with impairments and attitudinal and environmental barriers that hinder their full and effective participation in society on an equal basis with others" (UN General Assembly, 2007).

The European Union (EU) recognizes and respects the right of persons with disabilities to measures ensuring their independence, social and occupational integration, and participation in community life, as stated in Article 26 of the Charter of Fundamental Rights of the European Union. In the European Action Plan 2006-2007 on the situation of disabled persons, the EU sets one of its three goals: „removal of barriers in the environment that prevent disabled persons from using their abilities" based on the principle of 'design for all' (European Commission, 2005).

In Slovenia, the rights of persons with disabilities are guaranteed by Article 14 of the Constitution of the Republic of Slovenia, which guarantees equality before the law and „equal human rights and fundamental freedoms for all, irrespective of nationality, race, sex, language, religion, political or other opinion, property, birth, education, social status, disability or any other personal circumstance". The field of social inclusion and equal opportunities for persons with disabilities and ensuring unhindered access is regulated in Slovenia by legal acts, such as the Equalization of Opportunities for Persons with Disabilities Act (ZIMI), Social Inclusion of Disabled Persons Act (ZSVI), Building Act (GZ-1), and Rules on Universal Construction and the Use of Construction Works.

For all people, independent movement and mobility are essential. A requirement for ensuring the independent movement of persons with disabilities and their integration into society is the physical accessibility of urban areas and buildings. If space is adapted to the needs of persons with disabilities, it becomes suitable for all users. This paper aims to provide a systematic literature review in the field of architecture and urbanism related to the paradigms of universal design and the relationship of architecture and architects with persons with disabilities. Additionally, the article will shed light on examples of good practices regarding the involvement of disabled individuals in the planning process, mutual collaboration, and learning.

3 CONCEPTS OF ACCESSIBILITY

The concept of accessibility design and planning is called differently depending on its occurrence in different periods and geographical areas, e.g. 'universal design', 'inclusive design', 'design for all', 'barrier-free design', 'accessible design', etc. All of the mentioned concepts have the same common principle, which advocates the design of the environment and products in such a way that, to the greatest extent possible, all people can use it. However, different terms describing the same design concept can lead to poorer awareness, slower implementation of established concepts in practice, and deliberate omission of suitable solutions (Albreht et. al, 2017, Persson et. al, 2104, Iwarsson & Ståhl, 2003).

The concept of 'barrier-free design' first emerged in the United States of America (USA) in the 1960s when the American National Standard for Accessible and Usable Buildings and Facilities was issued. The impetus for the development of the standard was the return of persons with disabilities from the Vietnam War to the USA. The aim was to provide an alternative to institutional healthcare and to support independent living (Persson et al., 2014).

The concept of 'universal design' has its roots in the concept of 'barrier-free design'. The American architect Ronald L. Mace, in the 1970s, defined the concept of universal design as "design that is usable by all people to the greatest extent possible, without the need for adaptation or specialised design" (Mace et al, 1991). Mace, had been a wheelchair user since childhood, said that the removal of the 'special needs' label was the most significant change brought about by the use of universal design (Null, 2014).

116

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Architect Selwyn Goldsmith explored the field of 'universal design' in the United Kingdom (UK). Goldsmith placed the disabled at the top of the universal design pyramid, demonstrating a participatory approach to design 'from the bottom up' (Goldsmith, 2000). He was the first architect to introduce a system of sloping access over kerbs or ramps on the pavement to facilitate the passage of wheelchair users (Goldsmith, 1997:214).

The term 'design for all' was defined in the 'Stockholm Declaration' by the European Institute of Design and Disability (EIDD) as „design for human diversity, social inclusion and equality". The Declaration was adopted by EIDD members at the Annual General Meeting in Stockholm on May 9, 2004.

The term 'inclusive design' is the most commonly used term in the UK. The British Standards Institute has defined 'inclusive design' as: „the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible on a global basis, in a wide variety of situations and to the greatest extent possible without the need for special adaptation or specialized design" (BSI TBSI, Vol. BS 7000-6; 2005). The definition is similar to the purposes of 'universal design' and 'design for all', but includes the phrase 'as reasonably possible'. This means that adaptations to achieve accessibility do not have to be made if they are too expensive or difficult to achieve. This phrase allows accessibility solutions not to be implemented, which is unacceptable as it excludes vulnerable groups and denies them equal use of services and facilities.

The ISO standard defines the concept of 'accessible design' as a „design focused on principles of extending the standard design to persons with some type of performance limitation to maximize the number of potential customers who can readily use a product, building or service" (ISO/IEC Guide 71:2014).

In Slovenia, architect Marija Vovk worked on the topic of accessibility. With her handbook "Designing and adapting the built environment for the benefit of persons with disabilities"[1] (Vovk, 2000), she has made an outstanding contribution to the initiation of the process of removing architectural barriers and to raising awareness among professionals about the problem of the inaccessibility of the built environment. The research group, led by landscape architect Albreht Andreja, published a design manual 'Space for All', supplemented the guidelines for designing a space free of built and communication barriers, suitable for all users, with guidelines and examples of good practice also for members of the blind and partially sighted group (Albreht et al., 2010: 27-31).

The essence of universal design is to design and plan the built environment, products, and systems without creating barriers and, consequently, to enable the inclusion of different groups of people in social life. Vovkova stated that "the problems of the functionally handicapped or people with various disabilities in integrating into the living environment are mainly manifested in the inaccessibility and uselessness of the built environment; in other words, integration into everyday life, into society, is very difficult or even impossible for these people" (Vovk, 2000). By creating spaces that are adapted to different groups and the needs of people, social integration and inclusion are supported (Rodi, 2020). Therefore, designing spaces for different groups of people is a key element in the design process. An accessible physical environment has a significant impact on the accessibility of public spaces for persons with disabilities, and enables a change in the social environment, particularly in terms of society's behaviour and attitudes towards persons with disabilities (Butler & Bowlby, 1997). If persons with disabilities are given access to public spaces, their presence increases, thus strengthening their sense of independence and autonomy, while also fostering a more positive understanding of society. The inclusion of persons with disabilities in society also leads to destigmatization and awareness among professionals and the general public of the need to adapt the environment and services so that they can be used by all users on equal terms.

4 ENHANCING ACCESSIBILITY AND INCLUSIVE DESIGN IN ARCHITECTURE

Architects, planners and designers need to be aware of the needs and difficulties faced by persons with disabilities to plan and design a barrier-free built environment (Vovk, 2000), and this statement is often unfortunately not the case. In contemporary architectural practice, it has been repeatedly shown that architects do not consider the needs of persons with disabilities when designing architecture. Research shows that architects often stereotype disabled individuals as wheelchair users only, without considering the needs of persons with cognitive or sensory impairments (Imrie & Hall, 2001; 97). Furthermore, universal design

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[1] Načrtovanje in prilagajanje grajenega okolja v korist funkcionalno oviranim ljudem, Vovk, M., 2000.

guidelines and examples are based on standardized criteria and narrowly linked to legislation and regulations (Ahmer, 2014; Boys, 2014; Vermeersch & Heylighen, 2015; Kajita, 2020), which leads to a sense of creative limitation and an inability for designers to develop inventive solutions. The challenge for contemporary architecture in designing spaces for persons with disabilities lies in designing buildings and built environments that do not simply meet the requirements of regulations. Such a design requires creative thinking and a change in perspective, which will ultimately offer progressive and thoughtful solutions (Ahmer, 2021; Steinfeld & Maisel, 2012).

4.1 Embracing Inclusivity: The Impact of Inclusive Architecture

Inclusive design, which aims to make objects and spaces accessible to a wide range of people, including those with physical, visual, or cognitive impairments, is a direct response to the problems of inadequate design practices and marginalization. While some individuals might raise doubts about the importance of considering the needs of perceived 'minority' groups, such as persons with disabilities, in architecture, it is crucial to recognize and address potential challenges and concerns that might hinder the adoption of inclusive design solutions. One of the common concerns is that designing for accessibility might compromise the aesthetics or architectural integrity of a building or space. Some architects may fear that accommodating accessibility features could lead to a perceived loss of creativity or will impair their artistic vision. Concerns about the cost and viability of including inclusive design components, particularly in pre-existing structures, may also arise. It may appear that retrofitting older buildings to meet accessibility standards is a difficult and costly task.

Furthermore, resistance may result from a lack of understanding or awareness of the diverse needs of persons with disabilities and other marginalised groups. Architects and designers may not fully comprehend the variety of challenges encountered by various users, resulting in the inadvertent omission of certain accessibility requirements (Imrie & Hall, 2001). Outdated attitudes and stereotypes about disability may also contribute to a lack of willingness to embrace inclusive design principles.

Nevertheless, it is critical to recognise that inclusive solutions benefit a much larger community than just those believed to be 'minority'. Designing accessible ramps and entrances not only improves mobility for people with impairments, but also helps the elderly, parents with strollers, and anybody with temporary ailments or mobility issues. Similarly, features such as tactile walking surface markers at crossroads, which were originally designed to assist visually impaired individuals, now serve as useful cues for everyone, signalling changes in the surface and improving general pedestrian safety and direction.
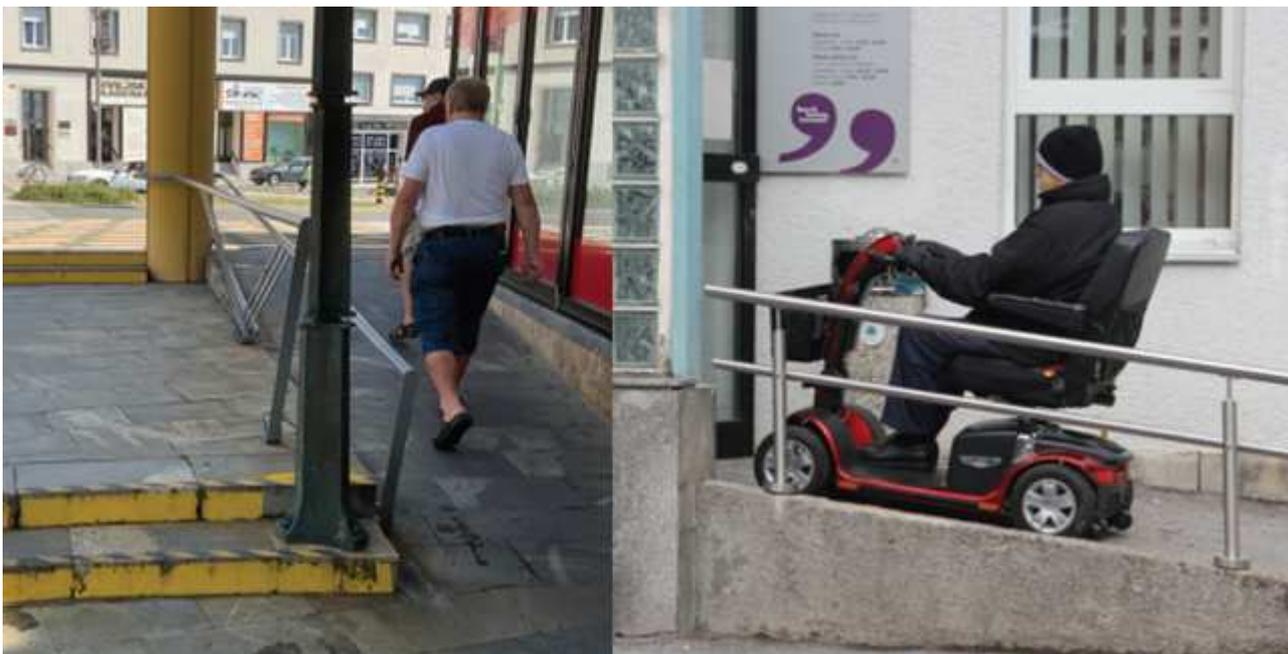
Figure 1: The ramps are also used by elderly people and elderly people on mobility scooters to make it easier to overcome the height difference. Source: Geodetic Institute of Slovenia

4.2 Shifting Perspectives: Designing for Inclusion

A good example of forward thinking in contemporary architecture is the Guggenheim Museum designed by Frank Lloyd Wright. The museum represents one of the first examples of the use of universal design. In this context, a ramp that runs through an entire building represents a space that is more than just a place for movement, an element to overcome the height difference. The ramp's meaning goes beyond its primary function of communication and becomes a space that allows equal and unobstructed use by all people regardless of their physical abilities.

Maison Bordeaux, designed by Rem Koolhaas for a person in a wheelchair, confirms the thesis that it is possible to design facilities that are accessible to functionally disabled people and at the same time offer technologically advanced and aesthetically perfect solutions. Koolhaas designed the concept of a house according to the needs of the user and outside the framework of the regulations' guidelines, which prescribe only the minimum technical requirements for the dimensions of doors, widths of corridors, ramps, etc. The house consists of three volumes with different programs connected vertically by a lifting platform. The lifting platform creates a spatial dynamic that always changes and redefines the space in which it stops (Ahmer, 2021). The house represents an innovative approach and an architectural achievement that manifests Le Corbusier's concept of the house as a 'machine for living'.

4.3 User participation and collaboration between architects and persons with disabilities

Accessibility should not be a constraint on quality architectural design. As Davis and Lifchez state, architects must actively seek out persons with disabilities to help them understand their needs. However, when designing, they should be careful not to stigmatize the client concerning possible functional impairments (David & Lifchez, 1987). In architectural practice, the embodied experiences of disabled people are rarely used as an important source for planning because they appreciate different spatial qualities than architects from different perspectives in their daily interaction with the built environment. (Vermeersch & Heylighen, 2015, Heylighen & Nijs, 2011).

Studies (Vermeersch & Heylighen, 2015; Heylighen et al., 2013; Heylighen et al., 2016; Heylighen & Nijs, 2011; Schijlen et al. 2015) conducted by architect Heylighen and colleagues show that collaboration between architects and persons with disabilities has been a positive experience for both parties. This study aimed to explore the potential of employing a disabled consultant who would experience their own space to advise architectural designers on how to improve architectural solutions. The findings of these studies suggest that such a service could add value to architectural design. However, additional efforts should be made to convince stakeholders of this added value, and alternatives for initiating innovative ideas should be further explored (Schijlen et al. 2015). This study also considered the social aspects and social value of employing a disabled person can bring. The presence of persons with disabilities in the workplace promotes awareness and acceptance of differences within the organization, which can have an impact on wider society. Employing a person with disability also has a positive impact on the disabled person, as they are affirmed as full members of society through employment.

Luck's study followed the work of designers who worked with persons with disabilities to create bespoke and tailored solutions to enable them to live more independently. An important conclusion that emerges from the results of this study is that people will respond positively to designer's products (this can also include architectural objects) if they are offered the opportunity to actively participate in the design process (Luck, 2018).

A notable example of collaboration with disabled persons is a project „Enabling multimodal mobility of persons with various disabilities" which is led by the Geodetic Institute of Slovenia and financed by the Ministry of Infrastructure of the Republic of Slovenia. The project's main goal is to improve the mobility of blind and partially sighted people, people with limited mobility, older people, and schoolchildren who may be at greater risk while navigating traffic. This can be achieved through innovative technologies, quality spatial data, useful information, and education for more independent and safer mobility of target groups. The project follows the principle of "Nothing about us without us" which is the motto of the European Disability Forum (EDF). Persons with disabilities were involved in all phases of the project, from the development of the data model to fieldwork and the promotion and transfer of knowledge. Engaging with representatives of different vulnerable groups is essential, as it provides insight into their needs and experiences of moving in space. (Rener et al., 2021).

Figure 2: Figure 2 shows the field capture training and the sharing of previous experiences among the capturers. Source: Geodetic Institut of Slovenia.

However, architects Davis and Lifchez warn that "participation will be unsuccessful if the architect is not genuinely committed to the idea of consultation by lay people in general or by lay persons with disabilities in particular, or if the architect considers such participation to be a waste of time that diminishes professionalism or compromises the aesthetic integrity of the project" (Lifchez & Davis, 1987). The negative stance against the participation of this kind can only stem from ignorance or fear of something that is not close to us or is completely unknown (Butler & Bowlby, 1997; 420). Furthermore, Boys (2014; 34) argues that user participation in architectural practice is often treated as an add-on, similar to how disability is considered an add-on to "normal" architecture.

In the process of architectural planning, considerations regarding accessibility in a building are typically addressed towards the end of the process. Accessibility and disability are equated solely to adherence to technical and functional requirements. Consequently, architects tend to neglect the consideration of disability as an integral part of their design activities, except in specific cases. Instead, they tend to rely on pre-existing off-the-shelf solutions that lack creative engagement. (Boys, 2014). Imrie suggested that universal design principles should be included to achieve high aesthetic requirements. Accessibility elements thus become part of the whole, not just an addition to architecture (Imrie, 2012). Elements, such as ramps and lifts are often seen as a functional addition to the architecture, which must be built to meet regulations and are devoid of any aesthetic considerations. They are most often placed where they will do the least harm to the aesthetic perfection of a building's architecture, hidden from the eyes of the majority.

Such practices are most often observed in historically protected existing buildings, where a solution must be found to allow access to persons with disabilities. In such cases, various half-solutions are used, such as a separate entrance for persons with disabilities, through the technical areas of the building away from the main entrance. In this way, we deny the non-discriminatory principle of inclusive design, as we marginalize a group of people, hide them, and thus promote stigmatization.
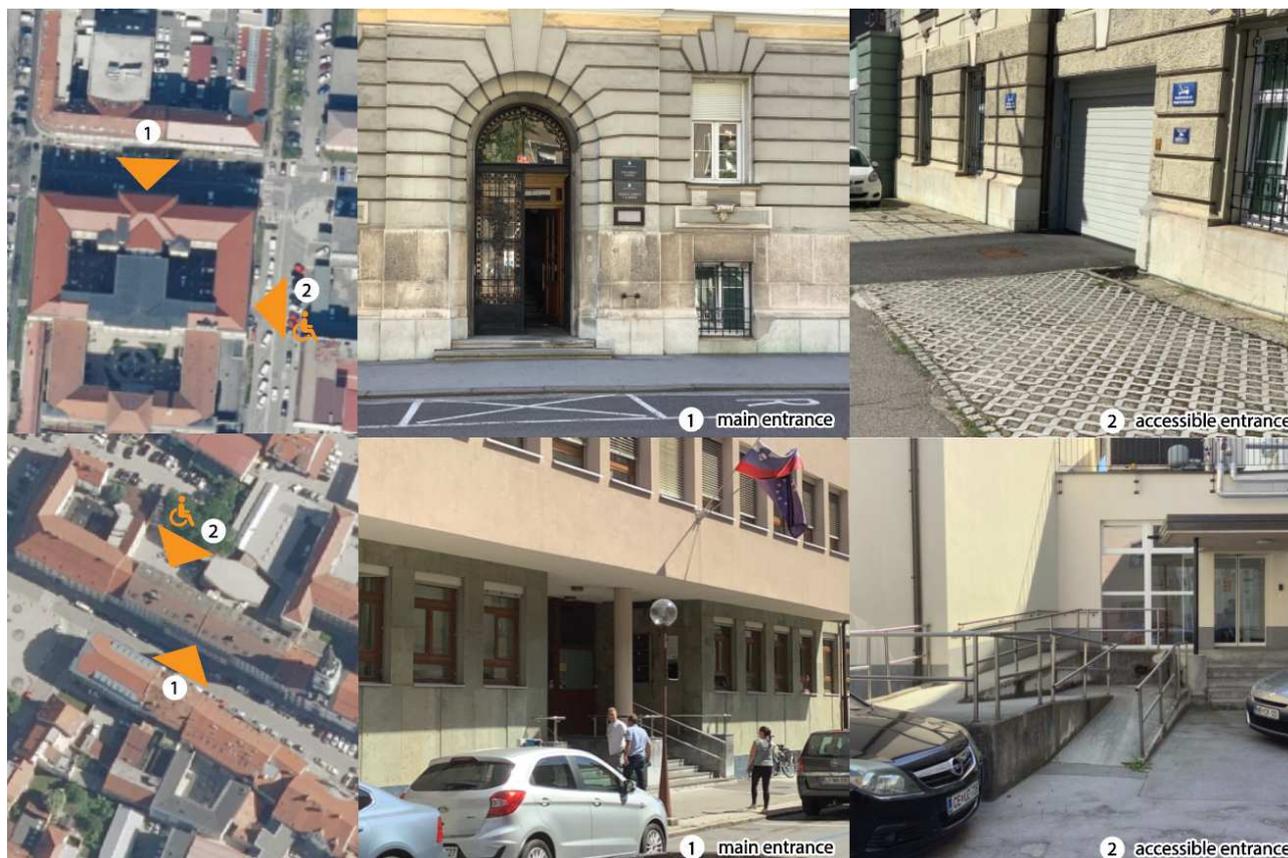
Figure 3: Figure 3 shows the location of the accessible entrance for people with reduced mobility away from the main entrance to the building. Source: Geodetic Institute of Slovenia.

4.4 Inadequate solutions and Marginalization

As an example of contemporary architecture that does not consider accessibility in its design process, we can mention the work of architect Peter Eisenman, specifically the Memorial to the Holocaust in Berlin. The memorial is situated in a city block and consists of stone volumes. These volumes are placed on an orthogonal grid intersected by pathways running in north–south and east–west directions. The varying heights of the volumes created an undulating relief that was also reflected in the ground, forming a dynamic topography of alternating valleys and hillocks. During the design process, the minimum technical requirements regarding pathway widths and slopes that would enable independent wheelchair access were not considered. Consequently, individuals using wheelchairs were deprived of the experiential aspect of the memorial. Following criticism from the Swiss Center for the Disabled, 13 out of 130 pathways were subsequently modified to comply with the accessibility regulations. The justification for not considering technical requirements during design was that it was an artistic work not bound by accessibility legislation (Fitzsimons, 2012). This raises the question of whether persons with disabilities are not allowed to appreciate art?

4.5 The Multisensory Experience of Space

The relationship between people and space and how people use and experience them is fundamental to architectural practice. Davis and Lifchez, in their 'Open Letter to Architects', point out that "accessibility is more than a question of access or logistics, it is also about the quality of the experience. How one feels in a space, how one interprets it, or even whether one can interpret it adequately - these are all less quantifiable but crucially important aspects of accessibility" (Davis & Lifchez, 1987). We experience space with all of our senses. "The senses, touch and taste as well as sight and hearing, have aesthetic qualities. They do not have them alone, but rather in connection; as interactive rather than as simple and separate entities." (Dewey in Pallasmaa, 2005). When addressing architectural quality, encompassing functional characteristics, appeal, suitability, and aesthetic worth, we frequently utilise an unimpeded user with fully functional senses as the primary metric of success. If we take away the sight of our user, we can no longer evaluate a certain

architectural quality. The criteria for evaluating architectural qualities change if the user is a wheelchair user (Fitzsimons, 2012).

If a person loses any of their senses, they start to rely more on the remaining senses. The experience of space, their use, and spatial orientation varies between different disability groups. People without disabilities first perceive the space as a whole and then individual elements; for blind people, the process of perceiving space is the opposite - they first perceive individual elements and then form an overall picture from the interconnected individual elements (Ahmer, 2021).

As part of their study at the University of Leuven, researchers not only investigated physical obstacles but also examined the sensory characteristics of objects. The results of this research highlight the key role played by sensory perception in the evaluation and experience of a space. Functionally impaired individuals rely on their senses of smell, sight, hearing, and touch to assist them in understanding and navigating the object more easily, and their senses also influence the way they experience space. Examples from this study illustrate that the extent to which a building was experienced as accessible depended not only on its physical accessibility but also on how the space was felt and experienced by these individuals, who may have a unique perspective differing from most architects. Persons in wheelchairs are more attentive to visual quality from a lower perspective. Individuals with visual impairments possess both acoustic and tactile qualities. Persons with low vision are able to pinpoint poor lighting conditions. Individuals with autism are strong at identifying the general atmosphere of spaces, providing insight into the legibility of a building; for example, whether a public passageway is also experienced as public (Vermeersch & Heylighen, 2015).

5 CONCLUSION

Co-creation and community involvement are essential components in establishing accessible and inclusive public spaces for individuals with disabilities. Creating an accessible and useful environment for a diverse group of people, such as those with impairments, is a huge challenge. Various approaches and concepts have arisen around the world in response to the accessibility challenge, with the common goal of improving accessibility and ensuring inclusion for all individuals. The concept of universal design, the most well-known concept of accessibility, is a relatively new concept, first appearing 60 years ago. As our understanding of diverse abilities and user needs continues to evolve, there is plenty of room to upgrade and enhance the principles and practices of universal design. Based on the research examples provided, it becomes evident that the experience of space for persons with disabilities is desirable but often undervalued. Despite its importance, it is not fully acknowledged as an essential and valuable aspect of the architectural design process.

Architecture, as a direct and unavoidable medium, carries the responsibility for social relevance and plays a vital role in creating an inclusive society. Contemporary architecture has, to some extent, lost touch with the holistic dimensions and emotional proportions of individuals, irrespective of their physical abilities or limitations. Pallasmaa also concluded that „the inhumanity of contemporary architecture and modern cities can result in the neglect of the body and senses and the imbalance of our sensory system" (Pallasmaa, 2005). However, it is critical to consider architecture not in isolation, but rather as part of a larger interdisciplinary framework.

With interdisciplinary cooperation, we could bring out the potential for more inclusive and successful design solutions by implementing the principles of co-creation and community involvement. By combining the expertise and viewpoints of various fields, such as sociology, psychology, and urban planning, architects are able to move beyond the constraints of a purely architectural approach and develop a deeper understanding of the holistic dimensions and emotional proportions of people. Understanding societal dynamics and the social effects of built environments requires sociological insights. Psychological perspectives on design serve to clarify the complex relationship between individuals and the built environment around them by focusing on the emotional and sensory components of design. Urban planning expertise ensures that accessibility and inclusivity are integrated into the planning of the wider built environment. Using this interdisciplinary approach, architects may create environments that promote emotional and sensory stimulation for all persons, going beyond simply physical accessibility. Recognising the significance of inclusive design and actively including specialists and persons with disabilities in the design process can lead to places that are not just physically accessible but also emotionally and sensory stimulating.

Regardless, when it comes to applying inclusive design practises, there may be certain restrictions and problems. To overcome these obstacles, a proactive strategy is required. Cooperation among specialists, stakeholders, and the community is vital for overcoming potential difficulties. It entails cultivating an inclusive mindset, raising awareness, and removing barriers to the construction of truly inclusive places on physical, social, and psychological levels. We may go closer to building a more inclusive society by acknowledging and actively trying to address these problems.

As society continues to evolve, the importance of designing for diverse needs has become increasingly evident. Architects can leverage knowledge from multiple disciplines to develop environments that reflect society's aspirations for a more inclusive environment by embracing multidisciplinary collaboration. The thought of architects Davis and Lifchez in a meaningful way summarizes the important role of architecture in the inclusive society we are striving for, as architecture must be socially responsible given its direct and inevitable nature.

"The architect as visionary must remind others that architecture reflects society's relationship to itself, that creating an environment is a dynamic process, and that architecture must express society's highest aspirations and ideals." (Davis and Lifchez, 1987)

6 REFERENCES

AHMER, Carolyn: Making Architecture Visible to the Visually Impaired. In: Assistive Technology Research Series. 2014. 2014 Jun 16-18; 35, 204–213. Amsterdam; Washington, DC, 2014.

AHMER, Carolyn: The Qualities of Architecture in Relation to Universal Design. In: Studies in Health Technology and Informatics. 2021 Jun 9 – 11, 282, 41–51. 2021.

ALBREHT, Andreja, KRIŠTOF, Petra, PUČNIK, Alenka, BERA, Alenka, ŽIBERNA, Franci: Prostor za vse, priročnik. Mestna občina Maribor. Maribor, 2010.

BOYS, Jos: Doing Disability Differently: An alternative handbook on architecture, dis/ability and designing for everyday life (1st ed.). Routledge. ZDA, 2014.

British Standards Document BS 7000-6:2005. Design management systems Managing inclusive design

Building Act (GZ-1). Official Gazette of the Republic of Slovenia, No. 199/21 and 105/22 – ZZNŠPP.

BUTLER, Ruth, and BOWLBY, Sophia: Bodies and Spaces: An Exploration of Disabled People's Experiences of Public Space. In: Environment and Planning D: Society and Space, 15(4), 411–433. 1997.

Charter of Fundamental Rights of the European Union. Official Journal of the European Union 2012/C 326/02

DAVIS, Cheryl and LIFCHEZ, Raymond: An Open letter to Architects. in Lifchez, Raymond: Rethinking Architecture: Design Students and Physically Disabled People. University of California Press. USA, 1987.

EUROPEAN COMMISSION: Situation of disabled people in the enlarged European Union: the European Action Plan 2006-2007. 2005.

Equalisation of Opportunities for Persons with Disabilities Act (ZIMI). Official Gazette of the Republic of Slovenia, No. 94/10, 50/14 in 32/17.

FITZSIMONS, J. Kent: Seeing Motion Otherwise: Architectural Design and the Differently Sensing and Mobile. In: Space and Culture, 15(3), 239–257. 2012.

GOLDSMITH, Selwyn: Designing for the Disabled. The New Paradigm. Architectural Press. Great Britain, 1997.

GOLDSMITH, Selwyn: Universal desgin: a manual of practical guidance for architects. Architectural Press. Great Britain, 2000.

Guide for addressing accessibility in standards. ISO/IEC Guide 71:2014.

HEYLIGHEN, Ann and NIJS, Greg: Studying (Architecture) in Dialogue with Disability. Reflections on the Public Role of the University. In: Curating the European University. Leuven, 2011.

HEYLIGHEN, Ann, SCHIJLEN, Jeandonné, VAN DER LINDEN, Valerie, MEULENIJZER, Dorien, VERMEERSCH, Peter-Willem: Socially Innovating Architectural Design Practice by Mobilising Disability Experience. An Exploratory Study. In: Architectural Engineering and Design Management, 12, 253-265. 2016.

HEYLIGHEN, Ann, VAN DOREN, Caroline, VERMEERSCH, Peter-Willem: Enriching Our Understanding of Architecture Through Disability Experience. In: Open House International, 38, 7-19. 2013.

IMRIE, Robert and HALL, Peter: Inclusive Design: Designing and Developing Accessible Environments (1st ed.). Taylor & Francis. ZDA, 2001.

IWARSSON, Susanne, STÅHL, Agneta: Accessibility, Usability and Universal Design: Conceptualizing Person-Environment Relationships, in: Age-Inclusive Public Space. Hatje Cantz, Berlin, pp. 57–66. Berlin, 2020.

IMRIE, Robert: Universalism, Universal Design and Equitable Access to the Built Environment. In: Disability and rehabilitation, 34(10), 873-82. 2012.

KAJITA, Masashi: What kind of bodies do architect imagine when designing? In: Hauderowicz, D., Serena K. L.: Age-Inclusive Public Space Book. Hatje Cantz Verlag, Berlin, 2020.

LUCK, Rachael: Inclusive design and making in practice: Bringing bodily experience into closer contact with making. Design Studies, 2018, Volume 54, 96–119. 2018.

MACE, Ronald L., HARDIE, Graeme, PLACE, Jaine: Accessible environments: Toward Universal Desgin. Raleigh, NC: Center for Universal Design, USA, 1991.

NULL, Roberta: Universal design: Principles and models. Taylor & Francis Group, LLC. USA, 2014.

PALLASMAA, Juhani: The Eyes of the Skin: Architecture and the Senses. John Wiley & Sons, Ltd. 2005.

PERSSON, Hans, ÅHMAN, Henrik, YNGLING, Alexander Arvei, GULLIKSEN, Jan: Universal design, inclusive design, accessible design, design for all: different concepts—one goal? On the concept of accessibility—historical, methodological and philosophical aspects. Universal Access in the Information Society 14, 505–526. 2015.

PRAHALAD, Coimbatore Krishnarao, and RAMASWAMY, Venkat: Co-creation experiences: The next practice in value creation. Journal of Interactive Marketing, 18(3), 5–14. 2004.

RENER, Roman, DEMŠAR, Jani, LOVRIĆ. Marina, JANEŽIČ, Miran, ŽNIDARŠIČ, Helena: Omogočanje multimodalne mobilnosti oseb z različnìmi oviranostmi : končno poročilo. Ljubljana, 2021.

RODI, Alcestis P.: (De)signs for dignity: Towards an enabling environment in Athens, Greece. In: Transactions of the Association of European Schools of Planning, 4(1), 59–79. 2020.

Rules on universal construction and the use of construction works. Official Gazette of the Republic of Slovenia, No. 41/18 and 199/21 – GZ-1.

SCHIJLEN, Jeandonné, VAN DER LINDEN, Valerie, MEULENIJZER, Dorien, VERMEERSCH, Peter-Willem, HEYLIGHEN, Ann: Exploring the potential of disability experience as consultancy in architectural design practice. In: Reframing Design. Proceedings of the 4th Participatory Innovation Conference 2015, 124-131. The Hague, 2015.

Social Inclusion of Disabled Persons Act (ZSVI). Official Gazette of the Republic of Slovenia, No. 30/18, 196/21 – ZDOsk and 206/21 – ZDUPŠOP.

STEINFELD, Edward. and MAISEL, Jordana.: Universal design: creating inclusive environments. John Wiley & Sons, Inc. Hoboken, New Jersey. USA, 2012.

The Constitution of the Republic of Slovenia (URS). Official Gazette of the Republic of Slovenia, No. 33/91-I, 42/97 – UZS68, 66/00 – UZ80, 24/03 – UZ3a, 47, 68, 69/04 – UZ14, 69/04 – UZ43, 69/04 – UZ50, 68/06 – UZ121,140,143, 47/13 – UZ148, 47/13 – UZ90,97,99, 75/16 – UZ70a in 92/21 – UZ62a.

UN General Assembly: Convention on the Rights of Persons with Disabilities: resolution / adopted by the General Assembly, 24 January 2007, A/RES/61/106

VERMEERSCH, Peter-Willem, HEYLIGHEN, Ann: Mobilizing Disability Experience to Inform Architectural Practice: Lessons Learned from a Field Study. In: Journal of Research Practice, 11(2). 2015.

VOVK, Marija: Načrtovanje in prilagajanje grajenega okolja v korist funkcionalno oviranim ljudem. Urbanistic Institute of Slovenia, Ljubljana, 2000.

WORLD HEALTH ORGANIZATION: Global report on health equity for persons with disabilities. 2022.

ZALLIO, Matteo. And CLARKSON, P. John: Inclusion, diversity, equity and accessibility in the built environment: A study of architectural design practice. In: Building and Environment. 206. 2021.

124

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Co-Creating Development in Mining Towns: the Nexus between Social Labour Plans and Integrated Development Plans for Urban Development Planning in Rustenburg, South Africa

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1 ABSTRACT

Integrated Development Plans (IDPs) and Social Labor Plans (SLPs) are two crucial short and medium-term development strategy documents guiding the development of mining towns in South Africa. Besides socioeconomic growth that mining brings to the 'host communities', mining towns experience mining-related socioeconomic problems, specifically dereliction upon the closure of mines. To ensure sustainable development guarantees for mining communities, SLPs are requirements from mining companies as part of licensing obligations in South Africa. On the other hand, IDPs are five-year strategic action plans that South African municipalities must produce at the onset of a political tenure to guide municipal development over the set period. IDPs and SLPs are mutually connected to advance municipal development planning. However, with multiple agencies involved in monitoring and implementing both development plans, there are developmental questions about integrating both plans to achieve a unity of purpose. In this article, we examine the case of Rustenburg Local Municipality, noted for its vast Platinum reserves and mining globally. The study evaluates the challenges of cocreating development through SLPs and IDPs, beginning with conceptualising, implementing and monitoring these plans. Findings were sourced from primary qualitative sources (key informant interviews) and secondary sources, including desktop reviews. The research's findings reveal that while broader stakeholder consultations exist in creating IDPs, the same is not assured for SLPs. This creates gaps in integrating and implementing both action plans. Notwithstanding this obstacle, there is substantial potential for SLPs and IDPs to collaborate on inclusive municipal development in South Africa. A synergised co-creation of SLPs and IDPs at the stages of conceptualisation and implementation by all stakeholders is vital to assuring transparency, accountability and effective implementation of both strategic action plans.

Keywords: Strategic Plans, IDPs, SLPs, Co-creation, Development Planning

2 INTRODUCTION

South Africa's Municipalities are tasked with development planning by the constitutional and policy frameworks (RSA, 1996; RSA, 2000). This developmental mandate revolves around providing basic service delivery and socioeconomic empowerment. Within this mandate, municipalities must produce IDPs, a medium termed development document projected to span the five years of municipalities' elected political leadership. IDPs elaborate the municipality's developmental blueprint "with emphasis on the municipality's most critical development and internal transformation needs" (RSA, 2000: 38). In the same vein, iterated Municipal IDPs are to align with sectoral, provincial and national development plans – these being longterm development plans while IDPs are medium termed. Development plans iterated by all the government tiers in South Africa include a Spatial Development Framework (SDF) blueprint for land use management (RSA, 2013). In essence, the developmental plans prescribe the socioeconomic future while the SDF component addresses the issue of land use management. Making these developmental plans requires a participation process for significant inputs and vetting from the stakeholders these plans serve.

SLPs can be likened to Local Economic Development strategies for mining towns, albeit prepared by mining companies as part of mining licencing requirements set by the Department of Mineral Resources and Energy (DMRE) (RSA, 2002; CALS, 2016). It is aimed at a regeneration initiative of mining towns to ensure they do not slide into dereliction resulting from mining activities. The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) defines the legal framework for SLPs (RSA, 2002). SLPs come under the mandate of addressing the mine host community needs (inclusive of labour-sending areas and adjourning locations around mining communities affected by mining activities); therefore, the application for mining rights must be accompanied by one. This is addressed in Human Resource Development programmes

(inclusive of skills development plan, career progression plan and its implementation, mentorship and its implementation and internship and bursary plan and its implementation), Local Economic Development (LED) Programme, labour downscaling and retrenchment plan, financial implementation for the SLP. As stipulated in Regulation 42 of the MPDRA, SLPs, upon approval by the DMRE, must undergo a consultation process with the host communities and be aligned with the Municipality's IDPs (ibid).

According to Regulation 43 of the MPDRA, SLPs are subject to periodic 5-year reviews, a continuous process until a closure certificate has been issued to close up mining activities in the area (RSA, 2002). SLPs and IDPs are strategic planning instruments charting the development course of mining towns in South Africa. This article begins with the methodology utilised for data collection and a literature review on development planning. An overview of the study area, presentation of findings, recommendations, and conclusion follows this.

3 OBJECTIVES

- To explore the linkage between SLPs and IDPs in municipal development planning in Rustenburg Local Municipality.

- To investigate the problems associated with implementing SLPs in Rustenburg Local Municipality.

4 METHODOLOGY

The study adopts a qualitative approach incorporating documentary reviews and key informant interviews. Documentary reviews comprised literature reviews approached with keyword searches on "strategic planning", "governance", "development planning", and "participatory planning" sourced from the Web of Science and Google Scholar. Other sources of documentary reviews were South African government policy documents guiding the legal framework for municipal development planning in South Africa. These documents include the 1996 Republic of South Africa Constitution, MPDRA and Municipal Systems Act of 2000. Information was also sourced from the Municipal Infrastructure Support Agent (MISA) archives, which provided details on the alignment and implementation of SLPs in Rustenburg Local Municipality. A total of ten key informant interviews were conducted between October 2022 and April 2023. Key informants were drawn from the Rustenburg Local Municipality staff, South Africa development stakeholders, municipal officials, DMRE officials, and residents of Rustenburg Local Municipality. Key informants were selected through the snowball sampling technique.

5 INTERPLAY BETWEEN DEVELOPMENT PLANNING AND GOVERNANCE

Governance and development planning are closely intertwined, and their interplay manifests in producing IDPs and SLPs. Development is a multidimensional process to improve the overall quality of life, encompassing economic, social, and environmental aspects (UN, 2023). Rabie (2016) defines development as an economic and technological procedure deployed to make the best use of the resources at hand to spur economic growth and elevate the quality of life of community residents. Governance, on the other hand, is, according to Fukuyama (2016), an established framework for societal cooperation and administration between sovereign and non-sovereign entities. It is a framework for interaction between private and public actors to ensure the stability of society and political entities (Kjaer, 2011; Cashore et al., 2021).

The relationship between governance and development planning comes under the nuances of 'the good governance campaign'- a definition coined by the UN-Habitat. This is defined as the quality and "access to the necessities of urban life, including adequate shelter, security of tenure, safe water, sanitation, a clean environment, health, education and nutrition, employment and public safety and mobility" (UN-HABITAT, 2002: 14).

Governance and development planning involves the imposition of subtle coercive influence over people (Rode, Terrefe and da Cruz, 2020). Although the government oversees governance, it is demonstrated that several governance players are in the urban sociopolitical sphere. Governments are charged with providing services like housing, power, education, and development control, among other duties, yet these commitments are typically not fully met (Alford and O'Flynn, 2012). Okunlola (2001) highlights the local government as critical to implementing governance and development planning. Asserted herein (ibid) as

complementary to this are poverty reduction, government accountability, participatory budgeting and planning.

From the mid-twentieth century, urban planning underwent a paradigm shift with advancements for participatory community planning rather than professional-led master planning. This is viewed as a bottom-up developmental approach and more entrusted to entrench sustainable development. According to (Clark 2013), controlling fast urban expansion is not a task the master planning idea can handle. On the global scale, frameworks for human settlement planning favoured the shift from "master planning" to "strategic planning" (Watson 2009). Its inclusion of citizen engagement was one of the justifications for adopting strategic planning. In support of strategic planning, it has been said that democracy is now more deeply ingrained in society, particularly with the rise and growing importance of civil societies and community-based groups (Friedman, 1998; Amin, 2002).

Advocacy planning, closely associated with this novel planning movement, encourages widespread community involvement to develop plans that meet the needs of underrepresented groups and give them more power (Grooms and Boamah 2018). This kind of planning encouraged chaos to bring about justice and forced public authorities to consider neglected interests (Berke 2002). Developmental Strategies are thus prepared with stated goals intending to improve local communities' quality of life and contribute to the realisation of sustainable development (Williams 2002). Essentially, development planning is devolved to the local government level, which, according to (Madzivhandila and Asha, 2012), creates favourable conditions for mobilising material, financial, and human resources. This intends to improve the delivery of services to local communities and permits the utilisation of locally accessible resources. In post-apartheid South Africa, long-term strategic city planning was embedded in the 5-year tenured Integrated Development Plans (IDPs), reviewed annually and came with 'neo-liberal' policies (Todes 2014). The allusion to neoliberal policies in planning points to private sector participation in initiating and implementing development action plans (Jessop, 2002; Brenner and Theodore, 2005). SLPs, as applicable herein, as local economic action plans prepared and implemented by mining companies can be attributed to evidential neoliberalism in South Africa's mining town development.

Monitoring and evaluation is a veritable tool for ensuring the implementation of development plans and urban growth management. According to the UN-HABITAT (2009), most urban planning frameworks fail to integrate monitoring and evaluation in their implementation processes. This trend makes it difficult to evaluate the impact of development plans. In developed countries, "monitoring and evaluation of the implementation of urban plans have become part of practice in the more progressive planning departments of cities and regions" and vice versa in "transitional and developing countries" (ibid, 2009: xvi). Development planning as a core function of local government enables crucial choices regarding the distribution of limited resources to maximise the provision of health, education, and other services. It better understands local priorities and enables accountability on resource allocation decisions. However, monitoring the implementation of local action plans will ensure good governance at the level of local government governance.

6 PRESENTING RUSTENBURG LOCAL MUNICIPALITY

Rustenburg Local Municipality (RLM) is located in the Northwest Province of South Africa, covering 3,423 square kilometers (RLM, 2022). The Gauteng City Region, which includes the metropolitan regions of Johannesburg, Tshwane, and Ekhuruleni, is within a 120km radius of the municipality regarding accessibility. The municipality is one of five municipalities comprising Bojanala District Municipality, the others being Kgetleng River Local Municipality, Moses Kotane Local Municipality, Madibeng Local Municipality and Moretele Local Municipality. RLM is a part of the Bushveld Complex. Merensky, Upper Group, Middle Group, Lower Group, and Upper Zone, rich in vanadium, are the economically significant reefs of the western limb of the Bushveld Igneous Complex (DMRE, 2022). More than half of the world's platinum-group metals (the six platinum-group metals are ruthenium, rhodium, palladium, osmium, and platinum), gold, silver, and other related minerals like vanadium, chromium, and base metals (copper, lead, tin, aluminium, nickel, and zinc) are found in this igneous body (ibid).

7 CO-CREATING DEVELOPMENT WITH THE IDP AND SLP AT RLM

The White Paper on Local Government defines IDPs as one of the tools to achieve developmental outcomes: budgeting, performance management, stakeholder collaboration and participatory planning (RSA, 1998). Typically, a municipality's IDP assesses the socio-economic and environmental realities, determines the community needs from the participatory planning and lists a developmental vision for the municipality. It is anticipated that with IDPs, municipalities would be able to align their financial priorities and conciliate with provincial, national and international strategic plans. The IDP is a tool for local development planning that assists local municipalities in creating a thorough and long-term plan to promote services and development under their purview. For IDPs to be legitimate, the conceptualisation process must entail meaningful engagement reflecting the needs and objectives of local communities. Additionally, there must be interdepartmental cooperation and horizontal governance coordination to deliver adequate service. Thirdly, the successful implementation of IDPs relies on institutionalism inclusive of professionalism and competence, especially in finance management.

The SLP is a documentary requirement by the DMRE for granting mining rights to prospective firms. Section 23 of the MPRDA (Act 28 of 2002) mandates the preparation of an SLP as one of the mining licencing and mining permit renewal requirements. Under the 2020 amendments of the Act, it became mandatory for mining firms to publish approved SLPs. Regulation, 41 of the MPRDA, gives the objectives of the SLP as set to ensure mining firms with mining rights contribute to the socioeconomic development of mining communities and labour-sending areas (RSA, 2002). The participation process is also included in the making of the MPRDA, which according to Regulation 42 of the Act, mining firms, upon notification of acceptance of mining licence application, must within 180 days consult with affected persons about the contents of the SLPs and align to the targets of the municipal IDP. The participation process must be conducted by the terms of the Environmental Impact Assessment Regulations of Sections 24 (5) of the National Environmental Management Act of 1998 (ibid). This involves an advertisement for the participation call via written notice, among others. SLPs, once approved by the DMRE, are lodged with the DMRE's Regional Manager and subject to five-year periodic reviews, which are perpetual till a mining closure certificate has been issued. Regulation 45 of the Act mandates a minimum of three annual meetings between the mining firm and stakeholders (mining communities and other affected persons) and which outcome should be included in annual reports submitted as compliance to the DMRE's Regional Manager. Regulation 46 of the Act specifies the content of SLPs and the publication mandate. Approved SLPs are to be published within 30 days of DMRE's approval in English and the dominant official local language of the mining community. This should feature on the mining companies' website, libraries, municipal and traditional council offices and mass media advertisements/publications.

8 CO-CREATING DEVELOPMENT WITH THE IDP AND SLP AT RLM

The IDP and SLP are strategic planning documents towards enhancing local economic development at RLM. The creation process of the IDP mandates participation from ward committee sessions to wider community participation sessions. Mining firms as stakeholders ought to be one of the participants of the IDP consultation sessions. This would enable knowledge of community needs and familiarisation with the IDP preparation process, thereby assisting the preparation of SLPs. Conversely, mining firms are not mandated to initiate the SLP participation process until the notification of acceptance of application documents by the DMRE. The mandatory participation process in making IDPs establishes the co-creative development protocol. However, the municipality leads the local economic development process with the support and participation of the community, civil society and other stakeholders.

9 FINDINGS

RLM, as a mining community, is listed among the Distressed Mining Communities Programme launched in 2012 (MISA, 2022). In line with this programme, MISA undertook a programme to evaluate the alignment of SLPs with IDPs. The project was carried out between May 2019 and May 2022. The evaluation procedure involved the review of Mine SLPs, IDP legal framework, meetings and discussions with municipal representatives, project site visits, compilation, and the review of status quo reports for RLM. Thirteen companies were operating in the RLM, and a total of twenty-four SLPs were noted to be operational between the period from 2004 and 2024. Only five SLPs are still in tenure; sixteen of the SLPs already expired, while

three SLPs are within two years of expiration.

A total of sixty projects were listed for implementation in the examined SLPs. Findings from the evaluation of the projects are illustrated in charts in categories of SLP-IDP alignment, Municipal awareness, and implementation status.
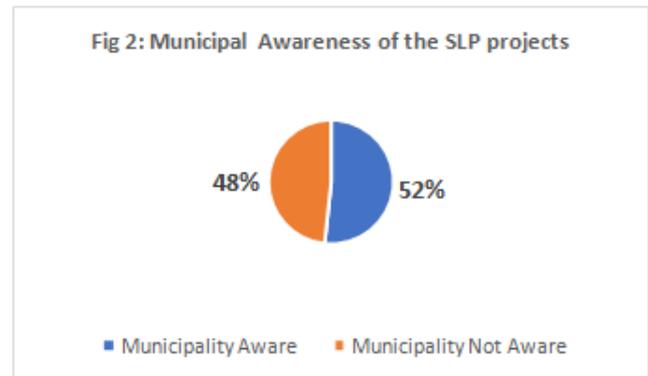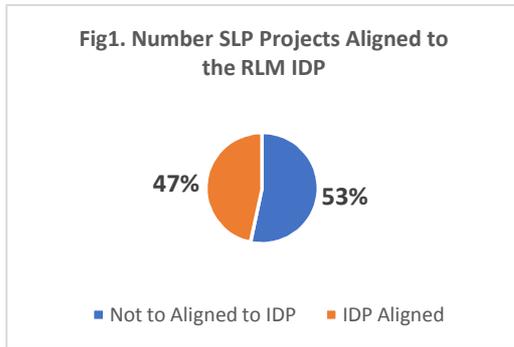
Fig. 1: Number of SLP projects aligend to the RLM IDP. Fig. 2: Municipal awareness of the SLP projects. Source: MISA, 2022.
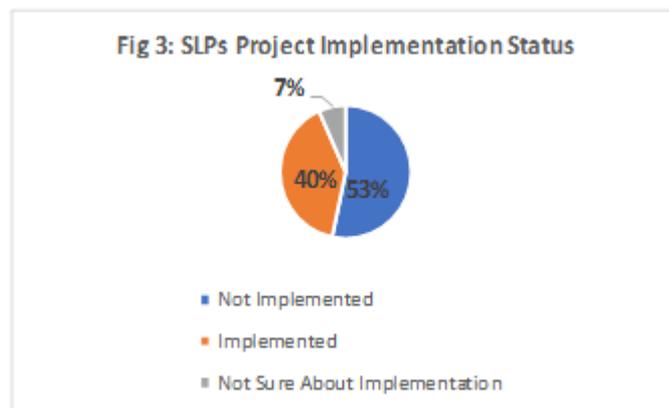
Fig. 3: SLP project implementation status. Source: MISA, 2022.

It was noted that all SLP projects not aligned with the RLM IDP(s) were not implemented. In contrast, most SLP-IDP-aligned projects were implemented except in 7% (4) cases where the implementation status is unconfirmed. Also, for the non-implemented projects, in most cases, RLM was not aware of the existence of such projects. However, ten such projects are listed in SLPs with a terminal implementation date of 2024. In summary, we find a strong correlation between SLP-IDP alignment and the successful execution of SLPs.

9.1 Discussion

The public participation process was identified as not adequately addressed by mining firms. An established engagement and communication channel between mining firms and core stakeholders (particularly the municipality and community) is critical to aligning and implementing SLPs. Though challenging, some mining companies participated through community meetings and communication (email exchanges) from the mines to the municipality. In cases where public participation was observed not to be held, this was noted in the lack of letters or proof of engagement (attendance register) between the mines and the municipality across the three generations of iterated SLPs.

SLPs are a means to assert relevance for service delivery by traditional leaders. Traditional councils hosting mining forms put together their infrastructure and socioeconomic needs for mines to input in the SLP. This asserted as a partnership between the community and the mining industry. The DMRE is noted to be ineffective in following up with the implementation of SLPs. According to a municipal official, requests by the municipality to resolve the adverse effects of mining activities are largely ignored. She elucidates the predicament by saying, "when you communicate with the mine as the municipality, the mine would say

DMRE says..".[1] The DMRE, operational within the national government's framework, cannot follow up with effectively monitoring SLP implementation at the municipal level.

The RLM has, however, sought ways to mitigate the misunderstanding with mines through the institution of the Mayoral Stakeholder Engagement Committee (MASECO). This committee consists of the executive mayor (as chairperson), Members of the Mayoral Committees (MMCs) and the directors. This committee monitors the implementation of SLPs to implemented within RLM. Though not entirely effective, this committee can coordinate the alignment and manage issues arising from the interaction of mining firms with the community. One issue of note is fiscal opacity by some mining companies. While some mining companies will not state the amount committed to listed projects, in other instances, fiscal discrepancies are observed between the declared budgeted funds and the actual amount committed. "For instance, the budget will state 5km of road to be constructed at the cost of 10 million Rands, and then you will discover only 5 million of the budgeted sum is spent. Where does another 5 million Rands go? You don't know.. they don't disclose…that is a problem."[2] There are allusions that mining companies as private entities may be desisting from publishing their financial allotments for SLPs to protect unwarranted public access to their financial records.[3] [4] However, with the 2020 amendments to the MPRDA now mandating SLPs to be published and legal provisions for public information access to organisations whose activities have a public impact, Mining firms as private liability holdings must declare their SLP financial commitments. SLPs are mandated by mining companies as a corporate social responsibility. Within this, mining firms must commit one per cent of declared profits to Corporate Social Responsibility.

Inadequacies of the participation process during the making of SLPs breed public dissatisfaction with the corporate efforts of mining companies. A community resident cites the perceived preferential treatment of mining companies to site projects mainly in traditionally administered areas. In contrast, dwellers of these perceived preferential project areas believe the labour-sending areas are better treated.[5] In another vein, there are cases in which mining companies do not carry out an effective project impact assessment. In the opinion of a resident respondent he acclaims mining companies offer training to his community on mining operations, which skills can only be used in the mines. However, most mining companies do not follow up the human resource training with employment offers, and as such, he sees such training as useless as the skill can only be deployed in the mines.

The poor participation process, fiscal opacity, and inefficient monitoring and evaluation process are co-creation challenges of integrating SLPs with IDPs and implementing SLPs in RLM. The nonstandardisation of the community consultation process and correspondence between the mining companies and municipalities is another conundrum. Examined SLPs were noted not to have implementation plans. "The format of this consultation and concurrence between the mines and municipalities and the contents of the SLP is currently not regulated. Most municipalities are requested to provide a letter with a list of projects to be included in the SLPs. The letter is not standardised and can be provided by either the Municipal manager, LED Manager, IDP Manager, or even a ward councillor."[6] This accounts for the awareness gap in the municipality of listed SLP projects. Similarly, approved SLP copies are not shared with municipalities. When published on the web pages of mining companies, it is well after the implementation tenure of the SLP. Associated with the fiscal opacity of SLPs is the nonstipulation of the procurement methodologies or strategies of the approved projects. The extant monitoring and evaluation process of SLP implementation requires mining companies to submit annual reports to the DMRE. However, municipalities are not involved in the monitoring and evaluation chain, which accounts for the implementation failings of many SLPs. The inadequacy of the IDP and SLP participation, monitoring and evaluation process of SLPs accounts for the ineffectual developmental co-creation the synergy of both plans was intended to achieve. This has bred mistrust among mining town residents, municipalities and mining companies. Associatedly, there are unrealistic expectations from the municipalities and communities towards mining companies to the extent of resentment towards the efforts of mining companies.

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[1] Interview with RLM official, February 2023.
[2] ibid.
[3] Interview with Black Business Council in the Built Environment official, April 2023.
[4] Interview with MISA official, April 2023.
[5] Interview with RLM resident, March 2023.
[6] Interview with MISA official, April 2023.

10 RECOMMENDATION AND CONCLUSION

SLPs, though the responsibility of mining companies, must be linked to the municipal IDP with attendant synergy in the implementation between both parties. The failure in some cases and non-appreciation of the successful impact of SLPs can be attributed to the co-creation inadequacies between the custodians of these two developmental plans. To mitigate the IDP-SLP co-creation shortcomings, the following recommendations are considered tangible to correct the inadequacies discovered from the findings of this study.

Mining companies must be compelled to attend IDP participation sessions and be included in the IDP steering committee in the wards of the jurisdiction of operations. SLPs, a Corporate Social Responsibility of mining companies, requires partnerships and collaborations among the stakeholders – the municipality, DMRE, mining companies, government departments and the community (inclusive of Community-Based Organisations, and formal and informal community leadership). The key to the success of a good partnership and working relationship between the municipality and the mining company is creating optimum institutional structures to ensure that projects decided on within and without the municipality are acted upon.

There is an observed gap in the chain of monitoring and implementation of SLPs. The reportage chain is directed solely to the DMRE, a national government department. This can be corrected by devoting monitoring and compliance checks to the municipalities (preferably the district municipality at the helm of local compliance checks). Such a tiered monitoring and evaluation arrangement devolving responsibility from the national to local government avails accountability and responsibility for coordination, handover, and delivery. The process of cocreating development through the synergy of the IDP and SLPs should be entrenched in partnerships intending to achieve a shared developmental goal. As medium strategic planning documents, coordinating the formulation and implementation of IDPs and SLPs is vital for efficiently allocating resources. So also, a devolved monitoring and evaluation framework incorporating inclusive participation of relevant stakeholders will ensure good governance delivery. This would be reinforced by institutional structures guaranteeing stakeholder collaboration with the essential character of cocreational planning.

11 REFERENCES

BERKE, P.R. Does Sustainable Development Offer a New Direction for Planning? Challenges for the Twenty-First Century. Journal of planning literature, 17 (1), 21–36. 2002

BRENNER, N. AND THEODORE, N. Neoliberalism and the urban condition. City, 9 (1), 101–107. https://doi.org/10.1080/13604810500092106. 2005.

CASHORE, B., KNUDSEN, J., MOON, J., and HAMISH van der VEN. Private authority and public policy interactions in global context: Governance spheres for problem solving. Regulation & Governance, 15 (4), 1166–1182. 2021.

CENTRE FOR APPLIED LEGAL STUDIES, (CALS). The Social and Labour Plan Series Phase 1: System Design Trends Analysis Report. Johannesburg. 2016.

CLARK, G. The Future of Cities: the Role of Strategic Planning. Future Studies Research Journal: Trends and Strategies, 5 (1), 3–32. https://doi.org/10.7444/fsrj.v5i1.140. 2013.

DEPARTMENT OF MINERAL RESOURCES AND ENERGY, (DMRE). Session on Rural Economy and Mining. 2022.

FRIEDMAN, J. Planning theory revisited. European Planning Studies, 6 (3), 245–254. 1998.

FUKUYAMA, F. Governance: What Do We Know, and How Do We Know It? Annual Review of Political Science, 19 (1), 89–105. https://doi.org/10.1146/annurev-polisci-042214-044240. 2016.

GROOMS, W. AND BOAMAH, E.F. Toward a political urban planning: Learning from growth machine and advocacy planning to "plannitize" urban politics. Planning Theory, 17 (2), 213–233. 2018.

JESSOP, B. Liberalism, neoliberalism, and urban governance: A state-theoretical perspective. Antipode, 34 (3), 452–472. https://doi.org/10.1111/1467-8330.00250. 2002.

KJAER, A.M. Rhodes' Contribution to Governance Theory: Praise, Criticism and the Future Governance Debate. Public administration, 89 (1), 101–113. 2011.

MADZIVHANDILA, T. S. AND ASHA, A.A. Integrated development planning process and service delivery challenges for South Africa's local municipalities. Journal of Public Administration, 47 (1.1), 369–378. 2012.

MUNICIPAL INFRASTRUCTURE SUPPORT AGENT, (MISA). SALGA Information Sharing Session on Rural Economy and Mining. 2022.

OKUNLOLA, P. Global campaign on urban governance launched in Nigeria. UN Chronicle, 38 (1), 39–42. 2001.

RABIE, M. Meaning of development. In: A theory of sustainable sociocultural and economic development. London: Palgrave Macmillan, 7–15. 2016.

REPUBLIC OF SOUTH AFRICA, 1996. Constitution of the Republic of South Africa No. 108 of 1996.

REPUBLIC OF SOUTH AFRICA, 2000. Local Government Municipal Systems Act (32 of 2000). Government Gazette of South Africa.

REPUBLIC OF SOUTH AFRICA (RSA). The White Paper on Local Government. 1998.

REPUBLIC OF SOUTH AFRICA (RSA). Mineral and Petroleum Resources Development Act 28 of 2002. 2002.

REPUBLIC OF SOUTH AFRICA (RSA). Act No.16 of 2013: Spatial Planning and Land Use Management Act, 2013. 2013.

RODE, P., TERREFE, B., and da CRUZ, N.F. Cities and the governance of transport interfaces: Ethiopia's new rail systems. Transport Policy, 91, 76–94. https://doi.org/10.1016/J.TRANPOL.2020.03.004. 2020.

RUSTENBURG LOCAL MUNICIPALITY (RLM). 5 Year IDP 2022/2027. Rustenburg. 2022.

TODES, A. The impact of policy and strategic spatial planning. In: C. HARRISON, P., GOTZ, G., TODES, A. & WRAY, ed. Changing Space, Changing City: Johannesburg after Apartheid. Johannesburg: Wits University Press, 83–100. https://doi.org/10.18772/22014107656.8. 2014.

UN-HABITAT (UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME). The global campaign on urban governance : an inventory. Nairobi: UN-HABITAT. 2002.

UN-HABITAT (UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME). Planning sustainable cities: Global report on human settlements 2009. Nairobi. 2009.

UNITED NATIONS (UN). UN Documentation: Development [online]. Dag Hammarskjold Library. Available from: https://research.un.org/en/docs/dev. 2023.

WATSON, V. 'The planned city sweeps the poor away...': Urban planning and 21st century urbanisation. Progress in Planning, 72 (3), 151–193. https://doi.org/10.1016/j.progress.2009.06.002. 2009.

WILLIAMS, P.M. Community strategies: mainstreaming sustainable development and strategic planning? Sustainable Development, 10 (4), 197–205. 2002.

132

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Community-Based Ecotourism Principles as a Framework for Community Development in Protected Areas

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1 ABSTRACT

Tourism is one of the most important sources of national & international income in the World. One type which has the potential to contribute to the sustainable development of local communities and alleviation of poverty levels is Ecotourism. Ecotourism implies responsibility to the environment, resident communities, and a duty to respect, invest, and develop local cultures. This definition not only suggests that there should be a recognition of and positive support for the conservation of natural resources, both by suppliers and consumers, but also that there is a necessary social dimension to ecotourism. The term 'community-based ecotourism' (CBET) takes this social dimension a stage further. This is a planning paradigm where the local community has substantial control over, and involvement in its development and management, and a major proportion of the benefits remain within the community. CBET is considered the logical link between the environment, the local community, and the tourism industry. It has become the newest planning process approach in tourism development, devised to support community involvement, improve their living standards and protect natural resources which is the main current problem resulting from the mass tourism industry in Egypt. Since 2002, also the year when eco-tourism was internationally promoted by the UN the Egyptian government began to seek new strategies and plans to actively support the participation of local communities in ecotourism development initiatives in Egypt's rich biodiversity and numerous protected areas. However, the actual implementation of involving communities in decision making is poorly achieved, which impacted negatively on the effectiveness and sustainability of these initiatives. This paper proposes an integrated community-based ecotourism framework. This was done through a theoretical study of the main principles and strartegies of community ecotourism that have been successfully applied in developing countries by using the Egyptian protected areas classifications which determine the applicable community participation types for effectively involving local communities in protected areas. Subsequently the framework can be applied to specific destinations and recommend action points for their development according to each area's needs and variable circumstances. Once developed, this integrated planning tool can be used to devise a local urban development plan by the local government and other organisations in protected areas to improve the physical and social environments and to create a better understanding of the relationship between tourism and community.

Keywords: protected areas, framework, community development, ecotourism, urban planning

2 TOURISM DEVELOPMENT

The ongoing influx of tourists, especially eco-tourists, intensifies the connection between protected areas (PAs) and ecotourism. There are two divergent and conflicting schools of thought among the academics regarding the expansion of ecotourism development in the PAs. On one hand, ecotourism is seen as being compatible with PAs and is therefore crucial to their creation and management (Foxlee, 2007). They are now recognised as one of the top ecotourism locations, offering visitors an exclusive experience. In this respect, ecotourism and PAs appear to be mutually reinforcing, with PAs needing ecotourists and the reverse (Ceballos-Lascurain, 1996). On the other hand, ecologists or conservationists typically resist the development of tourism-related activities in the PAs. Some contend that the historical compatibility of tourism and environmental preservation has been ambiguous (Lawton, 2001; Wall & Mathieson, 2006). Many PAs, for instance, were originally solely created with a non-profit environmental mission in mind; however, they are now increasingly dependent on tourism-based revenues, which could also degrade their resources (Lawton, 2001). This idea, however, seems dubious because certain tourist activity types, as well as their spatial and temporal dimensions, frequently influence resource degradation. Therefore, it would be irrational to consider tourism as a source of environmental degradation and to oppose its growth without considering the characteristics, form, and planning approach.

Therefore, governments, local communities, and non-governmental organisations have praised the promotion of ecotourism as a strategy to encourage environmental conservation in relation to the development of local communities in the PAs of developing nations (Butcher, 2007). In this regard, issues related to the evolution of community-based ecotourism development in a particular destination (like PAs), the ecotourism planning approaches, community-based ecotourism strategies, local attitudes towards ecotourism development, and the dynamics between local communities, (eco)tourism, and PAs have been discussed below to highlight the critical issues related to CBET development process.

3 ECOTOURISM

3.1 Ecotourism definitions

Ecotourism, as an alternative tourism, involves visiting natural areas in order to learn, study, or carry out environmentally friendly activities (Ruxandra-Irina Popescu, 2011). It's a tourism based on the nature experience, which enables the economic and social development of local communities as well as to ensure a meaningful experience to the tourists, increasing their awareness about sustainability issues and promoting sustainable tourism practices amongst them (UNEP, 2015). It focuses primarily on experiencing and learning about nature and their habitats, as well as about cultural artifacts from the locality. Ecotourism itself is meant to be a sustainable form of natural resource-based tourism. Even though ecotourism lacks a concrete definition, there are many well recognised definitions that have formed a clear picture of its core principles. Ecotourism, in its simplest form, is a responsible travel to relatively unaltered natural and cultural areas that, by building strong relationships and interactions between the place and its people as well as between the local community and ecotourists, fosters ecological and cultural awareness, by enhancing the natural and cultural heritage, and is based on social equity and leads to the long-term well-being of the local people. (World Tourism Organisation UNWTO, 2002).

3.2 Ecotourism planning and development approaches

Developing ecotourism and achieving its desired outcomes and goals requires strategy, careful planning, and ongoing evaluation (Denman, 2001). The unregulated tourism development is a market led view of tourism that basically provides attractions, facilities and services that the tourist market needs. The nature of this development lacks long term vision and usually results in environmental degradation and loss of socio-cultural integrity, even if it achieves short term economic benefits (Timothy, 2003). For successful ecotourism planning projects, the host countries have to recognise the importance and the urgent need for sustainable urban development. In recent decades, several tourism planning paradigms have emerged with a general aim to reduce the negative impacts of tourism and improve its positive impacts. These paradigms include: boosterism, the economic or industry-oriented approach, the physical/spatial approach, and the community-oriented approach. These the four recognised traditions of tourism planning.

3.2.1 Boosterism

It's a "growth-based strategy" that relies heavily on the marketing tactics for the expansion of tourism. This strategy predominated in the 1960s and the first few years of the 1970s (Wisansing, 2005), and it was reflected in the decision of the public and private tourism organisations to spend the full allocated budget to draw visitors. In accordance with this method, natural resources are viewed as assets to promote the market and boost the economic benefits, and tourism is seen as good to locations since it lowers development barriers (Getz 2008). However, this strategy disregards the consideration of the host community in the planning process and the carrying capacity of geographic areas. Boosterism continues to be supported by two kinds of people: politicians who think economic expansion is always advantageous and those who profit from tourism. (Farangiz Khaledi Koure, 2022)

3.2.2 Economic oriented

The second strategy is the economic tradition or industry-oriented strategy. Tourism is seen as an industry by which governments may achieve their growth goals, job creation, and regional development through financial incentives, research, and marketing. This custom is developed to bring in money and open employment prospects in particular regions, and it is centred on the economic advantages of tourism. This

strategy is a continuation of boosterism, emphasising commercial aims over social and environmental ones (Robinson, 2009).

3.2.3 Physical/Spatial

The environmental movement has been particularly critical of these two approaches since the 1980s, which helped give rise to the physical/spatial approach. Environmental issues were the main emphasis of the physical-spatial approach. Tourism should, in the opinion of proponents, be based on spatial patterns that minimise its detrimental effects on the environment. Additionally, they give the social, physical, and environmental carrying capacities particular consideration.

3.2.4 Community based

Critics only discovered the fundamental flaws in these three strategies throughout this decade. The main complaint was that contributions of local communities to tourism planning and decision-making were not given enough consideration (Hall, 2009). The community-based strategy was consequently proposed. It placed a strong emphasis on the equitable distribution of income and the bottom-up growth of tourism. The involvement of local organisations in the planning process was also emphasised. The dominant strategy was rejected in the 1980s due to its top-down methodology, which increased the importance of this approach. Participatory planning from the bottom up gained a lot more acceptance. According to this strategy, the planning and development process was facilitated and mobilised by the central government where locally defined goals and local development are an integral part of incremental tourism planning which allows for high levels of predictability, flexibility, and collaboration.

The beneficial function of local communities should not be disregarded in the development of ecotourism as a service-oriented and human-centred activity. Local communities should be seen as more than just consumers when it comes to ecotourism because their role goes beyond conceptions of production and supply. According to Nunkoo and Ramkissoon (2011), community participation gives locals the chance to express the significance of economic, social, cultural, and environmental repercussions from their point of view. He stressed the importance of contributions of local communities to sustainable development; as a result, it is advised to view community participation as the crucial piece lacking from the effective development of the ecotourism industry. Therefore, communities must be included and consulted in a way during the planning and policy-making phases to achieve a successful ecotourism development. It was cited that the lack of community interaction is the primary cause of the failed growth of ecotourism in their study regions.

3.3 Community based ecotourism

Community based ecotourism (CBET) is a type that improves the capacity of rural communities to manage tourism resources while ensuring the involvement of the local community. CBET can support the area local economy, maintain culture, protect the environment, and offer educational opportunities. It turns, it acts as a tool for reducing poverty because it might offer alternative sources of income to the neighbourhood. A long-term strategy for community-based ecotourism tries to enhance local community gains, and minimise the detrimental effects of tourism on the local population and its natural resources. It encourages the community to take part in connected initiatives and to be involved in observing and reducing negative effects. Below are a few general traits of CBET that UNEP and UNWTO have emphasised: (Bin Zheng, 2021)

- involving appreciation not only of nature, but also of indigenous cultures prevailing in natural areas, as part of the visitor experience
- containing education and interpretation as part of the tourist offer
- not exclusively, organised for small groups by small, specialised and locally owned businesses
- minimising negative impacts on the natural and socio-cultural environment
- supporting the protection of natural and cultural areas by generating economic benefits from it
- providing alternative income and employment for local communities; and
- increasing local and visitor awareness of conservation.

The development of community-based tourism must be done methodically, starting with an examination of the community's eligibility for participation in tourism and deciding which participation method is the most appropriate according to the local hosts and the destination circumstances.

The framework aim is to offer directions for tourist/rural planners, NGOs, industry participants, and CBET groups in determining which type could work for a certain community and, if it is practicable, how to participate in the tourism business and sustain it eventually. It's a flexible approach that suggests a step-by-step strategy with a list of actions to support each phase according to each participation type which will be discussed below.

3.3.1   Public consultation framework

The framework from the handbook is a result from the study of different case studies and best practices of government, NGO, industry, and community initiated CBETs in ten APEC member economies namely China, Viet Nam, the Philippines, Canada, Australia, New Zealand, Chinese Taipei, Indonesia, Korea and Malaysia. The framework offers two parts of nine procedures for establishing and maintaining CBET. The aim of this paper aim is to establish an appropriate similar framework for Egypt's protected areas, with deeper research when it comes to the first step "preparing the community for ecotourism", specifying the applicable community participation technique to each protectorate according to the different habitats, local communities, and protectorate type. The first four steps in Section A deal with launching and growing CBET efforts and are helpful for projects and sites that are starting CBET. The last five steps in Section B, which are more suitable for advanced CBET projects, are gradually advancing up the value chain, and are intended to address the sustainability of CBET initiatives. (Amran Hamzah, 2009) The development of CBET is advised in accordance with a set of action points that are presented in a tabular form below.

Fig. 1: Nine steps to develop and sustain CBET (Amran Hamzah, 2009)

3.4 Typology of community Participation

Starting with the consultation framework "assessing the community needs and preparing the community for tourism" highlights a very crucial issue which is the main question of this research: how and which technique to use when it comes to community participation. Although it has been referred to by many names and integrated into the development process in several ways, the participatory development concept has frequently surfaced in international development (Stone 1989). More specifically, there are differing viewpoints on the many forms of community involvement, and different experts have categorised the same idea under the same heading but with different titles. As a result, various categories under which to evaluate different forms of community participation exist. However, it has been suggested to categorise it under three broad sections in accordance with UN implications. (Farangiz Khaledi Koure, 2022)

3.4.1   Spontaneous participation

Spontaneous participation is voluntary, bottom-up without external support. It represents an ideal mode of participation, as it mirrors a voluntary and autonomous activity on the part of people to handle their problems without help from governments or other external agencies (UN 1981). This type is also referred to in the developmental literature as informal bottom-up. It may also represent a degree of community power in Arnstein's ladder of citizen participation. Although the above terms for spontaneous participation are used

interchangeably to a large extent, to explain some of them in further detail may help to identify some other dimensions of this kind of participation (Farangiz Khaledi Koure, 2022)

step 1

ACTION 1: ASKING THE RIGHT QUESTIONS
Why should the community be involved in tourism? Why tourism?

ACTION 2: DETERMINING THE ROLE OF TOURISM
a. Tourism as an alternative and lucrative source of livelihood and income
b. Tourism as a tool to justify the conservation efforts
c. Tourism as a "training ground" for future participation in other economic sectors

ACTION 3: CARRYING OUT A SITUATIONAL ANALYSIS
1. What does the community expect to gain from CBT?
a. Increase income
b. Employment opportunity
c. Upgrade the quality of life style
d. Complement the current physical development

2. Determine Community Values, Attitudes, Aspiration and Concerns
a. Pride in community
b. Conserve local culture
c. Sense of ownership

3. Identify the Labour Force Needs For Tourism
a. Level of education
b. Previous occupation
c. Current occupation
d. Special skills

step 2

ACTION 1: CONDUCT PRELIMINARY WORKSHOPS
WORKSHOP 1 : Identifying potential tourism activities to be developed and promoted
a. Discuss and identify the available resources and activities
b. Evaluate the existing resources and rank them
c. Select the top 5 – 10 attractions / activities to develop

WORKSHOP 2 : Developing linkages with surrounding tourism attractions
a. Identify the surrounding resources
b. Carry out an inventory of surrounding resources (location/distance/uniqueness/physical and etc.)
c. Develop corridors and packages

WORKSHOP 3 : Organising workshop on involvement of different sectors of community
a. Identify the types of contribution (e.g. services/ entrepreneurship and etc.)
b. Develop specific bureaus

WORKSHOP 4 : Identify training needs
a. Identify the gaps in term of the knowledge and skills
b. Determine the training needs for each section of community (e.g. women/ youth/guides and etc.)

WORKSHOP 5 : Developing and conducting training modules
c. Determine the training method (theory / hands on)
d. Determine the content of modules

ACTION 2: STUDY TRIPS AND "COMMUNITY TO COMMUNITY" TRAINING
a. To expose community to real life situation
b. To enhance the production, tourist experience and service quality

ACTION 3: FORMULATION OF TRAINING MANUAL
a. To ensure trainings carried out in a systematic and consistent manner
b. Documentation of the training modules and instructions
c. Formulate the training manual

step 3

ACTION 1: IDENTIFY LOCAL CHAMPION
a. Visionary
b. Good Communication
c. Disciplined
d. Proactive
e. Innovative
f. Sensible
g. Patient
h. Trustworthy
i. Courageous
j. Never say die attitude
k. Dedication
l. Commitment

step 4

TOURISM PRODUCT CYCLE
STAGE 1 : Community Organisation in Initial Phase of CBT
a. Drawing solely from the talents within the local community

STAGE 2 : Community Organisation As CBT Project Matures
a. Seeking professional help without sacrificing community structure

IDENTITY ROLES OF CBT ORGANISATION
1. Empowering women and youth
a. Creating specific bureau/association
b. Appointment of office bearers
c. Designation of roles and type of activities of each bureau

2. Formulating a common vision but realistic targets
a. Provide the direction to guide the community
b. Inform the locals about the impact of tourism
c. Formulated the common vision

Example of common vision
"to preserve the unique cultural heritage of the village by implementing the adaptive reuse of traditional buildings for the enjoyment of visitors without sacrificing the community structure, values and local way of life".

d. Set realistic targets (consider factors such as level of education, skills and training gaps)

3. Nurturing an anti handout mentality
a. Encourage self help sense of ownership

4. Establishing a community fund
a. Setup the community fund (to manage the income & expenditure)
b. Create revolving fund for community
c. Create microcredit facilities

step 5

1. Partnership with NGOs
a. To increase the community's capacity in undertaking of conservation project

2. Partnership with Universities
a. Educate the local community on the appropriate framework to develop CBT projects.
b. Equip the organisation with the tools and approaches to improve the quality of the tourist experience
c. Bring research expertise

3. Partnership with Government Agencies
a. Field officers stationed on site
b. Monitoring the project

4. Partnership with Tourism Industry
a. Focus on marketing and promotion
b. Establish network with specialist tour operators at the international level such as Intrepid Travel

step 6

1. Integration with conservation, sustainable development and responsible tourism projects
a. Spin offs in the form of conservation, sustainable development and responsible tourism
b. Provide employment opportunities for locals

2. Integration with other economic sectors
a. a "training ground" for the local community
b. prepare local community to undertake non-tourism projects
c. provide stable and better paying jobs for locals

step 7

ACTION 1: FORMULATING OF CBT MASTER PLAN
a. Detail inventory of tourism resources
b. Apply techniques (e.g. Product Inventory Matrix/ Product Competitiveness Index
c. Evaluate tourism products
d. Proposal (presented using plans, maps and illustrations
e. Approach expertise from universities or volunteers in preparing the Master Plan

CONTENTS OF CBT MATER PLAN
1. Product Development
a. Develop and showcase core product
b. Linkages with other attractions in the surrounding areas

2. Destination/Leisure Management
a. Adequate tourist infrastructure, facilities, good interpretation and high level service quality
b. Provide authentic experience
c. Provide educational experience
d. Provide entertaining experience
e. Enjoyable experience
f. Provide memorable experience

3. Interpretation and Communication
a. Visual presentation – interpretive trails/centre
b. Oral presentation – well-trained guides
c. Interactive relationship between host and tourists

step 8

ACTION 1: MATCHING THE PRODUCT WITH THE POTENTIAL MARKET SEGMENTS
a. Determine the potential market segments
b. Match product and market segments

ACTION 2: UNDERSTANDING THE CHANNELS OF DISTRIBUTION
a. Identify the channel of distribution
b. Network within "green tourism" and "responsible tourism operators

ACTION 3: EMBRACING ICT AS A PROMOTION TOOL
a. Carry out e-booking/online reservation
b. Carry out e-promotion
c. Build own website, blog, forum etc.
d. Invest in setting up hardware (computer and internet connection)
e. Invest in setting up software (training local youths)

ACTION 4: "PIGGY-BACK- RIDING" ON TOUR OPERATORS AND GROUND HANDLERS
a. Identify potential tour operators and ground handlers
b. Network with international counterparts such as Intrepid Travel

ACTION 5: SETTING UP AN IN HOUSE TRAVEL AGENCY
a. Set up in house travel agency
b. Nurture the spirit of entrepreneurship among youths

ACTION 6: LEVERAGING ON AWARDS CERTIFICATION TO SHAPE THE BRANDING

step 9

ACTION 1: CONSTRUCTION OF TOURIST FACILITIES GETTING THE COMMUNITY INVOLVED IN THE IMPLEMENTATION
a. Secured the funds to construct tourist facilities
b. Involved or empowered community in the construction of tourist facilities
c. Local community will enhance the existing skills and acquire the new skills

ACTION 2: REGULAR MONITORING OF PERFORMANCE
a. Create indicator to monitor the performance of CBT

Fig. 2: Nine steps action points (Amran Hamzah, 2009)

3.4.2 Induced participation.

On the other end of the spectrum, induced engagement is supported, required, and formally sanctioned. This type is the most prevalent method, present in 8 developing nations, as government plays a major role in institutionalising participatory action in several of these nations. Building self-management and cooperative organisations, encouraging local leaders to take on leadership positions, and assisting civic and community organisations are some of the techniques that have been used to achieve this (UN 1981).

Other names for induced involvement include formal top-down, passive. Understanding the terminology for induced participation in a broader sense may be aided by defining those terms, which are used interchangeably (Farangiz Khaledi Koure, 2022),

3.4.3 Coercive participation

Additionally, it is referred to as restricted participation and community oppressive. Eventually, forced community participation that lacks public support will prove to be counterproductive and erode community interest in participating in development activities, even though coercive forms of participation can sometimes be difficult to distinguish from the induced type in terms of form (UN 1981).

These three major types of community involvement in the development process undoubtedly represent a wide range of community involvement. Each of these categories includes several types of community participation, as shown in table 1. To draw a clear line between different forms of community participation in each broad category, nevertheless, appears to be quite challenging, as spontaneous, coercive, and induced involvement have similar scopes and meanings. Coercive participation involves more manipulation and tokenism than induced involvement. As a result, it is also known as non-participation. To engage in spontaneous participation, a community must take part in all phases of a development project, including

decision-making, implementation, benefit sharing, and assessment. In contrast, induced participation refers to community participation in the implementation and distribution of the benefits of development projects. Coercive participation, on the other hand, calls for a community to take part only in the implementation process of a development project, without necessarily sharing in its advantages. In the situation of coerced involvement, a community is left with no genuine alternatives (Farangiz Khaledi Koure, 2022).

The categorazation of community participation may enable us to understand the participatory development activities in a better way in the real world by distinguishing various forms of community participation from each other. Hence, this typology seems to have contributed to conceptual clarity of the term 'community participation' in the tourism literature. After having a clear view of the framework to establish and develop CBET in a destination and according to the typology of community engagement that has been mentioned, several interpretations of community participation in the TDP are acceptable in various situations. In this sense, community engagement in the TDP should be seen as an adaptive and flexible paradigm that enables us to legitimise different forms of community participation in the TDP, depending on site-specific conditions. The public consultation framework above is by providing three different approaches to implement the processes by reordering the phases in accordance with each technique in the diagram below. The hierachy will vary from point 3 through to point 9 to allow a more focused and efficient development when step 2 is complete and which involvement technique works best for the destination and community has been determined.
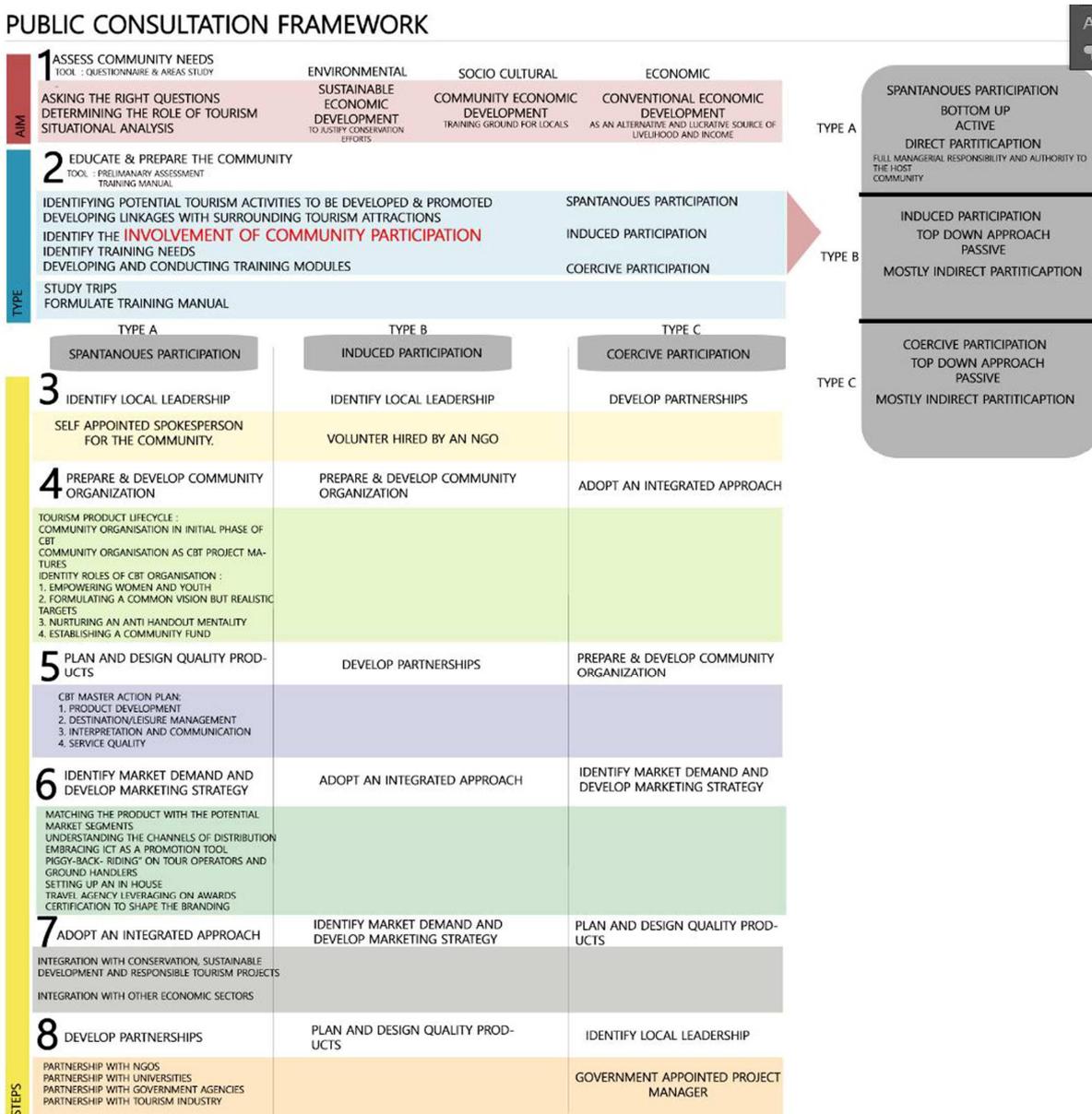
Fig. 3: Community based framework tailored to participation types (author)

4 EGYPT'S PROTECTED AREAS

Egypt's overall land area is 92% dry desert and 8% fertile land, and it is located midway between Africa and Asia. 22 major habitat groups, including Mediterranean Wetlands, the Nile Valley and Delta, Central and North Sinai, Numerous kinds of vegetation and 324 different types of desert animals are thought to be ecologically significant, particularly in Sinai. With 80 plants, 100 animals, and 82 fish, wetlands particularly those near the Nile constitute a significant ecosystem in addition to the deserts. Along with 26 bird species and 26 reptile species, there are 51 species of mammals that are endangered.

Egypt has made the creation, proper administration, and expansion of protected areas a top goal ever since the country's first national biodiversity policy and action plan were introduced in 1997. The nation, one of the first in the region, declared over 15% of its total land area as protected land area, putting it remarkably close to the 17% global objective thanks to its substantial dedication to this priority. Egypt was able to declare 30 protected areas.Indications show that Egypt's biodiversity is being lost at an accelerated rate, with habitat destruction, over exploitation and pollution (WorldSummit, 2002). Based on existing trends, unless mitigation measures are taken, in the next ten to twenty years Egypt will stand to lose most of its biodiversity. A strategy for a national system of protected areas has been developed and the management of these areas were bearing in mind to make use of the technologies such as GIS and remote sensing. The local economic significance and value of these protected areas and their contribution to the national economy was being considered particularly through the development of ecotourism (WorldSummit, 2002).

4.1 Protected areas classification.

Understanding the location, culture and demographics of the area can help identify the potential community participation types that are applicable. Assessing the level of involvment of the locals and stakeholders, considering the objectives of the protceted area whether its conservation or sustainable development or recreation is also important. This study attempted to classify 30 protected sites in accordance with their various habitats, types, local cultures, geographic regions, conservation goals and tourism niches. In turn, this categorisation will help to determine the community's appropriate participation type in the protected area when applying the community-based ecotourism framework on the destination, leading to the application of more specified and suitable action points for a more sustainable successful development. (NCS, 2018)

Category	Description
Ia	Strict Nature Reserve: Protected area managed mainly for science.
Ib	Wilderness Area: Protected area managed mainly for wilderness protection
II	National Park: Protected area managed mainly for ecosystem protection and recreation
III	Natural Monument: Protected area managed mainly for conservation of specific natural features
IV	Habitat /Species Management Area: Protected area managed mainly for conservation through management intervention
V	Protected Landscape/Seascape: Protected area managed mainly for landscape/seascape conservation and recreation
VI	Managed Resource Protected Area: Protected area managed mainly for the sustainable use of natural ecosystems

Fig. 4: IUCN protected areas classifications.

According to the international IUCN categorisation of protected areas, No PA in the Egyptian network of PAs is categorised as a Strict Nature Reserve (Category Ia) or a Wilderness Area (Category Ib), However, 15 PAs are designated as protected areas with sustainable management. Within the PAs network, there is the use of natural resources (Category VI), which accounts for 50% of all IUCN management categories. (NCS, 2018)

4.1.1 Successful examples

This research looked at the CBE policies of four developing nations the Republic of Kenya, Tunisia, Jordan, and India achieving successful outputs and effectiveness of the development using the specific community-based ecotourism indicators and particularly the community participation types when it comes to each destination circumstances and local culture. (M. M. ELBARMELGY).

One prominent example of a successful community-based ecotourism project in Jordan is the "Dana Biosphere Reserve.". the community participation approach employed is a combination of different types,

focusing on collaborative and inclusive decision-making and sustainable development. Here are the key community participation types that were used:

Collaborative Decision-Making: Local communities, NGOs, and governmental agencies collaborate to make decisions about the management and development of the biosphere reserve. This ensures that diverse perspectives are considered, and decisions are collectively formulated.

Empowerment and Ownership: The project empowers local communities by involving them in the ownership and management of tourism-related enterprises, such as guesthouses and guides. This ownership gives communities a direct stake in the success of the ecotourism activities.

Participatory Planning: Local communities actively participate in the planning process of ecotourism initiatives. They share their ideas, aspirations, and concerns, which are incorporated into the design and implementation of tourism activities and conservation efforts.

Cultural Preservation and Sharing: Local communities play a central role in preserving and sharing their cultural heritage. Traditional practices, crafts, and local knowledge are incorporated into the ecotourism experiences, giving visitors an authentic cultural encounter.

Sustainable Resource Management: Community members are actively involved in the sustainable management of natural resources. They take part in monitoring and conserving wildlife and habitats, ensuring that tourism activities do not harm the delicate ecosystem.

Capacity Building: The project invests in capacity-building programs that empower local individuals to become guides, craftsmen, and service providers. This builds human capital within the community.

Education and Awareness: The project focuses on educating both visitors and local community members about the importance of conservation and sustainable tourism practices.

By combining these community participation types, the Dana Biosphere Reserve project in Jordan has managed to create a holistic approach to ecotourism development that not only benefits the local communities economically but also ensures their active involvement in conservation and cultural preservation. This inclusive approach has contributed to the project's success in both sustainable development and biodiversity conservation.

The selection of a suitable community participation type for a specific ecotourism project involves a combination of factors that consider the local context, goals of the project, and the needs and aspirations of the community. Here's how they have decided on the appropriate community participation type:

Community Assessment: The project likely started with an assessment of the local community's characteristics, including their social structures, cultural practices, economic conditions, and existing levels of engagement in conservation and tourism.

Stakeholder Engagement: The project organizers likely engaged with a diverse range of stakeholders, including community members, local leaders, NGOs, government representatives, and experts in various fields. This would help identify the needs, concerns, and aspirations of different groups.

Cultural Sensitivity: Considering the importance of cultural preservation in the Dana Biosphere Reserve, the project planners would have assessed the significance of local traditions and how they could be integrated into the ecotourism experience.

Environmental Considerations: The type of community participation would also be influenced by the level of interaction required with the natural environment. If the goal is strong conservation involvement, a more hands-on approach to resource management might be chosen.

Community Readiness: The readiness of the community to actively participate in various roles, whether in managing enterprises, preserving cultural heritage, or engaging in sustainable practices, would influence the choice of participation type.

Local Economic Conditions: The economic conditions of the community would play a significant role. If there's a need for alternative livelihoods due to declining traditional industries, a focus on community-owned enterprises might be more appropriate.

140

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Local Skills and Expertise: The existing skills and expertise within the community would be considered. For instance, if there are individuals with guiding skills or traditional crafts, these could form the basis for community involvement.

Alignment with Goals: The selected participation type should align with the overall goals of the project, which might include environmental conservation, cultural preservation, economic development, or a combination of these.

Flexibility: A flexible approach might be chosen that allows for multiple types of participation. For example, the Dana Biosphere Reserve project combines cultural preservation, sustainable resource management, and economic empowerment.

Ultimately, the selection of the community participation type would be a result of careful consideration of these factors, with the aim of creating a model that best suits the local context and ensures the project's success in both conservation and community development.

4.1.2   Egypt's protected areas classification

The following table was suggested after studying each Egyptian PA, classifying the 30 Egyptian protectorates according to their various habitat types, attractions, geographic location, tourism niche, IUCN classification, type, and the local communities. Formulating a deeper study of the PAs to be able to suggest an applicable community participation technique to start with the first steps of the public consultation framework to apply community-based ecotourism effectively in a destination. Egypt has a rich and diverse cultures with different local cultures varying from Nubians, Siwan culture, Bedouin cultures, Coptic culture, and fellahin cultures. Each of these cultures has their own unique traditions, customs, and way of life, which help to determine the applicability of the community tourism participation type. Also, according to their category in the IUCN classifications. Bedouins and Nubians are suited for spontaneous or induced type because they are more likely to be willing to engage and conscious of the development difficulties. Due to their rigorous adherence to their culture and traditions and lack of awareness about ecotourism, the nomad, fallhin, and saidii cultures should use either coercive or induced participation, depending on the other factors listed in the table below. Also, the PA category plays a big role in deciding the participation type, so different factors have to be taken into consideration when applying the selected technique found in the table below and in alliance with all the given factors, the participation type is suggested.

5   CONCLUSION

This study demonstrates that, depending on the destination characterstics and cirucmstances, community involvement in the development process can take many different forms. Different forms of community participation in the tourism development. however, are hardly ever mentioned in tourism research. Instead, it is suggested that one type of participation in the community must be accepted everywhere. This rigidity in tourism studies may be an indication that the field has debated the idea of a participatory approach to tourism development in isolation and with little connection to more general studies on community participation that might produce better insights and greater maturity for the formulation of community participation policies in the ecooturism development. For instance, participatory studies on rural development, housing, irrigation, Third World development programmes, etc. suggest that before beginning any participatory development activity, considerations like operational, structural, and cultural limitations to community participation should be made. Ignoring these restrictions could jeopardise the efficacy and efficiency of a participatory development strategy. This paper aims to start a much-needed conversation about community involvement in the CBET as an adaptive categorical word. This reasoning is based on the idea that different tourist destinations will present different opportunities and difficulties for host communities to participate in the TDP. These tourist destinations will also have various sociocultural, economic, and political conditions as well as different levels and types of tourism development. Naturally, community involvement should occur in these tourist sites on many levels and in various forms. The most important finding from the analyses that came before it is that community participation in the TDP should be viewed as a categorical term that allows host communities to participate in the TDP in a variety of ways and under a variety of conditions. Subsequently the framework can be applied on a destination and thus recommending action points for its development according to each area needs and variable circumstances. This integrated planning tool can be used to devise a local urban development plan by local governments and organisations in protected areas to

improve the physical and social environments and create a better understanding of the relationship betweeen tourism and communities.

Protected Area :	Participation type	desert	marine/coastal	riverine	wetland	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
1.Ras Mohamed National Park	Induced		X		X	X				X
2. Zaranik PA	Spontaneous			X	X			X		X
3. Ahrash PA	Spontaneous			X	X			X		X
4. El Omayed PA	Induced	X	X			X				
5. Elba National Park	Coercive	X				X				
6. Saluga and Ghazal	Spontaneous			X	X	X				
7. St. Katherine National Park	Coercive	X								X
8. Ashtum El Gamil PA	Coercive				X					X
9. Lake Qarun PA	Induced				X	X				
10. Wadi El Rayan PA	Induced	X			X	X				
11. Wadi Alaqi PA	Induced	X				X				
12. Wadi El Assuti PA	Coercive	X						X		
13. El Hassana Dome	Coercive	X					X			
14. Petrified Forest PA	Coercive	X					X			
15. Sannur Cave PA	Coercive	X					X			
16. Nabaq PA	Spontaneous			X	X				X	
17. Abu Galum PA	Spontaneous			X					X	
18. Taba PA	Spontaneous	X	X				X			
19. Lake Burullus PA	Spontaneous			X	X					X
20. Nile Islands PAs	Coercive			X	X					X
21. Wadi Degla PA	Coercive	X					X			
22. Siwa Desert land	Induced	X				X				
23. White Desert	Induced	X				X				
24. Wadi El Gemal - Hamata	Induced		X		X	X				
25.red sea northern islands	Coercive		X			X				
26.elgulf el kebeer	Coercive	X							X	
27.el dababya	Spontaneous	X							X	
28.elsalum	Spontaneous	X							X	
29.elwahat elbahareya	Spontaneous	X				X				
30.mount kamel meteor	Spontaneous	X								

Protected Area :	easterndesert	northwest	western desert	sinai	nile valley	delta	culture
1.Ras Mohamed National Park				X			Local Bedouin (Mazayna or the Tarabin tribespeople)
2. Zaranik PA				X			Local Bedouin
3. Ahrash PA		X					Local Bedouin
4. El Omayed PA	X						Local Bedouin
5. Elba National Park	X						Nomads tribes
6. Saluga and Ghazal					X		Nubian
7. St. Katherine National Park				X			nomads with distict lifestyle
8. Ashtum El Gamil PA						X	between portsaid & damietta
9. Lake Qarun PA			X				Fallahin
10. Wadi El Rayan PA			X				Arab or Bedouin
11. Wadi Alaqi PA	X						Nubian
12. Wadi El Assuti PA					X		Saidii
13. El Hassana Dome					X		N/A
14. Petrified Forest PA	X						N/A
15. Sannur Cave PA					X		Saidii
16. Nabaq PA				X			Local Bedouin
17. Abu Galum PA				X			Local Bedouin/Nomad tribes
18. Taba PA				X			Local Bedouin
19. Lake Burullus PA						X	Local fishermen / peasants
20. Nile Islands PAs					X		N/A
21. Wadi Degla PA					X		N/A
22. Siwa Desert land			X				Amazighi
23. White Desert			X				Arabian tribes
24. Wadi El Gemal - Hamata	X						Ababda & bashareya local tribes
25.red sea northern islands				X			N/A
26.elgulf el kebeer			X				Saidii
27.el dababya			X				Nubian
28.elsalum		X					Nubian
29.elwahat elbahareya			X				Amazighi
30.mount kamel meteor			X				Nubian

Table 1: Egyptian Protected areas classification

6 REFERENCES

MINISTRY OF ENVIRONMENT, Egyptian enviromental affair. EEAA. 2017. 2 1 2017. http://www.eeaa.gov.eg/en-us/laws/envlaw.aspx.

AMRAN Hamzah, Zainab Khalifah. "community based tourism "How to Develop and Sustain CBT Asia-Pacific Economic Cooperation Secretariat Malaysia , 2009

BIEN, Amos: "The simple user's guide to certification for sustainable tourism and ecotourism." 2004.

BIN Zheng, Mingchuan Li ORCID,Boyang Yu and Lan Gao. "The Future of Community-Based Ecotourism (CBET) in China's Protected Areas: A Consistent Optimal Scenario for Multiple Stakeholders." MDPI 12.12 , 2021

BUTCHER, Jim: Ecotourism, NGOs and development: A critical analysis. Routledge, 2007.

CEBALLOS-LASCURÁIN, H.: Tourism, Ecotourism and Protected Areas: The State of Nature-Based Tourism around the World and Guidelines for Its Development. IUCN Publications, Cambridge, 1996

RICHARD Denman, Gordon Hickman, and Julius Slovak: "Rural tourism in Roznava Okres: a Slovak case study." Tourism Management 22, no. 2 ,2001

DATA, WORLD TRAVEL AND TOURISM COUNCIL. knoema. 2016. 20 5 , 2016. https://knoema.com/atlas/Egypt/topics/Tourism/Travel-and-Tourism-Total-Contribution-to-GDP/Total-Contribution-to-GDP-percent-share.

FARANGIZ KHALEDI KOURE, Marzieh Hajjarian, Omid Hossein Zadeh, Ahmad Alijanpour, Razieh Mosadeghi: "Ecotourism development strategies and the importance of local community engagement." SpringerLink , 2022

FOUDA, Mostafa. Protected areas of Egypt. cairo: Nature conservation sector , EEAA , Egypt, 2008.

FOXLEE, Jasmine. "Key principles and directions for tourism in protected areas: a review of existing charters, guidelines and declarations." In Tourism and protected areas: benefits beyond boundaries. The Vth IUCN World Parks Congress, pp. 44-70. Wallingford UK: CABI, 2007.

GALAL, Saifaddin: "Statista." 4 2022. 2023. https://www.statista.com/topics/5767/tourism-industry-of-the-egypt/#topicOverview.

HAMZAH, Amran. community based tourism how to develop and sustain cbt". Malaysia: Tourism Planning Research Group Universiti Teknologi Malaysia, 2009.

HALL, C. M.; Page, S. J. Progress in tourism management: From the geography of tourism to geographies of tourism – A review. Tourism Management. 30: 3-16., 2009

IUCN. "IUCN." 2018. 2023. https://iucngreenlist.org/country/egypt/.

KIPER, TUĞBA. "Role of Ecotourism in Sustainable Development." Advances in Landscape Architecture. turkey: intech, 2002. 30.

NCS. Management Effectiveness Evaluation of Egypt's Protected Area System. Cairo: NCS, 2018.

NUNKOO, Robin, and Haywantee Ramkissoon. "Developing a community support model for tourism." Annals of tourism research 38, no. 3 , 2011

ROBINSON, Mike, and Tazim Jamal. "The SAGE handbook of tourism studies." The SAGE Handbook of Tourism Studies , 2009

RUXANDRA-IRINA Popescu, Andreea Zamfir. "Strategic Role of Ecotourism for Romania's Regional Development." ostrava: University of Ostrava, 2011.

SIS. SIS. 26 1 2015. http://www.sis.gov.eg/section/5174/5175?lang=ar.

TIMOTHY, D.J., and C. Tosun. "Appropriate Planning for Tourism in Destination Communities: Participation, Incremental Growth and Collaboration." In Tourism in Destination Communities." : 181-204. CABI , 2003.

MINISTRY OF. TRADING ECONOMICS. 2016. 24 5 2016. http://www.tradingeconomics.com/egypt/tourism-revenues.

UNEP. UNEP. 2015. 3 2 2016. http://www.unep.org/resourceefficiency/Business/SectoralActivities/Tourism/FactsandFiguresaboutTourism/Definitions/tabid/78773/Default.aspx.

WISANSING, Jutamas: "A review of marketing ideas within the evolution of tourism planning thought." ABAC Journal 25, no. 2 , 2005.

WORLD SUMMIT, Johannesburg. Egypt country profile. Egypt: United Nations, Johannesburg, 2002.

Computational-based Generative Design Exploration, Multi-Agent System as an Approach

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1 ABSTRACT

Architecture design problems are known for their sequential steps that address a series of several interweaving, competing and/or aligning requirements. Describing them as open-ended, uncertain, solution searching processes makes them complex and ill-structured design problems. One of the methods to deal with nonlinear complex systems is that their components' properties and features must not be pre-determined and studied linearly in isolation. Instead, it is essential to consider the system as a whole, even if it means considering it generally and roughly, and then allow possible simplifications to occur from the dynamic interactions between components. Computational design methods that encounter distributed computation and artificial intelligence, such as Multi Agent System (MAS), showed promising abilities in addressing complexity and uncertainty faced with architecture design problems, as well as they proved positive effect on expanding architecture design exploration (ADE). This study has an interest in MAS capabilities in creating aesthetically innovative and performable architecture solutions.

Therefore, this research intends to investigate the use of MAS in Architecture in the years between 2010 to 2020. It contributes with a detailed examination of research papers to orient future research in the field of MAS. Hence, the applied literature review raises the question of what the proved capacities of MAS are and how future research can challenge it further to widen and develop the use of MAS in ADE and their possible capabilities when addressing building performances such as structural, functional, and environmental. The databases used for selecting these papers are Scopus, Web of Science, SAGE, Science Direct, Google Scholar, Connected Papers, CUMINCAD, IEEXplore, and ACM Digital Library. These studies are organized, analyzed, and compared to pinpoint key innovations in MAS's variable usage, study its applied methods, interesting results, important sources of data, implementation strategies, and shed the light on the gaps and shortcomings to draw a perspective of MAS in architecture. The examined studies are arranged chronographically. Then, each paper is analyzed and classified according to the aim of the methodology, domain, level, scale of application (experimentation level), model generation and optimization methods. Afterwards, a critical review is proposed.

Keywords: Computational Architecture, Design Optimization , Generative, Algorithmic & Evolutionary design, Agent based Modeling and Simulation, Multi-Agent Systems

2 INTRODUCTION

Architecture design problems are known for their sequential steps that address a series of several interweaving, competing and/or aligning objectives without a well-defined or specific design output (Terzidis, 2006). In all cases these objectives not only might align or conflict with one another, they are changed and uniquely defined in every single design problem based on the problem itself, the goal of the design, building program, constraints, client's requirements, surrounding context, etc. In addition, they are open-ended, uncertain, solution searching mechanism with no clear formulation of all required information and aspects any problem-solving processes would need. Therefore, they are identified as complex, wicked, and ill-structured problems (Rittel & Webber, 1973). To elaborate further; there are several clear aspects that complexifies such problems. For instance, the lack of the required definite and clear information for every attribute related to the problem, which challenges more the problem's tackling processes (Suh, 2005). Another aspect is related to creating innovative outcomes, which makes the expected product not specified and cannot be predicted. Another pivotal aspect that complexifies the architecture design problem further, is the nonlinear interrelationship, correlation and causation between whole system's pattern, properties, attributes and behvior observed on the global level and their inter-consequences and interactions of the constituent elements on the local level (Bar-Yam, 2002). It is a phenomenon described as micro-macro effect (Wolf & Holvoet, 2005).

One of the methods to deal with such nonlinear complex systems is that their components' properties and features must not be pre-determined and studied linearly in isolation. Instead, it is essential to take into

account the system as a whole, even if it means considering it generally and roughly, and then allow possible simplifications to occur from the dynamic interactions between components (Pantazis & Gerber, 2019). Computational design methods that encounter distributed computation and artificial intelligence, such as Agent based modeling and simulation (ABMS) and Multi Agent System (MAS), showed promising abilities in addressing complexity and uncertainty faced with architecture design problems (Macal & North, 2009), (Erdine & Kallegias, 2016a), (Gerber, Pantazis, & Wang, 2017), as well as they proved positive effect on expanding architecture design exploration (ADE) (Robertson & Radcliffe, 2009), (Liu, Li, Pan, & Li, 2011), (Zboinska , 2015), (Chang, Chien, Lin, Chen, & Hsieh, 2016), (Daemei & Safari, 2018), (Zboinska, 2019). Through the modeling of complex system in the level of their individual constituent, the whole system's pattern, structure and behvior can emerge without being explicitly programmed into the model (Heath & Hill, 2010), (Macal & North, 2010). Therefore, this research has an interest in the applications of MAS in architecture. It aims at developing a collective understanding of MAS capabilities between 2010 to 2020 and suggests future research.

3 MULTI AGENT SYSTEM DEFINITION AND NOTIONS

A Multi-Agent System is a computerized system composed of multiple interacting collaborating agents within an environment. These agents act autonomously and collaboratively to achieve more complex goals that any of the agents can do by itself (Pantazis & Gerber, 2018). Most research suggested that in order to deal with complexity and uncertainty faced in architectural design problems, non-conventional design methodology must be addressed. It is effectively proven that distributed computation and artificial intelligence can overcome such difficulties (Beetz, Leeuwen, & Vries, 2004) (Jennings & Wooldridge, 1999). Not only, but also the given nature of the design problem as "ill-structured" raises the necessity and ensure the provision of computational abstractions for design exploration and solutions optimization (Gerber, Pantazis, & Wang, 2017). The applicability of a distributed system provided by MAS described in abstractly fashioned agents with defined goals adapting to a local conditions, made MAS an appropriate for solving a large class of real world design problems, in several domains such as the work of (Davide , Pilosof, Hadas , Yahav, & Kalay, 2019) (Erdine & Kallegias, 2016a) (Davide, et al., 2016) and (Fernandes, 2013) (Viehweider & Chakraborty, 2015) to name a few.

4 LITERATURE REVIEW APPLIED METHODOLOGY

4.1 MAS in AEC Field, Collection and Selection

There is a significant interest in the field of MAS seen in the work of experimentalists in architecture in recent years. These include researchers, units, and practitioners such as David Jason Gerber, Achim Menges, as well as practices such as Zaha Hadid Architects and Morphosis Architects. Such approaches utilization is considered a paradigm shift in architecture thinking and exploration for more efficient solutions, challenging the complexity of a design problem. This section presents a brief representative of MAS in AEC, in the years between 2010-2020. The databases used for selecting these papers are Scopus, Web of Science, SAGE, Science Direct, Google Scholar, Connected Papers, CUMINCAD, IEEXplore, and ACM Digital Library. These studies are organized, discussed and compared to pinpoint key innovations in MAS's variable usage, study its applied methods, interesting results, important sources of data, and shed the light on the gaps and shortcomings to draw a perspective of MAS in AEC. Literature retrieval method is undertaken as follows: (Determine the time frame; (2010 – 2020) / Determined keywords: Agent based/ agent-based modeling (ABM)/ Agent based simulation (ABS)/ Agent based modeling and simulation (ABMS Multi agent system) / The targeted Language: English/ Search in Scientific Database Platforms: Scopus, Web of Science, SAGE, Science Direct, Google Scholar, Connected Papers./ Downsize them into papers concerned with architecture design phase./ Select a sample to show-case and represent MAS as a paradigmatic effect in the design process.)

4.2 Literature Review Analysis and Interpretation

The undertaken study went through several steps. First, they are arranged chronographically. Then, each paper is analyzed, classified and discussed according to aim of the methodology, domain, level, scale (application), model generation logic, optimization methods, refer to Figure 1, Table 1 and Section 6.

5   ANALYTICAL STUDY AND DISCUSSION OF MAS APPLICATION IN AEC

MAS is not just a system. MAS is a concept that can be seen in different areas and implemented on different scales to solve varies problems. There are several contributions made to the applicability of MAS in AEC they can be classified into three domains: knowledge capturing and recognition in drawings and sketches, simulation and performance of building designs, and collaborative environments (Beetz, Leeuwen, & Vries, 2004). The research will concentrate on the simulation and performance domain.

Levels of Design Problem Complexity: The usage of MAS can be seen in several precedents from conceptual design phase, seen in the work of (Erdine, 2016b) (Gerber, Pantazis, & Wang, 2017) (Guon & Li, 2017) (Yi & Kim, 2015) to name a few, to fabrication, found in the work of (Baharlou & Menges, 2013) (Gerber & Pantazis, 2016a) (Pantazis & Gerber, 2016) (Yazici & Gerber, 2016), (Smith, Danahy, & La Rotta, 2020). These contributions can be categorized into five different levels of process complexity. The first level is aesthetic-driven optimization. It was found that aesthetic is not usually a target or a measured target however it comes in form of interesting or exciting and novel outcomes and its suitability is measured in accordance to a targeted single performance or targeted multiple performances and/or fabrication feasibility, such the work of (Pantazis & Gerber, 2014) and (Smith, Danahy, & La Rotta, 2020). The second level is single-discipline optimization for instance; environmental performance (Sugihara, 2014), (López & Gerber, 2014), (Yi & Kim, 2015), (Pantazis, Gerber, & Wang, 2016), (Gerber, Pantazi, & Wang, 2017), (Pantazis & Gerber, 2018), (Agirbas, 2019), Material performance (Tsiliakos, 2012), Functional performance (Davide, et al., 2016), (Guon & Li, 2017), (Ghaffarian, Fallah, & Jacob, 2018), (Davide , Pilosof, Hadas , Yahav, & Kalay, 2019), (Fuchs & Neumayr, 2020). The third level is multi-discipline optimization, where more than one performance is targeted – such as. Environmental and Structural Performance, (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Gerber, Pantazis, & Marcolino, 2015), (Pantazis & Gerber, 2016), (Gerber, Pantazi, & Wang, 2017), (Pantazis, 2019). Environmental Performance and rationalization such as (Baharlou & Menges, 2013), (Gerber & Pantazis, 2016b). Aesthetic and structural performance and rationalization, seen in the work of (Smith, Danahy, & La Rotta, 2020) And the Fourth level is multi-discipline optimization and digital fabrication such as (Pantazis & Gerber, 2014), (Schwinn, Krieg, & Menges, 2014), (Gerber D. J., Pantazis, Marcolino, & Heydarian, 2015), (Erdine, 2016b), (Gerber & Pantazis, 2016a), (Yazici & Gerber, 2016), and as previously mentioned Building Systems (Wang, Yang, & Wang, 2010), (Lee, 2010), (Joumaa, Ploix, Abras, & Oliveira, 2011), (Ramchurn, Vytelingum, Rogers, & Jennings, 2011), (Klein, et al., 2012), (Zhao & Suryanarayanan, 2011).

Design Applications Scales: Multi-Agent systems have been applied to design problems of varying scales ranging from Urban design (López & Gerber, 2014). As well as building envelope design, (Sugihara, 2014), (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Yi & Kim, 2015), (Gerber D. J., Pantazis, Marcolino, & Heydarian, 2015), (Gerber D. J., Pantazis, Marcolino, & Heydarian, 2015), (Pantazis, Gerber, & Wang, 2016), (Pantazis & Gerber, 2018) (Agirbas, 2019) (Gerber, Pantazis, & Wang, 2017). In addition, structural element design like shading system or pavilion or a column, seen in the work of (Tsiliakos, 2012), (Baharlou & Menges, 2013), (Pantazis & Gerber, 2014), (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Schwinn, Krieg, & Menges, 2014), (Gerber, Pantazis, & Marcolino, 2015), (Pantazis & Gerber, 2016), (Erdine & Kallegias, 2016a), (Gerber & Pantazis, 2016a), (Yazici & Gerber, 2016), (Gerber, Pantazi, & Wang, 2017), (Pantazis, 2019), (Smith, Danahy, & La Rotta, 2020). Layout configuration driven by users' behavior simulation (Lee, 2010), (Klein, et al., 2012), (Davide, et al., 2016), (Guon & Li, 2017), (Ghaffarian, Fallah, & Jacob, 2018), (Davide , Pilosof, Hadas , Yahav, & Kalay, 2019) (Fuchs & Neumayr, 2020). Energy management demand such as (Wang, Yang, & Wang, 2010), (Lee, 2010), (Joumaa, Ploix, Abras, & Oliveira, 2011), (Ramchurn, Vytelingum, Rogers, & Jennings, 2011), (Klein, et al., 2012), and (Zhao & Suryanarayanan, 2011), to product design (Madhusudan, 2005) , (Sugihara, 2014).

MAS in terms of the Architecture Design Process: In order to comprehend more the strategy and technique of using MAS, it can be seen in terms of a design cycle stages. Any design cycle consists of synthesis (modeling, generation), analysis (simulation) and evaluation (examining and searching method for an optimal solution; optimization). In MAS, all these stages are represented as agencies, combined, and work autonomously and collaboratively to reach specific design goals assigned by the design team. MAS can be used in generation level (modeling) in terms of singular agency like the work of (Yi & Kim, 2015) (Guon & Li, 2017), and simulation (in simulating user behavior), seen in the research of (Dijkstra, Timmermans, & Jessurun, 2000), (Klein, et al., 2012), (Davide, et al., 2016), and (Davide , Pilosof, Hadas , Yahav, & Kalay,

2019), for evaluation and or optimization process (Madhusudan, 2005), (Tsiliakos, 2012), (Sugihara, 2014), (Pantazis & Gerber, 2014), (López & Gerber, 2014), (Schwinn, Krieg, & Menges, 2014), (Pantazis & Gerber, 2016), (Pantazis, Gerber, & Wang, 2016), (Erdine & Kallegias, 2016a), (Gerber & Pantazis, 2016a), and (Yazici & Gerber, 2016). Or Undertaken throughout the whole process, collaborating between agencies from generation to evaluation and optimization, where behavioral design methodologies do not only negotiate for geometry generation but also geometry generation in regard to local and global performance objectives that might align or compete with one another until reaching to the most optimal one (Wang, Yang, & Wang, 2010), (Joumaa, Ploix, Abras, & Oliveira, 2011), (Klein, et al., 2012), (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Yi & Kim, 2015), (Gerber, Pantazis, & Wang, 2017), (Gerber, Pantazi, & Wang, 2017), (Pantazis & Gerber, 2018), (Agirbas, 2019) and (Pantazis, 2019).

In synthesis (generation) stage, MAS has the ability to standalone through describing an agent-based modeling logic like the work of (Baharlou & Menges, 2013), (Sugihara, 2014) (Pantazis & Gerber, 2014), (Schwinn, Krieg, & Menges, 2014), (Pantazis & Gerber, 2016), (Davide, et al., 2016) (Pantazis, Gerber, & Wang, 2016), (Erdine & Kallegias, 2016a), (Gerber & Pantazis, 2016a), (Gerber & Pantazis, 2016b), (Yazici & Gerber, 2016), (Gerber, Pantazi, & Wang, 2017), (Guon & Li, 2017), and (Pantazis, 2019). OR it can be integrated with or governed by a generative approach (ex; Swarm Intelligence (SI), L-System (LS), Cellular Automata (CA), etc.) in several forms. To exemplify; all of (Tsiliakos, 2012) (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Agirbas, 2019) used the logic of SI in generation stage, while (López & Gerber, 2014) (Yi & Kim, 2015) (Gerber, Pantazis, & Marcolino, 2015) (Gerber D. J., Pantazis, Marcolino, & Heydarian, 2015) (Gerber, Pantazis, & Wang, 2017) (Pantazis & Gerber, 2018) used LS. In addition, (Dijkstra, Timmermans, & Jessurun, 2000) who used CA.

The efforts of optimization are enormous and can be enumerated in two areas; MAS can integrate an agent-based searching method (hypothetically speaking a linear form) or integrate heuristic searching method. Researchers who adopt MAS with an agent-based searching model always build a framework to reach to a better solution better than the base case, or embrace a concept, where reaching for a better solution is stimulated to find a better one than the previous one (a linear and in some cases exponential form), or tackling the area where when the searching method stops the resulted solutions are likely to be nearer to sub-optimal one than when the searching process started seen in the work of (Madhusudan, 2005), (Lee, 2010), (Ramchurn, Vytelingum, Rogers, & Jennings, 2011), (Tsiliakos, 2012), (Baharlou & Menges, 2013), (Sugihara, 2014), (Pantazis & Gerber, 2014), (López & Gerber, 2014), (Erdine, 2016b), (Erdine & Kallegias, 2016a), (Pantazis & Gerber, 2016), (Pantazis, Gerber, & Wang, 2016), (Gerber & Pantazis, 2016a), (Yazici & Gerber, 2016), (Ghaffarian, Fallah, & Jacob, 2018), and (Gerber & Pantazis, 2016b). In the area of optimization MAS uses as a rule-based searching methods written in agent's logic of thinking, where they use a linear searching system which always take a longer time than when using any other heuristic searching method.

MAS and Heuristic Searching Methods: In the area of integrating a heuristic searching method, the efforts are significant. To exemplify; (Klein, et al., 2012) used Markov Description Problems method, (Gerber, Shiordia, Veetil, & Mahesh, 2014)and (Gerber, Pantazi, & Wang, 2017) used Multi-objective optimization, (Yi & Kim, 2015) used Genetic algorithm, (Guon & Li, 2017) used Evolutionary Approach, (Wang, Yang, & Wang, 2010) used practical swarm intelligence, and (Gerber, Pantazis, & Wang, 2017), (Pantazis & Gerber, 2018), and (Pantazis, 2019) used hill climbing and simulated annealing. Despite these massive efforts in utilizing a heuristic approach, researchers did not clearly state how, or why they are using these approaches specifically. A more detailed explanation for the selection and how these heuristic approaches are integrated is strongly needed to be provided, which challenges and inspire the further research in this area. Solving multi objectives problems has been a challenge to researchers for a very long time until the first use of the evolutionary algorithms (EAs). It motivates them by its population-based nature of evolutionary algorithms - to solve such multi-objective problems (Coello, Lamont, & Van Veldhuizen, 2007). Evolutionary driven design targets the search for the optimum solution(s). It is applied after the initial level of conceptual design as a search engine, where applying evolutionary design supports the search of broader ranges of alternatives (Gerber & Lin, 2013).

Genetic Algorithm is one of the mostly used and successful investigative search methods for optimum solutions proved by several papers such as (Torres & Sakamoto, 2007) (El-Sheikh & Gerber, 2011) (Varendorff & Hansen, 2012) (El Daly, 2014) (Elghazi, Wagdy, Mohamed, & Hassan, 2014) and (El-

148

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Maghraby, 2016). Despite its promising capabilities limited number of papers utilized it in its search process for an optimal solution such as the work of (Yi & Kim, 2015). In this paper the researchers used a simplified design problem, where they used MAS in the modeling logic and did not appear further in the rest of the design process. Another attempt by (Smith, Danahy, & La Rotta, 2020) , where the researcher created three combined methods in one process. Each method tackle a part of the design process; topoform creates the column geometry using evolutionary-multi agent software, capable of generating diverse topological designs with structural and geometric performance governed and selected by GA integration - matform an agent based additive manufacturing tool-path able to produce gravitational material affects while adapting to local structural and geometrical data- and finally a matSim, a material physics simulation environment to simulate additive manufacturing material structurally and aesthetically in a high resolution. The proposed method showed a successful integration between GA with MAS, which inspire and challenge the research further in this area.

Human behvior in MAS: Research has proven that designing according to user needs, behavior and preferences has a great potential to reduce energy consumption. A usual applicability of user-related information is by informing the design process of user's possible interactions, comfort levels, preferences, and occupation schedules. In addition, research has proven that user-centered design could significantly increase the efficiency of any tested system. Despite these promising potentials and efforts applying them is usually harder as the designer does not necessarily have accurate information of possible occupants' behavior. In other words, people do not necessarily function according to these assumptions of occupancy pattern or such fixed schedules. Therefore, in the area of energy demand, (Klein, et al., 2012) presents, implements and integrates MAS encompassing Markov decision problems (MDPs) to model alternative management and control of building systems and occupants. Such strategies have a great potential in reducing energy through direct cooperation and coordination with building occupants in addition to improving control of building systems and energy resources. However, in the area of integrating MAS and ABMS researchers' attention were taken more towards behavior of human being, believing that instead of designing and constructing and then do post-occupancy assessment, they now design the other way around (bottom-up method). Through using anticipated behavior of people inside the space and accordingly the building will be created to most satisfy or provide these users with their needs and level of comfort inside the building, in terms of environmental, structural, or functional performance. A common approach of incorporating human-center design is by including user's behavioral model to simulate users' movements, interactions, and responses to examine a proposed design (Dijkstra, Timmermans, & Jessurun, 2000), (Davide, et al., 2016), (Davide , Pilosof, Hadas , Yahav, & Kalay, 2019) or to create a design like the work of (Ghaffarian, Fallah, & Jacob, 2018) in creating a spatial arrangement informed by the users' movements.

Another interesting attempt seen in the work of (Pantazis, Gerber, & Wang, 2016), when incorporating Immersive Virtual Environments (IVE) in the design process. Research has proven that participants perform similarly within IVE as they do in physical environments, and they also feel similar feelings of presence within such environments. To clarify the significance of such efforts, it is important first to define the word performance. Performance is a widely used word with different perceptions in architecture. Grobman and Neuman describe two different levels of performance (Grobman & Neuman, 2012). The first is a broad definition, which includes three dimensions: empirical, cognitive, and perceptual. The other level is the narrow definition, which is concerned with the empirical dimension disregarding the other two dimensions. The Empirical dimension can be translated into computer language; therefore, it is widely used. While the cognitive and perceptual ones mainly rely on questionnaires and statistical measurements, making them hard to achieve. In the work of (Pantazis, Gerber, & Wang, 2016) , they incorporate the use of IVE. This combination is very interesting where they could apply the broader definition of Performance by integrating IVE instance evaluation of a user. By doing this they can integrate designer's intuition into the design process to find an optimal solution technically, cognitively, and perceptually while considering user's experience with the proposed design.

Another research by Fuchs and Neumayr (2020) aims at developing a cross-disciplinary system that capable of generating spatial environments with higher social interactions. The intension is to design an office break out room governed by the occupants anticipated behvior and ensure increased human interaction. The researcher applies two layers of interactions; interactions between office spaces users which are governed by status, affiliation, position etc. and another between the users and the furniture elements such as tables,

reception desk, coffee machine etc. Despite this approach is valuable, it still has its limitations, here human behvior and interactions are still hard to be precisely mapped, which always comes at the expense of the whole system accuracy.

The Architecture Problem complication and using MAS: MAS made the integration of structural and environmental performance analysis to be possible, through decomposed design process into multiple agencies that work autonomously and collaboratively. This integration is seen in the work of (Pantazis & Gerber, 2014), (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Gerber, Pantazis, & Marcolino, 2015), (Gerber & Pantazis, 2016a), (Yazici & Gerber, 2016), (Gerber, Pantazi, & Wang, 2017), and (Pantazis, 2019). As well as the integration of material constrains and fabrication requirements in the early design stages, seen in the work of (Baharlou & Menges, 2013), (Pantazis & Gerber, 2014) (Gerber, Shiordia, Veetil, & Mahesh, 2014), (Schwinn, Krieg, & Menges, 2014), (Gerber, Pantazis, & Marcolino, 2015), (Erdine & Kallegias, 2016a), (Gerber, Pantazis, & Wang, 2017), and (Gerber, Pantazi, & Wang, 2017). Despite these essential studies paves the way to creating a system that is concerned with two different performable disciplines, an obvious gap seen in creating a MAS system that integrates environmental and functional performances all together, which challenges the research further to dig deeper in this area.

Spatial Planning, equivalent to word layout in this research; multiple researchers worked in this area from an evolutionary platform, refer to a review by (Calixto & Celani, 2015) concerning this issue. However, in the field of MAS spatial planning has been applied through three different methods: a proposed plan and testing its functional performance according to behavior of users and then adjust it accordingly, seen in the work of (Dijkstra, Timmermans, & Jessurun, 2000), (Davide, et al., 2016), and (Davide , Pilosof, Hadas , Yahav, & Kalay, 2019). A Users' behavioral model is used to create voids (circulation areas) and leftovers are defined as shape solid (functional spaces) like the work of (Ghaffarian, Fallah, & Jacob, 2018). Or MAS is used in achieving spatial relationship and functional requirements in two and three-dimensional, seen the work of (Guon & Li, 2017).

Tools of MAS: Concerning the tools to develop a MAS framework, most researchers develop their own tool or toolkit. In the work of (Sugihara, 2014), the researcher developed an open-source library on Processing called iGeo to help computational designers to explore design possibilities in agent-based algorithms. What is so distinctive about this paper is the detailed description of the code and its technical aspects. Therefore, it is considered a valuable source of inspiration in the realm. Though, other researchers use visual scripting platforms like grasshopper and then apply collaboration by wider platform that requires coding; external software that is concerned with the collaboration between different agents seen in the work of (Pantazis & Gerber, 2016) and (Gerber, Pantazis, & Wang, 2017). With their reliability on iGeo library, they provide detailed technical description, which is also considered valuable source for this research. In the area of human as agents the usage of Netlogo and unity is preferred, seen in the work of   (Fuchs & Neumayr, 2020). It has been noticed that utilizing MAS and ABMS requires the designers to create their own design toolkit to apply it, challenging the architects further to master several coding languages such as scripting coding, C# and Java script etc.

6 CONCLUSION AND FURTHER RESEARCH

There are various strategies in applying MAS. It can be used in any design stage, it can appears standing alone in the generation stage in terms of singular or multiple agent-based modeling, or simulation stage or optimization stage, or its agents can be distributed along the process where each agent act autonomously achieving its own local targets while collaborating with the other agents in the same stage or with other agents from a different stage to achieve the global targets, aiming for design exploration and/or optimization. It is obvious from the matrix seen in, Figure 1 , the selected sample fall in the area where agent-based is highly used in generation and/ or optimization level aiming to solve single/multi design problems that reflects system capabilities in addressing different level of design complexity. On the contrary, in the area of aesthetics the efforts are limited which raises the question towards the importance of aesthetics and how can they be measured and achieved so it can be tackled further by the use of MAS and ABMS. Finally using it in the building system and energy demand is noticeable specifically in the prime usability of the ABMS and MAS.

Architects are now capable of dealing with complex design issues targeting several performances at the same time, where MAS is capable of integrating several agents fall under different design stages and loaded with

its own set of behaviors and targets. Therefore, their vast capabilities are well-witnessed. To name a few: MAS ability in emergence which results in unexpected designs. Huge solutions spaces resulted when autonomous agents interact with one another while exploring design solutions. They can deal with huge and complex data set, computation and reasoning processes as they are conveniently distributed and modularized by using agents as the main module units. Different agents with varies roles for different practice aspects acting naturally. Dealing with different level of complexity, varies stages of design, different level of complexity and languages, different tasks (generating/ evaluating/ criticizing/ optimizing/ analyzing)., different parts of computational system.

It is also noticeable that agents can come in a form of mimicking human behavior, others acting like a building element and/or becoming as defined manipulators that when connected together they can form a building skin or column or a shading system. It can promote the achievement of several scenarios in the space; multiple users, multiple functions, using multiple sensors to control automation system etc.

In addition, integration of Environmental and structural design problems can be solved in holistic fashion. In addition to merging fabrication constraints while designing and using fabrication constraints as designing drivers. This also reflected that MAS usage seems to have a global-related concern, which is climate change issue, where researcher's intent to design in regard to environmental performance and/or when the process integrates rationalization techniques to ensure material suitability and constructability and reduce expected waste in material. Going for complex design outcomes aesthetically with performable solutions proved the system vast capabilities in handling several design issues without simplifying the design outcome and taking it to a more holistic approach in terms of fabrication rendered the complex forms feasible for construction. However, the selected building types and design problems are still simplified, where most of papers tackle from two to three design objectives at maximum, which still does not reflect a highly complex design issue like designing for a huge shopping mall, hospitals etc., where the objectives with equal importance increase dramatically.
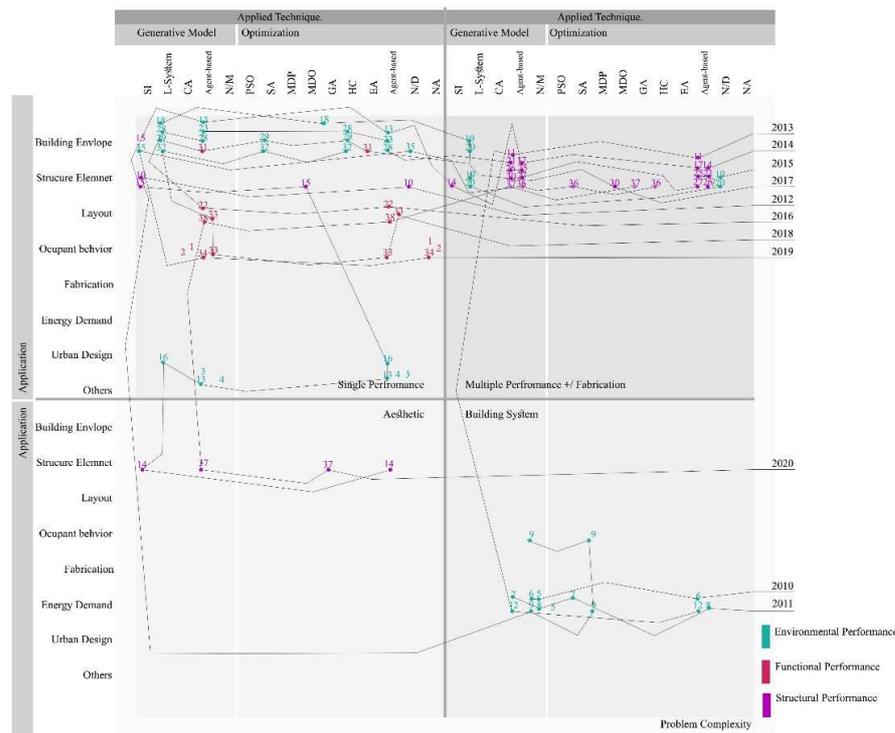
Figure 1: A Matrix Briefing the Applied Study (by author).

In the area of integrating heuristic searching method, relying only on agent-based searching method to find the optimal solution running to what this research called a linear searching process require extensive computation and time as handling that amount of rule-based parameter is endless. Therefore, incorporating a heuristic searching method is more promising to find the local-optimal or near optimal solutions in a reasonable time. Some insights on the optimization processes; Integrating two or more design objectives would complexify the design problem further making it a multi-objective optimization process. This was tackled differently by different researchers; Some would use multi objectives heuristic searching methods.

Others would combine all objectives in one formula where each objective is weighted differently in accordance with the researcher's criteria. And the process is turned into single objective optimization, where the system is trying to minimize or maximize the outcome. This formula would help to find the global optimal solution. However, this optimal solution is defined in terms of the designer/ creator weights to the formula's parameters which consequently affects the result greatly. This means the output is not necessarily the most optimal as for another weight factors the global optimal solution will result in a different one.

On the contrary, optimization based on pareto frontier in multi-objective optimization considered a more valuable technique, as it is seen to the user the different alternatives and where they fall on the pareto graph, how each solution out wins the other in each objective. This results in many alternatives and the designer can afterwards choose intuitionally and according to his/her own design targets which is the suitable or preferred solution. It can also give insights about the different objectives interrelation and correlation inside the system. Finally, the selected heuristic searching method is crucial in affecting the results outcome. They are another rule-based system with their own changing parameters added to the system, like the percentage of crossover to mutation in genetic algorithm. Therefore, defining the most suitable heuristic searching method is another research question. What is the most suitable searching method suitable for the problem at hand, especially with an ill-defined design problem like architecture design problems. Can one heuristic searching method outperform another? What are the internal parameters of the heuristic searching method and how they can drastically change the output? As they would. Should the designer use more than one to ensure the optimality of the output. Many questions can guide the research further in the area of integrating MAS with heuristic searching methods.

#	Year	REF	Domain			Complexity							Application								Applied Technique														
						Aesthetic	single Performance	Performance (+) A	B	Performance + C	D	Building System E	ENVELOPE	STRUCTURE ELEMENT	LAYOUT	OCT- BHR	FABRICATION	ENERGY	URABN DESIGN	OTHERS	Generative Model					Optimization									
			1	2	3																SI	L	CA	Agent-based	N/A	PSO	SA	MDP	MDO	GA	HC	EA	Agent-based	N/D	N/A
1	2000	(Dijkstra, Timmermans, & Jess		•					•								•							•											•
2	2001	(Dijkstra, Jessurun, & Timmermans, 2000)		•					•								•							•											•
3	2002	(Achten & Jessurun, 2002)	•																	•				•											•
4	2004	(Madhusudan, 2005)		•																•				•									•		
5	2010	(Wang, Yang, & Wang, 2010)	•									•							•				•	•											
6	2010	(Lee, 2010)	•									•			•				•				•									•			
7	2011	(Joumaa, Ploix, Abras, &	•									•							•				•			•									
8	2011	(Ramchurn, Vytelingum,	•									•							•				•									•			
9	2012	(Klein, et al., 2012)	•									•			•		•						•						•						
10	2012	(Tsiliakos, 2012)	•			•					•								•															•	
11	2013	(Baharlou & Menges, 2013)	•				•				•										•											•			
12	2013	(Zhao & Suryanarayanan,	•					•								•					•										•			
13	2014	(Sugihara, 2014)	•			•				•						SE VS			•											•			
14	2014	(Pantazis & Gerber, Material	•		•		•				•			•			•													•			
15	2014	(Gerber, Shiordia, Veetil, & Mahesh, 2014)	•			•			•	•																	•			•			
16	2014	(López & Gerber, 2014)	•			•			L am						•														•			
17	2014	(Schwinn, Krieg, & Menges,	•				•			•							•													•			
18	2015	(Yi & Kim, 2015)	•		•				•									•									•			•			
19	2015	(Gerber, Pantazis, &	•			•	•	•		•					•																•		
20	2015	(Gerber D. J., Pantazis,	•		•			•	•					•																	•		
21	2016	(Pantazis & Gerber,	•		•				•						•															•			
22	2016	(Davide, et al., 2016)	•		•					•					•															•			
23	2016	(Pantazis, Gerber, & Wang, A	•		•				•						•															•			
25	2016	(Erdine & Kallegias2,	•			•			•		•				•															•			
26	2016	(Gerber & Pantazis, 2016)	•			•			•		•				•															•			
27	2016	(YAZICI & GERBER, 2016)	•			•			•						•															•			
28	2016	(Gerber & Pantazis, A Multi-Agent System for Facade	•		•			•						•	•												•	•			
29	2017	(Gerber, Pantazis, & Wang,	•		•			•							•									•			•			•		
30	2017	(Gerber, Pantazi, & Wang, Interactive Design of Shell	•			•			•							•									•				•			
31	2017	(Guon & Li, 2017)	•		•					•					•													•				
32	2018	(Pantazis & Gerber, A	•		•				•						•									•			•				
33	2018	(Ghaffarian, Fallah, & Jacob,	•		•					•	•				•													•			
34	2019	(Davide , Pilosof, Hadas ,	•		•					•					•																•
35	2019	(Agirbas· 2019)	•		•			•					•																•		
36	2019	(Pantazis, Environmental	•			•			•						•					•			•					
37	2020	(Smith, Danahy, & La Rotta,	•	•		•			•						•					•			•				
38	2020	(Fuchs & Neumayr, 2020)	•		•				•						•													

Table 1: Showing the list of Studied Papers.

Some questions and notions were raised in response to this literature review to be investigated further in detail. Such as what is the possible validation processes a user can do to guarantee and validate the work of MAS, he/she created. Most researchers count on the end product; if the end product is valuable and falls under their criteria, the process can be considered valid. The question here is how can research validate further these processes what other possible ways of validation for such uncontrolled environments of exploration are witnessed on the level of ABMS usage in creation. In addition, the notion of constraints,

152

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

bias, and assumption. Can they offer a larger solution space or limit it, how the consequences of architects' bias and assumptions can be governed. With the intention to complexifies and yet produce exquisite forms the researchers adopt the concept of agent-based modeling and simulation in several levels such as manipulative level of agents that results into a form. The question here is how the design can be deliberate encompassing the architect's assumptions if ABMS gives and adapts an uncontrolled emergent phenomenon of exploration.

7 REFERENCES

López, R. S., & Gerber, D. J. (2014). Context-Aware Multi-Agent Systems: Negotiating Intensive Fields. Association of Computer Aided Design of Architecture (ACADIA. Los Angeles, CA, USA.

Zboinska , M. A. (2015). Hybrid CAD/E platform supporting exploratory architectural design. Computer-Aided Design, 59, 64-84.

Agirbas, A. (2019). Façade form-finding with swarm intelligence. Automation in Construction, 99, 140-151.

Baharlou, E., & Menges, A. (2013). Generative Agent-Based Design Computation: Integrating material formation and construction constraints. eCAADe : Computation and Performance. Delft, the Netherlands.

Bar-Yam, Y. (2002). General features of complex systems. UNESCO Encyclopedia of Life .

Beetz, J., Leeuwen, J. v., & Vries, B. d. (2004). Towards a Multi Agent System for the Support of Collaborative Design; Assembling a toolbox for the creation of a proof of concept. Developments in Design & Decision Support Systems in Architecture and Urban Planning. Eindhoven University of Technology.

Calixto, V., & Celani, G. (2015). A literature review for space planning optimization using an evolutionary algorithm approach: 1992-2014. SIGRADI .

Chang, Y.-S., Chien, Y.-H., Lin, H.-C., Chen, M. Y., & Hsieh, H.-H. (2016). Effects of 3D CAD applications on the design creativity of students with different representational abilities. Computers in Human Behavior, 65, 107-113.

Coello, C. A., Lamont, G. B., & Van Veldhuizen, A. D. (2007). Evolutionary Algorithms for Solving Multi-Objective Problems (2nd ed.). (J. R. Koza, & D. E. Goldberg, Eds.) New York, USA: Springer Science+Business Media, LLC.

Daemei, B. A., & Safari, H. (2018). Factors affecting creativity in the architectural education process based on computer-aided design. Frontiers ofArchitecturalResearch, 7, 100-106.

Davide , S., Pilosof, N. P., Hadas , S., Yahav, J., & Kalay, Y. E. (2019). Simulating multi-agent narratives for pre-occupancy evaluation of architectural designs. Automation in Construction, 106.

Davide, S., Morad, M. G., Zinger, E., Pilosof, N. P., Sopher, H., Brodeschi, M., . . . Kalay, Y. E. (2016). A computational framework to simulate human spatial behavior in built environments. Symposium on Simulation for Architecture and Urban Design. London, UK.

Dijkstra, J., Timmermans, H. J., & Jessurun, A. J. (2000). A Multi-Agent Cellular Automata System for Visualizing Simulated Pedestrian Activity. Theoretical and Practical Issues on Cellular Automata. Karlsruhe, Germany.

El Daly, H. M. (2014). Automated Fenestration Allocation as Complying with LEED Rating System . Alexandria Engineering Journal. Egypt: Retrived from Science Direct Database, doi: 10.1016/j.aej.2014.09.011.

Elghazi, Y., Wagdy, A., Mohamed, S., & Hassan, A. (2014). Daylighting Driven Design: Optimizing Kaleidocycle Facade for Hot Arid Climate. Proceedings of Fifth German-Austrian IBPSA '14 Conference: BAUSIM 2014, (pp. 314-321).

El-Maghraby, I. M. (2016). Parametric Evolutionary Performative Driven Design: An Approach towards Designing High Performance Façades. Alexandria, Egypt: Faculty of Egineering.

El-Sheikh, M., & Gerber, D. J. (2011). Building Skin Intelligence: a parametric and algorithmic tool for daylighting performance design integration. Proceedings of ACADIA 2012 Conference : Integration Through Computation, (pp. 170-177).

Erdine, E. (2016b). Rethinking Conceptual Design: Computational Methods for the Simultaneous Integration of Tower Subsystems. Symposium on Simulation for Architecture and Urban Design. London, UK.

Erdine, E., & Kallegias, A. (2016a). Modelling Natural Formations: Design and Fabrication of Complex Concrete Structures. Symposium on Simulation for Architecture and Urban Design. London, UK.

Fernandes, R. M. (2013). Generative Design: a new stage in the design process. (Unpublished M. Sc. Dissertation), Tecnico Lisboa.

Fuchs, M., & Neumayr, R. (2020). Agent-Based Semiology for Simulation and Prediction of Contemporary Spatial Occupation Patterns. Impact: Design With All Senses; Proceedings of the Design Modelling Symposium (pp. 648–661). Berlin: Springer.

Gerber, D. J., & Lin, S.-H. E. (2013). Designing-in performance: A framework for evolutionary energy performance feedback in early stage design. Automation in Construction. Retrieved 2014, from Science Direct Database, doi: 10.1016/j.autcon.2013.10.007. doi:10.1016/j.autcon.2013.10.007

Gerber, D. J., & Pantazis, E. (2016b). A Multi-Agent System for Facade Design; A design methodology for Design Exploration, Analysis and Simulated Robotic Fabrication. 36th Annual Conference of the Association for Computer Aided Design in Architecture.

Gerber, D. J., Pantazi, E., & Wang, A. (2017). Interactive Design of Shell Structures Using Multi Agent Systems; Design Exploration of Reciprocal Frames Based on Environmental and Structural Performance. CAADFutures 17. Istanbul .

Gerber, D. J., Pantazis, E., & Marcolino, L. S. (2015). Design Agency Prototyping Multi-Agent Systems in Architecture. : Computer-Aided Architectural Design Futures. The Next City - New Technologies and the Future of the Built Environment. São Paulo, Brazil.

Gerber, D. J., Pantazis, E., & Wang, A. (2017). A multi-agent approach for performance based architecture: Design exploring geometry, user, and environmental agencies in façades. Automation in Construction, 45–58.

Gerber, D. J., Pantazis, E., Marcolino, L., & Heydarian, A. (2015). A Multi Agent Systems for Design Simulation Framework: Experiments with Virtual Physical Social Feedback for Architecture. Simulation for Architecture & Urban Design, (pp. 1247-1254).

Gerber, D. J., Shiordia, R., Veetil, S., & Mahesh, A. (2014). Design Agency: Prototyping Multi-Agent System Simulation for Design Search and Exploration. Symposium on Simulation for Architecture and Urban Design. Tampa, Florida, USA.

Gerber, D., & Pantazis, E. (2016a). Design Exploring Complexity in Architectural Shells Interactive form finding of reciprocal frames through a multi-agent system. eCAADe 34: Generative desgin | Applications - Volume 1. Oulu, Finland.

Ghaffarian, M., Fallah, R., & Jacob, C. (2018). Organic Architectural Spatial Design Driven by Agent-Based Crowd Simulation. SimAUD . Netherlands.

Grobman, Y. J., & Neuman, E. (2012). Performalism; Form and Performance in Digital architecture. New York: Routledge.

Guon, Z., & Li, B. (2017). Evolutionary approach for spatial Architecture layout design enhanced by an agent-based topology finding system. Frontiers of Architectural Research.

Heath, B. L., & Hill, R. R. (2010). Some insights into the emergence of agent-based modelling. Journal of Simulation, 163–169.

Jennings, N., & Wooldridge, M. (1999). Software Agents. IEE Review.

Joumaa, H., Ploix, S., Abras, S., & Oliveira, G. D. (2011). A MAS integrated into Home Automation system, for the resolution of power management problem in smart homes. Energy Procedia, 6, 786–794.

Klein, L., Kwak, J.-y., Kavulya, G., Jazizadeh, F., Becerik-Gerber, B., Varakantham, P., & Tambe, M. (2012). Coordinating occupant behavior for building energy and comfort management using multi-agent systems. Automation in Construction, 22, 525–536.

Lee, J. (2010). Conflict resolution in multi-agent based Intelligent Environments. Building and Environment, 45, 574–585.

Liu, X., Li, Pan, P., & Li, W. (2011). Research on computer-aided creative design platform based on creativity model. Expert Systems with Applications, 38, 9973–9990.

Macal, C. M., & North, M. J. (2009). Agent-based modelling and simulation. Winter Simulation Conference.

Macal, C. M., & North, M. J. (2010). Tutorial on agent-based modelling and simulation. Journal of Simulation, 151-162.

Madhusudan, T. (2005). An agent-based approach for coordinating product design workflows. Computers in Industry, 56, 235–259.

Pantazis, E. (2019). Environmental aware shell design: Using solar path as a form finding force.

Pantazis, E., & Gerber, D. (2014). Material Swarm Articulations: New View Reciprocal Frame Canopy. eCAADe 32 - Fabrication - Volume 1. UK.

Pantazis, E., & Gerber, D. J. (2016). Designing with complexity, Interactive form finding of reciprocal frames through a. eCAADe 2016. Oulu, Finland.

Pantazis, E., & Gerber, D. J. (2018). A framework for generating and evaluating façade designs using a multi-agent system approach. International Journal of Architectural Computing, 4(16), 248–270. doi:10.1177/1478077118805874

Pantazis, E., & Gerber, D. J. (2019). Beyond geometric complexity: a critical review of complexity theory and how it relates to architecture engineering and construction. Architectural Science Review. doi:10.1080/00038628.2019.1659750

Pantazis, E., Gerber, D. J., & Wang, A. (2016). A Multi-Agent System for Design: Geometric Complexity in support of Building Performance. Symposium on Simulation for Architecture and Urban Design. London, UK.

Ramchurn, S. D., Vytelingum, P., Rogers, A., & Jennings, N. (2011). Agent-Based Control for Decentralised Demand Side Management in the Smart Grid. Autonomous Agents &.

Rittel , H. W., & Webber, M. M. (1973). Planning Problems are Wicked Problems. Developments in Design Methodology.

Robertson, B. F., & Radcliffe, D. F. (2009). Impact of CAD tools on creative problem solving in engineering design. Computer-Aided Design, 41.

Schwinn, T., Krieg, O. D., & Menges, A. (2014). Behavioral Strategies: Synthesizing design computation and robotic fabrication of lightweight timber plate structures. ACADIA. Los Angeles.

Smith, R. S., Danahy, P., & La Rotta, N. R. (2020). Topological and Material Formation; A Generative Design Framework for Additive Manufacturing Integrating Material-Physics Simulation and Structural Analysis. ACADIA 2020, (pp. 290-299).

Sugihara, S. (2014). Algorithm Development Environment for Computational Design Coders with Integration of NURBS Geometry Modeling and Agent Based Modeling. ACADIA. Los Angeles, USA.

Suh, N. P. (2005). Complexity in Engineering. CIRP Annals, 46-63.

Terzidis, K. (2006). Algorithmic Architecture. Great Britain: Architectural Press.

Torres, S. L., & Sakamoto, Y. (2007). Facade Design Optimisation for Daylight with a Simple Genetic Algorithm. Proceedings from IBPSA '07; Bulding Simulation - the International Building Performance Simulation Association (pp. 1162-1167). Beijing, China: Retrieved from http://www.ibpsa.org/proceedings/BS2007/p117_final.pdf.

Tsiliakos, M. (2012). Swarm Materiality: A multi-agent approach to stress driven material organization. eCAADe 30.

Varendorff, A., & Hansen, V. G. (2012). Building envelope: Performance optimisation processes for a daylight responsive architecture. Proceedings of the 28th International PLEA 2012 Conference : Opportunities, Limits and Needs Towards an Environmentally Resposable Architecture, Passive & Low Energy Architecture (PLEA). Lima, Perú. Retrieved from http://eprints.qut.edu.au/54459/

Viehweider, A., & Chakraborty, S. (2015). Multi-Agent based Distributed Optimization Architecture for Energy- Management Systems with Physically Coupled Dynamic Subsystems. IFAC-PapersOnLine, 48(30), 251-256.

Wang, Z., Yang, R., & Wang, L. (2010). Multi-agent Control System with Intelligent Optimization for Smart and Energy-efficient Buildings. 36th Annual Conference on IEEE Industrial Electronics Societ.

Wolf, T. D., & Holvoet, T. (2005). Emergence versus self-organisation: Different concepts but promising when combined. In J. G. Carbonell, & J. Siekmann (Ed.), Engineering Self-Organising Systems: Methodologies and Applications (pp. 1–15). Berlin Heidelberg: Springer.

Yazici, S., & Gerber, D. J. (2016). Prototyping generative architecture Experiments on Multi-Agent Systems, Environmental Performance and 3D. ASCAAD: Parametricism vs. materialism; Evolution of Digital Technologies for Development. London, UK.

Yi, Y. K., & Kim, H. (2015). Agent-based geometry optimization with Genetic Algorithm (GA) for tall apartment's solar right. Solar Energy(113), 236–250.

Zboinska, M. A. (2019). Influence of a hybrid digital toolset on the creative behaviors of designers in early-stage design. Journal of Computational Design and Engineering, 6, 675–692.

Zhao, P., & Suryanarayanan, S. (2011). An Energy Management System for Building Structures Using a Multi-Agent Decision-Making Control Methodology. IEEE Transactions on Industry Applications.

154

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Creating Resilient Public Spaces – a Global Perspective on the Conditions for Integrated Urban Development

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1 ABSTRACT

Urban public spaces play a central role in the regeneration of cities: their inclusive and sustainable design is crucial for creating equitable and climate-resilient urban environments. This paper presents the results of an applied research project that involved case studies in three cities on three continents - Dhaka, Maputo, and Santo Domingo – where the team of superwien, in partnership with local academic partners, developed designs for public spaces using an integrated approach. The participatory design process was implemented during the worldwide COVID-19 pandemic in 2021 and 2022 through academic urban living labs in our partner cities. Urban strategies and design solutions for the regeneration of public space were co-created with local communities through a moderated, innovative planning and design process. Additionally, accompanying research was conducted to explore the need for integrated planning approaches in urban regeneration that address multi-sectoral challenges. This approach aimed to ensure that the resulting proposals were holistic and responsive to the specific needs and aspirations of the local communities and urban environments in which they were implemented.

The case studies encompassed a range of sites reflecting diverse urban contexts: the urban lake of Shahjahanpur Jheel in Dhaka that had deteriorated into a dump site, central public spaces in informal neighbourhoods surrounding the historic centre of Maputo, and a central expressway in Santo Domingo. In intensive dialogue with the local populations, their needs and aspirations for these places were identified. Co-creation opportunities and place-making events empowered residents and local entrepreneurs to take an active role in the transformation of their neighbourhoods. Established participation tools were adapted to each local context and new techniques were developed for specific user groups. Additionally, young professionals were included in the design process through cooperation with local universities. Academic partnerships and the cooperation with local city administrations also supported capacity building and knowledge exchange. The results of the process included integrated urban strategies, urban designs, and architectural solutions, completed by cost estimates for implementation.

During the transnational work process, we identified seven overarching challenges that need to be addressed to transform public spaces with an integrated approach: inclusive mobility, housing, climate change adaptation, local economy, governance, as well as gender-sensitive and participatory planning. Considering these aspects in their specific local contexts supports the creation of lively public spaces for the development of inclusive, resilient, and sustainable cities. This paper presents how the challenges were identified and addressed through the applied research approach for the design of public spaces in Dhaka, Maputo and Santo Domingo.

Keywords: Co-Creation, Resilient Public Spaces, Participatory Urban Design, Academic Partnerships, Urban Design Lab

2 THE PANDEMIC AND OTHER JOINT CHALLENGES

In 2020 the COVID-19 pandemic spread across the world and left its mark in all aspects of human life. Urban life was hit particularly hard: high population densities, smaller housing units, and limited access to open space made life during the pandemic a serious struggle for many. In many cities, public parks and green spaces were closed or access restricted, people had to stay inside for days. Suddenly, the immense value of accessible public space became clearer than ever. This is the time when we started our research project in three cities around the world: Dhaka in Bangladesh, Maputo in Mozambique and Santo Domingo in the

Dominican Republic. All three cities are united in a notorious lack of public spaces. Especially poor or less developed areas face massive challenges when it comes to the provision of recreational outdoor spaces. Land prices are high and informal urban development swallows the remaining open spaces. However, the local municipalities are well aware of the need for quality open spaces for their inhabitants, especially after experiencing a global health crisis. Our task was to create and improve local public spaces in each city. Howeder, in order to approach the design in an integrated manner, several other challenges had to be addressed too.

2.1 Participatory design for inclusive public spaces

The main focus of the research and design challenge was to create inclusive public spaces for and with the local communities. The call for public participation in urban design processes is based on a paradigm shift in the planning world that started to recognize the place-based knowledge of local stakeholders. For most of the nineteenth century, positivism strongly influenced the social sciences and planning. There was a distinct division of roles and responsibilities among various actors, with architects and planners primarily serving as advocates for municipal government (König et al. 2023a). This separation has resulted in issues of injustice, marginalisation, and exclusion when higher authorities are solely responsible for designing public spaces (Rocco 2014). Other forms of planning started to emerge with the communicative turn in the 1960s and 1970s. In this approach, the city is made by the people who experience it in their daily lives. Contemporary planning approaches draw on the immense potential of local day-to-day practitioners and the expert knowledge of architects, urbanists, and other professionals. This approach is linked to the planner's position as an intermediary who has the task to reconcile interests, enable communication, and actively create a discourse about the production of space (Dangschat 2006). Participatory planning and design became the new tool for the creation of inclusive cities and public spaces.

2.2 Gender-sensitive planning

The discourse on participative and inclusive design also revealed a stark imbalance in the inclusion of girls, women and marginalised groups in planning processes. Urban design has long been a male-dominated discipline and this biased perspective on space has resulted in exclusive urban forms that make life more difficult for care-givers, disabled people, children, and other vulnerable groups (Falú 2020; Kern 2020). Feminist geographers have helped us understand how the unbalanced relationship between women and men is expressed spatially (Hurtig et al. 2023, 84). The feminist perspective on urban design therefore places the everyday life conditions of the neighbourhood at the centre of decision-making. It is necessary to understand the everyday activities and routines of different population groups, including the most vulnerable, to plan and build a city that is inclusive and offers the same opportunities for all. A participatory approach to urban design therefore must aim to include the diverse user groups of urban space with a particular focus on women, children, elderly, and disabled people.

2.3 Inclusive and sustainable mobility

The matter of inclusion is also an important topic in relation to urban mobility. Cities in the Global South are prone to particularly unjust mobility opportunities. Rapid urbanisation, uncontrolled urban sprawl in combination with a lack of road infrastructures and adequate public transportation lead to half of the inhabitants in this region suffering from restricted mobility (Venter et al. 2019). Especially inhabitants of urban peripheries and informal settlements, and thus the most disadvantaged members of society, face inequality in accessing urban opportunities such as employment, public institutions, and recreational facilities, which are primarily concentrated in the formal city centres (ibid.). For the working population in these areas, the everyday commute is a huge monetary and timely constraint, while the non-working population (often women, children, elderly) is entirely cut off from these urban amenities (Berger et al. 2014; König et al. 2023b). At the same time, mobility is still one of the biggest sources of CO_2 emissions and the transition towards sustainable modes of transportation is mandatory in order to respond to the ongoing climate crisis. The challenges of unjust and unsustainable mobility in cities of the Global South should therefore be addressed together and with a particular focus on the central role of public space. After all, streets make up for a large share of urban public spaces and the distribution of road space must be shifted towards a more just equilibrium that favours active mobility over individual motorised transportation (Nello-Deakin 2019).

2.4 Fostering local economies

Another activity that often takes place in public space, particularly in cities of the Global South, is trade and commerce. Small informal businesses provide the main income of many families and public spaces are often transformed into temporary or permanent workplaces. Informal economies are set apart from formal markets due the marginal nature of their activities that serve to sustain livelihoods. It is the result of insufficient demand for labour in underdeveloped countries (Young 2019). Up to 80% of urban dwellers rely on informal economic activities (Alison Brown 2018). Economic offerings greatly influence the overall atmosphere of a location. It's not surprising that areas with numerous shops and restaurants often become bustling urban hubs. With these places becoming more lively, they also have a greater impetus for new entrepreneurial endeavours. In this sense, economic activity can play an important role in reviving public spaces on the one hand, but can also foster unjust distribution of public space on the other (Gisinger 2023). City administrations play a vital role in managing public spaces and creating a balance between the stimulation of local economies and the provision of public spaces for other uses of general public interest (e.g. mobility, recreation, etc.).

2.5 Climate change adaptation

The local effects of climate change are becoming increasingly evident. The rise in sea levels is leading to a surge in natural disasters like floods, droughts, and heavy rainfall. Bangladesh, renowned for its severe floods, accounts for 50% of global cyclone-related deaths (Khan et al., 2011). Between 2011 and 2020, the Earth was 1.09ºC hotter compared to temperature records from the period between 1850 and 1900 when the first data on global surface warming became available (IPCC, 2021). Urban areas are facing mounting challenges due to the lack of green spaces, unplanned development, and inadequate soil permeability. Given the impact of climate change, it is crucial to transform cities in order to tackle these issues and implement eco-friendly urban development initiatives. Public spaces can play a significant role in urban adaptation efforts by harnessing their physical and social value to address weather phenomena (Silva & Costa, 2008). Incorporating large green areas and adopting sustainable practices are essential in densely populated cities to mitigate natural disasters and improve overall livability for all residents (WWF, 2020). Embracing nature-based solutions in urban planning is a vital approach to climate change adaptation, offering benefits like managing surface runoff and providing access to public green spaces (Abuje, 2022).

2.6 Providing affordable housing

Ensuring access to secure living environments is crucial for achieving inclusivity, resilience, and sustainability in all human settlements. However, in our project cities, there are significant gaps in accessing affordable housing. The inadequate supply of housing has resulted in the proliferation of informal settlements, currently housing approximately 880 million people (UN-Habitat, 2016). Furthermore, the commodification of housing has contributed to a global crisis of housing affordability. More than 330 million urban households are living in substandard housing or facing financial stress due to housing costs exceeding 30% of their incomes (McKinsey Global Institute, 2017). This housing crisis is particularly severe in the Global South, where rapid urbanisation is intensifying existing housing disparities. Spatial inequality within cities can lead to social segregation among communities (Martín, 2022). Our partner cities face formidable challenges due to accelerated urban growth. Moreover, the already precarious housing situation worsened during the Covid-19 pandemic, as strict curfews forced homes to become the primary spaces for work, study, and daily life.

2.7 Responsive city administration

In having to tackle all these challenges at once, municipalities often encounter significant governance challenges and limited resources for project implementation. They often adopt a reactive approach rather than proactive planning for the future. For example, prioritising investments in extensive road infrastructure like flyovers (as seen in Dhaka) or bridges (as observed in Maputo) over investments in health, safety, and well-being can perpetuate the struggle of communities to meet their basic needs and thrive. Moreover, insufficient resources hinder municipalities from fulfilling their responsibilities in urban development processes, and unclear roles and responsibilities can create power vacuums in project planning and implementation. Conversely, a responsive municipal administration takes action based on participatory urban development, whether at a small scale within an urban quarter or on a larger scale encompassing the entire

city (Reiter, 2021). In this context, addressing concerns related to public spaces becomes a crucial aspect of the responsive city discourse, as it directly influences the quality and accessibility of urban public areas. The following case studies in Dhaka, Maputo and Santo Domingo demonstrate how proactive city administrations can apply participatory design approaches to develop integrated projects that address multiple challenges at the same time.

3 CASE STUDY DHAKA – "DHAKA DREAMS"

In Dhaka, the World Bank is working with the Dhaka South City Corporation (DSCC), which administers the southern part of the metropolis, to implement the Dhaka Neighborhood Upgrading Project (DCNUP). The project focuses on the regeneration of public spaces, including the surroundings of Shahjahanpur Jheel, a small water body and green haven situated in one of Dhaka's most populated residential neighbourhoods. In order to address the many dimensions of this task, an interdisciplinary local team was set up for the work on the ground. The mixed team comprised young and experienced architects, urban designers, social anthropologists, and a geographer. The Department of Architecture at Daffodil International University was involved as local academic partner. The project sought to improve Shahjahanpur Jheel for and with the people. The community actively participated in this initiative from the beginning by taking part in various engagement activities.

3.1 Understanding the context of Shahjahanpur Jheel

The first project phase aimed to understand the local context, the challenges in public space, and aspirations of the community in relation to the development of the jheel. As a first step, the relevant stakeholders were identified. The local team was assisted by the Project Director of DSCC and the local ward councillor. They visited local communities, observed the area and compiled a comprehensive list of stakeholders which included members of the public administration, ward council members, a local police officer, land owners, residents, political figures, representatives of the local mosques, school teachers, and entrepreneurs.

Based on numerous stakeholder interviews and a detailed spatial analysis, the team identified eight Emerging Topics that are significant challenges and potentials related to the project development. These topics include poor water quality and pollution, insufficient waste management and maintenance, a lack of accessible public space, formal and informal economic activities, reduced public space due to construction, safety, and social conflict, as well as a strong sense of community and importance of human-scale mobility.

As a next step, residents were encouraged to express their ideas and opinions on the Shahjahanpur Jheel and its surrounding areas through anon-site spontaneous interaction. The goal was to involve groups like youngsters, the elderly, street vendors, mothers picking up their kids, guys spontaneously chatting, etc. who might not accept an offer to take part in a formal workshop or interview. The debate was centred around a big aerial map of Shahjahanpur Jheel and its surroundings. Men and women were asked about their favourite areas, places they did not like, and places that required improvement during the emotional mapping exercise. Blue, red, and yellow board pegs were used to indicate these locations. Another activity involved playing the Place Game with a group of invited stakeholders (PPS 2016). The game was modified to match the Shahjahanpur Jheel area, but the methodology remained the same.The participants included a variety of local decision makers, including representatives of mosques, business owners, landowners, educators, and political figures. Twenty people attended the workshop, seven of whom were women.

The results of the spatial analysis and community engagement activities were summarised to develop a common vision for the development of Shahjahanpur Jheel. This vision served as an overall guiding principle for the development of the conceptual design: clean recreational spaces for the community, lush greenery around the edge, a safe place for different groups, proper maintenance and an open public space for all.

3.2 Co-creation towards urban design

It was time to come up with specific concepts and design proposals for the Jheel area. Additionally, it was the consultant's duty to share the lessons learned from the first round of public engagement and provide seminars on developing capacity for students, faculty members, and DSCC associates. The Dhaka Urban Design Lab was organised with the academic partner, the Department of Architecture at Daffodil International University in Dhaka, as an online experience due to the pandemic situation at the time. It

Roland Krebs, Stefan Mayr, Sheikh Md. Rezwan, Katharina Höftberger, Theresa König, Victoria De Láncer Salas, Shaolin Saint Hilaire Jong, Anselmo Cani

included academic inputs on pertinent topics related to participatory urban design, training sessions on 24 participatory tools, and a student competition. A total of 120 participants joined the diverse program. The students who participated in the design competition for the area around Shahjahanpur Jheel received a competition brief, as well as all findings from the participation process, and data from the analysis. 92 students from five universities in Dhaka participated in the competitions. 24 teams completed their designs over the course of four days and sent them in for the jury's deliberation. All competition entries were of great quality and brought inspiration and new ideas to the project.

Based on this experience and valuable exchange, several co-creation workshops were held to include the opinions of local stakeholders into the design process. The first three workshops were aimed at specific groups, whose voices often go unheard: children, women, as well as street vendors and rickshaw pullers. The children sketched their ideas on tracing paper and pasted them over existing images around the jheel, women made detailed notes on specific locations and placed cut-outs of urban amenities on a map, local entrepreneurs provided input specific to particular locations that affect their businesses. Finally, local community representatives and officials participated in a workshop where they reviewed the top student projects from the Urban Design Lab and outlined and discussed their own ideas. It was innovative and new in the context of Dhaka, that a government project involved community members in the design of public space. The participants were carefully selected to represent diverse age, gender and occupations.

The second set of activities conducted in the co-creation phase were public events that took place directly at the Shahjahanpur Jheel site. The fundamental concept of the design-build workshop was to invite all neighbours and users of the public space to participate in the creation of their own environment, empower them to take care of the space, and create ownership. By promoting the event in advance on-site with banners and leaflets as well as by being present in the area when the event was taking place, many locals were reached. The workshop had an open structure, which allowed participants to drop in and out whenever they pleased, allowing for more flexible and impromptu involvement. A total of 50 to 60 members of the neighbourhood participated in the planning, design, and fabrication of temporary urban furniture as well as the painting of a wall in public space.

To close the series of co-creation activities, an interactive feedback exhibition was set up the day following the design-build workshop. The exhibition's goal was to present both the winning designs produced by the students during the Urban Design Lab and all the thoughts and suggestions that had been gathered from the neighbourhood during the co-creation workshops over the preceding weeks. The display also included a brief overview of the project and the opportunity to share further comments and suggestions.

3.3 Finalising the urban design

The vision and goals set the framework for the development of an urban design strategy that roughly outlines the main functions and features of the jheel development embedded into its urban context.The urban strategy is the initial step for changing the Shahjahanpur Jheel area. It is made up of various layers that describe the key characteristics, duties, and linkages of the site with respect to its surroundings. The plan focuses on the local requirements and potential for change while taking into account the urban layout, transportation patterns, and existing infrastructures in a larger area surrounding the jheel. The levels of the urban strategy deal with economic activity, green and blue networks, central locations, and accessibility.

Based on the vision, project goals and strategy, a conceptual design was developed for the regeneration of Shahjahanpur Jheel. The design incorporates most of the ideas and wishes formulated by the community and seeks to reconcile conflicting interests where possible. A continuous path around the jheel was recognised as the most crucial component mentioned by all stakeholder groups. More green space, public restrooms, a playground for children, an extra pedestrian bridge across the jheel, and seating areas are other design features that were requested and incorporated in the design. Some desired elements, like a large market area or a site for swimming and fishing, could not be included due to spatial or environmental limitations.Nonetheless, the implementation of the design will provide a climate-friendly and sustainable urban public space that accommodates the needs of diverse and vulnerable groups, offers opportunities for local entrepreneurs and fosters active mobility with a limitation for car traffic. It touches upon almost all challenges that have been identified in relation to the development of public spaces, and all of these topics emerged from a participatory process with the local community which is ready to take ownership and responsibility for their Jheel.

4 CASE STUDY MAPUTO – "MAPUTO URBAN LAB"

In Maputo, Mozambique, the World Bank has granted funding for the purpose of preparing and implementing the Maputo Urban Transformation Project (PTUM). This project aims to support the key priorities outlined in the Municipal Development Plan by undertaking impactful investments and reforms in urban infrastructure. It focuses on transforming specific areas into versatile community spaces and central hubs within neighbourhoods. Additionally, it involves the restoration of 20 km of pathways to facilitate pedestrian and cyclist connectivity across the city. The project's development has been guided by a collaborative urban design process and a place-oriented approach, actively involving local stakeholders throughout all phases. The engagement of various parties, such as local architects, urban planners, project residents, community leaders, and architecture students, has been instrumental in shaping the project from site selection to its final design.

4.1 Participatory analysis of neighbourhoods in the periphery

The project encompassed 20 neighbourhoods, covering an approximate area of 17.26 km2, and its benefits would extend to over 264,054 individuals (Instituto Nacional de Estatística 2019). To initiate the planning process, the neighbourhoods were prioritised based on various criteria, including vulnerability to climate conditions, poverty levels, and limited access to essential infrastructures. The areas exhibit high population density, with inadequate distribution of green and recreational spaces, and a lack of water supply, solid waste collection services, energy supply, and sewage services. Moreover, the neighbourhoods face recurring flood-related issues due to inadequate drainage systems (CMM, 2021).

To comprehensively analyse and evaluate the entire project area, a local team of architects and urban planners based in Maputo was assembled. They actively worked on-site, gathered essential information, and facilitated participatory activities. Furthermore, they served as a crucial link between local and international stakeholders. As part of an inclusive diagnostic process, the Municipality of Maputo identified 107 existing public spaces dispersed across the 20 project neighbourhoods, compiling a detailed dataset that analysed their condition and usage. The study revealed several deficiencies in these public spaces, including a lack of urban furniture and basic infrastructures such as public toilets and shaded areas. Additionally, many of these spaces were in a state of disrepair due to the absence of maintenance policies, exacerbating issues during rainy seasons when flooding occurs repeatedly.

The superwien team evaluated the data, focusing specifically on the accessibility of public spaces and the existing and future public transport systems. A "5 minutes walking distance" parameter was used to identify public transport stations, points of interest, and the road network close to public spaces. This analysis also incorporated the overlap between flooding areas and public spaces. All information was fed into a GIS-based multi-criteria analysis that considered all factors, and helped to select those public spaces with highest accessibility for as many residents as possible, distributed equitably throughout the entire project area.

Additionally, qualitative data was considered. Residents in each neighbourhood were interviewed about their mobility patterns. Participatory sessions were conducted in all 20 neighbourhoods, accompanied by the application of various engagement tools during interactions organised in collaboration with the neighbourhood secretaries. These participatory tools included emotional mappings, surveys, and interviews with key stakeholders to gather different perspectives on the public spaces. These methods provided an overview of the area, including the current state of the public spaces, maintenance challenges, characteristics of their current usage and the social groups that utilise them, as well as their development potential.

In order to involve even more local residents and future public space users, we sought out residents who held influential positions within the community, such as block chiefs, who could assist in reaching out to other interested residents and encouraging their participation in our workshops. The goal was to employ at least on of these multipliers in each of the twenty neighbourhoods within the project.

4.2 Expanding tested participation tools to all neighbourhoods

With the support of the multipliers, our team organised workshops with the local community in five pilot spaces. The aim was to test and determine the most effective participatory tools to be used in these irregular settlements of Maputo. The workshop concepts were tailor-made for the specific community groups that were engaged, and certain tools had to be adapted to suit the local context. Factors such as the participants'

160

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Roland Krebs, Stefan Mayr, Sheikh Md. Rezwan, Katharina Höftberger, Theresa König, Victoria De Láncer Salas, Shaolin Saint Hilaire Jong, Anselmo Cani

high illiteracy rate and the need to conduct activities in open spaces due to COVID-19 regulations were crucial considerations in tool adaptation.

In addition, supplementary activities were arranged for specific community groups, such as women, children, and community representatives. This approach enabled us to hear diverse perspectives and incorporate the viewpoints of vulnerable groups, fostering a more inclusive approach. The contrasting perspectives became evident during the workshops held for one particular public space. In the session with the general population (predominantly men), participants mentioned that the space was only used by women. However, in the workshop with women, they expressed that they indeed utilised the space frequently, particularly when men were absent. For engaging children, we found that creative and playful tools were most effective in keeping them interested and comfortable enough to share their opinions. For this purpose, we developed our own tools, such as an urban game called "Build-your-Square", which proved highly successful in engaging children and youth. Throughout the experimental pilot phase, dedicated to creating tailor-made co-creation tools for the design process in Maputo, lessons learned from each pilot were applied to subsequent ones. Based on these learnings, the tools were adjusted and gradually the most effective combination of co-creation tools for the local context in Maputo could be identified.

In order to implement these tools in the remaining 15 neighbourhoods, the team was supported by local architecture students from various universities who were interested in expanding their knowledge on participatory urban design. During the Maputo Urban Lab, we brought together representatives of the Municipality of Maputo, more than 35 local students, and 15 multipliers from the target neighbourhoods. The event, co-organised by the Municipality, superwien, Eduardo Mondlane University and the Ordem Dos Arquitectos de Moçambique, provided an opportunity to share the collective knowledge of all these parties and jointly envision the future of public spaces in Maputo. To prepare the students for their participatory workshops in the 15 neighbourhoods, the team offered training sessions for selected participatory tools. Under the guidance of the local multipliers, the students had the opportunity to put the tools into practice in the neighbourhoods. Through a dialog-oriented approach and with the support of the students and locals, we successfully gathered information, ideas, and visions for the public spaces to be transformed. The design process prioritised the co-creation of designs, involving residents from all locations.

4.3 A design concept based on seven essential elements

Collaborating with a diverse range of opinions provided valuable input for an inclusive design process, and the resulting design outcomes demonstrated the success of the approach. The development vision involved creating well-designed urban spaces that serve as central hubs for each of the 20 neighbourhoods and are accessible through an active mobility network. Seven essential design elements were identified that should be implemented in each of the 22 public spaces. The first element focused on maximising the size of public spaces, as well as increasing area densification. This addresses the current issue of limited and small public and open spaces. The second key design element is the inclusion of a community porch, which would act as the centrepiece for each neighbourhood's local community. This multifunctional community centre would serve various purposes, such as housing municipal offices, toilets, lecture and workshop spaces, and a library. The third element involved the economic revitalization of the area. Recognizing the importance of encouraging commercial activities in public spaces, we proposed incorporating specific marketplaces for both formal and informal commerce, as well as activating existing ground floor spaces. To promote inclusivity, the fourth key element focused on using diverse and inclusive urban furniture. This would ensure that public spaces can be utilised by people of all ages and genders. The fifth urban design element emphasised the significance of green infrastructure for sustainable future development. It involved planting trees and utilising sustainable materials in the design process. The sixth aspect was centred around local co-creation and maintenance. This approach would allow for some flexibility in each public space, enabling local adjustments while maintaining a cohesive design. It also encourages elements that foster a sense of local identity and can be developed and built by community members, strengthening their connection to the area. Lastly, security aspects and the integration of basic infrastructure are fundamental foundations for all designs, from the active mobility network to public spaces. These considerations ensure the safety and functionality of the overall design concept.

In accordance with the Dhaka case, the participatory process in Maputo revealed the multidimensional needs and functions of public spaces for the local community. The design concept builds on the identification of

multiple challenges and addresses them through an integrated design approach that incorporates elements of inclusive design.

5 CASE STUDY SANTO DOMINGO – "LABORATORIO SANTO DOMINGO"

Santo Domingo, capital of the Dominican Republic, is characterised by the dominance of car-traffic and the scarcity of public spaces. These aspects were the starting point of our research. A relevant example is the 'V Centenario' Expressway, built between 1992 and 1994, which connects Santo Domingo downtown with East Santo Domingo. This eight lane highway cuts through a homogeneous social and economic neighbourhood in District 3, a complex area characterised by a low-income population, high percentage of informal occupancy and lowest concentration of public space. Villa Juana and Villa Consuelo are two of the local neighbourhoods crossed by 'V Centenario' that were selected to be assessed and developed to improve the quality of life for residents through a new vision for the public space along the expressway.

5.1 A gender lens in public space diagnostics

As a first step of the participatory urban design process, the main stakeholders were identified. These included representatives of the public administration, community groups, street vendors, transport workers, national and international experts, and non-governmental organisations. The second phase included workshops in situ and collaboration with the Universidad Iberoamericana (UNIBE) to analyse the public spaces along V Centenario. Adapting superwien's experienced work methodology to the local context, resulted in a "Toolbox for Santo Domingo" with the followings tools: gender-sensitive responses, co-creation with the informal sector, co-creating inclusive public spaces: from ideas to sketches to conceptual designs, first-time bici (bycicle), build your daily route, digital collage, urban accessibility walk with people with disabilities, urban rally with athletes, cultural rally, and a case study discussion with vendors.

Based on the analysis, there were three specific topics that broadly structured the entire participatory process. Firstly, local economies through informal vendors, or street vendors, were generally considered a threat because they occupy sidewalks, obstruct public spaces, and generate garbage. There is competition for the use of public space and a sense of appropriation around it. Secondly, the V Centenario Expressway was designed at a point in history when the transportation model was very different from today's vision of inclusive mobility. This is reflected in the intervention strategies that focused on opening arteries to private cars, always prioritising the flow of traffic over the safety and comfort of pedestrians. And thirdly, a gendered focus on activities related to care and life support reveals inequalities that emerge from the prevailing logic of economic profitability in urban space. It allowed us to analyse some of the problems that had been identified as emerging topics, such as the lack of public space, which is monopolised by roads and parking lots, basketball courts and street vendors. Women, children, the elderly, and people with disabilities are disadvantaged in the distribution of uses in public space. In this way, the participatory process developed to identify the needs of the communities in relation to the expressway incorporated a diversity of perspectives in order to arrive at sensitive and contextualised project conclusions.

5.2 Talking to people to understand social spaces

The Laboratorio Santo Domingo was developed in close cooperation with the School of Architecture at UNIBE. It began with a cycle of open virtual workshops, in the form of master classes in which architects and urban planners with international experience were invited to a hybrid space between theory and practice. These workshops generated the basic skills to understand the methodology for participatory design. They were followed by a full week of concentrated activities, such as lectures, workshops on participatory urbanism, tactical urban planning strategies and placemaking, together with professors and enrolled students. The main question during these masterclasses was the role of participation in the specific context of Santo Domingo. At the end of the Laboratorio Santo Domingo, the students concluded that participation is about giving people the space to decide the future of their neighbourhoods. Talking to the local people is the most sensible approach to understanding places and their complexities. During the Urban Lab, the students went out into the street, talked to people using a range of tools, starting with the Goals Grid Analysis, to identify needs and desires regarding public spaces. They played the Place Game, conducting surveys to understand how different types of residents perceived their neighbourhoods. They carried out Exploratory Walks guided by residents, where they explored individual perspectives on space. We also carried out a Placemaking activity, where the students worked on preliminary ideas for the planning area on site and with the local

residents. This activity, using public space as the main stage and forum to gather people, was the highlight of the week. Neighbourhood leaders and local experts had the opportunity to give feedback on the students' ideas. The cycle was closed with an architecture and urbanism competition open to all students.

5.3 Design towards a green avenue

The participatory urban planning tools guided the design process, which resulted in three main approaches to public space intervention: a new urban avenue and inclusive green corridor; new centralities as game changers; and the transformation of residual public spaces into new parks. The overall concept was to take the subway stations as the main points of interest and focus the designs around that infrastructure.

The first essential aspect of the urban strategy was the transformation of the expressway back into an urban avenue. The second element of street transformation was the development of a green corridor, with trees along the avenue and in the neighbourhoods' service streets. The shade cast by the new trees would improve the conditions for active mobility like walking. In addition, specific public spaces would be transformed into new centralities characterised by urban or green functions. These parks were already there before, but nobody used them. Given that there would be more shade and thus more people walking, the project would also support the reactivation of ground floors, including commercial activities in public space, which could be better organised.

The resulting design reflects the lessons learned throughout the process, combining residents' views with technical requirements to create a proposal that responds to the environment, improves the urban quality of the two neighbourhoods it reconnects, and creates spaces for community gathering in new, inclusive, high-quality public spaces.

6   SEVEN TOPICS THAT LEAD TO INTEGRATED URBAN DEVELOPMENT

In conclusion, the applied research project highlighted the importance of inclusive, integrated, and locally rooted approaches in urban regeneration and how integrated designs could be implemented through participatory urban co-design processes. It showed that equitable cooperation across hierarchies is necessary and possible, icluding stakeholders on the global, national, local, and community level.The projects in Dhaka, Maputo, and Santo Domingo demonstrated the value of engaging local communities, considering gender perspectives, promoting sustainability, and fostering academic partnerships in creating equitable and sustainable urban public spaces. The study also demonstrated that successful implementation of public space projects depends on a multi-sectoral, integrated approach in the context of the given public space.

The seven overarching topics that were identified as crucial aspects in the transformation of public space were relevent in all three case studies. In each city, the specific context and potential of public space development was strongly characterized by the capacities of the local administration, the impacts of climate change and the lack of affordable housing. Informal settlements have encroached upon public spaces in Dhaka, Maputo and Santo Domingo, reducing public space and increasing the pressure on open spaces through high population densities. The housing crisis is therefore a main challenge, setting the framework for public space provision in the global south. Climate change increases the pressure on open spaces which are needed as retention spaces and habitats for biodiversity on the one hand, but also calls for the implementation of green infrastructured in the urban fabric to alleviate its immediate impacts like urban heat islands. This is particularly true for large urban conglomerations where the escape to natural areas around the city is reserved for high-income population groups. Local city administrations are confronted with numerous pressing issues and often fail to see the urgency of investments in public spaces. It is therefore even more important to highlight the integrated nature of public space interventions that bring along solutions for many other challenges.

The cases studies have also shown how two main activities are dominating and competing for public space: mobility and local economies. Both come along with great challenges and opportunities. Being considered more important than recreation and care work, car-dominated transportation infrastructures and economic activities often displace more vulnerable users like women, children, and elderly people who have different needs in relation to public space. However, economic activity is also vital for attractive public spaces that need activitiy and live in order to be interesting, enjoyable and safe. At the same time, the mobility transition towards sustainable transportation, that is mandatory in the face of climate change, has the potential to solve many challenges in relation to the unjust division of public space. As the design proposal for V Centenario in

Santo Domingo demonstrates, downsizing motorways can provide the space we need to enlargen public space and insert green areas into the city. Active modes of transportation are much more efficient in terms of space consumption, more compatible with nearby recreational uses, healthier and better for the environment.

Last but not least, these and other challenges as well as their potential solutions must be identified and developed with and through the local communities. Public participation with a gender-sensitive approach is key to an integrated urban design that is responsive to the local context. Adequate engagement tools must be adapted to the spatial context as well as to the culture and capabilities of the involved stakeholders. Moreover, co-creation should take place in situ to reach the actual space users. The findings of this project provided valuable insights and tools for practitioners and policymakers to adopt innovative approaches in their urban regeneration projects and promote inclusive and sustainable urban development in the Global South .

7 REFERENCES

ABUJE, S. J.: Case Study of Nature Based Solutions Application in Nairobi. Unpublished article, 2022.
BERGER, Gerald, FEINDT, Peter, HOLDEN, Erling and RUBIK, Frieder: Sustainable Mobility-Challenges for a Complex Transition. In: Journal of Environmental Policy & Planning. Volume 11, Issue 3, pp. 303-320. London, 2014.
BROWN, Alison: The Urban Informal Economy. UN-HABITAT, 2018. Available at: https://unhabitat.org/the-urban-informal-economy-alison-brown [Accessed 21.06.2023]
CMM, Conselho Municipal de Maputo Componente 1: melhoria integrada dos assentamentos informais: diagnóstico integrado 2021. Internal Projecto de Transformação Urbana de Maputo (PTUM P171449) report.
DANGSCHAT, Jens: Raumplanung unter Unsicherheiten--Beherrschbarer Widerspruch? In: Klaus SELLE (ed.) Planung neu denken, Band 1: Zur räumlichen Entwicklung beitragen. Konzepte. Theorien. Impulse. Dortmund, 2006.
FALÚ, Ana: La vida de las mujeres en confinamiento en las ciudades fragmentadas. Un análisis feminista de los temas críticos. In: Astrolabio, Volume 25, Issue 22–45. Buenos Aires, 2020. Available at: https://revistas.unc.edu.ar/index.php/astrolabio/article/view/29933 [Accessed 18.06.2023]
GISINGER, Emma, ARRUDA, Marcella, HERRERA, Viviana, DE OLIVEIRA, Ariela and KREBS, Roland: Activating the Local Economy. In: Roland Krebs and Stefan MAYR (eds.) Future Public Spaces. Urban Design in Times of Crisis. Berlin, 2023.
HURTIG, Milagros, FALÚ, Ana, HERRERA, Viviana, DE OLIVEIRA, Ariela, and KREBS Roland: Gender-sensitive Planning. In: Roland Krebs and Stefan MAYR (eds.) Future Public Spaces. Urban Design in Times of Crisis. Berlin, 2023.
INSTITUTIO NACIONAL DE ESTATISTICA: Censo 2017 Brochura dos Resultados Definitivos do IV RGPH. Maputo, 2019. Available at: http://www.ine.gov.mz/iv-rgph2017/mocambique/censo-2017-brochura-dos-resultados-definitivos-do-iv-rgphnacional.pdf/view [Accessed 22 June 2022].
IPCC: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge/NewYork, 2021.
KERN, Leslie: Feminist City. London/New York, 2020.
KHAN, Aneire E., XUN, Wei W., AHSAN, Habibul and VNEIS Paolo: Climate Change, Sea-Level Rise, & Health Impacts in Bangladesh. In: Environment: Science and Policy for Sustainable Development, Volume 53, Issue 5, 18–33. London, 2011.
KÖNIG, Theresa, GISINGER, Emma, NOGALES, Lucia, ALEGRE, Mariana, DE OLIVEIRE, Ariela and KREBS, Roland: Planning from Belwo. In: Roland Krebs and Stefan MAYR (eds.) Future Public Spaces. Urban Design in Times of Crisis. Berlin, 2023a.
KÖNIG, Theresa, HÖFTBERGER, Katharina, HERRERA, Viviana, DE OLIVEIRA, Ariela and KREBS, Roland: Transitioning to Inclusive Mobility. In: Roland Krebs and Stefan MAYR (eds.) Future Public Spaces. Urban Design in Times of Crisis. Berlin, 2023b.
MARTÍN, Carlos: Closing the Housing Gap. In: Resilient Public Spaces Webinar Series #6. Vienna, 2022. Available at: https://vimeo.com/688564343 [Accessed 2306.2023]
MCKINSEY: Housing Affordability. A Supply-Side Toolkit for Cities. Briefing Note Prepared for CityLab Paris. Paris, 2017.
NELLO-DEAKIN, Samuel: Is there such a thing as a 'fair' distribution of road space? In: Journal of Urban Design, Volume 24, Issue 5, pp. 698–714. London, 2019. Available at: https://www.tandfonline.com/doi/full/10.1080/13574809.2019.1592664 [Accessed 19.06.2023]
PPS (Project for Public Spaces): The Place Game: How We Make the Community the Expert. New York, 2016. Available at: https://www.pps.org/article/place-game-community [Accessed 26.06.2023]
REITER, Andreas: Von der Smart City zur Responsive City – was Städte zukunftsfähig macht. In: Webblog of ZTB Zukunftsbüro. Vienna, 2021. Available at: https://blog-ztb-zukunft.com/2021/05/09/von-der-smart-city-zur-responsive-city-was-stadte-zukunftsfahig-macht/ [Accessed 18.06.2023]
ROCCO, Roberto: Why should we discuss spatial justice in Urbanism studies? Delft, 2014. Available at: https://www.researchgate.net/publication/269930459_Why_should_we_discuss_spatial_justice_in_Urbanism_studies [Accessed 21.06.2023]
SILVA, Maria Matos and COSTA, João Pedro: Urban Floods and Climate Change Adaptation: The Potential of Public Space Design When Accommodating Natural Processes. In: Meenakshi ARORA and Hector MALANO (eds.) Urban Water Cycle Modelling and Management. Basel, 2018.
UN-Habitat. Slum Almanac 2015–2016. Tracking Improvement in the lives of slum dwellers. Nairobi, 2016.
VENTER, Christo, MAHENDRA, Anjali and HIDALGO, Dario: From Mobility to Access for All: Expanding Urban Transportation Choices in the Global South. WRI Working Paper. Pretoria, 2019. Available at: https://files.wri.org/d8/s3fs-public/from-mobility-to-access-for-all.pdf [Accessed 18.06.2023]

164

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
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Roland Krebs, Stefan Mayr, Sheikh Md. Rezwan, Katharina Höftberger, Theresa König, Victoria De Láncer Salas, Shaolin Saint Hilaire Jong, Anselmo Cani

WWF: What Are Nature Based Solutions and How Can they Help Us Address the Climate Crisis? Washington, 2020. Available at: https://www.worldwildlife.org/stories/what-are-nature-based-solutions-and-how-can-they-help-us-address-the-climate-crisis [Accessed 23.06.2023]

YOUNG, Graeme: The State and the Origins of Informal Economic Activity: Insights from Kampala. In: Urban Forum, Volume 30, p. 407-423. Heidelberg, 2019.

Crisis and Green Urban Development: Urban Agriculture and Post-Earthquake Urban Resilience in Christchurch, New Zealand

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1 ABSTRACT

The paper examines urban agriculture and local food initiatives in post-earthquake Christchurch, New Zealand and discusses their role for urban resilience. Like many other coastal cities in the world, Christchurch is prone to a range of natural and anthropogenic disasters including earthquakes, floods, extreme weather events, and sea-level rise. In 2010 and 2011, the Canterbury region was struck by two major earthquakes and a series of aftershocks. It was one of the most devastating natural disasters in the history of New Zealand killing 185 and injuring 7000 people. 90 per cent of residential properties were damaged, resulting in the demolition of around 8000 households and 80% of central Christchurch. In addition, recurrent flood events have been devastating large areas of the city on a regular basis.

Shortly after the experiences of the 2010/11 Canterbury earthquakes, various bottom-up urban agriculture initiatives sprung up and have led to the development of a network of organisations and spaces across the city. With the help of exemplary case studies, the paper discusses post-earthquake urban agriculture initiatives in Christchurch against notions of urban resilience. It critically reflects on knowledge gaps, potential areas for future research and related barriers and enablers for green urban development.

Keywords: green sustainable urban development, food networks, urban resilience, urban crisis, urban agriculture

2 INTRODUCTION

In the context of both natural and anthropogenic crises and disasters, urban gardens and farms can play an important role for community recovery (Fox-Kämper, 2016, p. 365). In disaster situations, urban gardens can help mitigate food shortages when supply chains are interrupted, for examples after earthquakes (Sioen, Sekiyama, Terada, & Yokohari, 2017). Urban agriculture can be "a survival strategy for displaced people to obtain food on a temporary basis, but also a valuable livelihood strategy for those who settle permanently, and for those who eventually return to their home cities" (Adam-Bradford & van Veenhuizen, 2015, p. 407). In the context of Hurricanes Katrina and Rita in Southern Louisiana, Sims-Muhammad (2012) demonstrated the role of urban community gardens in minimizing food insecurity when conventional food sources became unavailable. Following natural disaster, open spaces are often considered safer than built structures that may be damaged, unusable, unreliable, or unsafe. For example, when Hurricane Sandy devastated New York City in 2012, community gardens were considered as safe "multi-purpose community refuges which hosted meaningful and restorative greening practices" (Chan, DuBois, & Tidball, 2015, p. 625). Social activities in gardens help address physical and mental health issues in times of severe stress by increasing "psychosocial resilience after a disaster" (Heather A Okvat & Zautra, 2014, p. 85) and providing post-trauma therapy to "alleviate negative emotions and […] engage in experiences that enhance positive emotions" (p. 81).

Urban gardens encourage social interaction and help build networks between people through collaborative action (Firth, Maye, & Pearson, 2011, p. 565). Kato, Passidomo, and Harvey (2014) observed that community gardens empowered local communities in deprived urban areas to counteract socio-economic injustice in New Orleans following Hurricane Katrina. Disaster resilience depends on "the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures" (UN/ISDR, 2004). Social interaction encourages social capital construction and thus disaster preparedness (Aldrich, 2012). With regard to disaster risk reduction and disaster preparedness, cities have been urged to include urban agriculture as part of their climate change strategies and plans (Dubbeling, van Veenhuizen, & Halliday, 2019). Urban gardens do not only provide benefits following a disaster, but can help prepare cities for future crises by increasing "the resilience of urban social–ecological systems" (Barthel & Isendahl, 2013; see also Barthel, Parker, & Ernstson, 2015; Bendt, Barthel, & Colding, 2013; Chan et al., 2015, p. 632; Colding & Barthel, 2013).

In this paper, urban agriculture is broadly defined as "the cultivation, processing and distribution of agricultural products in urban and suburban areas" (USDA, 2023). The paper presents a case-study informed discussion of urban agriculture projects in Christchurch since the 2010/11 Canterbury earthquakes against notions of urban resilience. It critically reflects on potential knowledge gaps, areas for future research, and barriers and enablers.

3 POST-EARTHQUAKE URBAN AGRICULTURE IN CHRISTCHURCH

Christchurch is historically known as the 'garden city' thanks to an abundance of public parks and private gardens in the context of low suburban residential densities. While the development of allotment and community gardens started in the early 1980s, the majority of gardens became established since the early 2000s with a clear upwards trend in recent years. In 2016, Christchurch City Council published community garden guidelines to "encourage community gardens throughout the city" (CCC, 2016, p. 1). In 2019, the Canterbury Community Gardens Association (CCGA) listed about 30 community gardens on their website within the Greater Christchurch metropolitan area (Shimpo, Wesener, & McWilliam, 2019). By January 2023, the number of gardens had grown to 52 (CCGA, 2023), an indication that community gardens in post-earthquake Christchurch have become increasingly popular.

Shimpo et al. (2019), who studied an urban community garden in New Brighton, a coastal suburb of Christchurch, argued that "community gardens may help secure food supplies and provide essential infrastructural support following a disaster. However, first and foremost, community gardens help strengthen social interactions, relieve stress and build the social capital that is needed when a disaster strikes" (p. 31). Wesener (2020), who studied eight urban community gardens in post-earthquake Christchurch, discussed three commonly experienced benefits against the backdrop of the 2010/11 earthquakes: First, community gardens became post-earthquake sanctuaries and places for social exchange. They were perceived as safe and accessible places to meet other people, work and talk together, participate in shared activities and events and "escape from the difficult situation – at least for a few hours" (p. 82). Second, community gardens provided food to those who needed it. Examples include transporting food supplies by helicopter from a community garden in Kaiapoi to a cut-off coastal suburb in Christchurch, participating in food donation schemes such as the delivery of food packages via local charity organisations, and contributing directly to the food supplies of people in need. And finally, local community gardens became post-disaster learning spaces where people could explore practical skills such as cooking, DIY repairs, or how to save water and install a composting toilet if regular infrastructure had become dysfunctional.

Following the Canterbury earthquakes, a variety of community groups developed projects for the temporary use of vacant urban spaces across the destroyed city with the idea to re-activate spaces until permanent urban redevelopment started (Wesener, 2015). One of these projects was 'Agropolis', a "scalable transitional urban farm" (LIVS, 2015) and collaborative community initiative that opened in 2013, conceptualised as a temporary urban space. Agropolis continued for about three years featuring regular working bees, workshops and community events. However, more importantly, it became an inspiration and incubator for other urban agriculture projects such as a vertical pop-up garden (LIVS, 2016) and 'Cultivate Christchurch', an urban farm that started on a vacant central city site in 2014 and extended to a network of urban farms combining urban food production with social work around youth development and community engagement. Cultivate merged with a larger commercial organic farm in 2021, realising "that our small scale model of urban farming is not robust enough for supporting our youth programme over the long term, nor a viable business in the competitive Canterbury organic veggie market" (Cultivate Christchurch, 2021). The Ōtākaro Orchard project is another example of a post-earthquake urban agriculture project with a distinct educational rationale. It combines a food forest and edible garden with a food information centre, a restaurant, office, event spaces and outdoor educational facilities (Ōtākaro Orchard, 2023). Other types of edible urban gardens in Christchurch include traditional indigenous Mahinga kai sites (Ngāi Tahu, 2023), community orchards and food forests, institutional and school gardens, and food foraging sites (CCC, 2016, p. 2).

Outside the central city, particularly in the Eastern suburbs, large areas were affected by earthquake-related soil liquefaction and lateral spreading causing widespread damage to land and properties. After the February 2011 earthquake, the decision was made to 'red-zone' these areas, and to demolish existing structures and prevent future rebuild (CERA, 2016). The largest residential red zone, the Crown-owned 'Ōtākaro Avon River Corridor', is a vast 602-hectare area in the East of Christchurch that has become home to various food

168

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projects and edible gardens. The 2019 Ōtākaro Avon River Corridor Regeneration Plan lists as preferred land uses "farming and food-based opportunities" including commercial farming, horticulture, market and community gardens, food forests, and "plot to plate" facilities including cafes and restaurants (DPMC, 2023, p. 46). An example for urban agriculture in the Ōtākaro Avon River Corridor is the 2015 established Richmond Community Garden. The garden provides a range of community services and activities from a recycling drop station to community composting, olive oil production, spring fairs and dog-friendly 'day-outs' in the red zone. Another example, the 'Moon River Flower Farm', is the first commercial nursery in the residential red zone "selling cut flowers and bouquets to the public" (Harvie, 2021). Christchurch City Council (CCC) encourages food foraging in the Ōtākaro Avon River Corridor and publishes a web-based fruit tree map that allows people to find specific fruit tree species across Christchurch.

4 URBAN RESILIENCE

Urban resilience is a contested and politicized concept often involving different narratives (Amin, 2014; Leitner, Sheppard, Webber, & Colven, 2018; Wilson & Jonas, 2018). However, despite many conceptual differences, most urban resilience narratives involve a high and continuous level of preparedness: "The resilient city – depending on local affordance – is imagined as the city of active citizens, intelligent technologies, and vigilant governance, a body on full alert" (Amin, 2014, p. 310). Likewise, urban resilience narratives rely on "the many bureaucracies, supply chains and metabolic systems" that work "constantly in the silent background" (ibid: , p. 311). In the context of urban agriculture in post-earthquake Christchurch, there are at least two relevant sub-categories of urban resilience that require attention: food resilience and community resilience.

4.1 Food Resilience

The Canterbury earthquakes became a catalyst to reflect upon the production and distribution of food in Christchurch. The Food Resilience Network was born in 2013 "from a range of organisations who all had an interest in food resilience" (Edible Canterbury, 2023). The Food Resilience Network developed a 'Food Resilience Strategy', that was adopted by the City Council in November 2014 with the key objective to provide "healthy, affordable and locally grown food for all people" (CCC, 2014a). The related 'Food Resilience Network Action Plan' seeks to establish a "patchwork of food growing at local hotspots, linked together like a ribbon and woven into the fabric of our communities" by growing networks and partnerships across organisations, educating people, and supporting and strengthening the local food economy, for example by developing supportive policy frameworks (CCC, 2014b). In 2015, the 'Edible Canterbury Charter' was signed by a range of organisations including CCC and the Canterbury District Health Board setting out "guiding principles of our collective efforts to create a more food resilient region". The Edible Canterbury web-portal was developed "as a one-stop shop for information about growing and enjoying local food" (Edible Canterbury, 2023). CCC defines food resilience as "[p]hysical and economic access, by all people, at all times, to enough food to maintain an active and healthy life" based on a "local food production and distribution system based on ecological sustainability, able to withstand natural and man-made shocks" (CCC, 2014a). This definition makes a distinct connection to natural and anthropogenic disasters. This is echoed by local urban agriculture initiatives such as the Ōtākaro Orchard who reflect on their website that following the earthquakes "we realised that supermarkets carry only 3 days' worth of food and if our supply chains get disrupted, we go hungry" (Ōtākaro Orchard, 2023). Similarly, Edible Canterbury defines food resilience as "the ability to prepare for, withstand, and recover from disruptions in the food supply chain in order to make food accessible for all" (Edible Canterbury, 2023). The specific connection between food and disaster resilience prevalent in above definitions is contextually interwoven with the history of a city and region that went through a major earthquake in its recent history.

4.2 Community Resilience

Community resilience (CR) is a concept of collaborative action at various levels (Daly, Becker, Parkes, Johnston, & Paton, 2009) to obtain and utilise resources to cope with and thrive under unpredictable and continuously changing circumstances (Magis, 2010). At an institutional level, CR requires governance arrangements that enable community action, empower communities, and provide support from and collaboration with governmental and civic agencies (Daly et al., 2009). Urban gardens, in particular community garden, are places that encourage community action and empower communities. They can help

increase "the resilience of urban social–ecological systems" (Chan et al., 2015, p. 632) before a disaster "by providing the structure and practices to support social–ecological diversity, learning, and community support networks to better respond to future disturbances" (Chan et al., 2015, p. 633). After a disaster, they can provide "psychosocial resilience […], especially by enhancing cognitive capacity, positive emotions, and community engagement" (Heather A Okvat & Zautra, 2014, p. 85) and encouraging neighbourhood social interaction to help build social capital (Aldrich & Meyer, 2015). Community gardens are accessible open spaces with multiple opportunities for collaborative action that can strengthen the role of a community within the complexity of local and regional power relationships following a disaster: "By expanding their social network and deepening their extant social ties, community gardens were able to mobilize resources (ranging from grant money to volunteers) to support their garden, their members, and their neighbourhood" (Chan et al., 2015, p. 632).

5 DISCUSSION

Looking at post-earthquake urban agriculture initiatives in Christchurch through the lens of urban resilience shows that urban gardens are part of systems that operate "in the silent background" (Amin, 2014, p. 311) and only expand their full potentials in a disaster situation (Wesener, 2020). The above discussion of urban agriculture initiatives in Christchurch shows that urban gardens strengthened community resilience in the immediate aftermath of the earthquakes by providing multiple benefits with regard to coping strategies. However, and perhaps more importantly, many of these projects have become learning spaces and incubators for future action. Such findings support studies that have highlighted the important role of urban gardens as educational hubs (e.g., D'Abundo & Carden, 2008; Gregory, Leslie, & Drinkwater, 2016; Surls et al., 2014; Wesener, Fox-Kämper, Sondermann, & Münderlein, 2020) for developing community resilience beyond an immediate crisis situation.

The Canterbury Earthquakes created also new opportunities for green urban development in Christchurch. However, there are opportunities to rethink the role of urban gardens and further develop their potential contribution to urban resilience. For example, in the context of urban design, landscape architecture and planning, new spatial networks that link existing urban gardens could become green corridors connecting with the Ōtākaro Avon River Corridor. Such a network of green spaces could provide far-reaching sustainable urban development opportunities, e.g., with regard to integrated green-grey infrastructure systems (Wesener & McWilliam, 2021), urban transport, biodiversity, stormwater management, and recreation.

There are plenty of other opportunities for urban agriculture to increase urban resilience. Climate change is one of the most imminent global threats to human survival. Many countries – including New Zealand – have signed the UN Framework Convention on Climate Change and passed corresponding national acts to address related issues. Cities need to adapt to climate change related adversities such as extreme weather events, droughts, and higher temperatures. At the same time, certain urban structures, processes and lifestyles can contribute to reduce greenhouse gases as a mitigation measure. Urban gardens can help cities mitigate and adapt to climate change, e.g. by sequestering carbon emissions (Heather A. Okvat & Zautra, 2011; Richter, Haase, Thestorf, & Makki, 2020), and reducing carbon footprints through the local production of food (Edmondson et al., 2020). In addition, urban gardens strengthen urban socio-ecological systems that are vulnerable to the adverse effects of climate change (Demuzere et al., 2014; e.g., Gill, Handley, Ennos, & Pauleit, 2007). Gardens could, for example, play a more vital role with regard to stormwater storage and filtration (Pauleit & Duhme, 2000), urban temperature reduction (Rost et al., 2020), and environmental education (Bendt et al., 2013). However, the (potential) role of urban gardens within local urban climate change policy frameworks has rarely been studied and represents a significant research gap (Clarke, Davidson, Egerer, Anderson, & Fouch, 2019).

6 CONCLUSIONS

The paper discussed urban agriculture through the lens of urban resilience in the context of crisis and disaster. However, disasters can also be catalysts to learn, rethink sustainable urban development and explore new development options. The international literature provides many examples of how urban gardens have contributed to urban resilience. However, while beneficial links between urban agriculture, sustainable food production, social interaction, community empowerment, education and urban resilience have been

170

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discussed, national and local government agencies remain often unaware of the full potentials of urban agriculture and its abilities to make cities more resilient to natural and anthropogenic disasters. This opens up various opportunities for research. For example, it would be valuable to find out how community gardeners perceive the potential contribution of their garden and their own role with regard to climate change mitigation and adaptation strategies (bottom-up perspective). This would produce valuable insights about how urban gardens could be better integrated as part of local urban climate change policy frameworks.

Urban gardens remain underestimated assets for urban development. Garden initiatives suffer from a lack of funding, struggle to find affordable land to set up new gardens, and do not receive adequate administrative and political support to keep them running for a longer period of time (Fox-Kämper et al., 2018; Wesener et al., 2020). There are rarely comprehensive urban planning and design strategies that include urban gardens as core components of resilient green urban development at city scale. It is time to reconsider such attitudes and treat urban gardens as valuable tools to strenghten urban resilience and prepare cities better for crisis.

7 REFERENCES

ADAM-BRADFORD, Andrew, & VAN VEENHUIZEN, René. Role of urban agriculture in disasters and emergencies. In: H. de Zeeuw & P. Drechsel (Eds.), Cities and Agriculture: Developing Resilient Urban Food Systems, pp. 387-409. Abingdon, Oxon, 2015.

ALDRICH, Daniel P: Building Resilience: Social Capital in Post-Disaster Recovery. Chicago, 2012.

ALDRICH, Daniel P, & MEYER, Michelle A: Social Capital and Community Resilience. In: American Behavioral Scientist, Vol. 59 (2), pp. 254–269. 2015.

AMIN, Ash: Epilogue: The Machinery of Urban Resilience. In: Social Sciences, Vol. 3 (3), pp. 308-313. 2014.

BARTHEL, Stephan, & ISENDAHL, Christian: Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. In: Ecological Economics, Vol. 86, pp. 224-234. 2013.

BARTHEL, Stephan, PARKER, J., & ERNSTSON, H.: Food and Green Space in Cities: A Resilience Lens on Gardens and Urban Environmental Movements. In: Urban Studies, Vol. 52 (7), pp. 1321–1338. 2015.

BENDT, Pim, BARTHEL, Stephan, & COLDING, Johan: Civic greening and environmental learning in public-access community gardens in Berlin. In: Landscape and Urban Planning, Vol. 109, pp. 18-30. 2013.

CCC: Christchurch City Council Food Resilience Policy. 2014a. Retrieved from https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/policies/sustainability-policies/food-resilience-policy

CCC: Food Resilience Network Action Plan. Christchurch, 2014b. Retrieved from https://www.ccc.govt.nz/assets/Documents/Environment/Sustainability/FoodResilienceActionPlan2014.pdf

CCC: Christchurch City Council Community Gardens Guidelines. Christchurch, 2016. Retrieved from https://www.ccc.govt.nz/assets/Documents/Environment/Sustainability/CouncilCommunityGardensGuidelines2016.pdf

CCGA: Garden Directory. 2023. Retrieved from http://www.ccga.org.nz/garden-directory/

CERA: Land Zoning Policy and the Residential Red Zone: Responding to land damage and risk to life. Christchurch, 2016. Retrieved from https://quakestudies.canterbury.ac.nz/store/object/524765

CHAN, Joana, DUBOIS, Bryce, & TIDBALL, Keith G: Refuges of local resilience: Community Gardens in post-Sandy New York City. In: Urban Forestry & Urban Greening, Vol. 14 (3), pp. 625-635. 2015.

CLARKE, Mysha, DAVIDSON, Melissa, EGERER, Monika, ANDERSON, Elsa, & FOUCH, Nakisha: The underutilized role of community gardens in improving cities' adaptation to climate change: A review. In: People, Place & Policy, Vol. 12 (3), pp. 241-251. 2019.

COLDING, Johan, & BARTHEL, Stephan: The potential of 'Urban Green Commons' in the resilience building of cities. In: Ecological Economics, Vol. 86, pp. 156-166. 2013.

CULTIVATE CHRISTCHURCH: Changes at Cultivate. 2021. Retrieved from https://www.cultivate.org.nz/cultivateischanging

D'ABUNDO, Michelle L., & CARDEN, Andrea M.: "Growing Wellness": The Possibility of Promoting Collective Wellness through Community Garden Education Programs. In: Community Development, Vol. 39 (4), pp. 83-94. 2008.

DALY, Michele, BECKER, Julia, PARKES, Bruce, JOHNSTON, David, & PATON, Douglas. Defining and Measuring Community Resilience to Natural Disasters. In: V. Cholewa, L. Mamula-Seadon, & R. Smith (Eds.), TEPHRA Volume 22. Community Resilience: Research, planning and civil defence emergency management, pp. 15-20. Wellington, 2009.

DEMUZERE, M., ORRU, K., HEIDRICH, O., OLAZABAL, E., GENELETTI, D., ORRU, H., . . . FAEHNLE, M.: Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. In: Journal of Environmental Management, Vol. 146, pp. 107-115. 2014.

DPMC: Ōtākaro Avon River Corridor Regeneration Plan. 2023. Retrieved from https://www.dpmc.govt.nz/our-programmes/greater-christchurch-recovery-and-regeneration/recovery-and-regeneration-plans/otakaro-avon-river-corridor-regeneration-plan

DUBBELING, Marielle , VAN VEENHUIZEN, René, & HALLIDAY, Jess: Urban agriculture as a climate change and disaster risk reduction strategy. In: Field Actions Science Reports, Vol. (Special Issue 20), pp. 2019.

EDIBLE CANTERBURY: Our Story. 2023. Retrieved from https://ediblecanterbury.org.nz/our-story-2/

EDMONDSON, Jill L., CHILDS, Dylan Z., DOBSON, Miriam C., GASTON, Kevin J., WARREN, Philip H., & LEAKE, Jonathan R.: Feeding a city – Leicester as a case study of the importance of allotments for horticultural production in the UK. In: Science of The Total Environment, Vol. 705, pp. 135930. 2020.

FIRTH, Chris, MAYE, Damian, & PEARSON, David: Developing "community" in community gardens. In: Local Environment: The International Journal of Justice and Sustainability, Vol. 16 (6), pp. 555-568. 2011.

FOX-KÄMPER, Runrid. Concluding remarks. In: S. Bell, R. Fox-Kämper, N. Keshavarz, M. Benson, S. Caputo, S. Noori, & A. Voigt (Eds.), Urban allotment gardens in Europe, pp. 364-369. Abingdon, 2016.

FOX-KÄMPER, Runrid, WESENER, Andreas, MÜNDERLEIN, Daniel, SONDERMANN, Martin, MCWILLIAM, Wendy, & KIRK, Nick: Urban community gardens: An evaluation of governance approaches and related enablers and barriers at different development stages. In: Landscape and Urban Planning, Vol. 170 (Supplement C), pp. 59-68. 2018.

GILL, S. E., HANDLEY, J. F., ENNOS, A. R., & PAULEIT, S.: Adapting Cities for Climate Change: The Role of the Green Infrastructure. In: Built Environment, Vol. 33 (1), pp. 115-133. 2007.

GREGORY, Megan M., LESLIE, Timothy W., & DRINKWATER, Laurie E.: Agroecological and social characteristics of New York city community gardens: contributions to urban food security, ecosystem services, and environmental education. In: Urban Ecosystems, Vol. 19 (2), pp. 763-794. 2016.

HARVIE, Will. Nursery the first commercial business in Christchurch's red zone. In: The Press. October 21, 2021. Retrieved from https://www.stuff.co.nz/the-press/news/126732272/nursery-the-first-commercial-business-in-christchurchs-red-zone

KATO, Yuki, PASSIDOMO, Catarina, & HARVEY, Daina: Political Gardening in a Post-disaster City: Lessons from New Orleans. In: Urban Studies, Vol. 51 (9), pp. 1833–1849. 2014.

LEITNER, Helga, SHEPPARD, Eric, WEBBER, Sophie, & COLVEN, Emma: Globalizing urban resilience. In: Urban Geography, Vol. 39 (8), pp. 1276-1284. 2018.

LIVS: Agropolis. 2015. Retrieved from https://www.livs.org.nz/project/agropolis

LIVS: Pop-up Garden. 2016. Retrieved from https://www.livs.org.nz/project/pop-up-garden

MAGIS, Kristen: Community Resilience: An Indicator of Social Sustainability. In: Society & Natural Resources: An International Journal, Vol. 23 (5), pp. 401-416. 2010.

NGĀI TAHU: Mahinga Kai. 2023. Retrieved from https://ngaitahu.iwi.nz/ngai-tahu/the-settlement/settlement-offer/cultural-redress/ownership-and-control/mahinga-kai/

OKVAT, Heather A, & ZAUTRA, Alex J. Sowing Seeds of Resilience: Community Gardening in a Post-Disaster Context. In: K. G. Tidball & M. E. Krasny (Eds.), Greening in the Red Zone, pp. 73-90. Dordrecht, 2014.

OKVAT, Heather A., & ZAUTRA, Alex J.: Community Gardening: A Parsimonious Path to Individual, Community, and Environmental Resilience. In: American journal of community psychology, Vol. 47 (3-4), pp. 374-387. 2011.

ŌTĀKARO ORCHARD: Ōtākaro Orchard. 2023. Retrieved from https://otakaroorchard.org/about-us/

PAULEIT, Stephan, & DUHME, Friedrich: Assessing the environmental performance of land cover types for urban planning. In: Landscape and Urban Planning, Vol. 52 (1), pp. 1-20. 2000.

RICHTER, Scarlet, HAASE, Dagmar, THESTORF, Kolja, & MAKKI, Mohsen: Carbon Pools of Berlin, Germany: Organic Carbon in Soils and Aboveground in Trees. In: Urban Forestry & Urban Greening, Vol. 54, pp. 126777. 2020.

ROST, Annemarie Tabea, LISTE, Victoria, SEIDEL, Corinna, MATSCHEROTH, Lea, OTTO, Marco, MEIER, Fred, & FENNER, Daniel: How Cool Are Allotment Gardens? A Case Study of Nocturnal Air Temperature Differences in Berlin, Germany. In: Atmosphere, Vol. 11 (5), pp. 500. 2020.

SHIMPO, Naomi, WESENER, Andreas, & MCWILLIAM, Wendy: How community gardens may contribute to community resilience following an earthquake. In: Urban Forestry & Urban Greening, Vol. 38, pp. 124-132. 2019.

SIMS-MUHAMMAD, Toni Y.: After the Storms: South Louisiana Sustainable Food System Assessment in light of Environmental Natural Disasters Hurricanes Katrina & Rita. In: International Journal of Humanities and Social Science, Vol. 2 (3), pp. 129-135. 2012.

SIOEN, Giles Bruno, SEKIYAMA, Makiko, TERADA, Toru, & YOKOHARI, Makoto: Post-Disaster Food and Nutrition from Urban Agriculture: A Self-Sufficiency Analysis of Nerima Ward, Tokyo. In: International Journal of Environmental Research and Public Health, Vol. 14 (7), pp. 748. 2017.

SURLS, Rachel, FEENSTRA, Gail, GOLDEN, Sheila, GALT, Ryan, HARDESTY, Shermain, NAPAWAN, Claire, & WILEN, Cheryl: Gearing up to support urban farming in California: Preliminary results of a needs assessment. In: Renewable Agriculture and Food Systems, Vol. 30 (1), pp. 33-42. 2014.

UN/ISDR: Terminology: Basic terms of disaster risk reduction. 2004. Retrieved from http://www.unisdr.org/2004/wcdr-dialogue/terminology.htm

USDA: Urban Agriculture. 2023. Retrieved from https://www.usda.gov/topics/urban

WESENER, Andreas: Temporary urbanism and urban sustainability after a natural disaster: transitional community-initiated open spaces in Christchurch, New Zealand. In: Journal of Urbanism, Vol. 8 (4), pp. 406-422. 2015.

WESENER, Andreas. Growing Resilient Cities: Urban Community Gardens and Disaster Recovery after the 2010/11 Canterbury/Christchurch Earthquakes. In: D. Brantz & A. Sharma (Eds.), Urban Resilience in a Global Context: Actors, Narratives, and Temporalities, pp. 77-100. Bielefeld, 2020.

WESENER, Andreas, FOX-KÄMPER, Runrid, SONDERMANN, Martin, & MÜNDERLEIN, Daniel: Placemaking in Action: Factors that Support or Obstruct the Development of Urban Community Gardens. In: Sustainability, Vol. 12 (2), pp. 657. 2020.

WESENER, Andreas, & MCWILLIAM, Wendy. Integrated Urban Green and Grey Infrastructure. In: The Palgrave Encyclopedia of Urban and Regional Futures, pp. 922-927. Cham, 2021.

WILSON, David, & JONAS, Andrew E. G.: Urban resilience: an urban political movement. In: Urban Geography, Vol. 39 (8), pp. 1265-1267. 2018.

172

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Decoding Stress – ein interdisziplinärer Stressforschungsansatz zur Förderung qualitätsvoller öffentlicher Stadträume für den Rad- und Fußverkehr

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1 ABSTRACT

Wie nehmen wir Stadträume wahr, wenn wir mit dem Fahrrad oder zu Fuß unterwegs sind? An welchen Orten in der Stadt fühlen wir uns wohl, respektive unwohl und gestresst? Welche spezifischen Faktoren beeinflussen dabei unsere Emotionen? Und vor allem: Wie können diese Einflussfaktoren für die Planung entschlüsselt werden?

Ausgehend von den Emo-Cycling-Stressmessungen der Urban Emotions Initiative untersucht die Studie „Decoding Stress" auffallende Stress-Hotspots für Radfahrende im urbanen Kontext. Im Fokus steht dabei die Entwicklung eines interdisziplinären und multimodalen Analyseansatzes zur Erweiterung der Stressorenanalyse. In diesem Zusammenhang greift die Studie zum einen auf bereits vereinzelt in der Radverkehrsforschung zur Anwendung kommende, digitale Analysetools und Open-Data-Ansätze zurück. Darüber hinaus beschäftigt sich der vorgestellte Forschungsansatz intensiv mit der Erweiterung der Methodik um einen bislang vorwiegend im Bereich der Architektur- und Stadtplanung bekannten, analogen Werkzeugkasten. Innerhalb eines experimentellen Rahmens erprobt die Studie dabei die vielfältigen Einsatzmöglichkeiten von Mappings und fotografischen Annäherungen, sowie deren Kombination. Im Kontext der Ursachenforschung des Stressempfindens von Radfahrenden soll damit ein holistischer Analyseansatz erprobt werden, der quantifizierbare „harte" Faktoren und qualifizierbare „weiche" Faktoren gleichermaßen berücksichtigt. Die gewonnenen Erkenntnisse leisten einen Beitrag dazu, die interdisziplinäre Zusammenarbeit von Stadt- und Verkehrsplanung zu fördern und schließlich gemeinsame Lösungsansätze für qualitätsvolle und menschengerechte öffentliche Stadträume zu erarbeiten.

Im Rahmen dieses Beitrags werden erste Ergebnisse der experimentell im Untersuchungsgebiet der Karlsruher Innenstadt durchgeführten Stressorenanalyse vorgestellt. Der Beitrag evaluiert die durchgeführten Analysen sowohl inhaltlich, als auch methodisch und skizziert darüber hinaus erste Lösungsansätze.

Keywords: Emotion Sensing, Stadtplanung, Stressorenanalyse, öffentlicher Raum, Radverkehrsforschung

2 EINLEITUNG

Seit der Errungenschaft des Autos und dem damit verbundenen autogerechten Umbau unserer Städte in den 60er Jahren hat sich das Mobilitätsverhalten unserer Gesellschaft stark verändert. Trotz der unveränderten Beliebtheit des Autos, das in Deutschland immer noch für rund 57 Prozent aller Wege genutzt wird (BMVI, 2018), gewinnen aktive Mobilitätsformen, wie zum Beispiel das Fahrrad, vor allem in den urbanen Ballungsgebieten zunehmend an Bedeutung. Aber auch erst kürzlich neu hinzugekommene Verkehrsmittel wie Pedelecs, E-Roller und Lastenräder stellen in den Städten nicht nur neue Mobilitätsangebote dar, sondern konfrontieren den öffentlichen Raum auch mit ganz neuen Herausforderungen. So beginnt sich die zunehmende Überlastung unserer öffentlichen Räume in Form von Staus, Luftverschmutzungen und steigenden Unfallzahlen allerdings auch immer negativer auf die Lebensqualität in den Städten auszuwirken.

Durch diese Entwicklung sehen sich sowohl die Politik, als auch die Verwaltung und Planung nunmehr dazu aufgefordert, sich diesem Problem zu stellen und nachhaltige, menschengerechte Lösungen für die Mobilität in unseren Städten zu entwickeln. Im Rahmen der Diskussion um die Reduktion des Autoverkehrs und die damit verbundene „Rückeroberung" öffentlicher Räume durch den Menschen ist es dabei vor allem der Langsamverkehr, also der Rad- und Fußverkehr, der im urbanen Raum als eine flächensparende, gesunde und vor allem klimafreundliche Form der Mobilität (BMDV, 2022), eine Schlüsselrolle einnimmt.

Dass der Faktor Urbanität diesbezüglich eine wichtige Rolle spielt, lässt sich an der aktuellen Aufteilung des bundesweiten Modal Splits nach Raumtypen (BMVI, 2018) gut erkennen. In Abbildung 1 werden die Langsamverkehrsanteile (Rad- und Fußverkehr) im Vergleich zu den restlichen Verkehrsmitteln (Auto und ÖPNV) dargestellt. Festzustellen ist dabei, dass der Anteil des Langsamverkehrs am Gesamtverkehrsaufkommen in Metropolen bei überdurchschnittlichen 42 Prozent liegt, wohingegen er in

ländlichen Regionen im dörflichen Raum nur rund 24 Prozent beträgt. Dieser extreme Unterschied lässt sich zum einen durch das vielfältige und gut erreichbare Anbegot im urbanen Raum begründen. Denn ganz nach dem Leitbild der 15-Minuten-Stadt (Kurth, 2021) werden aktive Mobilitätsformen vorrangig innerhalb solcher Raumtypen genutzt, in denen die Wegstrecken nur wenige Kilometer betragen.
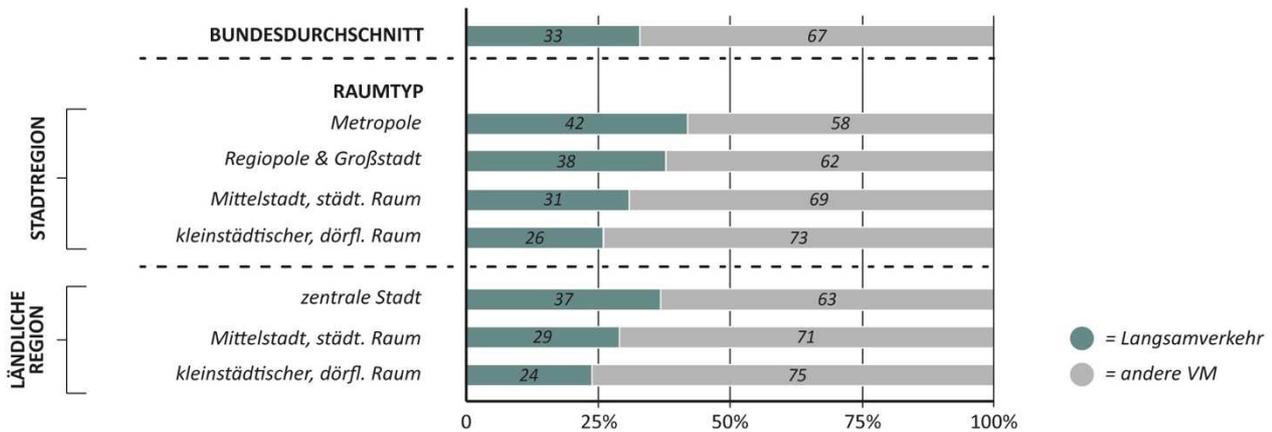
Abb. 1: Langsamverkehrsanteile im Modal Split nach Raumtypen. (Quelle: Eigene Darstellung nach Datenquelle BMVI, 2018)

Darüber hinaus wird die Entscheidung der Nutzerinnen und Nutzer für oder gegen das Fahrrad, beziehungsweise das Zufußgehen, jedoch maßgeblich auch von Aspekten des Wohlbefindens und Sicherheitsempfindens beeinflusst. In diesem Kontext konstatiert auch der Nationale Radverkehrsplan 3.0, dass sich eine Person nur dann für ein Verkehrsmittel entscheidet, wenn sie dieses subjektiv als sicher einstuft (BMDV, 2022). Hinsichtlich der Förderung aktiver Mobilitätsformen in der Stadt ist es daher essentiell, stressfreie Räume für den Rad- und Fußverkehr zu gestalten. Es erscheint daher evident, dass der Identifikation und Untersuchung von neuralgischen Stresspunkten für den Rad- und Fußverkehr eine Schlüsselrolle zugeschrieben werden muss. In diesem Kontext stellt die Methode des Emotion Sensings, beziehungsweise auf das Fahrradfahren bezogen die EmoCycling-Methode, seit einigen Jahren eine echte Innovation in der Stadtplanung (Polis Magazin, 2022) dar. Mithilfe dieser innovativen Stressmessungen ist es schließlich gelungen, das subjektive Empfinden von Probanden während ihrer Bewegung durch die Stadt anhand biostatistischer Marker objektiv messen zu können (Höffken et al., 2014; Zeile et al., 2014). Die Ergebnisse der Messungen werden als Heatmaps visualisiert und geben standortgenau Auskunft darüber, an welchen Punkten die Probanden Stress, respektive keinen Stress empfunden haben. Über die Ursachen, die die physiologisch messbare Stressreaktion bei den Probandinnen und Probanden ausgelöst hat, kann nach diesem Verfahren jedoch keine Aussage getroffen werden.

Die notwendige und auf diesen Erkenntnissen aufbauende Ursachenforschung (Stressorenanalyse) befindet sich hingegen noch in den Anfängen. Die Mehrheit der in diesem Kontext angeführten Studien fokussieren sich dabei jedoch auf eine reine Analyse der Verkehrssituation, wie beispielsweise der Untersuchung von Führungsformen und Spurbreiten. Vereinzelt wird auch auf „digitalen" Analysetools, meist in Form von Entwicklungen aus der Sensorik, zurückgegriffen. Diese berücksichtigen allerdings ausschließlich quantifizierbare „harte" Faktoren und können im Rahmen einer Ursachenforschung nur ein sehr fragmentarisches Bild der Situation liefern. Im Gegensatz dazu macht es sich der Ansatz der hier vorgestellten Studie zur Aufgabe, den Einfluss qualifizierbarer „weicher" Faktoren und die damit verbundenen Einsatzmöglichkeiten „analoger" Analysemethoden zu erforschen. Mithilfe eines multimodalen und interdisziplinären Ansatzes soll es dadurch ermöglicht werden, die spezifischen räumlichen Situationen der identifizierten Stress-Hotspots ganzheitlich zu betrachten und dabei nicht nur verkehrsplanerische, sondern auch stadträumliche Faktoren zu berücksichtigen.

3 STAND DER FORSCHUNG

3.1 Stressmessungen mithilfe der EmoCycling-Methode

Im Gegensatz zu Ansätzen, die mit rein qualitativen Befragungen arbeiten und die bewusst von den Probanden wahrgenommenen Gefühle abfragen, werden beim EmoCycling die menschlichen Emotionen

anhand ihrer nahezu unverfälschbaren körperlichen Reaktion gemessen (Polis Magazin, 2022). Damit leistet die EmoCycling-Methode einen Beitrag zur Operationalisierung von Emotionen in der Planung.

3.1.1 Physiologische Stressreaktion des menschlichen Körpers

Empfindet ein Mensch Stress, so schüttet der Körper Hormone aus, die bestimmte Teile des Nervensystems (HHN-Achse und autonomes Nervensystem) aktivieren. Damit versucht der Körper, den Stress auszugleichen und den Zustand der Homöostase, also einen „stabilen" Zustand, wiederherzustellen. Für diese Anpassung verändert der Körper mitunter die Herztätigkeit, Schweißdrüsenaktivität und die Hauttemperatur (Chrousos et al., 1988; Boucsein, 1988; Kreibig, 2010). Diese messbaren physiologischen Signale können eindeutig in Verbindung mit der Reaktion des menschlichen Körpers auf eine Stresssituation gebracht werden (Karthikeyan et al., 2013) und können als Indikatoren dienen. Heutige Messungen im Kontext des Emotion Sensings greifen hauptsächlich auf die Elektrodermale Aktivität (EA) zurück, die als empfindlichster und zuverlässigster Marker für eine emotionale Erregung (Kyriakou, Resch, et al., 2019) gilt.

3.1.2 Methodik, Setting und Auswertung

Die Ursprünge der EmoCycling-Methode gehen auf Christian Nold zurück, der für seine „emotionalen Kartografien" im Jahr 2009 ein eigenes „Bio-Mapping"-Gerät (Nold, 2009) entwickelte. Damit wurde es erstmals möglich, die messbaren Stress-, beziehungsweise Erregungszustände georeferenziert innerhalb eines situativ-räumlichen Kontexts aufzuzeichnen und visualisieren. In den späten 2000er Jahren wurden die Methode dann von der Urban Emotions Initiative an der TU Kaiserslautern und der Universität Heidelberg mit einem ähnlichen Aufbau erprobt und erste Stadtkartierungen vorgenommen (Zeile et al., 2010). Später wurde dieser Ansatz vor allem am Karlsruher Institut für Technologie (KIT) und der Paris Lodron Universität Salzburg (PLUS) weiterentwickelt. Schnell konnte im Rahmen dieser ersten Annäherungen festgestellt werden, dass sich die Methode mit der sekundengenauen Messung des emotionalen Zustands der Probanden auch bestens für die Anwendung im Kontext des Fahrradfahrens (Höffken et al., 2014) eignet.

Abb. 2: Heatmap als Ergebniskarte der EmoCycling-Messungen in Karlsruhe (links) und Setting mit Smartband Empatica E4 und Smartphone (rechts). (Quelle: Eigene Darstellung nach Datenquelle Cape Reviso)

Das Setting der seither als „EmoCycling" bekannten Methodik wurde daraufhin weiter optimiert und erzielte schnell einen Durchbruch in der Radverkehrsforschung. Die Messungen werden nunmehr lediglich mithilfe eines Sensorarmbandes (Empatica E4) und einem Smartphone durchgeführt (Zeile et al., 2021; Zeile et al, 2022; Werner et al., 2019). Das Sensorarmband misst dabei die Vitaldaten der Probanden (Hautleitfähigkeit und Hauttemperatur), synchonisiert diese mithilfe des Smartphones mit den dazugehörigen GPS-Daten und sammelt sie in einer App. Das Auswertungsmuster ist seit den Anfängen der Methodik unverändert: Eine Stressreaktion, auch Moment of Stress (MOS) genannt, wird dann identifiziert, wenn direkt nach einem Reiz ein temporärer Anstieg der Hautleitfähigkeit in Kombination mit einem Absinken der Hauttemperatur messbar ist.

Die ausgewerteten Datensätze werden daraufhin mithilfe eines Geoinformationssystems (GIS) georeferenziert dargestellt und in Form einer Heatmap visualisiert. Über die verwendete Farbcodierung der Heatmap kann dann ausgewertet werden, in welcher Intensität und an welcher geografischen Position die Probanden Stress, beziehungsweise keinen Stress empfunden haben. Die entsprechend der Farbcodierung rot

dargestellten Punkte, sogenannte „Hot-Spots", symbolisieren dabei eine Konzentration der gemessenen Stressmomente, wohingegen in den blau dargestellten Bereichen verhältnismäßig weniger Stressmomente gemessen wurden.

3.2 Stressorenanalyse

3.2.1 Ursachenforschung mithilfe „digitaler" Analysemethoden aus der Radverkehrsforschung

Die Disziplin der Verkehrsplanung gilt mit ihrem Feld der Radverkehrsforschung als Vorreiter der Stressorenanalyse. Vor allem was das sensorengestützte Messen verkehrsspezifischer Faktoren anbelangt, kann hier mittlerweile auf ein verhältnismäßig großes Methodenspektrum zurückgegriffen werden. Zu nennen sind hier beispielsweise Entwicklungen wie der OpenBikeSensor (OpenBikeSensor, 2023) zur Abstandsmessung bei Überholvorgängen, beziehungsweise sein Pate, der Radmesser (Tagesspiegel, 2018). Aber auch experimentelle Ansätze, wie der Einsatz von Eye-Tracking-Geräten zur Überprüfung der Blickerfassung von Beschilderungen (Walther et al., 2022) kommen in ersten Studien zum Einsatz. Im Rahmen der Radverkehrsforschung der BMDV-Stiftungsprofessur Radverkehr wurde an der Hochschule Karlsruhe in diesem Zusammenhang ein „SensorBike" (Temmen, 2020) als standardisiertes Messfahrrad entwickelt, das sowohl über fest verbaute Messinstrumente verfügt, als auch situationsspezifisch mit Sensoren ergänzt werden kann. Zu den fest verbauten Sensoren des SensorBikes zählen neben einem Leistungsmesser, Vitalsensoren, Beschleunigungs- und Erschütterungssensoren, einem Abstandsmesser und Kameras auch Sensoren zur Erhebung spezifischer Umweltfaktoren. Dabei gelingt es vor allem durch die Verknüpfung der verschiedenen Datensätze, neue Erkenntnisse für die Stressorenanalyse zu generieren.

3.2.2 Ursachenforschung mithilfe von Crowdsourcing-Ansätzen

Durch die zunehmend auch im Freizeit-Radsport ankommende Digitalisierung konnten in den letzten Jahren neue Möglichkeiten zur partizipativen Datenerfassung und -auswertung in der Radverkehrsforschung (Lißner et al., 2018) entwickelt werden. In diesem Kontext bietet primär das Smartphone, das mittlerweile nahezu flächendeckend in der Bevölkerung verbreitet ist, als ein ubiquitärer und multifunktionaler Sensor (Eckart et al., 2020) mannigfaltige Möglichkeiten, um spezifische Bewegungs- und Umweltdaten zu erheben. Verschiedene, meist frei verfügbare Applikationen bieten hier eine sehr niederschwellige Anwendungsmöglichkeit. Darüber hinaus konnten auch durch die wachsende Beliebtheit sozialer Sport-Netzwerke erste Erfolge in der Nutzung von Big Data in der Radverkehrsforschung erzielt werden. So untersuchte zum Beispiel ein Forschungsprojekt der Technischen Universität Dresden (Lißner et al., 2018) im Jahr 2017 die Anwendungsmöglichkeiten von Radverkehrsdatensätzen der Provider „Strava" und „BikeCitizens" in der Evaluation kommunaler Radverkehrsnetze. Mithilfe der Analysefunktionen der beiden Plattformen gelang es dem im Rahmen des Nationalen Radverkehrsplans geförderte Forschungsprojekt, wichtige Erkenntnisse für die Stressorenanalyse zu generieren. So konnten zum Beispiel die analysierten Fahrgeschwindigkeiten und die Wartezeiten an Ampeln direkt mit gemiedenen, beziehungsweise bevorzugten Streckenabschnitten in Beziehung gesetzt werden.

3.3 Analyseansätze aus der Stadtforschung

Wie die vorangegange Untersuchung zeigt, ist im Feld der Stressorenanalyse bislang eine starke Ausrichtung auf verkehrsspezifische Faktoren und deren Erhebung mithilfe von digitalen Analysemethoden zu beobachten. Die Einsatzmöglichkeiten von analogen, beziehungsweise grafisch und visuell arbeitenden, Analysemethoden, wie sie aus der Stadtforschung und -planung bekannt sind, bleiben in diesem Kontext noch weitestgehend unerforscht.

3.3.1 Umweltpsychologische Grundlagen zur Wahrnehmung von Stadträumen

Die Disziplinen der Umweltpsychologie und Raumwahrnehmung definieren die Stadt als eine äußerst komplexe Umwelt mit einem hohen Reizvolumen für den Menschen (Mehrabian, 1987). Bei seiner Bewegung durch die Stadt nimmt der Mensch in seinem Unterbewusstsein davon deutlich mehr wahr, als ihm bewusst ist. Er ist stetig damit beschäftigt, sich ein inneres Bild dieser komplexen Umwelt anzufertigen (Lynch, 1965). Zurückzuführen ist dieser Vorgang der inneren Verbildlichung auf sein natürliches Bedürfnis nach Orientierung, beziehungsweise der Notwendigkeit eines Bezugsystems, das für seine ursprüngliche Lebensweise überlebensnotwendig war. Wir Menschen beziehen unsere Wahrnehmung von Stadt, respektive

unser Bild der Stadt, deshalb noch heute auf uns bekannte, wiederkehrende und klar ablesbare Elemente und aktivieren zur Wahrnehmung unserer Umwelt unterbewusst all unsere Sinne. Je nachdem, ob dabei eine positive oder negative Wahrnehmung der Umgebungsreize überwiegt, empfinden wir Sicherheit und Wohlbefinden oder Unbehagen (Mehrabian, 1987). In unseren heutigen urbanen Stadträumen sind wir jedoch einer solch enormen Masse an Reizen ausgesetzt, dass sich die Auswirkungen von einzelnen Reizen auf unser Empfinden kaum noch herausfiltern lassen. Es wird daher in der Umweltpsychologie immer das Zusammenspiel unterschiedlicher Faktoren und dessen Auswirkungen auf das menschliche Empfinden betrachtet, beziehungsweise eine Art von „Rauschen" mitberücksichtigt.

3.3.2   Analysemethoden aus der Stadtforschung

Die Stadtforschung steht als ein interdisziplinäres Forschungsfeld im engen Zusammenhang sowohl mit der Geografie, der Anthropologie, der Soziologie und der Ethnologie, als auch mit einigen anderen raumbezogenen Forschungsfeldern (Pelger et al., 2021). Im Kontext ihres Forschungsgegenstandes ist diese Interdisziplinarität notwendig, um das komplexe Raumgefüge Stadt nicht nur beschreibend in ihrer Theorie, sondern auch in ihrer Dynamik als ein sich stetig verändernder Raum zu durchdringen. In der Erforschung von Stadt gibt es deshalb kein vordefiniertes Forschungsdesign, wie es in anderen wissenschaftlichen Disziplinen Usus ist, sondern es wird sich meist an einer Kombination unterschiedlicher Methoden bedient (Eckardt, 2014).

Innerhalb der Stadtforschung kann somit auf einen breiten Fächer an Analysemethoden und entsprechender Darstellungsmöglichkeiten zurückgegriffen werden, die je nach Umfang und Art der Aufgabe ganz unterschiedliche Analyseaspekte und Detailtiefen bearbeiten können. Mitunter sind dabei Interviews, Beobachtungen, Kartierungen, Mappings, Fotografien und künstlerische Annäherungen als gängige Methoden (Eckardt, 2014) zu nennen. Die mithilfe dieser visuellen und grafischen Methoden entstehenden Analysegrafiken können im Rahmen komplexer Aufgabenstellungen dabei helfen, die Grenzen des digital Erfassbaren, beziehungsweise quantitativ Messbaren zu überwinden.

In diesem Zusammenhang geht es bei der Erforschung von Stadträumen jedoch nicht nur um eine Erhebung und Analyse vorhandener raumbezogener Daten, sondern immer auch um ein In-Beziehung-Setzen der Daten (Pelger et al., 2021). Im Rahmen von Mixed-Methods-Ansätzen können so zum Beispiel durch die Kombination von räumlichen Darstellungen mit anderen Datensätzen, respektive Werkzeugen, wie zum Beispiel abstrahierten Illustrationen oder fotografischen Annäherungen, neue Erkenntnisse gewonnen werden.

Abb. 3: Schnittanalyse verschiedener Straßenräume im Vergleich zu Las Vegas in Bezug auf Raum, Maßstab, Symbol und Geschwindigkeit. (Eigene Darstellung nach Venturi et al., 1979; Beschriftung und Anordnung der Ursprungsgrafik verändert)

Abbildung 3 zeigt in diesem Kontext eine frühe analytische Annäherung Robert Venturis Ende der 70er Jahre (Venturi et al., 1979), die im Kontext der Analyse von Straßenräumen und Symbolik der Geschäftsstadt Las Vegas durchgeführt wurde. Dabei kombiniert Venturi nach dem Mixed-Methos-Ansatz eine Schnittanalyse mit der abstrahierten Darstellung der vor Ort beobachteten Symbolik und den Bewegungsgeschwindigkeiten. Durch die vergleichende Darstellung und die Kombination der analysierten

Inhalte wird in der Analysegrafik die Beziehung zwischen verschiedenen Bewegungs-, beziehungsweise Fahrgeschwindigkeiten und der daran angepassten Dimension von Stadträumen und Symbolen deutlich.

4 ANWENDUNG DES INTERDISZIPLINÄREN STRESSFORSCHUNGSANSATZES

4.1 Bezug zu den Projekten der Urban-Emotions-Initiative

Vor dem Hintergrund der Analyse von Stresspunkten im urbanen Kontext, gliedern sich die Forschungen der vorliegenden Studie im Kontext der Urban Emotions Initiative ein. Die Studie unterstützt dabei insbesondere das aktuelle NRVP-Projekt „Cyclist and Pedestrians on Real and Virtual Shared roads", kurz: „Cape Reviso" (Zeile et al., 2021), in der experimentellen Weiterentwicklung der Stressorenanalyse. Sowohl inhaltlich, als auch methodisch sollen mit der Studie Erkenntnisse gewonnen werden, wie die bislang rein auf infrastrukturelle Faktoren konzentrierte Ursachenforschung des Projekts in Richtung einer ganzheitlichen Stadtraumanalyse weiterentwickelt werden kann.

4.2 Aufbau und Ablauf der Studie in der Untersuchungsstadt Karlsruhe

Der interdisziplinäre Ansatz der Studie wird seit April 2023 im Rahmen erster experimenteller Untersuchungen zunächst in der Stadt Karlsruhe erprobt.

4.2.1 Datengrundlage der Untersuchungen: EmoCycling-Heatmap

Als eine wichtige Grundlage dient der Studie die Stress-Heatmap aus dem Urban Emotions Projekt „Cape Reviso" (Zeile et al., 2021), die als Ergebniskarte von zwei EmoCycling-Messungen im Winter 2021/22 entstanden ist. Dabei wurden die Stressreaktionen von insgesamt 17 Radfahrenden auf einer vorgegebenen Route gemessen. Nach Abzug einiger fehlerhafter Datensätze konnten bei dieser Erhebung 26 Tracks gesammelt werden und dabei 1121 Moments of Stress detektiert werden. Die entstandene Heatmap dient der Studie als ein erster Überblick über die neuralgischen Stress-Hotspots für Radfahrenden in Karlsruhe. Die auffallende Ballung der Stressmomente am Berliner Platz im Bereich des KIT-Campus ist der Start- und Endpunkt der Route und muss als Fehler in der Auswertung von den Betrachtungen ausgenommen werden.

4.2.2 Strukturanalyse der Untersuchungsstadt Karlsruhe

Im weiteren Verlauf setzt die Studie die Ergebniskarte der Stressmessungen in Beziehung mit den Strukturelementen der Stadt Karlsruhe (siehe Abbildung 4). Methodisch werden dabei frei verfügbare Datensätze der Plattform OpenStreetMap zu verschiedenen Themenbereichen, wie zum Beispiel zu Freiraumnetz, Baustruktur und Nutzungsverteilungen, in einem GIS-Programm inhaltlich und grafisch aufbereitet. Durch das Rückkoppeln der verschiedenen Strukturelemente mit dem Layer der EmoCycling-Heatmap sollen für das weitere Vorgehen der Studie Untersuchungsräume identifiziert werden, die nicht nur innerhalb der Stressmessungen auffallend waren, sondern denen auch stadtstrukturell und -räumlich eine besondere Bedeutung beizumessen ist.

Abb. 4: Überlagerung der EmoCycling-Heatmap mit prägenden Strukturelementen und Nutzungen der Stadt Karlsruhe. (Quelle: Eigene Darstellung nach Datenquelle OpenStreetMap, Heatmap nach Datenquelle Cape Reviso)

178

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In diesem Zusammenhang werden neben den meist auch in anderen Städten häufig an großen Kreuzungspunkten auftretenden Stresspunkten in der „Fächerstadt" Karlsruhe insbesondere die räumlichen Schnittstellen zu den prägenden „Strahlen" als Hotspots identifiziert. Zu erwähnen sind in diesem Kontext der Bereich um den Ludwigsplatz im Westen, der ringförmig verlaufende Zirkel, der Rondellplatz im Zentrum, sowie das Gebiet um den Kronenplatz und das Durlacher Tor im Osten. Insbesondere in den belebten und hochfrequentierten Bereichen des Zentrums, in denen sich eine Vielzahl an Nutzungen ballen, konnten dabei vermehrt Stressmomente gemessen werden. Auch in diesem Kontext ist der Bereich um den Ludwigsplatz auffallend, an dem sich darüber hinaus nicht nur das Radwege- und Schienennetz kreuzt, sondern auch die wichtige Nord-Süd-Achse der Karlstraße verläuft.

4.2.3 Auswahl eines Untersuchungsgebiets als Experimentierfeld für die Stressorenanalyse

Aufgrund des besonderen Anspruchs der Studie, die Wahrnehmung von Stadträumen und die damit verbundenen „weichen" Faktoren in den Fokus der Stressorenanalyse zu rücken, fällt die Wahl des ersten Untersuchungsgebiets für die Studie auf den Bereich rund um den Karlsruher Ludwigsplatz. Die Route führt dabei von Westen über den Stephanplatz und die Karlstraße über den Ludwigsplatz weiter nach Osten. Die Abgrenzung des Untersuchungsraums und der Routenverlauf sind in Abbildung 5 zu sehen. Neben den stadtstrukturell prägenden Elementen, dem Verlauf wichtiger Fahrradrouten und der hohen Frequentierung können in diesem Gebiet verschiedene Raumansprüche und -konflikte beobachtet werden.

Abb. 5: Das Untersuchungsgebiet Karlsruhe Ludwigsplatz als Zoom-In der Strukturanalyse (links) und im Luftbild (rechts) mit Route. (Quelle: Eigene Darstellung nach Datenquelle OpenStreetMap und Google Satellite, Heatmap nach Datenquelle Cape Reviso)

4.2.4 Identifikation potentieller Einflussfaktoren

Im Rahmen der Studie „Decoding Stress" wurde beginnend im Mai 2023 auf dem Untersuchungsgebiet des Ludwigsplatzes dann zunächst mit der Identifikation und Analyse verschiedener Einflussfaktoren begonnen.

Abb. 6: Auswahl-Pool potentieller Stressfaktoren zur experimentellen Analyse im Untersuchungsgebiet Karlsruhe Ludwigsplatz.

In einer ersten Annäherung wurde in diesem Zusammenhang ein Pool (siehe Abbildung 6) aus verschiedenen Themengebieten und potentiellen Stressfaktoren definiert, bei denen von einer Einflussnahme auf das subjektive Empfinden von Radfahrenden bei der Bewegung durch den Untersuchungsraum ausgegangen werden kann, beziehungsweise vermutet wird. Dabei wurden neben beispielsweise baulichen, gestalterischen

und freiraumspezifischen Faktoren auch sensuelle Faktoren, wie zum Beispiel die Wahrnehmung von Gerüchen, Geräuschen und Lärm als zu untersuchende Faktoren identifiziert.

4.2.5 Experimentieren mit adäquaten „analogen" Analysemethoden

Aufbauend auf diesem Pool zu untersuchender Faktoren experimentiert der in der Studie erprobte Ansatz intensiv mit der Entwicklung adäquater „analoger" Analysemethoden und deren Übersetzungsmöglichkeiten. Neben den intensiven Vor-Ort-Untersuchungen mithilfe von Mappings, Skizzen und fotografischen Dokumentationen, die sehr spezifisch auf die Analyse der jeweiligen Stressfaktoren zugeschnitten sind, konnte dabei insbesondere mit der Übersetzung der Analyseerkenntnisse in schematische „Stressorenabwicklungen" erste Erkenntnisse generiert werden. Durch die anschließende Gegenüberstellung in der „Stressorenmatrix" (Abbildung 7) können die verschiedenen Einflüsse der analysierten Faktoren auf das Stressempfinden, beziehungsweise auch mögliche Korrelationen zwischen den einzelnen Faktoren auf diese Weise vergleichsweise einfach identifiziert werden.

4.3 Erste Ergebnisse der Studie

Im Juni 2023 konnten mit dem erarbeiteten Methodenbaukasten erste Ergebnisse präsentiert werden. Die Vor-Ort-Erhebungen fanden in einem Zeitraum von zwei Wochen im Untersuchungsgebiet Ludwigsplatz statt und behandelten insgesamt 23 potentielle Stressfaktoren. In Abbildung 7 wird die Stressorenmatrix exemplarisch mit den Stressorenabwicklungen von drei analysierten Faktoren gezeigt und mit den Ergebnissen der Stressmessungen verglichen. Für jeden Faktor wurden dabei unterschiedliche Farbcodierungen, Symoble und Bewertungsskalen angesetzt.
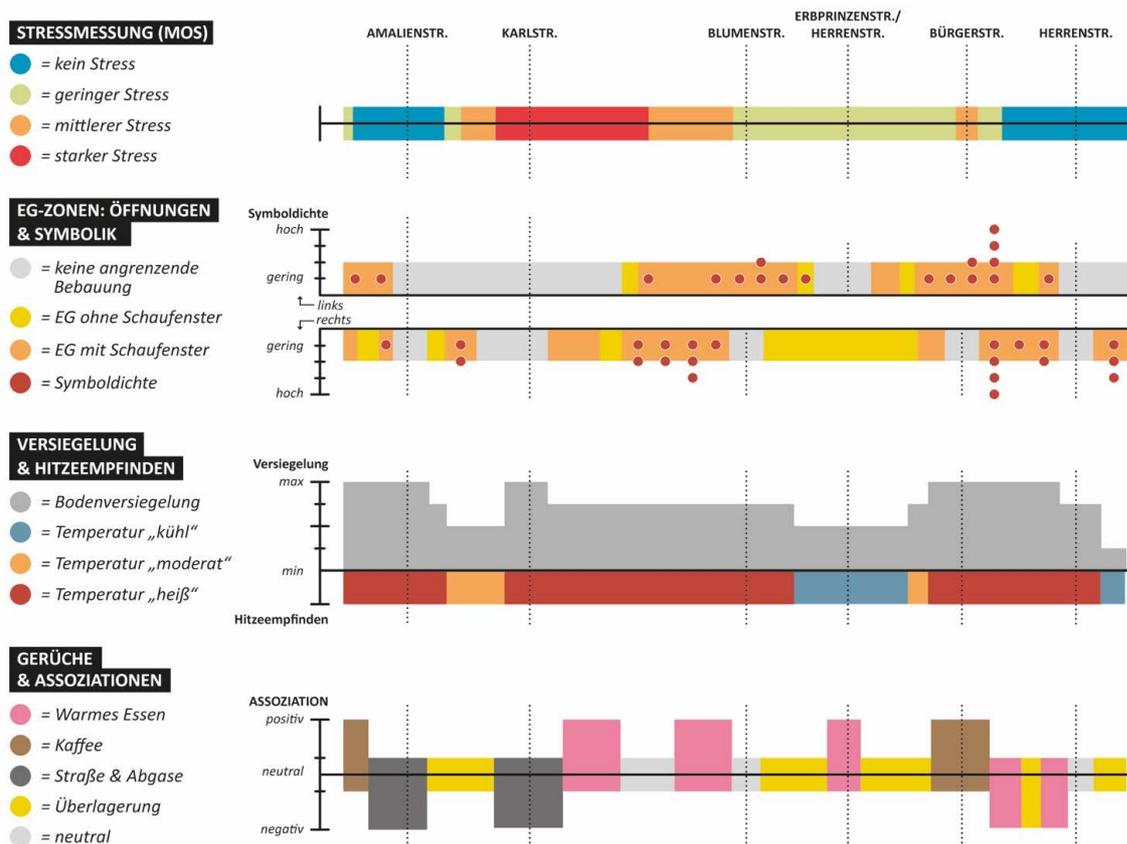
Abb. 7: Auszug aus der Stressorenmatrix: Vergleichende Darstellung der Stressmessungen mit den analysierten Faktoren Öffnungen & Symbolik, Versiegelung & Hitzeempfinden, Gerüche & Assoziationen.

Die Analyse der Erdgeschosszonen untersucht die angrenzende Bebauung des definierten Streckenabschnitts hinsichtlich ihrer Öffnungen und Schaufensterflächen. Darüber hinaus wurde auch die Symboldichte in den Erdgeschosszonen untersucht, die zum Beispiel in Form von Werbeplakaten, Leuchtreklamen und Aufstellern auf die Wahrnehmung Einfluss nehmen können. Bei der Darstellung in der Abwicklung wurde die linke und rechte Seite der Straße getrennt voneinander betrachtet.

180

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Als eine weitere Analyse wurde die Versiegelung der Bodenflächen in Kombination mit dem subjektiven Hitzeempfinden untersucht. Im Anfangsbereich der Route weist der Bodenbelag des Stadtraums dabei einen hohen Versiegelungsgrad auf und wird als sehr heiß wahrgenommen. Im Bereich des Stephanplatz wird die Versiegelung durch Baumscheiben und Beete punktuell aufgebrochen und das Temperaturempfinden deutlich abgesenkt. Nach der Überquerung der hochversiegelten Karlstraße wird die Waldstraße dann größtenteils mit Kopfsteinpflaster fortgeführt, das im Bereich des Ludwigsplatzes erneut punktuell aufgebrochen wird und für Abkühlung sorgt. Die Fortführung der Route auf der Erbprinzenstraße weist schließlich wieder einen höheren Versiegelungsgrad und äquivalent dazu ein stärkeres Hitzeempfinden auf.

Der letzte Stressfaktor, der in der dargestellten Matrix analysiert wurde, betrifft die olfaktorische Wahrnehmung des Stadtraums und analysiert die wahrnehmbaren Gerüche und ihre positive, beziehungsweise negative Assoziation. Hierbei ist auffallend, dass um die Kreuzungspunkte zur Amalienstraße und Karlstraße starke Abgasgerüche wahrnehmbar sind, die negativ assoziiert werden. Im Bereich des Ludwigsplatzes sind dann vorwiegend positiv konnotierte Essensgerüche der Gastronomie wahrnehmbar, die große Bereiche auf dem Platz einnimmt. An der Einmündung zur Bürgerstraße ist darauf folgend intensiver Kaffee-Geruch positiv wahrzunehmen. Im darauf folgenden Abschnitt vermischen sich die Essensgerüche verschiedener Imbisse und werden größtenteils negativ assoziiert.

Auch, wenn die Analysen noch zu einem sehr frühen Zeitpunkt der Studie vorgenommen wurden und in der Abbildung nur ausschnitthaft dargestellt sind, lassen sich in der Auswertung im direkten Vergleich zu den Ergebnissen der Stressmessungen erste vorläufige Thesen zu etwaigen Abhängigkeiten aufstellen. Faktoren wie negativ wahrgenommene Gerüche, ein hohes Hitzeempfinden durch starke Versiegelung der Bodenflächen, sowie auch ablenkend hohe Schaufenster- und Symboldichten zeigen sich zum aktuellen Stand der Untersuchung als potentielle Einflussfaktoren.

4.4 Ausblick

Die Studie „Decoding Stress" befindet sich aktuell noch in den Anfängen. In einem nächsten Schritt sollen die bis dato identifizierten Stressfaktoren und die exemplarisch im Untersuchungsgebiet Ludwigsplatz angewendeten Analysemethoden deshalb zunächst weiter erprobt und die Erhebungen systematisiert werden. In diesem Zusammenhang sollen die angeführten Analysen in einem zweiten Untersuchungsgebiet innerhalb der Stadt Karlsruhe wiederholt und entsprechend adaptiert werden. Es ist dabei zu klären, ob die im Rahmen der ersten Untersuchungsergebnisse getroffenen Annahmen über die Korrelationen zwischen den einzelnen Stressfaktoren dann auch in anderen Untersuchungsgebieten zu beobachten sind.

In einer nächsten Arbeitsphase soll der entwickelte Ansatz zur Stressorenanalyse dann auch in weiteren Untersuchungsstädten zur Anwendung kommen. Perspektivisch sollen mit dem entwickelten Ansatz nicht nur die Einfluss nehmenden Stressoren identifiziert werden, sondern dadurch auch zukünftige Stellschrauben für die Planung benannt werden können. Die gewonnenen Erkenntnisse sollen damit einen Beitrag dazu leisten, Lösungsansätze für die Gestaltung qualitätsvoller und menschengerechter öffentlicher Stadträume zu erarbeiten.

5   DISKUSSION

Mit den ersten Ansätzen der vorgestellten Studie „Decoding Stress" wurde eine Methodik entwickelt, die es ermöglicht, Aspekte der Stadt- und Raumwahrnehmung in die Stressorenanalyse miteinzubeziehen. Damit wird ein Beitrag dazu geleistet, das subjektive Empfinden des Menschen bei seiner Bewegung durch die Stadt zu erforschen und ihn erstmals auch in den Fokus der retrospektiven Stressorenanalyse zu rücken. Aus diesem Verständnis heraus bleibt das Subjekt, also der seine Umgebung wahrnehmende und verarbeitende Mensch, ein wichtiger Teil der Methodik. Es ist ihr Anspruch, unsere subjektive Raumwahrnehmung zu erfassen und zu objektivieren, ohne dabei jedoch die subjektive Komponente vollständig zu eliminieren. Die in den Stressorenabwicklungen analysierten Faktoren können deshalb zwar nicht als vollumfänglich objektiv angesehen werden, vielmehr soll mit der entwickelten Methodik jedoch das Zusammenspiel aus objektiven und subjektiven Komponenten systematisiert und vergleichbar gemacht werden.

In diesem Kontext bleibt schließlich auch die Frage nach der Anwendbarkeit des Methodenansatzes in der Praxis zu stellen. Bis dato gestalten sich die Erhebungen und Auswertungen der Studie noch sehr zeitintensiv. Im weiteren Verlauf bleibt deshalb zu klären, inwieweit sich die Erfassung der Stressfaktoren, sowie die Darstellung in der Stressorenabwicklung, beziehungsweise in der Stressorenmatrix, zukünftig

Decoding Stress – ein interdisziplinärer Stressforschungsansatz zur Förderung qualitätsvoller öffentlicher Stadträume für den Rad- und Fußverkehr

systematisiert werden könnte. Dabei könnten Crowdsourcing-Ansätze, beziehungsweise digitale Erfassungstools eine Schlüsselrolle spielen, um die Methodik schließlich für die Planung zu einem anwendbaren Tool zu transferieren.

6 REFERENCES

BOUCSEIN, W.: Elektrodermale Aktivität: Grundlagen, Methoden und Anwendungen. Springer Berlin, Heidelberg, 1988.

BUNDESMINISTERIUM FÜR DIGITALES UND VERKEHR (BMDV): Fahrradland Deutschland 2030 – Nationaler Radverkehrsplan 3.0. Berlin, 2022. Abgerufen am 23.04.2023 von https://bmdv.bund.de/SharedDocs/DE/Anlage/StV/nationaler-radverkehrsplan-3-0.pdf?__blob=publicationFile

BUNDESMINISTERIUM FÜR VERKEHR UND DIGITALE INFRASTRUR (BMVI): Ergebnisbericht Mobilität in Deutschland (MiD) 2017. Bonn, 2018. Abgerufen am 10.04.2023 https://www.mobilitaet-in-deutschland.de/archive/pdf/MiD2017_Ergebnisbericht.pdf

CHROUSOS, G. P., LORIAUX, D. L., & GOLD, P. W.: Mechanisms of Physical and Emotional Stress. Erschienen in: Advances in Experimental Medicine and Biology, Volume 245. Springer Verlag, 1988.

ECKART, F.: Stadtforschung – Gegenstand und Methoden. Erschienen in: Stadtforschung. Wiesbaden, 2014.

ECKART, J., MERK, J.: Die sensorbasierte Vermessung des Radverkehrs: Analyse des Radverkehrs mit einem SensorBike mit ubiquitären Sensoren. Erschienen in: Lecture Notes in Informatics (LNI), Gesellschaft für Informatik. Bonn, 2021

HÖFFKEN, S., WILHELM, J., GROSS, D., BERGNER, B. S., & ZEILE, P.: EmoCycling – Analysen von Radwegen mittels Humansensorik und Wearable Computing. Erschienen in: Real CORP 2014: Plan it smart – Clever solutions for smart cities, S. 851–860. Wien, 2014.

KURTH, D.: In 15 Minuten zur Europäischen Stadt? Erschienen in: Bauwelt, Ausgabe 19.2021, Berlin, 2021.

KARTHIKEYAN, P., MURUGAPPAN, M., & YAACOB, S.: Multiple physiological signal-based human stress identification using non-linear classifiers. Erschienen in: Elektronika ir Elektrotechnika, Vol. 19, No. 7, S. 80–85. Kaunas, 2013.

KREIBIG, S.: Autonomic nervous system activity in emotion: A review. Erschienen in: Biological Psychology, Volume 84, Issue 3, 2010. S. 394-421.

KYRIAKOU, K. & RESCH, B.: Spatial Analysis of Moments of Stress Derived from Wearable Sensor Data. Erschienen in: Advances in Cartography and GIScience of the International Cartographic Association, 2. Wien, 2019.

KYRIAKOU, K., RESCH, B., SAGL, G., PETUTSCHNIG, A., WERNER, C., NIEDERSEER, D., LIEDLGRUBER, M., WILHELM, F., OSBORNE, T., & PYKETT, J. (2019). Detecting Moments of Stress from Measurements of Wearable Physiological Sensors. Erschienen in: Sensors, Vol. 19, No. 17. Basel, 2019

LISSNER, S., FRANCKE, A. & BECKER, T.: Big Data im Radverkehr. Ergebnisbericht: Mit Smartphones generierte Verhaltensdaten im Radverkehr. Technische Universität Dresden. Dresden, 2018. Abgerufen am 30.03.2023 von https://tud.qucosa.de/api/qucosa%3A31011/attachment/ATT-0/?L=1

LYNCH, K.: Das Bild der Stadt. Bauwelt Fundamente 16, Berlin, 1965.

MEHRABIAN, A.: Räume des Alltags – Wie die Umwelt unser Verhalten bestimmt. Frankfurt am Main, 1987.

NOLD, C.: Emotional cartography: Technologies of the self. London, 2009.

OPENBIKESENSOR: Dokumentation OpenBikeSensor, 2023. Abgerufen am 02.05.3023 von https://www.openbikesensor.org/docs/user-guide/

PELGER, D., KELLING, E. & STOLLMANN, J.: Multiskalares Mapping. Erschienen in: Handbuch qualitative und visuelle Methoden der Raumforschung. Bielefeld, 2021.

POLIS MAGAZIN: Für mehr Gefühl in der Planung. Erschienen in: Polis - Magazin Für Urban Development, Vol. 03/2022. Wuppertal, 2022.

TAGESSPIEGEL: Radmesser, 2018. Abgerufen am 02.05.2023 von https://interaktiv.tagesspiegel.de/radmesser/

TEMMEN, M.: Messen mit SensorBikes – Wie der Alltagsradverkehr von der Digitalisierung im Radsport profitieren kann. Erschienen in: Fahrradlabor Hochschule Karlsruhe, S. 9-14. Karlsruhe, 2022.

VENTURI, R., SCOTT BROWN, D. & IZENOUR, S.: Lernen von Las Vegas – Zur Ikonographie und Architektursymbolik der Geschäftsstadt. Bauwelt Fundamente 53, Wiesbaden, 1979.

WALTHER, N., PILS, M., TREFZGER, M. & SCHLEGEL, T.: Vergleich des Blickverhaltens von Rad- und E-Scooterfahrenden auf Fahrradstraßen: Analyse einer Eye-Tracking-Studie in Bezug auf Verkehrsschilder und Straßenmarkierungen. Erschienen in: Fahrradlabor Hochschule Karlsruhe, S. 27-37. Karlsruhe, 2022.

WERNER, C., RESCH, B. & LOIDL, M.: Evaluating Urban Bicycle Infrastructures through Intersubjectivity of Stress Sensations Derived from Physiological Measurements. Erschienen in: ISPRS International Journal of Geo-Information, 2019, 8(6), 265. MDPI AG. 2019.

ZEILE, P., EXNER, J.-P., HÖFFKEN, S., & STREICH, B.: Menschen als Messfuehler - Die Kombination von Geowebmethoden und Sensorik. Erschienen in: REAL CORP 2010: Cities for everyone – Liveable, Healthy, Prosperous. Promising vision or unrealistic fantasy? S. 419–426. Wien, 2010.

ZEILE, P., HAUG, N., SCHMIDT-HAMBURGER, C., BENGEL, S., & MOTZER, N.: Emotion Sensing für (E-)Fahrradsicherheit und Mobilitätskomfort – Das BMDV-Projekt ESSEM. Erschienen in: REAL CORP 2022: Mobility, Knowledge and Innovation Hubs in Urban and Regional Development, S. 259-268. Wien, 2022.

ZEILE, P., RESCH, B., EXNER, J.-P., SAGL, G., SUMMA, A.: Urban Emotions – Kontextuelle Emotionsinformationen für die Räumliche Planung auf Basis von Echtzeit- Humansensorik und Crowdsourcing-Ansätzen. Erschienen in: Angewandte Geoinformaitk – Beiträge zum AGIT-Symposium Salzburg. Salzburg, S. 664–669. Salzburg, 2014.

ZEILE, P., OBST, T., DEMBSKI, F., DRESCHER, J., CINAR, Ö. & WÖSSNER, U.: Radfahren und Zufußgehen auf realen und virtuellen Flächen – Das NRVP-Projekt Cape Reviso. Erschienen in: REAL CORP 2021: Cities 20.50 Creating Habitats for the 3rd Millenium smart – sustainable – climate neutral. S. 613-622. Wien, 2021.

182

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Design Studio Environment: Using Biophilic Patterns for Creative Performance

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1 ABSTRACT

In design education, the architectural design studio environment is one of the most significant environments that should be a stimulator of creativity. It's known for the amount of time students spend there, so it's considered their second home. Researchers aspire to create a unique and different design studio environment that motivates students' creativity. This study presents the biophilia theory as a technique that generates a creative design studio environment. The purpose is to determine the applicability of the biophilic design theory patterns to the design studio environment, which in turn has an impact on motivating the students' creativity. The research method will be conducted through a comprehensive analysis of several world-famous architectural schools, by understanding the application of the principles of nature and connecting them with biophilic patterns. As a result, the research has yielded applicable criteria for biophilic patterns in existing design studios.

Keywords: Architectural design studio, Creative learning environment, Biophilia, Biophilic design studio, Biophilic Patterns

2 INTRODUCTION

Creativity is described as the ability to create something unique. As a result, creative talents are required in many forms of education and jobs. Creative students are necessary for all sorts of education, including the arts, music, sciences, mathematics, and engineering, and architecture is one of them ("10 Jobs That Require Creative Thinking Skills", 2023; "Best Degrees for Creative People", 2022; Easton & Djumalieva, 2018; Rufener, McCaulley, & Sealey-Morris, 2023; Vilorio, 2015). The design studio has always been a rich material for investigation. Its impacts on interpersonal interactions, academic performance, and meeting students' psychological needs are crucial (Dhanapala, 2021). As a space, it extends beyond just being a box-shaped classroom to play a larger role. It has to be configured to encourage students to work and unwind when they encounter conceptual difficulties (shaqour, 2021); in addition, it has to be a source of inspiration and imagination (Davies et al., 2013; McCoy & Evans, 2002; Thoring, Desmet, & Badke-Schaub, 2018; Thoring, Gonçalves, Mueller, & Badke-Schaub, 2017; Vyas, van der Veer, & Nijholt, 2012). Actually, architecture students want spaces for chilling, places for socializing and conversing, suitable furniture, views rather than just walls, and a corner for laptops with the necessary equipment (Lewinski, 2015; Vyas et al., 2012). These needs are reflected in the studio's furnishings, which are usually divided up into smaller groupings to create a more intimate setting that supports the desired social interactions (Utaberta, Hassanpour, Handryant, & Che Ani, 2013). In addition, they prefer a panoramic view of the surrounding landscape, especially greenery elements in all the interior and exterior spaces, outside nature, green open spaces, green elements, indoor greenery, and indoor plants, as they feel comfy while working (shaqour, 2021). This is according to many references (Dhanapala, 2021; Ibrahim & Utaberta, 2012; Lewinski, 2015; Obeidat & Al-Share, 2012; shaqour, 2021). They have highlighted incorporating aspects of the natural environment as a prerequisite to its optimal performance as a catalyst for creativity.

Biophilia is a biological tendency to affiliate with nature (Stephen R. Kellert, 2012; WILSON, 1984). Biophilic design, as a reflection of the Biophilia principles in the design studio, presents a viable translation of "nature" to shape the design studio environment and accordingly affect its creativity potential (Stephen R. Kellert & Calabres, 2015). The challenge lies in the applicability of the biophilic patterns to the physical configurations of the design studio. It has to be addressed within a proper understanding of students' perceptions as related to incorporating elements of nature into the architectural design studio (WILSON, 1984).

This paper raises questions about the creative potential of applying biophilic design patterns to the existing design studio. To answer these questions, it reviews related literature to come up with a solid understanding of the typology of the 'creative design studio' on one hand, and the relation between nature-based interventions that influence these creativity potentials. In addition, three featured examples (mentioned within the leading 10 existing schools of architecture worldwide) are analyzed. A correlation analysis between the natural features of these schools and the related biophilic patterns is used to conclude a framework for applying the biophilic patterns in design studios to enhance their creative potential, This methodology has been shown in Figure 1.
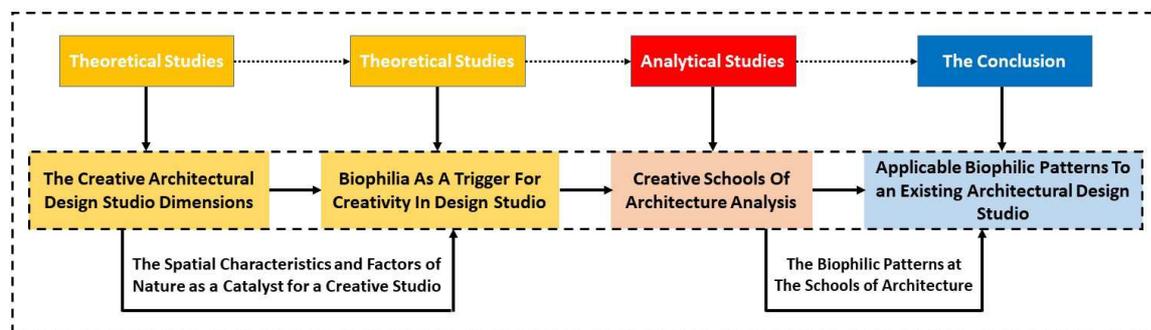
Fig. 1: The Reaserch Methodology. Source: Researchers.

3 THE CREATIVE DESIGN STUDIO

The design studios' physical environment should be a trigger for creativity and innovation (CANNON & UTRIAINEN, 2013). because It is not only important to improve students' performance but also to make them more inventive and increase their creativity potential to create innovative products (Thoring et al., 2018). To establish an educational environment that inspires students to be more creative, several guidelines can be followed. Several literature reviews have mentioned certain spatial principles, characteristics, or requirements that can be applied to the educational environment. Many sources discussing spaces as triggers for creativity within academic, practice, or other innovation environments were identified.

The spatial requirements that can be applied were pointed out. Through these references, it was discovered that there are several spatial guidelines that are constantly repeated in different references and which turned out to be related to the natural environment. Some of the literature reviews allude to various learning environments in general. (Bramble, 2017; McCoy & Evans, 2002; Thoring, Desmet, & Badke-Schaub, 2019; Thoring, Guerreiro Goncalves, Mueller, Badke-Schaub, & Desmet, 2017; Thoring, Mueller, Desmet, & Badke-Schaub, 2020; Williams, 2013). Additionally, some other literature reviews were cited specifically pertaining to the architectural design studio. (Muniandy, Khan, & Ahmad, 2015; Obeidat & Al-Share, 2012; shaqour, 2021; Thoring et al., 2018; THORING, LUIPPOLD, & MUELLER, 2012,). Practitioners, educators, and researchers can use the presented overview to investigate the possible impact of creative space design and to identify research gaps for conducting further research in the field. The spatial characteristics that are connected with nature as a trigger for creative space will be analyzed in Table 1.

3.1 The Spatial Characteristics and Factors of Spaces as Triggers for Creativity

The first factor is the visual connection with nature. That factor can be applied by using open views and making many openings, windows, or curtain walls, which give a wider perspective. Additionally, using greenery, which can be used in the space by using living indoor plants and flowers of various shapes, sizes, and types (CANNON & UTRIAINEN, 2013; Davies et al., 2013; De Paoli & Ropo, 2017; Dul & Ceylan, 2014; McCoy & Evans, 2002; Muniandy et al., 2015; Oksanen & Ståhle, 2013; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Gonçalves, et al., 2017; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020; Williams, 2013).

The second factor is the components of the space, which focus on furniture arrangement and design as well as unusual and activating furniture, which can be applied by using different shapes of furniture that express nature. Also, using visual details in the interior design gives rich sensory information. Furthermore, the size and shape of internal object organization follow a spatial hierarchy similar to those found in nature. (CANNON & UTRIAINEN, 2013; Ceylan, Dul, & Aytac, 2008; De Paoli & Ropo, 2017; Dul & Ceylan,

184

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2014; McCoy & Evans, 2002; Muniandy et al., 2015; Setola & Leurs, 2014; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020; Williams, 2013).

Factor	Identification	Factor	Identification	Factor	Identification	Factor	Identification
Connection with nature	Open Views	components of the space	Interior Haptics and Finishing	Stimulating	Stimulation	Natural light	Light, Quantity of light
	view of natural environment		less use of manufactured materials.		Sensory stimulation		Use of Natural Daylight
	extended views		Complexity, Complex Shapes		Sound (positive sound)		Use of Ambient, Soft Light
	Use of Outdoor Spaces		Size, Shape Internal Organization of Objects		Smell (Positive Smell)	Natural colours	Pale Colors, Calming, Inspiring Colors
	Use of Open Space				Natural Textures		
	Use of Park Theme Inside		Visual Detail	Materials	Transparency, Semi-Transparency		Fewer Cool Colors
	Greenery		Furniture Design & Arrangement		Use Of Natural Materials		Warm Color
	Living Plants Indoor		Unusual Furniture	Ventilation	Micro-Climate		Energetic Colors, Bright Colors
	Vista				Indoor Climate		
			Activating Furniture		Fresh Air		

Table 1: Overview of The spatial characteristics that are connected with nature as a trigger for creative space. Source: Researchers.

Stimulation is the third factor. That factor can be applied by using furniture that imitates elements of nature and biomorphic forms and shapes. And any suggestions for simulating nature in space (Bramble, 2017; CANNON & UTRIAINEN, 2013; Davies et al., 2013; Jindal-Snape et al., 2013; McCoy & Evans, 2002; Muniandy et al., 2015; Oksanen & Ståhle, 2013; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Gonçalves, et al., 2017; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020).

The fourth factor is the material connection with nature. This factor can be applied by using natural materials and textures in the space on furniture, walls, floors, ceilings, and any other elements in the space (CANNON & UTRIAINEN, 2013; Davies et al., 2013; De Paoli & Ropo, 2017; De Paoli, Sauer, & Ropo, 2018; McCoy & Evans, 2002; Muniandy et al., 2015; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Gonçalves, et al., 2017; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020).

The fifth factor is natural ventilation and airflow. These factors affect the indoor microclimate that can be created by using many sources of natural ventilation, such as windows, courtyards, and atriums (CANNON & UTRIAINEN, 2013; Jindal-Snape et al., 2013; McCoy & Evans, 2002; Muniandy et al., 2015; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020; Williams, 2013).

The sixth factor is natural light. The quantity of natural daylight and ambient, soft light affects students' mental and physical health. Therefore, using natural light enhances our wellbeing, which impacts students' creativity (Davies et al., 2013; De Paoli, Sauer, & Ropo, 2017; Dul, Ceylan, & Jaspers, 2011; Jindal-Snape et al., 2013; Makhmalbaf & Do, 2007; McCoy & Evans, 2002; Oksanen & Ståhle, 2013; Peschl, 2014; Thoring et al., 2018; Thoring et al., 2020; Williams, 2013).

The seventh factor is natural colors, which have a positive influence. Colors affect our feelings. Natural, pale, bright, calming, and inspiring colors create a connection with nature. Warm and energetic colors create a feeling of power. All this can create a creative space (Bramble, 2017; CANNON & UTRIAINEN, 2013; Davies et al., 2013; Eismann et al., 2021; Jindal-Snape et al., 2013; McCoy & Evans, 2002; Muniandy et al., 2015; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020).

After recognizing the role of nature in stimulating creativity in the design studio, theories have been explored through which the experience of nature can be applied. The biophilia theory is one of these theories.

4 BIOPHLIC DESIGN

Biophilia, our biological connection to natural environments (Browning, Ryan, & Clancy, 2014; Stephen R. Kellert, 2012; WILSON, 1984) has been theoretically linked with creative output and performance. (Ulrich, 1993). The justifications for selecting the biophilia hypothesis as a foundational approach to applying the experiences of nature in design studio environments are:

- Biophilic design's fundamental objective is to handle these imperfections of contemporary or current building and landscape practice by setting up a new framework for the fulfilling experience of nature in the constructed and built environment (Browning et al., 2014; Stephen robert Kellert, 2008; Stephen R. Kellert & Finnegan, 2011).

- Biophilic design aims to create useful habitat for people as an organic and biological organism in the built environment that improves people's creativity, productivity, health, fitness and wellbeing (Browning et al., 2014; Calabrese, 2015; Stephen R. Kellert & Finnegan, 2011).

- The biophilic theory was chosen based on some research and literature reviews that carried out quantitative and computational experiments on some space users and measured their creativity in different environments (Chulvi, Agost, Royo, & García-García, 2020; McCoy & Evans, 2002; Ulrich, 1993), including: a) The first one is the neutral study space; b) The other one is the same educational space, but a simulation of the natural environment inside this space was made by relying on the biophilic theory; and c) The last environment is the natural environment itself (the outdoor natural environment), as shown in Figure 2. The results indicate that both types of environments – simulated (biophilic) and natural settings – have higher creative values than a neutral situation.

Fig. 2: Photos showing 1) Real nature: outdoor garden area. 2) Simulated nature by biophilic theory: artificial representation of the garden indoors. 3) Neutral environment: normal lecture room. adapted from: (Chulvi et al., 2020).

With the aforementioned justifications, it can be concluded that biophilic design can create a creative design studio. Therefore, it was necessary to know the components of biophilia theory, which consist of principles and patterns (Browning et al., 2014; Stephen R. Kellert & Calabres, 2015). Several fundamental principles must be followed in order for biophilic design to be successfully implemented, which are:

- Frequent and continuous contribution to nature;

- Focusing on human willingness to accept nature;

- Encouraging emotional linking to similar environments and places;

- Strengthening the interaction between people and nature, which helps to increase the sense of responsibility towards human and natural societies;

- Inspiring the existence of interconnected and integrated architectural solutions (Browning et al., 2014; Stephen R. Kellert & Calabres, 2015).

There are 14 patterns of biophilic design that can be used when applying biophilic design within any space, and the 14 patterns fall into three groups: nature in space, natural analogues, and nature of space (Browning et al., 2014; Stephen R. Kellert & Calabres, 2015; WILSON, 1984), as shown in Table 2.

Based on this, it was determined that the biophilic theory is concerned with interior environments that are surrounded by nature. It can also provide a sense of the natural context, even if this interior space is in the center of a city in a built environment. Through various treatments and the application of additional principles and patterns within the space, it is possible to convey a sense of the natural environment and

context even though that space is inside the built environment. This is possible thanks to biophilic theory (Browning et al., 2014; Stephen robert Kellert, 2008; Stephen R. Kellert & Finnegan, 2011).

NATURE IN THE SPACE	P1	Visual Connection with Nature	NATURAL ANALOGUES	P8	Biomorphic Forms and Patterns	NATURE OF THE SPACE	P11	Prospect
	P2	Non-Visual Connection with Nature					P12	Refuge
	P3	Non-Rhythmic Sensory Stimuli		P9	Material Connection with Nature		P13	Mystery
	P4	Thermal and Airflow Variability						
	P5	Presence of Water		P10	Complexity and Order		P14	Risk/Peril
	P6	Dynamic and Diffuse Light						
	P7	Connection with Natural Systems						

Table 2: showing the biophilic design patterns and its description. Source: Browning et al., 2014.

5 CREATIVE SCHOOLS OF ARCHITECTURE'S ANALYSIS

Some examples from a number of the top architectural schools in the world will be singled out based on the Quacquarelli Symonds Rankings (QS) ("QS World University Rankings", 2022). The criteria for selection depend on the existence of the largest number of natural principles, creativity simulation, Their existence in a built or natural environment, and the availability of data. At the school, an analysis of the natural characteristics as a creative space trigger will be conducted in relation to the factors in Table 1. The main goal is to know the differences in the application of nature and natural elements in different locations, like a built environment, a tropical climate environment, and a mixed environment. As a result, the application of those natural characteristics will be connected through biophilic patterns. The three schools are: 1) TU Delft Faculty of Architecture and the Built Environment (rank 2), which is located in a mixed area (built-up and natural areas). 2) National University of Singapore School of Design and Environment (rank 6), which is located in a natural area. 3) Manchester School of Art (rank 7), which is located in a built-up area.

The following descriptions are analyzed based on some literature reviews, which contain journal articles, papers, reports, websites, and books that were utilized to describe the building designs and the aim, purposes, and values of the three architectural schools.

5.1 TU Delft Faculty of Architecture & the Built Environment

In terms of research and education, the faculty of architecture and the built environment is a global leader. The faculty's solid research reputation as well as the passion, enthusiasm, and creativity of its academic community and student body are what drive its success (Hoeven et al., 2022; Voordt, Jonge, & Hans; Wamelink, 2010). Academics and students have been working on enhancing the built environment to create a creative learning environment for students to become excellent, brilliant, and creative architectural engineers (Avermaete et al., 2014; "BK CITY, DELFT: a vibrant educational environment", 2022; Hoeven et al., 2022; ir-arch. T. (Tom) Coppens, Dipl.-Ing. Dr.techn. I. (Iva) Kovacic, G. (Gabriele) Lobaccaro, D.M. (Despina) Stratigakos, & Verbakel, 2023; Rooij, Klaassen, Cavallo, & Arts, 2019; "TU Delft Architecture and the Built Environment: About the faculty", 2022; Voordt et al., 2010).

5.1.1 Spatial Characteristics of Nature Principles as a Creative Space Trigger Related to Table 1

One of the factors at the TU Delft Faculty of Architecture and the Built Environment is the connection with nature. It's demonstrated inside the school through the presence of different plants, gardens, parks, and a backyard gathering area, as shown in Figures 3 and 4. The studio walls are mostly glass curtain walls, allowing views of nature. The second is components of the space, which are similarly characterized by complex geometries, internal haptics, and distinctive finishing. Then, as seen in Figure 5, there is a simulation of plants and other natural elements using their colors, shapes, and functions. The utilization of natural materials in multiple places is one of the distinctive characteristics. The studio at TU Delft is distinguished by its significant reliance on natural light, which enters through the ceiling's 17 skylights and curtain walls. As seen in Figure 6, the design studio is also defined by the presence of natural colors that provide many sources of inspiration. (Avermaete et al., 2014; "BK CITY, DELFT: a vibrant educational environment", 2022; Hoeven et al., 2022; ir-arch. T. (Tom) Coppens et al., 2023; Rooij et al., 2019; "TU Delft Faculty of Architecture & the Built Environment", 2022; Voordt et al., 2010).

Fig. 3: The faculty's surrounding context. Fig. 4: Outdoor gathering area. Both adapted from: "BK CITY, DELFT: a vibrant educational environment", 2022.

Fig. 5: The design studio hall. Fig. 6: The orange hall. Both adapted from: "BK CITY, DELFT: a vibrant educational environment", 2022.

5.2 National University of Singapore School of Design and Environment

The aim of the school is to become a top one that brings creative minds together to create a better future ((NUS), 2019 ; P, 2021; "School of Design and Environment", 2021). The design seeks to emphasize learning as a communicative, collaborative, and creative method. The design concept isn't just to create a creative learning environment for students but also to benefit the entire system by opening up the debate over design in general. So what distinguishes the building design is not only creating a learning environment that helps students communicate, be more creative, and collaborate ((NUS), 2019; Lasternas, 2018; "National University of Singapore School of Design & Environment", 2019; "NUS School of Design & Environment" " 2022; P, 2021; Poh et al., 2018; "SERIE ARCHITECTS", 2022).

5.2.1   Spatial Characteristics of Nature Principles as a Creative Space Trigger Related to Table 1

The building is widely connected with nature in many ways; it's extremely open. Nature and the landscape all around the building, as shown in Figure 7, As seen in Figure 8, there are various terraces and planted balconies. A huge overhanging roof protrudes along the south façade, integrating a tropical porch surrounded by mature trees. The building's architecture is adaptable and efficient. There are no formal distinctions between study, work, and social environments, as shown in Figure 9. The raw and natural features of the building materials have a major relationship with the biophilia notion. The ventilation at the school depends on natural sources. The building is called a "climate-responsive building." The majority of the rooms may be exposed to the prevailing winds, and more than half of the space is naturally ventilated. When necessary, only air conditioning is used. The school also depends on natural light. Parts of the façade can be taken apart and replaced with new methods and systems. a veil-like metal curtain that filters sunlight. There are also about 1,200 solar photovoltaic panels above the roof, as shown in Figures 10 and 11 ((NUS), 2019 ; Lasternas, 2018; "National University of Singapore School of Design & Environment", 2022; "NUS School of Design & Environment", 2022; P, 2021; Poh et al., 2018; "SERIE ARCHITECTS", 2022).

Fig. 7: The building's surrounding. Fig. 8: The building's terrace. Fig. 9: The design studio hall. Both adapted from: "NUS School of Design & Environment", 2022.

Fig. 10: Longitudinal Section components. Fig. 11: Cross Section components. Both adapted from: ("NUS School of Design & Environment","2022).

5.3 Manchester School of Art

The vision of the school is to be an inclusive art gallery for the people of Manchester and the wider world, opening minds to the essential role of creativity in making a healthy society and contributing to social change (Fallon, 2018; Jefferies, Stone, & Kwan, 2017; "Manchester Art Gallery", 2022; university, 2016). The Manchester School of Art's significant expansion by Feilden Clegg Bradley Studios has helped raise the prominence of the university and the art school by creating a creative, vibrant, interesting, and engaging environment for staff and students to work in (Fallon, 2018; Jefferies et al., 2017; "Manchester Art Gallery", 2022; "MANCHESTER SCHOOL OF ART", 2015; ofsted, 2013; University, 2013, 2016).

5.3.1   Spatial Characteristics of Nature Principles as a Creative Space Trigger related to Table 1

The school is characterized by a great connection with nature through the presence of living indoor plants and flowers of different types and shapes. A hybrid creative environment was created. There is also a green roof for the gathering, called the design garden, and a skylight. The size of the internal configurations is appropriate, and the visual details are simple. The arrangement of the interior furnishings of the studio, workshops, and cafes is active and unusual. There is a simulation of some elements in the school. There are some motifs on the column faces, including plants and small flowers, as shown in fig. 12. Most of the surfaces in the space and the furniture are made of natural materials, such as wood. There are no complex manufactured materials inside the space. The interior design of the space provides good ventilation and air renewal due to the presence of the atrium, which ends with a skylight. The building facades are curtain walls, so the whole building relies on natural light. Also, the colors inside the school are natural, calm, and motivating colors that generate a feeling of inspiration and creativity, as shown in fig. 13 (Fallon, 2018; Jefferies et al., 2017; "Mnchester school of art", 2015; "Manchester School of Art", 2022; ofsted, 2013; University, 2013, 2016).
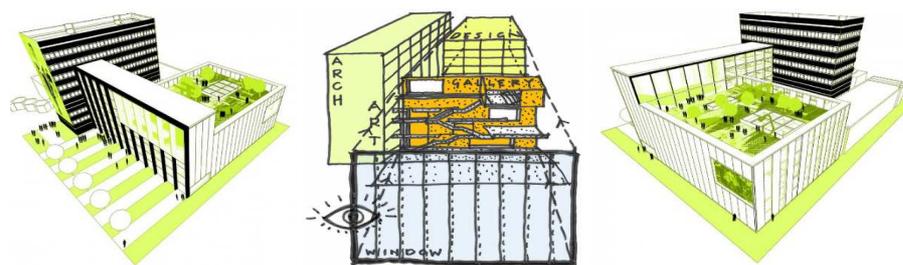

Fig. 12: Photos showing 3D shot showing the green roof and the outdoor green areas around and above the building. Adapted from: "Manchester School of Art", 2022.
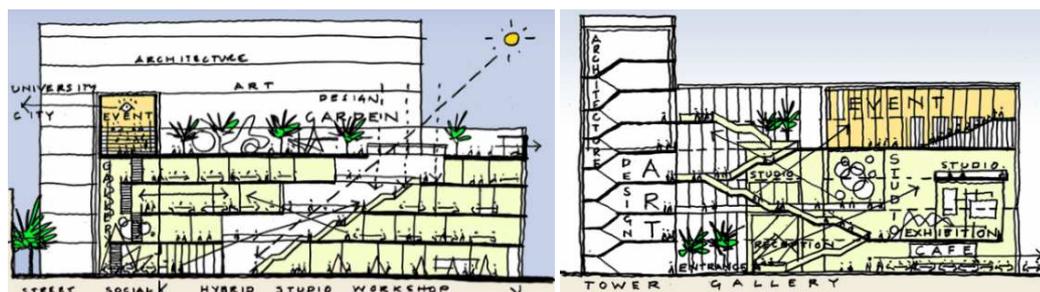

Fig. 13: Photos showing Two orthogonal sections of the building zoning showing the biophilic patterns in the different zone of the building. Adapted from: "Manchester School of Art", 2022.

5.4 Results: The Biophilic Patterns at The Previous Schools of Architecture

In order to create a creative architectural studio environment that depends on the application of biophilia theory as a translation of nature's principles, it was necessary to know how to connect the principles of nature and the biophilic patterns. The following paragraphs will explain how the aforementioned Spatial characteristics of nature principles have been applied to the biophilic pattern for each school.

The Visual Connection with Nature pattern was applied at the three schools in different ways. It mainly depends on green plants, which can be employed in any style of interior design, like residential, educational, and office settings. The focus here is on how it is employed within the architectural studios, and the following can be used to determine this: It was applied at the first school by creating views of nature from windows and curtain walls, the existence of parks with seasonal plants, pots, bushes, and trees, gathering gardens, and inner plants. But at the third school, it depends on the curtain wall on the north façade, windows on walls in the other façade called "windows on the arts," and a roof with green plants that is called a terraced hybrid environment. However, this pattern is stronger in the second school, by making terraces, planted balconies, and constructing a tropical portico, inner areas and exterior spaces can be in close proximity to the surrounding landscape. The non-visual connection with nature pattern was implemented at all three schools in a similar way, by relying on the indoor plants' smell and sounds from the outer gardens through birds, insects, and plants' movements and seasonal outdoor plants' changes.

At the first school, the non-rhythmic sensory stimuli pattern was performed by combining emerging with rich, layered ground and wall coverings, skylights, and tall trees. At the second school, it was applied by making outdoor and indoor seasonal plants. Then at the third one, they used various ground and wall coverings, a skylight, and tall grass. The thermal and airflow variability pattern was utilized at the first and third schools by creating curtain walls and operable skylights. In the second example, a majority of the rooms are exposed to the prevailing breezes, areas are created to capture natural light throughout the day, and more than 50% of the space is naturally ventilated. Only air conditioning is utilized when necessary, as the biophilic theory can deal with the spaces found in a natural setting to apply "climatic, or eco-design, using natural processes" due to its availability. However, if the spaces are located inside a built environment, mechanical or artificial methods (such as natural ventilation, direct sunlight, solar electricity production, etc.) may be used. In case of the inability to use the natural processes (Browning et al., 2014; Stephen robert Kellert, 2008; Stephen R. Kellert & Finnegan, 2011).

At the three schools, there is no presence of the Water pattern. The dynamic and diffuse light pattern is achieved in the first school by adding 3-sided curtain walls, 13 skylights, and dynamic artificial warm lighting. Then at the second school, there is a veil-like metal curtain that filters sunlight and emphasizes a link to the environment. The four facades are curtain walls with light filters. But the third school includes skylights, window units on the other facades, and an oblique court. The connection to natural systems was visible in the first and third schools through seasonal changes in vegetation in the gardens. However, the second school contains a landscape that improves water quality; nearly 50% of the plants selected are native species, and most are from the southern tropics; 1200 solar photovoltaic panels on its rooftop; and an innovative hybrid cooling system that supplies rooms with 100% fresh pre-cooled air.

The pattern of biomorphic forms and patterns at the first and second schools was applied by making one-colored spaces, motifs, and ornaments of natural elements; most of the colors and materials are from nature. At the third school, that pattern was implemented by using a curtain wall that allowed a view of the old buildings with ornaments and motifs that simulated elements from nature. The Material Connection with Nature pattern was implemented at the first and third schools by designing furniture and space elements from natural materials. At the second school, the building has a strong biophilic component, which is the deliberate use and celebration of the raw and natural characteristics of the materials. also the use of natural colors and materials for walls, floors, and columns, such as wood, stone, and glass.

The Complexity and Order pattern was applied at the first school by making patterned ceiling and wall tiles. On the second, there are patterned wall tiles; different sizes and textures of the stone are utilized; patterned ceiling tiles for lighting fixtures; and ordered facade panels. Patterned vertical ceiling tiles and orderly window units were used in the third one. The Prospect pattern was used at the first and second schools by creating a studio layout with views across for surveillance, an unobstructed view from the mezzanine floor, and an upper level elevated above street level. Besides that, the third school added open floor plans for

studios and galleries. The Refuge pattern appeared at the first school by relying on a landscaped courtyard to separate it from the city. Then, at the second one, there are many outdoor terraces and corridors. Finally, at the third school, there were enclosed conference and work rooms. The mystery pattern didn't appear in the first school. But at the second school, it was applied by creating a partially obscured view of plants from the studios and the hallway; an entry switchback creates visual intrigue. At the third school, there were glimpses of plants and greenery through openings in the walls. The risk/peril pattern wasn't significantly represented in the three examples.

After realizing the biophilic patterns that were applied to the previous three architectural schools, the common patterns that were applied in the schools were extracted at Table 3. as they are essential patterns that can be applied to any design studio.

The Biophilic Design Patterns			TU Delft Faculty	Singapore University	Manchester School	Common Biophilic Patterns between the school
NATURE IN THE SPACE	P1	Visual Connection with Nature	yes	yes	yes	Nature views; open views; extended views; large windows; curtain walls; exterior plants, park, and gardens; private gathering open spaces and gardens; inner Living indoor plants of different types, such as greenery, pots, trees; view of the natural environment.
	P2	Non-Visual Connection with Nature	yes	yes	yes	The plants' smells, sounds, and movements; Birds, insects, and bees exist; seasonal plants.
	P3	Non-Rhythmic Sensory Stimuli	yes	yes	yes	Native landscaping; tall trees; rich and various layered wall and floor cover; seasonal plants.
	P4	Thermal & Airflow Variability	yes	yes	yes	Operable Curtain wall, tall windows, skylight.
	P5	Presence of Water	x	x	x	Not significantly represented in the project.
	P6	Dynamic & Diffuse Light	yes	yes	yes	Curtain walls; tall windows; skylights.
	P7	Connection with Natural Systems	yes	yes	yes	seasonal changes in the plants, gardens, and parks outside and inside; possibilities to observe interactions between plants, bees, insects, and birds.
NATURAL ANALOGUES	P8	Biomorphic Forms & Patterns	yes	yes	yes	motifs and ornaments of natural elements; most of the colors and materials are from elements of nature.
	P9	Material Connection with Nature	yes	yes	yes	Natural colors and materials for most surfaces; pale colors for walls and floors; many wooden surfaces for furniture, walls and floors.
	P10	Complexity & Order	yes	yes	yes	patterned tiles for the ceiling, walls, and curtain walls; different sizes and textures of furniture and materials.
NATURE OF THE SPACE	P11	Prospect	yes	yes	yes	A clear view over a long distance for observation, surveillance and planning.
	P12	Refuge	yes	yes	yes	Outdoor terraces and passageways that can be used to create a secure area where one can withdraw from their surroundings or the main activity stream while yet being shielded from above and behind.
	P13	Mystery	x	yes	yes	partially obscured views and glimpses for the surroundings
	P14	Risk/Peril	x	x	x	Not significantly represented in the project.

Table 3: The common methods of applying the biophilic patterns at the previous schools. Source: Researchers.

6 CONCLUSION: APPLICABILITY OF THE BIOPHILIC PATTERNS TO THE ARCHITECTURAL DESIGN STUDIO

The educational environment affects students in several ways. It motivates students to provide their best performance, particularly for architecture students. Therefore, the design studio learning environment should

foster creativity. After research and analysis, it was discovered that connection with nature, such as using living plants, greenery, open views, and other guidelines that promote nature's connectedness, can help create a creative learning environment while also enhancing students' creative performance. As a result, theories were investigated to determine how nature could be applied within the space. The biophilia theory, which expresses the human proclivity for nature, consists of 14 patterns that can be used to create a connection with nature within a space. In order to find out how these patterns can be applied, a number of examples of different biophilic environments were analyzed. Through the examples' analysis, it has been concluded that these patterns can be applied through many of the methods that have been mentioned.

After discovering how to apply the biophilic pattern, it was found that some patterns could be applied to an existing design studio but others could not. The following will present an analysis of the biophilic patterns that can be applied to an existing design studio. The patterns: visual connection with nature; non-visual connection with nature; non-rhythmic sensory stimuli; thermal and airflow variability; dynamic and diffuse light; connection with natural systems; material connection with nature; Biomorphic Forms and Patterns; complexity and order, can be applied to an existing design studio as long as its application capabilities are available and affordable. The methods, additions, and treatments by which they can be applied are listed in Table 3. As for the "Presence of Water" pattern, that wasn't applied to any school due to the lack of application capabilities.

The prospect and refuge patterns were applied to the three schools; the mystery pattern was applied to only two of the three schools; and the risk/peril pattern also wasn't applied to any schools. However, those three patterns are difficult to implement in an existing architectural design studio. because mostly those patterns depend on the location in which the studio's building is sited and also the surrounding spaces around the studio. And with this, the aim of this paper was reached, which was to find out the possibility of applying the biophilic patterns to an existing architectural design studio and to determine the methods by which these patterns could be applied. In order to give all existing design studios, the opportunity to transform their usual design studio into a biophilic design studio, which helps improve their creative performance and enhances their efficiency.

7 REFERENCES

10 Jobs That Require Creative Thinking Skills. (2023). Retrieved from https://www.indeed.com/career-advice/finding-a-job/creative-thinking-skills-jobs

(NUS), T. N. U. o. S. (2019). The NUS story. Retrieved from Avermaete, T., Elsinga, M., Ham, M. v., Hoeven, F. v. d., P, U. K., Altes, W. K.; Zlatanova, S. (2014). Architecture and the built environment research portfolio 2010-2015 (F. v. d. Hoeven Ed.).

Best Degrees for Creative People. (2022).

BK City, Delft: a vibrant educational environment. (2022). Retrieved from https://braaksma-roos.nl/project/bk-city/

Bramble, R. J. (2017). The Influence Of The Physical Workspace On Creative Performance: Alternative Mediation Models.

Browning, W., Ryan, C., & Clancy, J. (2014). 14 patterns of biophilic design

ImprovIng HealtH & Well-BeIng In tHe BuIlt envIronment.

Calabrese, E. (2015). The Practice of Biophilic Design.

Cannon, D., & Utriainen, T. (2013). Spaces supporting creative design work.

Ceylan, C., Dul, J., & Aytac, S. (2008). Can the office environment stimulate a manager's creativity? Human Factors and Ergonomics in Manufacturing, 18(6), 589-602. doi:10.1002/hfm.20128

Chulvi, V., Agost, M. J., Royo, M., & García-García, C. (2020). The effect of nature on designers' creativity, according to their personality profile. Alexandria Engineering Journal, 59(2), 987-998. doi:10.1016/j.aej.2020.03.036

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education—A systematic literature review. Thinking Skills and Creativity, 8, 80-91. doi:10.1016/j.tsc.2012.07.004

De Paoli, D., & Ropo, A. (2017). Creative workspaces – a fad or making real impact? Journal of Corporate Real Estate, 19(3), 157-167. doi:10.1108/jcre-09-2016-0029

De Paoli, D., Sauer, E., & Ropo, A. (2017). The spatial context of organizations: A critique of 'creative workspaces'. Journal of Management & Organization, 25(02), 331-352. doi:10.1017/jmo.2017.46

De Paoli, D., Sauer, E., & Ropo, A. (2018). The spatial context of organizations: A critique of 'creative workspaces' – CORRIGENDUM. Journal of Management & Organization, 25(02), 353. doi:10.1017/jmo.2018.2

Dhanapala, R. M. (2021). The effect of learning environment on academic performance from students' perspective. Doi:10.11216/gsj.2021.03.49602

Dul, J., & Ceylan, C. (2014). The Impact of a Creativity-supporting Work Environment on a Firm's Product Innovation Performance. Journal of Product Innovation Management, 31(6), 1254-1267. doi:10.1111/jpim.12149

Dul, J., Ceylan, C., & Jaspers, F. (2011). Knowledge workers' creativity and the role of the physical work environment. Human Resource Management, 50(6), 715-734. doi:10.1002/hrm.20454

Easton, E., & Djumalieva, J. (2018). Creativity and the future of skills.

Eismann, T. T., Pakos, O., Rücker, M., Meinel, M., Maier, L., & Voigt, K.-I. (2021). Understanding the Mechanisms of Activity-based Workspaces: A Case Study. Environment and Behavior, 54(1), 170-210. doi:10.1177/00139165211008240

192

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Fallon, L. (2018). Manchester School of Art.

Hoeven, F. v. d., Janina Gosseye, Kaan, K., Thaleia Konstantinou, Michiel Kreutzer, Martin, C., . . . Ham, M. v. (2022). TU Delft | Bouwkunde Architecture and the

Built Environment Self-evaluation report on Research '16-'21.

Ibrahim, N. L. N., & Utaberta, N. (2012). Learning in Architecture Design Studio. Procedia - Social and Behavioral Sciences, 60, 30-35. doi:10.1016/j.sbspro.2012.09.342

ir-arch. T. (Tom) Coppens, DIpl.-Ing. Dr.techn. I. (Iva) Kovacic, G. (Gabriele) Lobaccaro, D.M. (Despina) Stratigakos, & Verbakel, W. W. (2023). Research assessment report

Faculty of Architecture and the Built Environment Delft University of Technology. Retrieved from

Jefferies, T., Stone, S., & Kwan, D. (2017). Manchester School of Architecture.

Jindal-Snape, D., Davies, D., Collier, C., Howe, A., Digby, R., & Hay, P. (2013). The impact of creative learning environments on learners: A systematic literature review. Improving Schools, 16(1), 21-31. doi:10.1177/1365480213478461

Kellert, S. r. (2008). Dimensions, elements, and attributes of biophilic design.

Kellert, S. R. (2012). Review of Birthright: People and Nature in the Modern World.

Kellert, S. R., & Calabres, E. F. (2015). The Practice of Biophilic Design.

Kellert, S. R., & Finnegan, B. (2011). Biophilic design: the architecture of life.

Lasternas, B. (2018). Net-Zero Energy Building in the Tropics School of Design and Environment.

Lewinski, P. (2015). Effects of classrooms' architecture on academic performance in view of telic versus paratelic motivation: a review. Front Psychol, 6, 746. doi:10.3389/fpsyg.2015.00746

Makhmalbaf, A., & Do, E. Y.-L. (2007). Physical environment and creativity: comparing children's drawing behaviour at home and at the bookstore.

Manchester Art Gallery. (2022).

Manchester School of Art. (2015). Retrieved from https://www.metalocus.es/en/news/manchester-school-art-feilden-clegg-bradley-studios

Manchester School of Art (2022).

McCoy, J. M., & Evans, G. W. (2002). The Potential Role of the Physical Environment in Fostering Creativity. Creativity Research Journal, 14(3-4), 409-426. doi:10.1207/S15326934CRJ1434_11

Muniandy, S., Khan, T. H., & Ahmad, A. S. b. (2015). Evaluating the Physical Environment of Design Studios: A Case study in Malaysian Private Architecture Schools.

National University of Singapore School of Design & Environment. (2019).

National University of Singapore School of Design & Environment. (2022). Retrieved from https://archello.com/pt/project/national-university-of-singapore-school-of-design

NUS School of Design & Environment. (2022).

Obeidat, A., & Al-Share, R. (2012). Quality Learning Environments: Design-Studio Classroom. Asian Culture and History, 4(2). doi:10.5539/ach.v4n2p165

ofsted. (2013). Establishing an excellent foundation for drawing: Manchester Metropolitan University.

Oksanen, K., & Ståhle, P. (2013). Physical environment as a source for innovation: investigating the attributes of innovative space. Journal of Knowledge Management, 17(6), 815-827. doi:10.1108/jkm-04-2013-0136

P, K. P. L. (2021). School of Design and Environment National University of Singapore.

Peschl, M. F. a. F., Thomas. (2014). Designing and enabling interfaces for collaborative knowledge creation and innovation. From managing to enabling innovation as socio-epistemological technology.

Poh, L. K., OOI Thian Leong, J., Wei, K. H., CHEONG Kok Wai, D., Kim, L. S., Hien, W. N., & Gerard, E. (2018). School of Design & Environment.

QS World University Rankings. (2022). Retrieved from https://www.topuniversities.com/university-rankings/university-subject-rankings/2022/architecture-built-environment

Rooij, R., Klaassen, R., Cavallo, R., & Arts, J. A. (2019). Architecture and built environment design education: disciplinary and pedagogical developments (Vol. 30).

Rufener, B., McCaulley, J., & Sealey-Morris, C. (2023). Top 20 Degrees for Creative People.

School of Design and Environment. (2021). Retrieved from https://www.nus.edu.sg/nusbulletin/ay202122/programmes/school-of-design-and-environment/overview/

Serie Architecs. (2022). Retrieved from https://divisare.com/projects/332055-serie-architects-new-school-of-design-environment-national-university-of-singapore

Setola, B., & Leurs, B. (2014). The wild, the pub, the attic and the workplace: a tool for negotiating a shared vision on creative learning spaces. Doi:10.13140/2.1.3784.9600

shaqour, E. (2021). Improving the Architecture Design Studio Internal Environment at NUB. Journal of Advanced Engineering Trends, 41(2), 31-39. doi:10.21608/jaet.2020.51955.1073

Thoring, K., Desmet, P., & Badke-Schaub, P. (2018). Creative environments for design education and practice: A typology of creative spaces. Design Studies, 56, 54-83. doi:10.1016/j.destud.2018.02.001

Thoring, K., Desmet, P., & Badke-Schaub, P. (2019). Creative Space: A Systematic Review of the Literature. Proceedings of the Design Society: International Conference on Engineering Design, 1(1), 299-308. doi:10.1017/dsi.2019.33

Thoring, K., Gonçalves, M., Mueller, R. M., & Badke-Schaub, P. (2017). Inspiration Space: Towards a theory of creativity-supporting learning environments. doi:10.21606/dma.2017.19

Thoring, K., Guerreiro Goncalves, M., Mueller, R. M., Badke-Schaub, P., & Desmet, P. (2017). Inspiration Space: Towards a theory of creativity-supporting learning environments.

Thoring, K., Luippold, C., & Mueller, R. M. (2012,). Creative Space in Design Education: a Typology of Spatial Functions.

Thoring, K., Mueller, R. M., Desmet, P., & Badke-Schaub, P. (2020). Spatial design factors associated with creative work: a systematic literature review. Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 34(3), 300-314. doi:10.1017/s0890060420000232

TU Delft Architecture and the Built Environment :- About the faculty. (2022). Retrieved from https://www.tudelft.nl/en/architecture-and-the-built-environment/about-the-faculty/about-the-faculty

TU Delft Faculty of Architecture & the Built Environment. (2022).   Retrieved from https://www.tudelft.nl/en/architecture-and-the-built-environment/about-the-faculty/about-the-faculty

Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes.

University, M. M. (2013). MANCHESTER SCHOOL OF ART 2012—2013.

university, M. m. (2016). Manchester School of Art. Retrieved from

Utaberta, N., Hassanpour, B., Handryant, A. N., & Che Ani, A. I. (2013). Upgrading Education Architecture by Redefining Critique Session in Design Studio. Procedia - Social and Behavioral Sciences, 102, 42-47. doi:10.1016/j.sbspro.2013.10.711

Vilorio, D. (2015). Careers for creative people.

Voordt, v. d., Jonge, T. d., & Hans; Wamelink, H. (2010). Innovations in management of the built environment.

Vyas, D., van der Veer, G., & Nijholt, A. (2012). Creative practices in the design studio culture: collaboration and communication. Cognition, Technology & Work, 15(4), 415-443. doi:10.1007/s10111-012-0232-9

Williams, A. (2013). A grammar of creative workplaces.

Wilson, E. O. (1984). Biophilia.

Designing Learning Environments in Response to Pandemics: a Comparative Analysis for COVID-19 Best Practises Schools Interventions

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1 ABSTRACT

The design of learning environments has a significant role in students' health and well-being, particularly in the light of the COVID-19 pandemic which has highlighted many challenges concerning the quality of learning environments in our schools, especially elementary schools. This emergency caused a massive closure of schools and around 1.2 billion students were unable to learn in their physical learning environments during this period. Before developing medications for the epidemic, one solution to limit the infection was transforming our learning environments and adding layers of protection to ensure healthy and safe spaces for students.

This paper aims at investigating the design principles of healthy learning environments according to AIA strategies for safe reopening schools which can be included in providing healthy indoor environmental quality, integrating nature with the learning environments, and providing safe contact in the learning environments. Then, a comparative analysis will be conducted on three existing schools which have succeeded to limit infection transmission and transform into healthy learning environments during COVID-19. Finally, the paper provides a framework and recommendations for the designing of future healthy learning environments to face any potential pandemic which may occur in the future.

Keywords: COVID-19 Pandemic, AIA Strategies, Schools Interventions, Designing Learning Environments, Healthy Learning Environments

2 INTRODUCTION

The COVID-19 pandemic has proven that a catastrophe does not always face a recognized enemy. The enemy might be hidden with disastrous impacts (Goniewicz et al., 2020). The most immediate effects of COVID-19 are on physical health, but it also has severe effects on social and emotional functioning. Globally, the COVID-19 pandemic has had a negative impact, particularly in the field of education, as the rapid spread of the virus has forced governments to take extreme actions, including the total or partial closure of existing schools in over 190 countries as shown in Fig. 1, in an effort to prevent the spread of the disease and limit its effects. By the middle of May 2020, more than 1.2 billion students were unable to learn in physical learning environments (Spitzer, 2021).
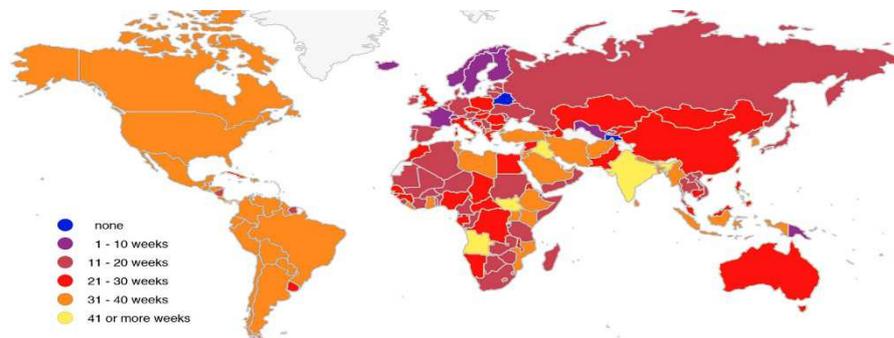
Fig. 1: Location and duration of school closures by country, (Spitzer, 2021).

School closure was the only solution to protect students from the COVID-19 pandemic because schools are not designed to adapt to any urgent crises or health pandemics for the following reasons:

- Current schools neglect social isolation; instead, schools have a large density of students and were designed to be a place where students can interact with each other (Van Doremalen et al., 2020), so keeping social distancing will lead to difficulty because the number of classrooms in existing schools is not sufficient to meet the whole number of students while maintaining social distancing.

- The surfaces and furnishings in existing schools were not designed for hygienic purposes; rather, they were only designed with sustainability and environmental concerns as priorities (Khanam et al., 2006). In addition, hygienic strategies in existing schools are not enough to face the pandemic; students must also physically push or touch surfaces to operate doors, windows, lights, etc., which increases the risk of COVID-19 spreading among students (Chin et al., 2020).

- The ventilation rates of existing schools are only 3.44 dm3/s/person, which is insufficient because the minimum needed ventilation rate for schools must be 8.5 dm3/s/person to be able to fight infection transmission according to the Dutch Building Code (Blocken et al., 2020).

Because of these problems, learning environments were not healthy enough to adapt to the COVID-19 pandemic and were obliged to be closed. During this period, education was provided through distance learning. Although distance learning offers a secure way to ensure learning continuity while protecting students, there is no substitute for physical classrooms because of the drawbacks of distance learning, like the difficulty of using distance learning for younger students. Also, distance learning can lead to social isolation by keeping students away from physical activities that are essential for learning, growth, and innovation. This will lead to issues related to mental health (Jiao et al., 2020). Consequently, AIA, CDC, and WHO started preparing strategies for the existing schools to reopen securely, and for future learning environments, the design principles won't be similar because health factors will be required to add safety layers to adapt to any pandemic that may happen in the future (CDC, 2021).

3 METHODOLOGY

This study is an exploratory study that is based on three main sections, as shown in Fig. 2. The first is a literature review presenting the relationship between designing learning environments and infection transmission control, and the importance of being healthy future learning environments. The research then investigates the design principles of healthy learning environments according to AIA strategies for safe learning environments. The second section presents a comparative analysis conducted on three existing schools that have succeeded in applying AIA strategies to their schools to limit infection transmission and transform them into healthy learning environments during COVID-19. According to these findings, in addition to the researches conducted during COVID-19, we can finally devise a framework and a checklist of measures for designing future learning environments that will be constructed post-COVID-19 to be resistant to any potential pandemic that may occur in the future.
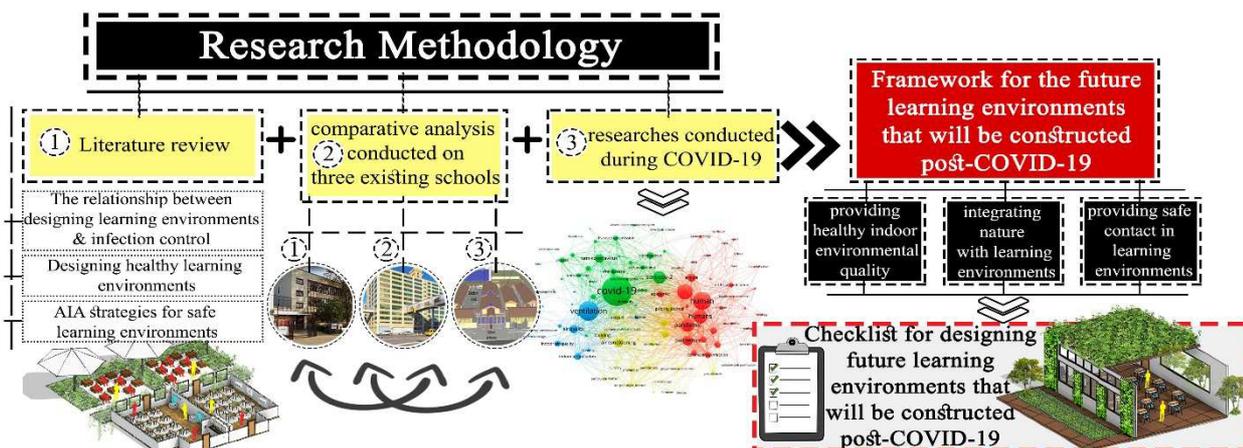
Fig. 2: Research methodology.

4 LITERATURE REVIEW

4.1 The relationship between designing learning environments and infection transmission control

Pandemics and intense catastrophes have always had a harmful impact on our built environment. In addition, they have transformed our built environment for many years. As a result, architects and urban planners acted as the treaters, helping stop pandemics by upgrading the design considerations of buildings throughout the years as a response to pandemics, as during pandemics, the form, like the function, has always followed the fear of infection (Ellin, 1999). As a consequence, the current health crisis demands upgrading the principles

196

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of designing future schools to be healthy and resistant to any pandemic that can occur in the future (Megahed & Ghoneim, 2020). According to the hierarchy of hazard control, there are numerous strategies to maximize our defense against the infection transmission of COVID-19 or any virus, which can be concluded in five layers of defense as shown in Fig. 3. All layers must always be applied together to limit infection transmission, and the measure at the bottom of the hierarchy is more effective than those at the top. This hierarchy of hazard control shows that to limit infection transmission among students in schools, designing healthy learning environments will be an essential aspect in the future (CDC, 2015).
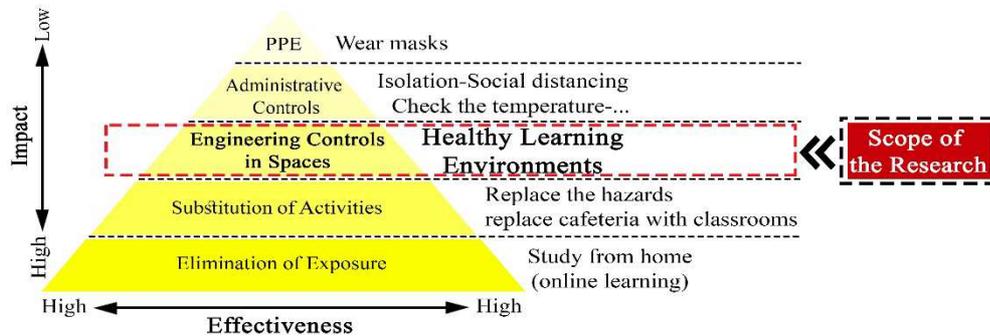
Fig. 3: Applying the hierarchy of controls in schools for COVID-19, upgraded from (CDC, 2015).

4.2 Designing healthy learning environments

According to Zhen et al., (2019), a "healthy building" is a physical structure that improves an individual's well-being and promotes healthy spaces as well as promoting physical, mental, and social health. Post-COVID-19 pandemic, healthy learning environments became a concept that must be applied to both future and existing schools to create ergonomic and healthy indoor learning environments (Megahed & Ghoneim, 2020; Saeed et al., 2021). This is because healthy learning environments can protect students from sickness and harm and promote preventative methods versus risk factors that might result in disease in the future by promoting suitable essential environmental factors (such as relative humidity, ventilation, thermal, acoustic, and lighting comfort, etc). It also can protect students from physical threats as well as protection from chemical and biochemical threats (WHO, 2004) as shown in Fig. 4.
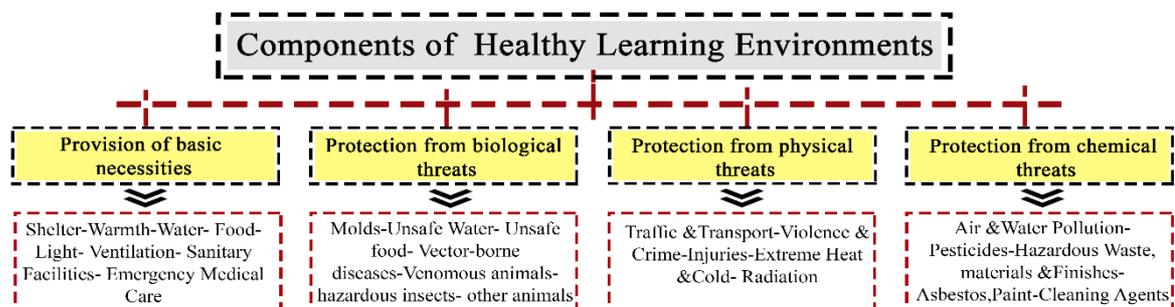
Fig. 4 : Components of healthy learning environments, upgraded from (WHO, 2004).

As previously mentioned, it will be crucial to design healthy learning environments in the future, not just to protect students from pandemics but also to protect them from any viruses or diseases that may harm their health. For instance, influenza is hazardous for young students due to their lack of immune systems, and this can harm their bodies to the extent of death (CDC, 2021). Healthy learning environments will enable students to learn and succeed in an atmosphere free from environmental risks or diseases, which will enhance their social, mental, and physical health (Saeed et al., 2021; WHO, 2004).

4.3 Strategies of AIA for the existing learning environments during the COVID-19 pandemic

For some students, the ability to attend physical classrooms can mean the difference between life and death, and there is no alternative to physical classrooms (OECD, 2020). Thus, AIA provided strategies focused on developing existing schools' designs in accordance with CDC and WHO guidelines to provide safe reopening for learning environments (AIA, 2020). The strategies of AIA for safe reopening schools can be concluded in three parameters: providing healthy indoor environmental quality, integrating nature with learning environments, and providing safe contact in the learning environments, as shown in Fig. 5.
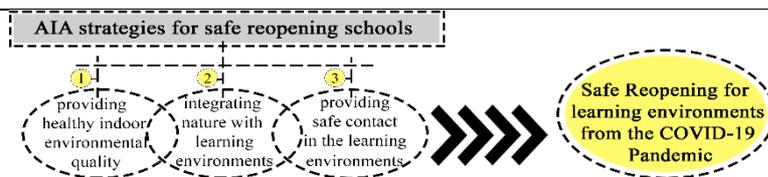
Fig. 5: AIA strategies for reopening schools safely.

4.3.1 Providing healthy indoor environmental quality

Indoor air quality (IAQ), thermal comfort, lighting and acoustic comfort are the four main indicators of indoor environmental quality. The quality of the indoor learning environment influences the built environment, affects students' health, and protects them from learning in a sick building syndrome (Megahed & Ghoneim, 2021). Fig. 6 shows The relationships between environmental health and its impact on health.

Fig. 6 : The relationships between environmental health and its impact on human health, (Megahed & Ghoneim, 2021).

The AIA has recommended the following strategies, as shown in Fig. 7, for ensuring indoor air quality:

- Relying on natural ventilation because it is very essential to control cross-infection by removing virus-laden aerosols exhaled by infected student by keeping windows and doors open, using ceiling exhausts to enhance the flow of air, and holding outdoor classrooms (CDC, 2019).

- Enhancing ventilation systems following ASHRAE recommendations, which include updated relative humidity (40–60 percent) and temperature (68–78 °F), as well as installing CO2 monitors, upgrading air filtration from MERV 8 to MERV 13 filters, and using UV light in HVAC and/or classrooms to purify the air from any pollutants and viruses(ASHRAE, 2023).

AIA recommended providing natural lighting whenever possible, Also AIA proposed using temporary shades to promote thermal comfort in outdoor spaces and outdoor classrooms during extreme weather; on the other hand, AIA suggested the use of microphones and speakers in the classrooms to provide acoustic comfort because masks can be considered as a sound barrier (AIA, 2020).
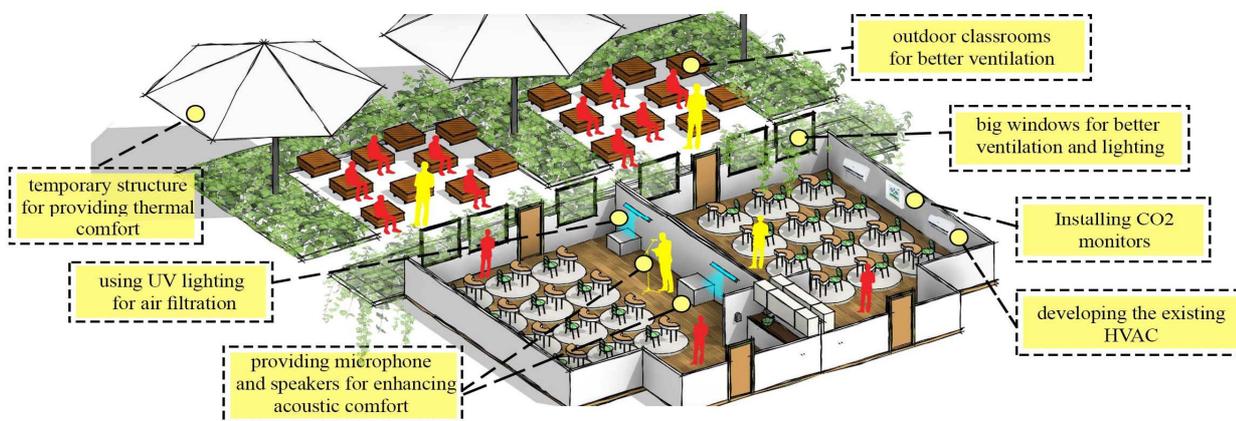
Fig. 7: AIA strategies for providing healthy indoor environmental quality in the learning environments.

4.3.2 Integrating nature with the learning environments

The COVID-19 pandemic has significantly changed learning environments, including increasing awareness that learning in outdoor areas can be safer than learning in indoor spaces when the infection is a a concern

198

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(Jones et al., 2020). So AIA suggested holding classrooms and activities in outdoor spaces to promote natural ventilation and interactions between students and nature, as well as providing big windows and doors in each classroom to promote views to outdoor greenery and to provide access to outdoor spaces (AIA, 2020).

4.3.3 Providing safe contact in the learning environments

AIA proposed strategies that provide safe contact between students, which can be provided via hygienic control, using hygienic materials, providing touchless systems, and enhancing social distancing. AIA proposed measures to provide hygienic control by adding hygienic stations at schools' entrances, as shown in Fig. 8, as well as creating isolation rooms for infected students. AIA recommended using hygienic materials with short-term COVID-19 stability, such as copper and its alloy. As well as providing touchless systems by substituting flush valves and drinking water dispensers with touchless ones, controlling artificial lights and door openers is also recommended with touchless systems. AIA proposed several strategies to maintain social distancing between students in entrances, classrooms, circulation, and spatial organization. At entrances, social distancing was maintained by using ground markings indicating a minimum distance of 1.8 m between students. In addition to providing multiple points of entry, and applying staggered schedules to decrease traffic at entrances. In classrooms, AIA suggested keeping social distancing between students (with 1.8 m between each other) and, where social distancing is not feasible, placing transparent physical barriers. On the other hand, AIA promoted social distancing in circulation and spatial organization by creating one-way circulation in corridors and mapping the floors. Social distancing in schools caused a problem, which is that classroom areas are not large enough to accommodate all students at the same time while maintaining social distancing. Therefore, AIA proposed converting cafeterias and gyms into bigger classrooms and converting outside areas to outdoor classrooms and outdoor activities, also by using movable partitions. Another solution was providing distance and hybrid learning by providing classrooms with the essential tools, as shown in Fig. 9 (AIA, 2020).
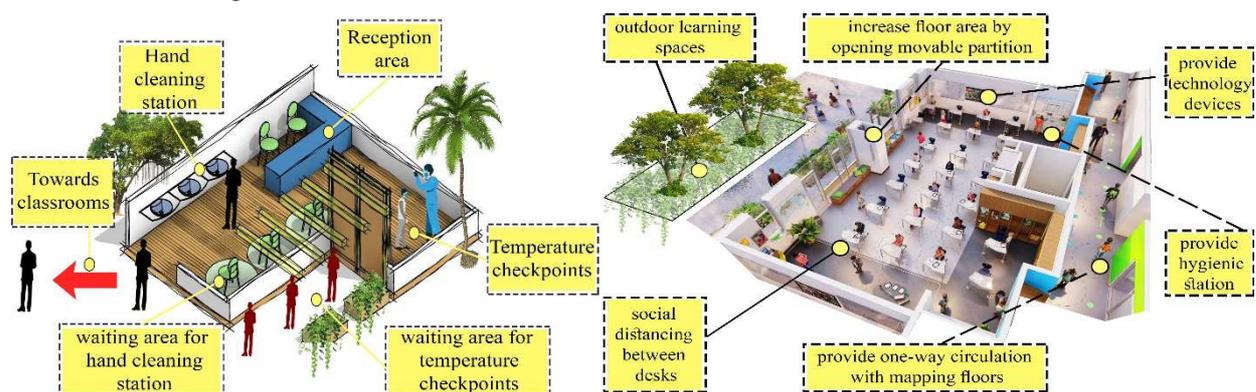
Fig. 8 (left) : Providing hygienic stations at schools' entrances. Fig. 9 (right) : AIA strategies for maintaining social distancing in classrooms, upgraded from (AIA, 2020).

5 COMPARATIVE ANALYSIS

This comparative analysis includes three examples of schools worldwide that have succeeded (if they were compared with other schools) to apply AIA strategies in their schools and transformed them into healthy learning environments during COVID-19 to limit infection. This comparative analysis is conducted according to AIA strategies between these examples, which are public school 138 Samuel Randall in the Bronx, Brooklyn Laboratory Charter Schools in New York, and Projeto Espaço Educativo 12 Salas – PEE-12 in Brazil. This comparative analysis aims to investigate the parameters and strategies of healthy learning environments that will be essential to make future learning environments resistant to any potential pandemic.

5.1 Public school 138 Samuel Randall in the Bronx, NY (elementary school)

The Urbahn architects designed a transforming proposal for this school to enable it to adapt to the COVID-19 pandemic. The Urbahn strategy focused on promoting hygienic control, so Urbahn suggested establishing two prefabricated handwashing stations before each entrance of the school, as shown in Fig. 10, as well as installing prefabricated wash stations in the hallways and each classroom to be accessible to all students, and also reusing auditoriums as isolation spaces. The Urban additionally concentrated on maintaining social distancing in entrances by adding entry points, providing social distancing in the sidewalk queue area (1.8m)

by mapping the floor, and using transparent barriers between washbasins. They additionally maintained social distancing in classrooms by rearranging the furniture in a diagonal pattern to keep a distance of 1.8 meters between students. Besides using one-way circulation in stairways and pathways by using coloured tape on the flooring as shown in Fig. 11 and Fig. 12. (Dubey, 2020).
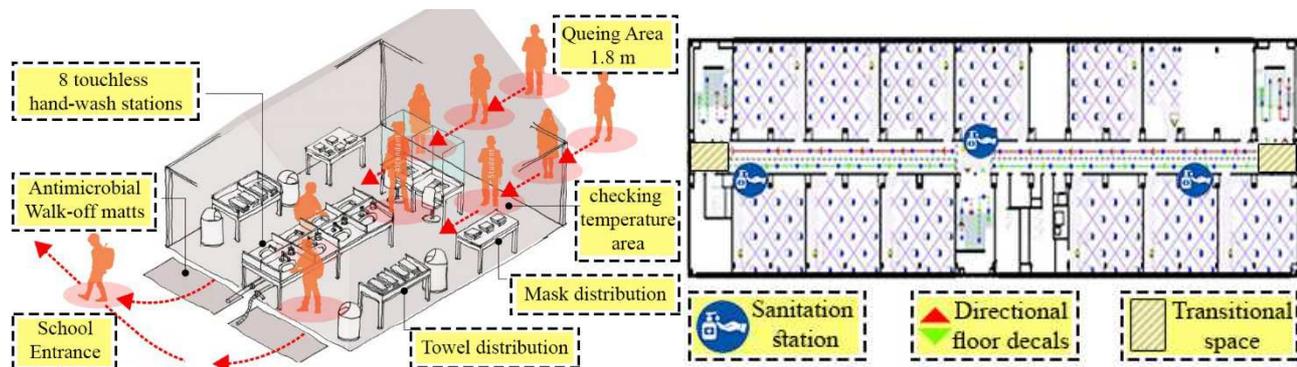
Fig. 10 (left) : Prefabricated handwashing stations before each entrance of the school, upgraded from (Dubey, 2020). Fig. 11 (right) :Social distancing in classrooms and paths, upgraded from (Dubey, 2020).

Because classroom sizes are insufficient to accommodate all the students with social distancing at once, one solution was to divide the cafeteria and gym into classrooms, as shown in Fig. 13. Other alternatives included offering an alternate schedule and encouraging hybrid learning to decrease densities. For long-term strategies, Urbahn architects proposed that future classrooms must be widened (AIA, 2020; Dubey, 2020).
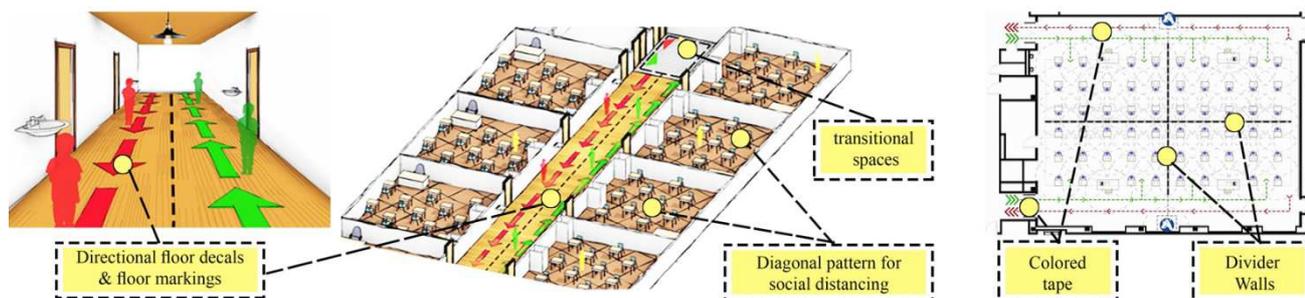
Fig. 12 (left) :Social distancing in classrooms and paths. Fig. 13 (right): Dividing gym into four classrooms by using divider walls , upgraded from (Dubey, 2020).

Furthermore, Urbahn suggested improvement of ventilation systems, particularly natural ventilation by using exhaust vents on the roof to speed up airflow and shutting return dampers to avoid air recirculation to decrease infection transmission. As well as utilizing MERV 14, 15, or 16 filters instead of MERV 13 filters and adding UV lamps and portable filtration devices in classrooms (ASHRAE, 2023; Dubey, 2020).

5.2 Brooklyn Laboratory Charter Schools in NY (middle and high school)

This school applied adaptation strategies to face COVID-19 pandemic, so the school collaborated with five design companies, including Gensler, PBDW, PSF Projects, SITU, and WXY, to come up with the best solutions, which were executed in the school. SITU designed a sidewalk with a shed at entrances, as shown in Fig. 14, for sanitizing hands and checking the temperature of students while maintaining social distancing (a minimum 1.8 m distance between students) by mapping the floor. They also proposed increasing entry points and using an alternative schedule. Whereas SITU and PSF suggested adding exterior stairs to the school as an additional vertical circulation to promote social distance, PBDW and Gensler concentrated on promoting social distance inside the classrooms (1.8 m) between students and/or utilizing a transparent barrier between students, as shown in Fig. 15. They additionally enhanced social distancing in circulation by providing one-way circulation in the paths and stairways by using coloured tape, as shown in Fig. 16. Because the classroom area is not big enough to accommodate all students while maintaining social distancing WXY suggested that sidewalks before entrances can be used as outdoor classrooms, as shown in Fig. 17, whereas PBDW proposed designing flexible classrooms with movable acoustic and whiteboard walls to promote extension, in addition to applying staggered schedules for online and hybrid learning.

200

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Further, PBDW emphasized creating hygienic indoor learning environments by increasing airflow through window openings, upgrading HVAC air filters to MERV 13 filters, and keeping humidity levels 40%-60%

. Additionally, they provided touchless systems by adding foot controls for doors and sensor-operated hands-free technology for valves and flushometers in bathrooms (Brooklyn Lab Charter School, 2020).
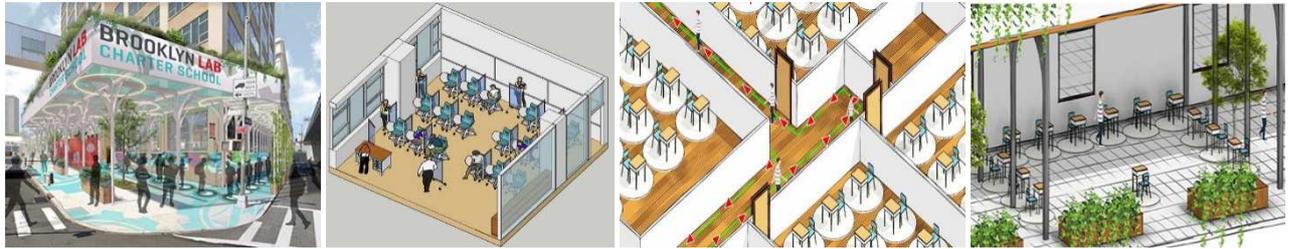
Fig. 14 (left): SITU design for the shed before entrance, (Brooklyn Lab Charter School, 2020). Fig. 15: Transparent barrier between students in classroom. Fig. 16: One-way circulation in the paths. Fig. 17(right): The proposed outdoor classrooms.

5.3 Projeto Espaço Educativo 12 Salas –PEE-12 in Brazil (elementary school)

During the COVID-19 pandemic, Furlani and Cardoso architects presented several adaptation solutions for the return to face-to-face classrooms in this standard public school in Brazil. They suggested strategies for hygienic control in schools, including providing sanitizer for the hands in all classrooms, using furniture made of cleanable material, and placing sanitary mats outside the school as shown in Fig. 18 (Fantini et al., 2020). They also recommended improving natural ventilation by providing cross ventilation which is more effective towards infection control than single-sided ventilation. Improving visual comfort was achieved by covering windows with shades to reduce glare, as shown in Fig. 19 (Furlani & Cardoso, 2021).
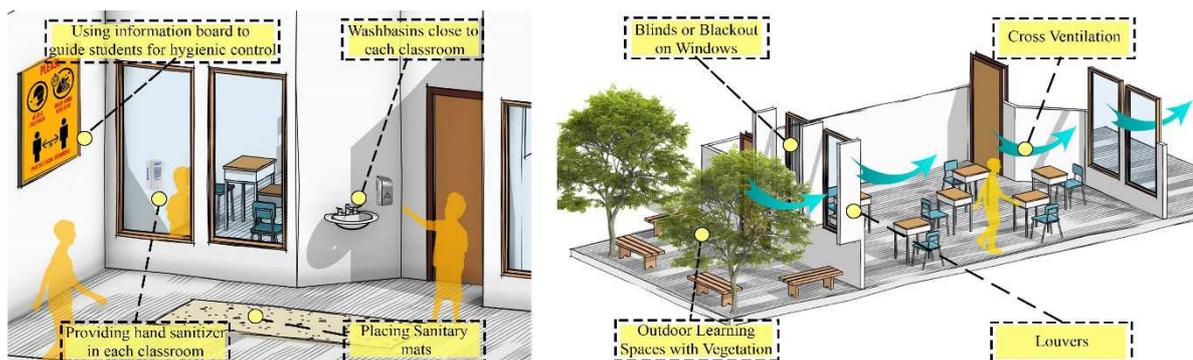
Fig. 18 (left): Hygienic control techniques in school. Fig. 19 (right):Techniques for better ventilation and lighting in classroom.

To connect students with nature, they encouraged creating areas in the outside yards that might serve as learning spaces and casual eating areas, as shown in Fig. 20 & Fig. 21. In order to maintain social distancing, they provided a polycentric layout in classrooms with a 2-metre space between student chairs, which can be movable as shown in Fig. 22. They also provided hybrid learning, so they supplied classrooms with technology devices like laptops, PCs, or tablets, projectors, printers, digital whiteboards, etc. Additionally, they provided alternative schedules to reduce traffic between students (Furlani & Cardoso, 2021).
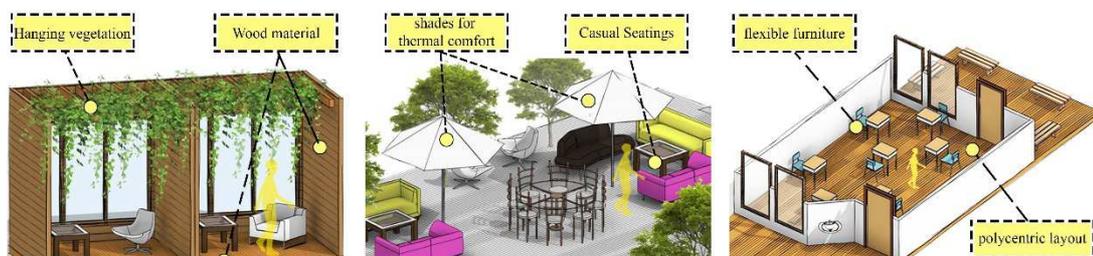
Fig. 20 (left): Outdoor learning spaces. Fig. 21 (middle): Outdoor casual eating area. Fig. 22 (right): Social distancing in classrooms.

6   DISCUSSION AND RESULTS

The comparative analysis reveals three main parameters of healthy learning environments, as shown in Table 1, that made these schools partially able to cope with COVID-19 as much as possible. On the other hand, these schools could not apply all strategies of the three parameters because they were restricted by many

factors related to the existing schools' design, like site location and size, the condition of these schools, and the integration of the schools with surrounding areas. So applying strategies to existing schools will not fit or succeed completely in all the schools because of the restrictions in existing schools. On the other hand, these parameters and their strategies will be effective when considered in designing future learning environments.

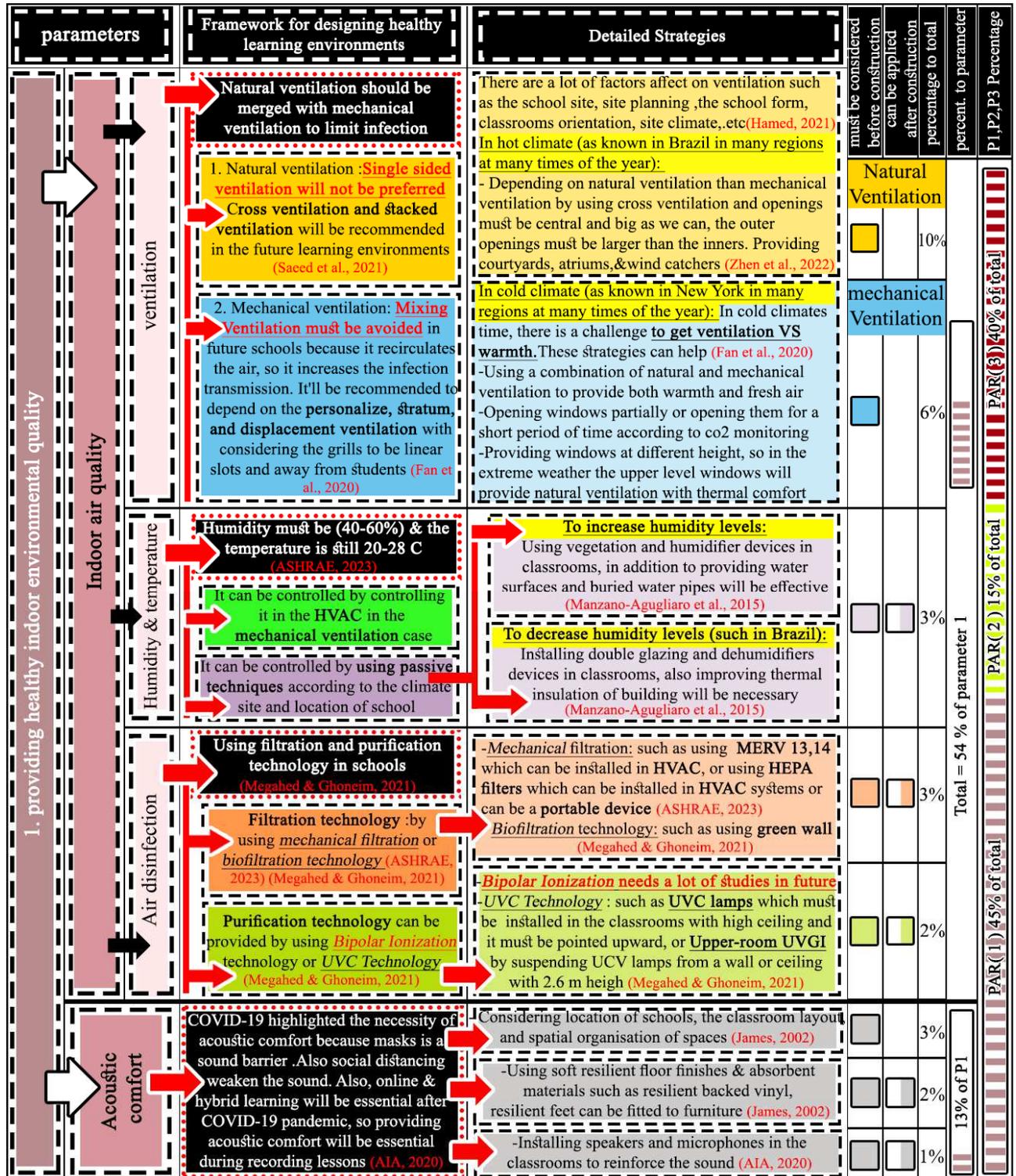| Parameters		public school 138 Samuel Randall in the Bronx	Brooklyn Laboratory Charter Schools in NY	Projeto Espaço Educativo 12 Salas – PEE-12 in Brazil
1. Providing healthy indoor environmental quality	Indoor Air Quality	- Promoting natural ventilation and using running exhaust vents on the roof -Using MERV 14, 15, or 16 filters and adding portable filtration units - Installing UV disinfection lamps -Closing return dampers	- Sanitizing ducts of HVAC - Keeping the humidity (40% - 60 %) -Opening windows to improve ventilation - Upgrading filters into MERV 13 filters -Providing outdoor classrooms and outdoor activity areas	-Promoting cross ventilation by opening the windows on the two sides. - Using the outside yards as outdoor classrooms and outdoor eating areas to increase natural airflow
	Acoustic comfort	....	- Installing speakers on sidewalks that were as outdoor learning spaces	....
	Lighting	....	-Providing natural lighting in outdoor learning spaces by designing the shed with transparent material, also installing artificial lighting to the sidewalk areas	- Using blinds and louvers on windows to avoid glare in classrooms -Providing artificial lighting in outdoor spaces
	Thermal comfort	....	- Designing outdoor sheds at sidewalks areas & outdoor learning spaces	-providing shades for outdoor space - using louvers on classrooms facade
2. Integrating nature with the learning environments		....	-Providing terraces and outdoor spaces to encourage outdoor learning & activities - Using vegetation elements in outdoor areas and terraces.	- Designing classrooms with big windows to provide views to outdoor green areas - Using outdoor areas as learning spaces - Using natural materials such as wood
3. Providing Safe contact in the learning environments	Hygienic Control	- Installing two prefabricated hygienic stations at each entrance - Adding prefabricated wash stations in the hallways and in each classroom - Reusing auditoriums to be isolation rooms	- Creating sidewalk sheds before entrances to be hygienic stations and to check temperature of students before entering schools -Setting up hygienic stations in each classroom.	-Installing information signages to guide students to avoid sharing items and wear masks - Putting washbasins near each classroom, and providing sanitizers in other spaces
	Hygienic Materials	- Adding antimicrobial walk-off mats before school entry	....	-Replacing coatings that are difficult to maintain and clean, in addition to using furniture made of cleanable material - Placing sanitary mats outside the school
	Touchless Systems	- Installing sensor control faucets and liquid soap dispensers in hygienic stations	- Adding foot controls for doors, and sensor-operated hands-free technology for valves and flushometers in bathrooms	....
	In physical learning environments — entrances	- Adding additional entry points in addition to maintaining social distancing in the sidewalk queuing area (1.8m) by mapping the floor	- Increasing entry points - Using an alternative schedule - Adding exterior stairs to the school as an additional vertical circulation	....
	classrooms	- Rearranging the furniture in a diagonal pattern to keep a distance of 1.8 meters between students - Dividing the cafeteria and gym with divider walls to be smaller classrooms -Providing an alternative schedule - In the long-term strategies, classrooms must be bigger in the future	-Promoting social distance (1.8 m) between students by mapping floors - Utilizing a transparent barrier - Holding outdoor classrooms to reduce the density of students - Applying staggered schedules - Designing flexible classrooms with movable walls to promote the extension	- Providing a polycentric layout in classrooms with a 2-meter space between student chairs which can be movable - Using an alternative schedule - Repurposing the outside yards into spaces for informal eating and classrooms
	circulation&spatial organization	-Using one-way circulation in stairways and pathways by using colored tape on the flooring to define circulation patterns	-Providing one-way circulation in the paths and stairways by using colored tape on the floors	....
	In online learning	- Promoting hybrid & Online learning	- Providing hybrid & Online learning	-Providing hybrid learning by supplying classrooms with technology devices like laptops, PCs, tablets, projectors, etc.

Table 1: Comparative analysis between the three examples.

7 FRAMEWORK FOR FUTURE HEALTHY LEARNING ENVIRONMENTS

According to AIA strategies, comparative analysis, and a lot of studies that have been recently done in light of the COVID-19 pandemic, a framework has been reached for designing future learning environments. This framework is generic and does not relate to specific countries (considering Brazil & New York) and provides a lot of detailed strategies to achieve the same parameters, while each future school can apply the appropriate strategies from the framework according to its factors like school location, climate, cost, etc. So the framework isn't prescriptive for schools, but it defines the priorities of strategies according to their importance to make schools healthy. On the other hand, it's very hard to apply this framework to existing schools because of their restrictions, like site planning, existing building conditions, etc. While it will be effective when applied to future schools. The framework provides three parameters that must be promoted in future learning environments: providing healthy indoor environmental quality, integrating nature with the learning environments, and providing safe contact in the learning environments (Table.2). The framework provides a scoring system; Each parameter gets a different percentage according to its importance to make the school healthy and able to cope with pandemics based on the literature review and the WELL rating system for healthy buildings. Each parameter can be prompted by a lot of strategies that have a percentage to achieve the main parameter. Parameter 1 strategies make schools healthy with 45%, Parameter 2 strategies

202

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make schools healthy with 15%, and Parameter 3 strategies make schools healthy with 40%. The framework will help architects to identify (before construction) if the future school will be able to face pandemics or not by giving it a percentage for each strategy of the proposed design. If the percentage of the school is less than 50%, then additional strategies from the framework can be added to make schools resistant to pandemics.

parameters	Framework for designing healthy learning environments	Detailed Strategies	must be considered before construction	can be applied after construction	percentage to total	percent. to parameter	P1,P2,P3 Percentage
1. providing healthy indoor environmental quality — Indoor air quality — ventilation	Natural ventilation should be merged with mechanical ventilation to limit infection	There are a lot of factors affect on ventilation such as the school site, site planning, the school form, classrooms orientation, site climate,..etc (Hamed, 2021) **In hot climate (as known in Brazil in many regions at many times of the year):** - Depending on natural ventilation than mechanical ventilation by using cross ventilation and openings must be central and big as we can, the outer openings must be larger than the inners. Providing courtyards, atriums,&wind catchers (Zhen et al., 2022)			Natural Ventilation 10%		PAR(3) 40% of total
	1. Natural ventilation : Single sided ventilation will not be preferred **Cross ventilation and stacked ventilation** will be recommended in the future learning environments (Saeed et al., 2021)						
	2. Mechanical ventilation: Mixing Ventilation must be avoided in future schools because it recirculates the air, so it increases the infection transmission. It'll be recommended to depend on the **personalize, stratum, and displacement ventilation** with considering the grills to be linear slots and away from students (Fan et al., 2020)	**In cold climate (as known in New York in many regions at many times of the year):** In cold climates time, there is a challenge to get ventilation VS warmth. These strategies can help (Fan et al., 2020) -Using a combination of natural and mechanical ventilation to provide both warmth and fresh air -Opening windows partially or opening them for a short period of time according to co2 monitoring -Providing windows at different height, so in the extreme weather the upper level windows will provide natural ventilation with thermal comfort			mechanical Ventilation 6%	Total = 54 % of parameter 1	
Humidity & temperature	Humidity must be (40-60%) & the temperature is still 20-28 C (ASHRAE, 2023)	**To increase humidity levels:** Using vegetation and humidifier devices in classrooms, in addition to providing water surfaces and buried water pipes will be effective (Manzano-Agugliaro et al., 2015)			3%		PAR(2) 15% of total
	It can be controlled by controlling it in the HVAC in the mechanical ventilation case						
	It can be controlled by **using passive techniques** according to the climate site and location of school	**To decrease humidity levels (such in Brazil):** Installing double glazing and dehumidifiers devices in classrooms, also improving thermal insulation of building will be necessary (Manzano-Agugliaro et al., 2015)					
Air disinfection	Using filtration and purification technology in schools (Megahed & Ghoneim, 2021)	-Mechanical filtration: such as using MERV 13,14 which can be installed in HVAC, or using HEPA filters which can be installed in HVAC systems or can be a portable device (ASHRAE, 2023) Biofiltration technology: such as using green wall (Megahed & Ghoneim, 2021)			3%		PAR(1) 45% of total
	Filtration technology :by using mechanical filtration or biofiltration technology (ASHRAE, 2023) (Megahed & Ghoneim, 2021)						
	Purification technology can be provided by using Bipolar Ionization technology or UVC Technology (Megahed & Ghoneim, 2021)	-Bipolar Ionization needs a lot of studies in future -UVC Technology : such as UVC lamps which must be installed in the classrooms with high ceiling and it must be pointed upward, or Upper-room UVGI by suspending UCV lamps from a wall or ceiling with 2.6 m heigh (Megahed & Ghoneim, 2021)			2%		
Acoustic comfort	COVID-19 highlighted the necessity of acoustic comfort because masks is a sound barrier .Also social distancing weaken the sound. Also, online & hybrid learning will be essential after COVID-19 pandemic, so providing acoustic comfort will be essential during recording lessons (AIA, 2020)	Considering location of schools, the classroom layout and spatial organisation of spaces (James, 2002)			3%	13% of P1	
		-Using soft resilient floor finishes & absorbent materials such as resilient backed vinyl, resilient feet can be fitted to furniture (James, 2002)			2%		
		-Installing speakers and microphones in the classrooms to reinforce the sound (AIA, 2020)			1%		

parameters	Framework for designing healthy learning environments	Detailed Strategies	must be considered before construction	can be applied after construction	percentage to total	percent. to parameter	P1,P2,P3 Percentage
1. providing healthy indoor environmental quality — Lighting	Daylighting and electrical lighting should be integrated together due to the increased use of technological devices in classrooms (Ochs, 2022) / Sunlight was used to treat microbial infections, so the future classrooms must depend on daylighting to be antivirus places (Megahed & Ghoneim, 2020)	Considering the orientation and ratio of classrooms, shape and orientation of windows, and placement of shading devices by using simulation programs according to site climate. Also providing cut-outs in the school form, increasing the ceiling height for natural lighting, providing blackout shades, especially during the switch-on of projection, and providing light shelves if needed (Autodesk Education Community, 2018b)	●		5%	15% of P1	
	Artificial lighting doesn't limit infection transmission, but it'll be very essential with the increased technology devices after COVID-19 (Ochs, 2022)	Considering the type of lighting fixtures, their illumination, and the distribution of it. For added flexibility, using dimming and sensor controls will be effective, artificial lighting will be more important especially in cloudy weather (Pelet et al., 2015)	●	●	2%		
Thermal Comfort	Humidity became (40-60%) instead of (20-80%) and the temperature is still 20-28 C (ASHRAE, 2023)	Using flexible solutions such as thermal mass, providing movable façade with suitable shading devices, using suitable trees around classrooms, using BPS Simulations,..etc (Fan et al., 2020)	●	●	3%	18% of P1	PAR (3) 40% of total
	humidity control ways have been mentioned, to control temperature there are two ways: (ASHRAE, 2023) / Temperature can be controlled by controlling it in HVAC systems in the mechanical ventilation case / Temperature can be controlled by using passive techniques in the natural ventilation case / Considering orientation of classrooms, site climate, form of schools buildings and the surroundings (ASHRAE, 2023)	In hot climate (as known in Brazil in many regions at many times of the year): Providing big windows, courtyards, atriums, & wind catchers for ventilation. Also using double glazing, louvers, double skin, thicker walls, overhangs & shading of the glazed openings, providing green roofs, and using light reflective paint (Manzano-Agugliaro et al., 2015) / In cold climate (as known in New York in many regions at many times of the year): using thicker wall, atriums, suitable shading and overheads, designing windows with different levels and sizes to provide natural ventilation with warmth in cold climates (Manzano-Agugliaro et al., 2015)	●		5%		PAR (2) 15% of total
2. Integrating nature with the learning environments — Direct experience with nature	It must be provided in future schools if possible because it influences students' health and can also limit infection transmission (Jones et al., 2020)	-By providing planting elements in classrooms such as green walls, .etc or/& Enabling views to outdoor landscape by glass of windows as possible according to the climate in school (Almusaed et al., 2022)	●	●	4%	67 % of Parameter 2	
	Visual connection with nature which can be inside or outside classroom / Providing outdoor classrooms / Considering the location, orientation of it and environmental factors in the site - Considering the outdoor classroom relation with surroundings in site and the size of site - Considering providing infrastructure and being near to utilities like toilets and hand sanitizers,..etc. - Providing clear accessibility by clear paths and doors from each classroom -Considering alternative schedule and capacity of outdoor classrooms -Providing wind control devices source (NAAEE, 2020)	In extreme climates such as heavy winters or extreme heat, these strategies will be suitable : -Using rolling garage- style doors or movable facade in classrooms to enable the indoor and outdoor to be one space for thermal comfort -Providing shades, tree canopies, and shelters -Using movable shading to open in extreme weather for thermal comfort and close in nice weather - Physical& online classrooms will be more suitable / In hot climate (as known in Brazil in many regions at many times of the year): Providing cooling devices, Providing enclosed outdoor spaces like courtyards or recessed for shading for protection from heat / In a cold climate (as known in New York in many regions at many times of the year): Providing heater devices, Providing Artificial lighting in cloudy weather, and Providing semi-closed or semi-pened outdoor spaces for protection from rain source (NAAEE, 2020)	●		6%		PAR (1) 45% of total
In-Direct experience with nature	It has an effect on mental health, but it doesn't control infection transmission, so it must be merged with the direct experience it can be suitable more in schools which can't provide direct experience techniques according to the extreme climate there (Roös, 2021)	It'll be preferred to use natural colors to help students feel calm, for example, using blues, light browns, greens, and avoiding red and orange	●	●	1%	33% of P2	
	Natural color	It will be preferred to use wood in chairs, desks, flooring, and walls because not only it is a natural material, but it's also a hygienic material	●	●	2%		
	Natural material	Natural features such as plants, water, etc. through using paintings, photographs, sculptures, etc	●	●	1%		
	Image of nature / Natural shapes and forms	It should be inspired by nature, such as the shapes of plants, waves, mountains etc., as patterns on an exterior façade or a column, such as tree columns source (Roös, 2021)	●		1%		

204

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Table 2: Framework for designing future learning environments.

8 CHECKLIST FOR DESIGNING FUTURE LEARNING ENVIRONMENTS THAT WILL BE CONSTRUCTED POST COVID-19

Table 3 provides checklist for designing future learning environments to make them resistant to pandemics.

Classrooms	
☐ Installing signs for prevention measures.	☐ Providing classrooms with technological devices such as laptops, projectors, cameras, speakers, etc. for hybrid and online learning.
☐ Mapping floors to delineate one-way walking paths and furniture locations.	
☐ Designing classrooms with flexible walls or partitions. ☐ Using movable furniture.	☐ Creating touchless handwashing hygiene stations in or adjacent to the classroom or sanitizing station(s).
☐ Considering the finishing materials to be a hygienic material like antibacterial paint, wooden and vinyl coverings, nanomaterial, etc.	☐ hexagon layout of the classroom If it's possible, this shape will be suitable based on the shape of the virus head biologically.
	☐ Expanding the size of classrooms than in current schools.
Acoustic comfort	
☐ Considering being away from sources of noise such as mechanical rooms, etc.	☐ Using touchless systems to open doors and windows as much as possible, if it isn't possible, using mechanical push by arm or foot to open them, or if it isn't possible, using copper in door and window handles and elevator buttons will be effective.
☐ Considering the layout and geometry of the classroom, and avoid using domes or barrel vaults in the classroom section, also avoid using a curved wall in opposition to a flat wall.	
☐ Enhancing acoustic treatment in classrooms by using absorbent materials if it's needed.	**Engaging classrooms with nature**
☐ Installing microphones and speakers.	☐ providing planting elements in classrooms.
	☐ Using natural and organic shapes in furniture if it's impossible according to learning styles.
Providing suitable ventilation	☐ Providing natural features and natural colors.
☐ Considering the site climate, location of classroom, and the wing walls placement by using simulation programs.	☐ Using natural materials that can be antibacterial ☐ Enabling views to outdoor landscape through as many windows as possible according to the climate in school.
☐ Installing CO2 monitoring.	
☐ Considering the form of the school, the height of the classrooms, and the roof shape of them.	☐ Each classroom should have a door for entry and another for accessibility to outdoor classrooms if the climate is suitable for outdoor classrooms, as we will mention in the checklist.
☐ Considering the orientation of the classroom according to the climate and the style of learning, it's generally recommended to have a northern orientation.	**Providing thermal comfort (20-28 C) & (40-60%) humidity**
☐ Providing windows at different heights, so in extreme weather, the upper-level windows will provide natural ventilation with thermal comfort.	☐ Considering the orientation of classrooms & site climate.
☐ Using suitable mechanical ventilation like POV, Stratum, PEV, Displacement ventilation, Mixing ventilation must be avoided.	☐ Using movable façade with suitable louvers
In hot climate, for example (**as known in Brazil in many regions at many times of the year**):	☐ Using suitable trees and considering thermal mass
☐ Using cross ventilation. Openings must be as central and big as possible .The outer openings must be larger than the inners.	☐ Using Building Performance Simulations (BPS)
☐ Providing courtyards, atriums, & wind catchers	☐ Using suitable HVAC systems
☐ Using single sided ventilation with improving by splitting the opening into two by using wings wall , using fans, and providing transom window above the door if the cross ventilation is impossible to be achieved.	In hot climate, for example (**as known in Brazil in many regions at many times of the year**): ☐ Providing big windows, courtyards, atriums, and wind catchers for providing cross ventilation. ☐ Using double glazing, louvers, double skin, thicker walls, overhangs, and shading of the glazed openings. ☐ Providing green roofs and light reflective paint. ☐ The humidity in Brazil is more than 60%,, so using a dehumidifier in classrooms will be effective.
In cold climate, for example (**as known in New York in many regions at many times of the year**):	In cold climate, for example (**as known in New York in many regions at many times of the year**): ☐ Using thicker walls, atriums, and suitable shading ☐ Designing windows with different levels and sizes to provide natural ventilation with warmth in cold climates.
☐ Using a combination of natural and mechanical ventilation to provide both warmth and fresh air.	
☐ One way is to partially open windows or to open them for a short period of time, according to CO2 monitoring.	
☐ Opening higher-up windows during heavy rain.	**Lighting comfort**
	☐ Considering the orientation and the classroom ratio, also the shape and orientation of windows and shading device placement by using simulation programs ☐ Providing cut-outs in the school form if it is possible.
Using filtration and purification technology in classrooms	☐ Providing blackout shades, especially during projection.
☐ Using green walls or planting filters.	☐ Increasing the ceiling height for natural lighting.
☐ Installing UVC lamps or UVGI at high levels.	☐ Considering artificial lighting using sensors
☐ Using MERV 13,14 or/ and HEBA.	

outdoor classrooms	Site

☐Considering the location of it to be in quiet spaces, well connected to classrooms to enable teachers to monitor students, and not in dark or corner places for student safety. ☐ Considering the climate in the schools and whether it's possible to provide outdoor classrooms or not in schools. ☐ Considering outdoor classrooms orientation and relation of them with the surroundings on site and the site size. ☐ Considering providing infrastructure and being near utilities like toilets and hand sanitizer. ☐Providing Clear accessibility by providing clear paths and doors from each classroom and making them well defined. ☐Providing wind control devices in outdoor classrooms. ☐Designing them with buffer space around them for movement. ☐Considering the alternative schedule and capacity of it. ☐Considering designing soft and hard landscape elements.	☐Considering the location of the school's site to be away from noisy. ☐Providing multiple points for entry and exits. ☐Having enough space before each entrance to have a waiting area before the entrance for checking the temperature of students and providing hygienic stations. ☐Considering the site size and site planning to enable it to extend to future needs and to provide outdoor classrooms, playgrounds, and classrooms in suitable spaces. ☐Considering providing separate parking circulation away from students. ☐Considering staggered times for entry if it is needed. ☐Considering spacing buildings' schools by a distance of at least 5 times the height of schools to provide natural ventilation ☐Considering the placement and types of vegetation and trees on the site.
In extreme climates, such as heavy winters or extreme heat	**Services and additional spaces**
☐**physical and online classrooms will be more suitable** ☐Using rolling garage- style doors or movable facade in classrooms to enable the indoor and outdoor spaces to be one space for thermal comfort. ☐Using movable shading to open in extreme weather for thermal comfort and close in nice weather. In hot climate, for example (**as known in Brazil in many regions at many times of the year**): ☐Providing cooling devices in hot regions. ☐considering drainage and protection from landslides. ☐Providing enclosed outdoor spaces like courtyards or recessed for shading for protection from heat. In cold climate, for example (**as known in New York in many regions at many times of the year**): ☐Providing heater devices in cold regions. ☐Providing Artificial lighting in cloudy weather. ☐Providing semi-closed or semi-open outdoor spaces for protection from rain.	**General notes** ☐Using touchless systems to open doors and windows as much as possible, if it isn't possible, providing mechanical push by arm or foot to open them, or if it isn't possible, using copper in door and window handles will be effective. ☐Considering the finishing material to be hygienic material like using antibacterial paint, nano coating materials, etc. ☐Using touch-free faucets, sinks, soap dispensers,etc. ☐Mapping the floor of the cafeteria, gym, and other service spaces to define the circulation path as one-way. **New additional spaces should be considered in schools** ☐Providing isolation rooms for infected students with negative pressure, separated entry and exit, and a separate toilet. Also, it should be located on an exterior wall. ☐Providing recording rooms with technological devices for recording lessons in hybrid and online learning. **Bathrooms** ☐Providing toilets with side exhaust fans. ☐providing enclosed bathroom stalls. ☐Cleaning automation in bathrooms will now be a priority. ☐Using cleaning robots and self-cleaning devices with touch-free faucets, sinks, soap dispensers,etc.
Circulation and Spatial organizations	**Cafeteria, gym, and other services spaces**
☐Breaking down the school into separate zones, and classrooms can be grouped around common services. ☐Avoiding pinch points. ☐Providing one-way circulation in corridors and stairs. ☐Mapping the floor to define the circulation paths. ☐Eexpanding the width of corridors than in current schools. ☐Providing single-loaded corridors if possible for ventilation if it'll be suitable according to the climate. ☐Considering cutouts in a building's form by classroom organization for daylighting if it will be suitable with climate.	☐Considering acoustics, lighting, thermal comfort, ventilation, air filtration, and engaging spaces with nature as mentioned in the checklist of classrooms. ☐Installing signs for prevention measures. ☐Providing entry and exit for the large service spaces. ☐Providing hygienic stations in each space. ☐Using flexible furniture in cafeterias, gyms, etc.

Table 3: Checklist for designing future learning environments, Author based on the previous framework sources.

9 CONCLUSION

COVID-19 has highlighted the lack of health in our learning environments, so the parameters for designing learning environments must be updated in the future to provide healthy learning environments. The parameters that must be provided in future learning environments to make them able to face any pandemic or crisis are: providing healthy indoor environmental quality (by promoting indoor air quality, acoustic, lighting, and thermal comfort); integrating nature with the learning environments (by providing natural views, outdoor classrooms, etc.); and providing safe contact in the learning environments(by providing hygienic stations, hygienic materials, touchless systems, and making the learning environment flexible to extend or be able to maintain social distancing in case there is any pandemic).

10 REFERENCES

AIA. (2020). Reopening America: Strategies for Safer Schools. Cdc, 1–12. http://content.aia.org/sites/default/files/2020-06/BuildingTypeReport-Office.pdf

Almusaed, A., Almssad, A., & Najar, K. (2022). An Innovative School Design Based on a Biophilic Approach Using the Appreciative Inquiry Model : Case Study Scandinavia. 2022.

ASHRAE. (2023). Design Guidance for Education Facilities: Prioritization for Advanced Indoor Air Quality. ASHRAE. www.ashrae.org

Autodesk Education Community. (2018). Massing & Orientation for Daylighting . Autodesk Education Community. https://knowledge.autodesk.com/support/revit/learn-explore/caas/simplecontent/content/massing-orientation-for-daylighting.html

Blocken, B., van Druenen, T., van Hooff, T., Verstappen, P. A., Marchal, T., & Marr, L. C. (2020). Can indoor sports centers be allowed to re-open during the COVID-19 pandemic based on a certificate of equivalence? Building and Environment, 180(May), 107022. https://doi.org/10.1016/j.buildenv.2020.107022

Brooklyn Lab Charter School. (2020). Back to School Facilities Tool Kit. Brooklyn Lab Charter School.

CDC. (2015). Hierarchy of Controls | NIOSH | CDC. https://www.cdc.gov/niosh/topics/hierarchy/default.html

CDC. (2019). Reopening Guidance for Cleaning and Disinfecting Public Spaces, Workplaces, Businesses, Schools, and Homes. CDC.

CDC. (2021). Flu & Young Children. https://www.cdc.gov/flu/highrisk/children.htm

Chin, A. W. H., Chu, J. T. S., Perera, M. R. A., Hui, K. P. Y., Yen, H.-L., Chan, M. C. W., Peiris, M., & Poon, L. L. M. (2020). Stability of SARS-CoV-2 in different environmental conditions. The Lancet Microbe, 1(1), e10.

Dubey, P. (2020). The Great Reopening: Architects and Engineers Help Schools Envision Safe Designs for COVID Era . Informed Infrastructure.

Ellin, N. (1999). Postmodern urbanism. Princeton Architectural Press.

Fan, M., Fu, Z., Wang, J., Wang, Z., Suo, H., Kong, X., & Li, H. (2020). A review of different ventilation modes on thermal comfort , air quality and virus spread control. Building and Environment, January.

Fantini, M. P., Reno, C., Biserni, G. B., Savoia, E., & Lanari, M. (2020). COVID-19 and the re-opening of schools: A policy maker's dilemma. Italian Journal of Pediatrics, 46(1), 10–12. https://doi.org/10.1186/s13052-020-00844-1

Furlani, S., & Cardoso, G. T. (2021). Rethinking post-Covid-19 school design in Brazil: Adaptation strategies for public schools PEE-12 FNDE. Strategic Design Research Journal, 14(1), 339–350. https://doi.org/10.4013/sdrj.2021.141.28

Goniewicz, K., Khorram-Manesh, A., Hertelendy, A. J., Goniewicz, M., Naylor, K., & Burkle, F. M. (2020). Current Response and Management Decisions of the European Union to the COVID-19 Outbreak: A Review. In Sustainability (Vol. 12, Issue 9).

Hamed, S. (2021). The Effect of External Openings in Buildings in Reaching Man's Thermal Comfort. International Journal of Advanced Engineering and Business Sciences, 2(2), 21–42. https://doi.org/10.21608/ijaebs.2021.91631.1016

James, A. (2002). Acoustic design of schools. Acoustics Bulletin, 27(6), 24–29.

Jiao, W. Y., Wang, L. N., Liu, J., Fang, S. F., Jiao, F. Y., Pettoello-Mantovani, M., & Somekh, E. (2020). Behavioral and Emotional Disorders in Children during the COVID-19 Epidemic. The Journal of Pediatrics, 221, 264-266.e1.

Jones, E., Young, A., Clevenger, K., Salimifard, P., WU, E., Lahaie, M., Lahvis, M., Lang, J., Bliss, M., Azimi, P., Wilson, C., Allen, J., & Cedeno, J. (2020). Principal Investigator/Corresponding Author SCHOOLS FOR HEALTH Risk Reduction Strategies for Reopening Schools.

Khanam, C. N., Reddy, M. V., & Mrunalini, A. (2006). Designing Student's Seating Furniture for Classroom Environment.

Korsavi, S. S., & Montazami, A. (2020). Children's thermal comfort and adaptive behaviours; UK primary schools during non-heating and heating seasons. Energy and Buildings, 214, 109857. https://doi.org/https://doi.org/10.1016/j.enbuild.2020.109857

Larsson, N. (2020). Pandemics and the Built Environment. International Initiative for a Sustainable Built Environment, June, 1–25.

Manzano-Agugliaro, F., Montoya, F. G., Sabio-Ortega, A., & García-Cruz, A. (2015). Review of bioclimatic architecture strategies for achieving thermal comfort. Renewable and Sustainable Energy Reviews, 49(February 2018), 736–755.

Megahed, N. A., & Ghoneim, E. M. (2020). Antivirus-built environment: Lessons learned from Covid-19 pandemic. Megahed, N. A., & Ghoneim, E. M. (2021). Indoor Air Quality: Rethinking rules of building design strategies in post-pandemic architecture.

NAAEE. (2020). Outdoor Infrastructure Planning Strategies for Taking Learning Outside As Schools Reopen.

OECD. (2020). Combatting COVID- 19 ' s effect on children. Tackling Coronavirus (COVID-19): Contributing to a Global Effort.

Pelet, J. E., Pratt, M. A., Fauvy, S., Sinclair, J., & Kalvala, S. (2015). Learning Technology for Education in Cloud.

Roös, P. B. (2021). SUSTAINABLE URBAN FUTURES A Biophilic Pattern Language for Cities Environments.

Saeed, D. M., Elkhatib, W. F., & Selim, A. M. (2021). Architecturally safe and healthy classrooms: eco-medical concept to achieve sustainability in light of COVID-19 global pandemic. Journal of Asian Architecture and Building Engineering, 00(00), 1–16.

Samodra, F. X. T. B., & Harahap, B. P. N. (2021). Classroom concept as a response to the COVID-19 pandemic: An antivirus built-environment approach. IOP Conference Series: Earth and Environmental Science, 881(1).

Spitzer, M. (2021). Open schools! Weighing the effects of viruses and lockdowns on children. Trends in Neuroscience and Education

Van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., Tamin, A., Harcourt, J. L., Thornburg, N. J., & Gerber, S. I. (2020). Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1

WHO. (2004). The physical school environment : an essential element of a health-promoting school.

Zhen, Q., Huang, Q., & Zhang, Q. (2019). Contribution of space factors to decisions on comfort of healthy building design.

Zhen, Q., Zhang, A., Huang, Q., Li, J., Du, Y., & Zhang, Q. (2022). Overview of the Role of Spatial Factors in Indoor SARS-CoV-2 Transmission: A Space-Based Framework for Assessing the Multi-Route Infection Risk.

208

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Diagnose Digital Skills Gap between Professional and Academic Sectors in Architecture Discipline – Jordan Case Study

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1 ABSTRACT

There are many studies on digitization. The newly graduated engineer has a way of thinking, currency, and outlook on engineering work. Research on the ability of universities to graduate qualified architects for the professional market has become necessary to bring about changes in teaching methods and link them to digital programs. This paper looks at if there is a consensus between the opinion of professionals and academics about digital skills, trying to integrate urgent digital skills needed by the labor market in the Architecture education study plans.

Mixed between quantitative and qualitative research methods, researchers analyze the study plan of 12 universities, using the Curriculum Content Mapping)CMM(method, and conduct a questionnaire for academics and professionals. Accordingly, we prove the gap between the profession and the academic world in the discipline, and there is no agreement between them about the digital programs needed. Then researchers provide a matrix expressing the relationship between the digital courses and the AE courses in a way to connect the two.

Keywords: Study plan, Factor Analysis, Digital Architecture, Curriculum Mapping Method CMM, Architecture Engineering Education(AE)

2 INTRODUCTION

The study plans are linked to a set of competencies, transferring them to students to prepare competent engineers who can meet the needs of the labor market, and the most important of these competencies is the ability to work on digital programs, starting from thinking of the idea until preparing plans and then implementation. Researchers note that there is a gap between what architectural universities teach in Jordanian universities and the need for the labor market due to the tendency of many students to take reinforcement courses to improve their chances of obtaining a job.

2.1 Research Hypothesis:

There is a difference between the programs taught in universities and those needed by the professional market.

2.2 Methodology

This research used mixed techniques (quantitative and qualitative research methods). Firstly, to prove the gap quantitative method was used, depending on CMM; It is a technique used to explore how architectural knowledge is to be taught together with skills in curriculums, depending on the competency concept. (The Organisation for Economic Co-operation and Development, 2020)

(maart, Frantz, & Mphil, 2021) Use curriculum mapping to demonstrate the alignment of an undergraduate dental curriculum with a competency framework, and curriculum mapping revealed areas for improvement or gaps in the UWC dentistry curriculum's Afro MEDS competencies.

(Alshanqiti, Benaida, Alam, and Namoun, 2020) use the same method as a two-dimensional matrix expressing the relationship between the student's learning outcomes and the courses.

Secondly, to create the digital -course's network, researchers distributed questionnaire forms to professionals and academic architects and then analyzed the result using factor analysis and Cohen's weighted kappa in SPSS.

2.3 Goals and objectives

(1) The research aims to prove the existence of a difference between what architectural universities teach in the study plans in the field of architecture and the need of the labor market, especially technical programs.

(2) It also aims to provide a realistic touch of emergent programs in the era of digitization.

(3) Develop a network of relationships between teaching courses and digital programs that enhances the student's digital and architectural efficiency.

3 LITERATURE

3.1 Architecture Discipline in Jordan

According to JEA (Jordanian Engineers Association, 2021), unemployed engineers increased to 34% in 2021; Architects registered at JEA equal to 9% of the total engineers, while 38% of architects are unemployed, table 1.

Discipline	Total engineers that Able to work	A worker at offices and companies	Work outside the country	Un employee	Un employee percentage
Civil engineers	46265	21630	8750	15885	34 %
Architecture engineers	14436	6326	2559	5551	38 %
Mechanical engineers	31968	15952	6453	9563	30 %
Electrical engineers	57534	27540	11141	17955	31 %
Mining	1149	870	120	159	14 %
chemical	8284	4640	1877	1767	21 %
total	159636	76958	30900	50880	32%

Table 1: Unemployment rate in each engineering section. Source: JEA (Jordanian Engineers Association, 2021).

Graduated students mainly work in the following sectors: Private practices, large construction companies, the public sector, large industry organizations, or in the academic sector. The engineering sector was counting on job opportunities outside Jordan, but these opportunities seem to diminish over time (see Table 2). In the same manner, there is an increase in obtaining professional degrees between 2014-2020, as shown by Table 3.

YEAR	2012	2013	2014	2015	2016	2017	2018	2019	2020
Local Opportunities	1515	1809	1679	1888	1597	1320	685	1489	438
International Opportunities	1201	2399	4941	6209	2187	587	451	566	173
Total	2716	4208	6620	8097	3784	1907	1136	2055	611

Table 2: Job opportunities by JEA 2012-2020, 2020. Source: (Jordan Engineers Association, 2020).

	2014	2015	2016	2017	2018	2019	2020	TOTAL
Civil	1	22	61	59	64	90	64	361
Architecture	4	24	14	16	19	16	13	106
Mechanical	43	47	42	31	70	55	29	317
Electrical	24	50	37	30	85	61	42	329
Mining	----	---	10	1	3	6	1	21
Chimical	---	5	11	2	17	9	14	58
TOTAL	72	148	175	139	258	237	163	1192

Table 3: Engineers with professional degrees 2014-2020. Source: (Jordan Engineers Association, 2020).

The number of engineers working in engineering offices was (7971) in 2020, (5063) in design, (and 2908) in supervision. On the other hand, (8003) engineers worked in 2019, (5004) in design, and (2999) in site supervision, with a drop ratio were (0.4%).

3.2 Digital Skills in the Professional Market

(Khodeir & Nessim, 2020) evaluated the level of importance of the graduate skills, they found that responsibility, positive attitude, and researchers rate teamwork as the top. However, (Salleh, Md Yousof, & Momon, 2016) in their research highlighted that the quality of graduates evaluated through technical and non-technical skills. Employers in the professional world usually seek other skills apart from the technical skills gained during undergraduate studies in architecture schools. Correspondingly, there is a high demand for architects with the skills to manage real projects. Those skills are not limited to planning and designing but also include diverse employability skills, including critical thinking, teamwork, leadership, and

210

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negotiation. Also, (Khodeir & Nessim, 2020) evaluated the importance of graduate skills; they found that responsibility, positive attitude, and teamwork skills were at the top.

Figure :1 advertisements examples for demand skills in Jordan professional market, source: architects of Amman-facebook group.

3.3 Digital Skills in Architecture Education

The standard architectural curriculum incorporated design studio as the center subject; the teaching happens within the studio, and the other basic abilities are design theory, history, visual communication, and representation, building innovation. The researchers divided the educational environment into two main titles: "distance education" and "formal education." Formal education environments are varied, such as classrooms, workstations (cluster, group), and one-by-one interactive and educational tools, such as traditional and digital tools. (Yıldırım, Yavuz, & Kırcı, Experience of traditional teaching methods in architectural design, 2012),researchers illustrate that teachers manage design studios in both a "teacher-oriented" and "student-oriented" manner in terms of the method.

Moving toward new teaching methods in the architectural design studio is a need as (Ciravoğlu, 2014) and (Walter & Rangaswamy, 2014) mentioned: "By bringing technology into the classroom and by doing complex and realistic problems, we can make our classes livelier and relevant." (Saghafi, Mozaffar, Moosavi, & Fathi, 2015)

Mention two techniques in architecture teaching which are the teaching method with the creation of the Design Studio and the free-Hand Drawing Teaching Method as insured by (Tepavčević, 2017), "rethinking of models for design-led research provides a new framework for design pedagogy that responds to technological shifts and new design thinking."

Rivka Oxman (2006), in her paper "Theory and Design in the first digital age," proposed a theory of digital design that tried to map the different levels of interaction of the user with digital media and integration of the computer into the design. Oxman identified four components of digital design - representation, generation, evaluation, and performance - specified performance (Oxman, 2006).

4 FINDING AND DISCUSSION

Digital technology changed the way we teach and learn architecture, even digital design courses or standalone courses. Digital technology, such as the virtual design studio, many architectural schools introduce a new method of teaching architectural design. Focusing on the fact that computerized design education plays a significant part in tomorrow's architectural education, the curriculum developer can create computerized substance into a platform in the modern architectural curriculum.

By Analyzing Jordan universities' study plans researcher aims to know the standing-alone computerized courses, and digital design courses in Jordanian education as shown in Table 4.

4.1 Curriculum Content Mapping (CCM) Results

	Name of Universities	Credit hours	Computerized courses		Digital design courses	
			CREDIT HOURS	PERCENTAGE	CREDIT HOURS	PERCENTAGE
1	University of Jordan	178	10	5.6%	3	0.01%
2	Hashemite University	172	10	5.8%	0	0 %
3	AlbalqaApplied University	166	10	6%	0	0 %

4	Philadelphia University at Jordan	165	10	6%	3	0.01%
5	AlAl-Bayt University	165	9	5.4%	0	0 %
6	Muta University	172	14	8%	0	0 %
7	Al Ahliyya Amman University	165	11	6.6%	0	0 %
8	Zarqa University	167	12	7.1%	0	0 %
9	Amman Arab University	169	7	4%	0	0%
10	Al Isra Private University Amman	169	10	5%	0	0 %
11	Al Ahliyya Amman University	165	11	6%	0	0%
12	Al Yarmouk university	167	6	3.5	0	0%

Table 4: Credit hours and computerized courses in the study plan at the sampling universities. Source: Researchers.

(5.4 -8 %) the study plan in AE are separate courses that teach computer science as stand-alone courses; (BIM,2DCAD,3D CAD, C++, GIS), and there are no digital courses except in two universities, the University of Jordan and Philadelphia University.

Those numbers do not mean that universities do not use several programs in the educational process. However, they use them in a non-programmed way that differs from one teacher to another according to the instructor's efficiency.

4.2 Questionnaire Results

The researchers sent the statistical survey digitally to 32 professional and 16 curriculum developers; the survey consisted of three items, and the value of Cronbach's alpha for the survey α= 0.9, as shown in Table 5.

Ratings	Weighted Kappa	Asymptotic Std. Error	z^c	Sig.	95% Asymptotic Confidence Interval Lower Bound	Upper Bound
academic - professional	-.061	.073	-.713	.476	-.205	.083

Table 5: Cohen's Weighted Kappa using SPSS.Source: Researchers.

In general, by asking professionals and academics to rank the programs, we found that:

To professionals, REVIT is the most important, then Sketch up, Photoshop, 3DMAX, GIS, GRASSHOPPER, and finally, the least important are BIM and RYNO, but in the academic sector CAD is the most important program, as is 3DMAX, and finally REVIT. By asking about essential programs according to job requirements, we found that: Private architects, Large construction companies, Public sector bodies, Academic sector differ in their needs, as Table 6 shows.

On average private architects prefer 3DMAX, BIM, GRASSHOPPER, AND RYNO. Large construction companies need GIS,3DMAX, GRASSHOPPER, and RYNO. Public sector-governmental: prefer GIS. The academic sector emphasizes CAD and REVIT.

Competence	Role	Private architect practices	Large construction companies	Public sector bodies	Academic sector
Media and Visualization skills	BIM	3	4	4	1
	CAD	4	3	4	4
	GIS	2	2	3	3
	3DMAX	3	2	2	2
	REVIT	4	4	4	4
	GRASSHOPPER	3	2	2	2
	RYNO	2	2	2	3
	PHOTOSHOP	3	3	4	3
	Average rank	3	2	3	4

Table 6 categorizes the digital program by job role. Source: Researchers.

The researchers found no consensus between the academic and professional points of view about the digital programs needed; this ensures the gap between the professional and academic sectors.

By asking to interrelate digital programs into courses: Academic architects arrange digital programs integrated into curriculum courses. Also, professionals give their views, and then the researcher conducts factor analysis using SPSS to discover the pattern of digital programs and explore how it interacts with other courses. Researchers conclude the following model,figure 2.
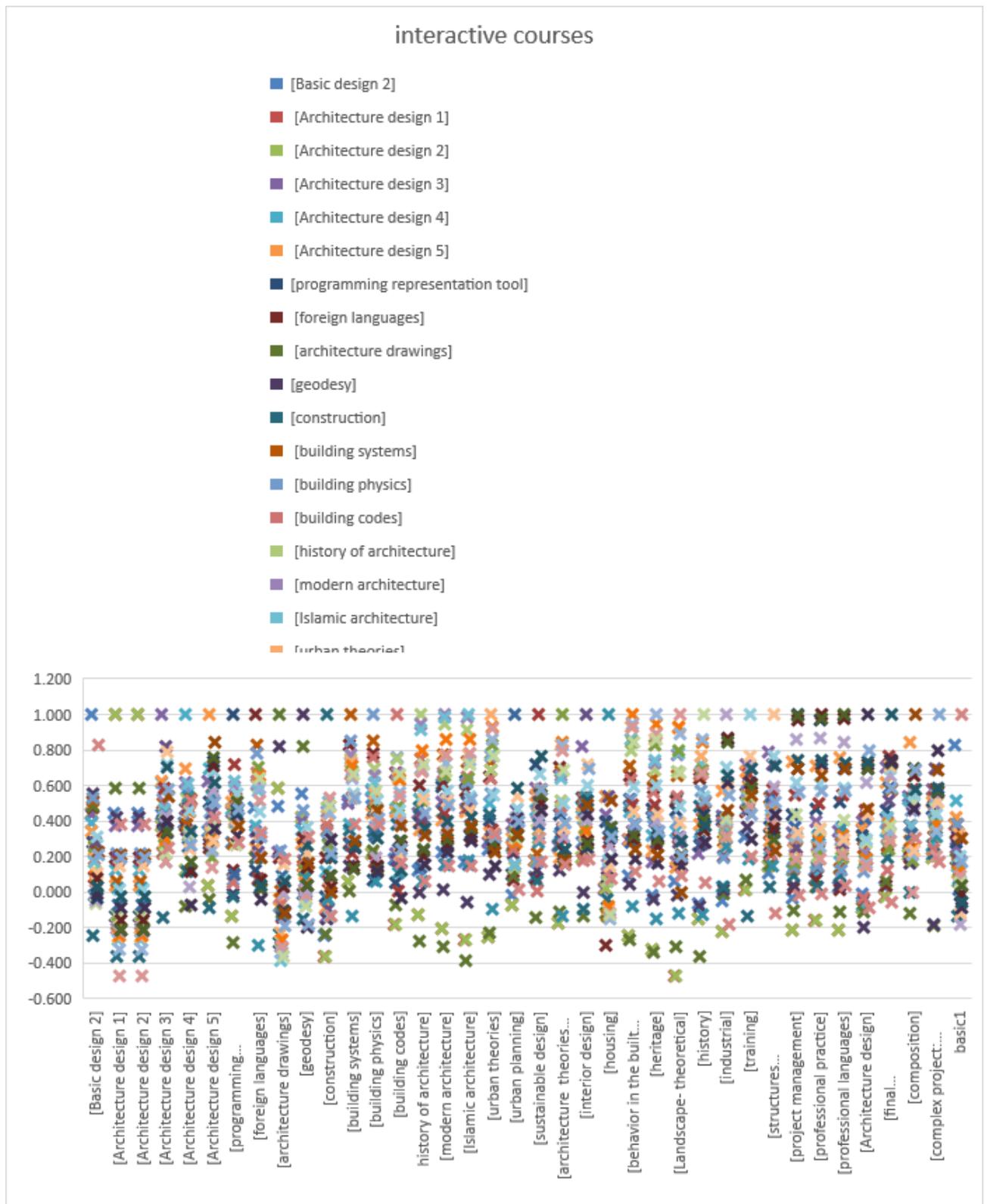
Figure (2): Horizontal and vertical relations between courses group. Source: Researchers.,using factor analysis in SPSS

The researchers noted from tables 7-12 that the participants suggested the link between electronic programmes in the educational process at different levels. However, most agreed that cad and sketch can integrate with all courses; it is appropriate to filter which programmes are more useful and include them in the study plans. The multiplicity of programmes may be helpful to be in harmony with the labour market's needs and the times requirements, where decision makers form a flexible framework for digital competencies.

RYNO	basic 1
	architecture design 4
	architecture design 5
	geodesy
	construction
	modern architecture
	islamic architecture
	urban theories
	sustainable design
	architectural theories and critique

PHOTOSHOP	basic 1
	[programming representation tool]
	architecture drawing
	[building codes]
	[history of architecture]
	[modern architecture]
	[Islamic architecture]
	[urban theories]
	[architecture theories and critique]
	[behavior in the built environment]

GRASSHOPPER	[programming representation tool]
	[foreign languages]
	[geodesy]
	[building systems]
	[sustainable design]
	[architecture theories and critique]

Table :7 Course–RYNO program relation. Source: Researcher. Table 8: Course–PHOTOSHOP program relation. Source: Researcher. Table 9: Course–GRASSHOPPER program relation. Source: Researcher

REVIT	
	[Architecture design 1]
	[Architecture design 2]
	[Architecture design 3]
	[Architecture design 4]
	[Architecture design 5]
	[foreign languages]
	architecture drawing
	[construction]
	[building systems]
	[building physics]
	[building codes]
	[urban theories]
	[urban planning]
	[sustainable design]
	[architecture theories and critique]
	1 [interior design]
	[housing]
	[behavior in the built environment]
	[heritage]
	[Landscape- theoretical]
	[history]
	[industrial]
	[training]
	structures &construction]
	[project management]
	[professional practice]
	[professional languages]
	[Architecture design6]
	[final project :architecture, structure, urban, landscape design]
	[composition]
	[complex project: architecture engineering]
	islamic architecture
	modern architecture
	history

GIS	
	[Architecture design 5]
	[programming representation tool]
	[foreign languages]
	architecture drawing
	[geodesy]
	[construction]
	[building systems]
	[modern architecture]
	Islamic architecture
	[urban theories]
	[urban planning]
	[sustainable design]
	[architecture theories and critique]
	[interior design]
	[housing]
	[behavior in the built environment]
	[heritage]
	[Landscape- theoretical]
	[history]
	[industrial]
	[training]
	[project management]
	[professional languages
	[final project :architecture, structure, urban, landscape design]
	[composition]
	[complex project: architecture engineering]
	[building physics]

GIS	
	[Architecture design 5]
	[programming representation tool]
	[foreign languages]
	architecture drawing
	[geodesy]
	[construction]
	[building systems]
	[modern architecture]
	Islamic architecture
	[urban theories]
	[urban planning]
	[sustainable design]
	[architecture theories and critique]
	[interior design]
	[housing]
	[behavior in the built environment]
	[heritage]
	[Landscape- theoretical]
	[history]
	[industrial]
	[training]
	[project management]
	[professional languages
	[final project :architecture, structure, urban, landscape design]
	[composition]
	[complex project: architecture engineering]
	[building physics]

Table 10: Course–REVIT program relation. Source: Researcher. Table 11: Course–GIS program relation. Source: Researcher. Table 12: Course– BIM program relation. . Source: Researcher.

5 CONCLUSIONS

(1) Researchers expect that the findings and discussion help AE programs evaluate their current study plans for Jordanian universities, as we conclude:

(2) There needs to be a consensus between the academic and professional points of view about the digital programmes needed that ensure the gap between the two.

(3) Emphasize using digital tools in architectural courses.

(4) It is necessary to study and develop study plans from time to time to achieve a higher level of the graduated architect who can work and keep pace with changes in the era of digitization.

(5) During curriculum development, it is essential to consider the stakeholder's views.

(6) There is a must to integrate courses with digital programs to enhance professional skills.

(7) Some digital programs are emerging according to the era's demand, and curriculum developers must consider them in AE study plans, such as BIM, RYNO, and GRASSHOPPER.

(8) The job market in Jordan needs trained workers who graduate from educational institutions and who need more advanced technology produced by educational institutions and for research that leads to increased production and improvement of its quality

(9) Teachers must integrate digital educational software, interactive learning, virtual schooling, and online education to simulate the learning process.

(10) The framework that AE schools require expands on the Core Curriculum while incorporating new components like Mandatory Competencies and Career Role Levels.

214

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(11) Researchers ensure the importance of reconsidering the engineering programs that are taught based on the needs of the practice market. Moreover, specify the most critical programs that new engineers should master.

One of the study outputs is a contextual framework that aims to provide a theoretical basis from which to understand and empirically establish a common language for describing domain-specific epistemic beliefs in architecture education to globalize the plan of work, figure (3) take the following actions:

Demand analysis:

(1) To specify emerging architect characteristics and skills from a professional point of view.

Supply analysis:

Analyses the current curriculums based on selected competence models or accreditation board standards.

To extract specifications that form the study plan guidelines from the stakeholder's point of view.
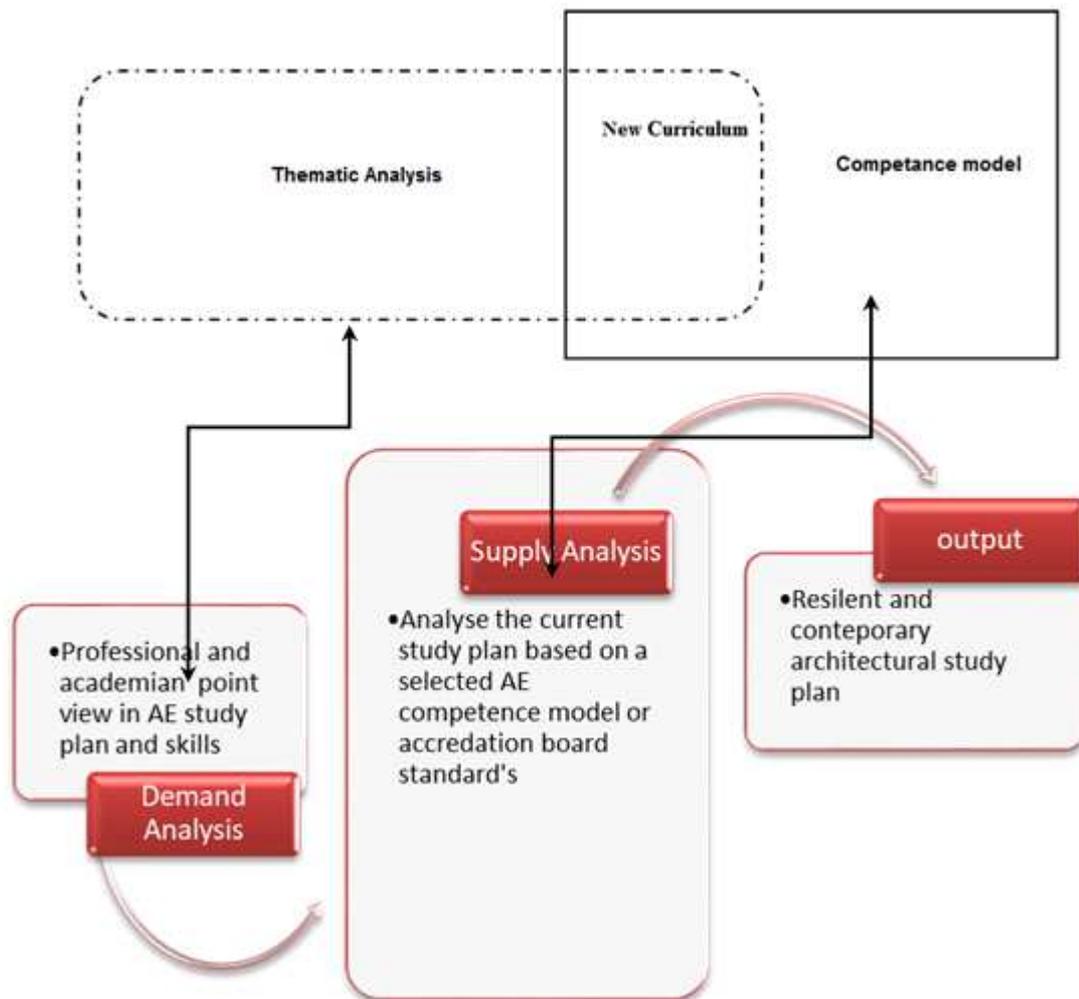
Figure 3: plan of contextual model.Source: Researcher.

6 REFERENCES

RIBA. (2018). International Schools with courses recognized.
Al-Matarneh, R., & Fethi, I. (2017). Assessing The Impact Of Caad Design Tool. Malaysian Online Journal of Educational Technology, 5(1).
AL-QAWASMI, J. (2004). REFLECTIONS ON E-DESIGN: THE E- STUDIO EXPERIENCE. 1st ASCAAD International Conference, e-Design in Architecture (pp. 177-193). Dhahran, Saudi Arabia: : https://www.researchgate.net/publication/30867319.
Alshanqiti , A., Benaida, M., Alam, T., & Namoun, A. (2020). International Journal of Advanced Computer Science and Applications, Vol. 11(No. 12).
Bashabsheh, A., Alzoubi, H., & Ali, M. (2019). The application of virtual reality technology in architectural pedagogy for building constructions. Alexandria Engineering Journal, 58, 713-723.

Boyd, D., & Thurairajah, N. (2015). Construction Education in the New Digital World. Birmingham City University. Birmingham UK: RESEARCH GATE.

Bruffee, K. (1999). Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge. The Journal of Higher Education, 66(4), 483-485 .

Ciravoğlu, A. (2014). Notes on architectural education: An experimental approach to. Social and Behavioral Sciences, pp. 7 – 12.

Gerber, B., Gerber, D., & Ku, K. (2011). THE PACE OF TECHNOLOGICAL INNOVATION IN ARCHITECTURE, ENGINEERING, AND CONSTRUCTION EDUCATION: INTEGRATING RECENT TRENDS INTO THE CURRICULA. (T. Z, Ed.) Journal of Information Technology in Construction, 16, 411-432.

GROSS, M., & YI-LUEN DO, E. (1999). Integrating Digital Media in Design Studio. Proc. ANational Conference '99 (Minneapolis, Minn). CSA (American Collegiate Schools of Architecture).

House, R. (1994). Webster's New Universal Unabridged Dictionary: Fully Revised and Updated. New York: Barnes and Noble.

https://www.statista.com/statistics/385565/unemployment-rate-in-jordan. (n.d.).

Jordan Engineers Association. (2020). JEA Magazine. Engineering education and the job market, 88.

Jordanian Engineers Association. (2021). Unemployment in the engineering sector. Jordanian Engineers Association.

Kensek, K. (n.d.). Visual Programming for Building Information Modeling: Energy and Shding Analysis Case Studies. Journal of Green Building, 10(4).

Lang, J. (1987). New York: Van Nostrand Reinhold.

lynn, G. (1999). Animate Form. Princeton Architectural Press.

maart, R., Frantz, J. M., & Mphil, A. R. (2021). Curriculum mapping: A tool to align competencies in a dental curriculum. Vol. 13(No. 2). doi:10.7196/AJHPE.2021.v13i2.1257

Makaklı, E. (2019). STEAM approach in architectural education. ERPA International Congresses on Education , 66(SHS Web Conf).

MAO-LIN, C. (2006). THE JUMP OF DIGITAL DESIGN THINKING.

Ministry of Higher Education and Scientific Research . (2012/2013). Ministry of Higher Education and Scientific Research statistics in Jordan. Ministry of Higher Education and Scientific Research .

Monsur, M., & Islam, Z. (2014). GIS for Architects:Exploring the Potentials of IncorporatingGIS in Architecture Curriculum. ARCC/EAAE 2014 | Beyond Architecture: New Intersections & Connections. Manoa : University of Hawaiá.

Oxman, R. (2006). Theory and design in the first. Design Studies, 27, 229-265.

OXMAN, R. (2010). Theory and design in the first digital age. DESIGN DTUDIES, pp. 229-265.

Parasonis, J., & Jodko, A. (2013). Competence Model for the Architectural Engineering Professional. PROCEDIA ENGINEERING, pp. 876-881.

Riccobono, A. (2014). Architectural design in the digital era,identifying computer influence and new experessive trends in current architecture. Università degli Studi di Palermo.

Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. John Wiley & Sons.

Saghafi, M., Mozaffar, F., Moosavi, S., & Fathi, N. (2015). Teaching Methods in Architectural Design Basics. Ciência eNatura, 37(1), 379–387.

Schon, D. (1992). The Reflective Practitioner: How Professionals Think In Action Paperback. London: Routledge.

Soliman, S., Taha, D., & Sayad, Z. (2018). Architectural education in the digital age. Alexandria Engineering Journal, 809–818.

Tamimi, A. (2015). Higher Education in Jordan: Crisis & Opportunities. The Fifth PRME MENA FORUM. Amman.

Tepavčević, B. (2017). Design thinking models for architectural education. The Journal of Public Space, 2(3), 67-72.

The Organisation for Economic Co-operation and Developmen. (2020). Technical Report: Curriculum Analysis of the OECD Future of Education and Skills 2030. OECD.

Uskov, V., & Howlett, R. (2016). Smart Education and Elearning 2016. (L. Jain, Ed.) SPRINGER.

Walter, T., & Rangaswamy, A. (2014). TEACHING METHODS FOR HIGHER EDUCATION. Dept. of Management Studies, Infant Jesus College of Engineering.

Wastiels, L., & Wouters, I. (2008). Material Considerations in Architectural Design:. Design Research Society Conference.

Yıldırım, T., Özen Yavuz, A., & Kırcı, N. (2012). Experience of tradiational teaching methods in architectural designeduacation: "mimesis technique". Procedia social and behaviour science, pp. 234-238.

Yıldırım, T., Yavuz, A., & Kırcı, N. (2012). Experience of tradiational teaching methods in architectural design. Social and Behavioral Sciences, 51, pp. 234 – 238.

Die dunkle Nacht erhebt sich – Sternenparks als informelles und kommunales Steuerungselement für Natur- und Freiraumschutz

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1 ABSTRACT

Die anthropogene Aufhellung des Nachthimmels durch künstliche Beleuchtung hat in den letzten Jahren stetig zugenommen. Straßenlaternen, Flutlichtanlagen, Skybeamer und Bodenstrahler erhellen mehr oder weniger große Flächen, die eigentlich nicht beleuchtet werden sollten. Dieses Phänomen wird als Lichtverschmutzung oder Lichtsmog bezeichnet. Überall verdrängt anthropogenes Licht die natürliche Dunkelheit, nicht ohne Folgen für die menschliche Gesundheit. Aber auch aus ökonomischer Sicht sind die Folgen der Lichtverschmutzung für Städte und Gemeinden eine nicht zu vernachlässigende Aufgabe.

Es ist festzustellen, dass ein ineffizient gesteuerter Einsatz von künstlichem Licht, gleich welcher Art, eine enorme Energieverschwendung darstellt. Für das langfristige Erreichen der gesteckten Klimaschutzziele, wie z. B. die Einsparung von CO_2-Emissionen, ist der unkontrollierte und ungesteuerte Einsatz von anthropogenem Licht kontraproduktiv. Die daraus resultierenden volkswirtschaftlichen Auswirkungen auf den Energieverbrauch unserer Städte und Gemeinden sind nicht zu vernachlässigen. Inzwischen hat das Phänomen der Lichtverschmutzung den Charakter einer „schädlichen Umwelteinwirkung" im Sinne des Bundes-Immissionsschutzgesetzes. Damit existiert ein konkretes System zur Bewertung der Auswirkungen von Lichtimmissionen auf den Menschen und die natürlichen Lebensgrundlagen.

Nutzungspotentiale von Licht können sich aus anthropogenen Lichtquellen ergeben, wenn diese z. B. touristisch vermarktet werden, architektonische Stimmungslagen hervorheben oder das individuelle Sicherheitsempfinden durch beleuchtete öffentliche Plätze und Straßen erhöht wird. Im kommunalen Bereich ergeben sich daraus Zusammenhänge, die für die Themen „Lichtverschmutzung" und „Sternenparks" von Bedeutung sein können. Öffentliche Beleuchtung emittiert Licht. Hier ist zu klären, wo es ankommt und welche Bedeutung dies für den jeweiligen Raum hat. Daraus ergeben sich finanzielle Aspekte, die eng mit dem Thema „Lichtverschmutzung" verbunden sind. Ineffiziente Lichtquellen einfach abzuschalten ist jedoch keine Option. Gefragt sind informelle Lösungen und ein innovatives Management des anthropogenen Lichtbedarfs, wie es beispielsweise durch die Einrichtung von „Sternenparks" bereits praktiziert wird. Durch den aktiven Schutz natürlicher Nachtlandschaften ergeben sich positive Nebeneffekte, da nicht nur Energie, sondern auch monetäre Mittel eingespart werden.

Bei dem Versuch einer theoretischen Einordnung von „Sternenparks" als informelles und kommunales Steuerungselement für den Natur- und Freiraumschutz lässt sich die aktuelle klimapolitische und umweltpolitische Diskussion als übergeordnete Struktur sehr gut heranziehen. Der Lichtverschmutzung wird in diesem komplexen Wirkungsgefüge auf den ersten Blick keine entscheidende Rolle zugeschrieben. Es lassen sich jedoch sozioökonomische und sozioökologische Zusammenhänge herstellen, deren Bedeutung für die angesprochenen Teilbereiche erstaunlich ist. Die „Sternenparks" können als ein Element betrachtet werden, das diese negativen Entwicklungen zwar nicht vollständig umkehrt, aber einen wichtigen Beitrag zum Natur- und Freiraumschutz leistet, indem sie sich für den Schutz der natürlichen Nachtlandschaften einsetzen.

Das Projekt soll einen Beitrag zur informellen Regionalentwicklung leisten und innovative Impulse für eine breite Vernetzung und einen Informationsaustausch der Akteure geben. Das Format des „Sternenparks" als informelles Steuerungselement für den Natur- und Freiraumschutz wird herausgearbeitet und als Grundlage für ein nachhaltiges Konzept einer ökonomisch und ökologisch orientierten Lichtkultur genutzt. Ebenso soll durch eine gezielte Analyse untersucht werden, wie einzelne Regionen dieses informelle Instrument für Natur- und Freiraumschutzmaßnahmen nutzen, um z. B. die öffentliche Straßenbeleuchtung ökologisch und vor allem ökonomisch umzurüsten.

Keywords: Naturschutz, Sternenparks, Treibhausgasreduktion, Klimaschutzmaßnahmen, Lichtverschmutzung

2 EINLEITUNG

Der Sternenhimmel ist ein faszinierendes Naturschauspiel, das viele Dichter und Denker inspiriert hat. Lange vor der Erfindung der Glühbirne wurden die Gedanken, die der nächtliche Sternenhimmel auslöste, in zahlreichen literarischen Werken festgehalten.

Diese Schlüsselerfindung, die Glühlampe, war Licht und Schatten zugleich. Während sie Generationen die Möglichkeit zu nahezu unbegrenzter Produktivität bot, galt sie mit ihrem erhellenden Licht in vielen Bereichen der Kulturgeschichte als Symbol für Fortschritt und Wohlstand (Porsch et al. 2013).

Die Menschen der Moderne leben in einer erleuchteten Welt, doch rückblickend muss man feststellen, dass dieser beeindruckende Meilenstein des Erfindergeistes auch der Ursprung der heutigen Lichtverschmutzung ist.

Die anthropogene Aufhellung des Nachthimmels durch künstliche Beleuchtung hat in den letzten Jahren weltweit stetig zugenommen. Neben den vielen positiven Wirkungen des Lichts wird in letzter Zeit immer deutlicher, dass Licht auch negative Seiten hat.

Anthropogene Beleuchtung überlagert nicht nur das natürliche Licht der Himmelskörper, sondern hat auch negative Auswirkungen auf natürliche Nachtlandschaften mit ihrer Tier- und Pflanzenwelt.

In letzter Zeit werden die negativen Auswirkungen auf den Menschen immer deutlicher, denn als eher tagaktive Lebewesen ist es uns von der Natur vorgegeben, nachts zur Ruhe zu kommen und zu schlafen. Jeder weiß aber aus eigener Erfahrung, dass der Schlaf selbst sehr unterschiedlich sein kann. Viele wichtige Körperprozesse laufen nachts ab, es gibt also eine Art „Nachtschicht" im und für den Körper (Natur, 2016). Nur wer tief und fest schläft, fühlt sich wirklich erholt. Doch für viele Menschen ist das nur ein Traum, der immer seltener in Erfüllung geht. Überall vertreibt das anthropogen hervorgerufene Licht die natürliche Dunkelheit, nicht ohne Konsequenz für die Gesundheit des Menschen. Unser Schlaf-Wach-Verhalten wird nicht einfach durch den Wechsel von Hell und Dunkel beeinflusst, oder völlig bewusst durch den Menschen gesteuert, sondern unterliegt dem strengen Diktat einer inneren Uhr, die endogen und autonom für die Steuerung der Zirkadian-Rhythmik verantwortlich ist (Wissen, 2023). Diese Rhythmik hat sich im Laufe der Evolutionsgeschichte weiterentwickelt, mit dem Ziel, den natürlichen Übergang zwischen Hell und Dunkel zu antizipieren, um physiologische und biochemische Prozesse unseres Körpers optimal auf die Rotation abzustimmen.

3 LICHTVERSCHMUTZUNG – WAS IST DAS?

Es ist unbestritten, dass der Mensch heute einen erheblichen Anteil am Ende der Nacht hat. Verantwortlich dafür ist das Phänomen der Lichtverschmutzung. Der Begriff Lichtverschmutzung beschreibt das Phänomen der Aufhellung des Nachthimmels über besiedelten Gebieten durch physikalische Brechungseffekte in der Atmosphäre. Sie breitet sich, wie bereits beschrieben, weltweit aus und hat den Charakter einer „schädlichen Umwelteinwirkung" im Sinne des deutschen Bundes-Immissionsschutzgesetzes (BImSchG). Auch Licht zählt rechtlich zu den Emissionen im Sinne des BImSchG. Mit der Verabschiedung der „Licht-Richtlinie" im Mai 1993 existiert ein konkretes System zur Bewertung der Auswirkungen von Lichtimmissionen auf den Menschen und zur Konkretisierung des Begriffs „schädliche Umwelteinwirkung" im Sinne des BImSchG (BImSchG, 2021).

Durch Reflexionen an Schwebeteilchen in der Atmosphäre kommt es zu einer Streuung des Lichts, die dann die künstliche Aufhellung des Nachthimmels, auch „Skyglow" genannt, „begünstigt" (LRC, 2023). Beispielsweise erhellt das Licht einer konventionellen Straßenbeleuchtung nicht nur die zu beleuchtende Fläche, sondern auch weite Teile der unmittelbar angrenzenden Objekte, bis hin zur unsystematischen Aufhellung des natürlichen Sternenhimmels.

Streng genommen ist der Begriff Lichtverschmutzung eine irreführende Wortbildung, da der englische Begriff „light pollution" wörtlich übersetzt „verschmutztes Licht" bedeutet (Darksky, 2023). Die Quelle der Verschmutzung ist jedoch das Licht selbst, das in die Umgebung abgestrahlt wird. Hierbei handelt es sich um die Verschmutzung der Umwelt durch ein Übermaß an künstlichem Licht unterschiedlicher Intensität, das durch den Menschen verursacht wird.

Vor allem nachtaktive Tiere wie Fledermäuse sind von diesen anthropogenen Störungen ihrer Umwelt besonders betroffen (Svensson, 1998). Beobachtungen haben gezeigt, dass Fledermäuse aufgrund der Lichtverschmutzung ihr Jagdverhalten geändert haben. Unter anderem können sie ihre Quartiere erst später verlassen, da es draußen durch die künstliche Beleuchtung heller ist. Das verkürzt die Zeit der Nahrungssuche und hat langfristige Folgen für die Entwicklung der Tiere und ihrer Nachkommen (Frank & Schmidt, 2015). In einigen Regionen Deutschlands geht das so weit, dass ganze Generationen durch Lichtverschmutzung gefährdet sind. Lichtverschmutzung wirkt sich auch auf die Beutetiere der Fledermäuse aus, denn auch nachtaktive Insekten sind von Lichtverschmutzung betroffen.

Der so genannte „Staubsaugereffekt" an starken Beleuchtungskörpern ist vielen Menschen heute kein unbekanntes Bild mehr (s. Abb. 1)

Abb. 1: Exemplarische Darstellung des „Staubsaugereffektes" (Quelle: WDR, 2023).

4 AUSGANGSSITUATION

Um sich das Phänomen der Dunkelverschmutzung – besser bekannt unter dem aus dem Englischen abgeleiteten Begriff „light pollution" „Lichtverschmutzung" – vorzustellen, legt Abbildung 2 exemplarisch Nachtaufnahmen dar, die vom Luitpoldturm beim Hermersbergerhof (Rheinland-Pfalz, Deutschland) aufgenommen wurden. Mitten im Pfälzerwald gelegen, bietet er einen 360°-Rundblick auf die Umgebung. Während der Himmel über dem Turm noch sternenklar ist, zeigt sich am Horizont der Regionen um Mannheim, Karlsruhe und Straßburg in der Rheinebene sowie Pirmasens und Kaiserslautern in der Pfalz deutlich eine künstliche Aufhellung des Nachthimmels. Mehrere Lichtglocken sind zu sehen, die durch ihre Leuchtkraft die einzelnen Regionen nachts über weite Strecken gut sichtbar machen. Die Lichtsäule bei Ramstein sticht hier deutlich hervor, da durch die besondere technische Anordnung der Leuchten eine massive Aufhellung des Nachthimmels erreicht wird.

Abb. 2: Nachtblick vom Luitpoldturm; ISO:1600, Belichtungszeit: 30 Sekunden, Brennweite: 50mm; eigene Aufnahme.

Am Flughafen der Air Base Ramstein sind die Scheinwerfer unterhalb der Spiegel angebracht. Diese werfen das Licht nach oben, von wo es wieder nach unten reflektiert wird und so die Start- und Landebahn und den „Taxiway" beleuchtet. Bei diesem Vorgang ist jedoch gut zu erkennen, dass sehr viel Licht nach oben in den natürlichen Nachthimmel abgestrahlt wird und diesen fast vollständig erhellt. Diese Beispiele sind jedoch keine Einzelfälle, denn die Aufhellung des Nachthimmels hat in den letzten Jahrzehnten kontinuierlich zugenommen. In einigen europäischen Ländern geht man von einer jährlichen Zunahme der Lichtverschmutzung von bis zu 5 % aus (Porsch et al., 2013).

Diese Zunahme lässt sich durch eine Kombination aus einer steigenden Anzahl von Beleuchtungskörpern und steigender Lichtausbeute der einzelnen Lampen erklären, die in der Regel auch mit einer Zunahme der suburbanen Lichtglocken einhergeht.

Doch woher kommt diese Lichtverschmutzung? Die Langzeitaufnahme einer mit Bodenstrahlern beleuchteten Kirche in Fischbach bei Dahn um 02:00 Uhr nachts zeigt deutlich, dass nur ein kleiner Teil des Lichts den Kirchturm erreicht, der größte Teil aber weit in den Himmel strahlt. Hier wird nicht auf die richtige Helligkeit, Intensität und Dauer des Lichteinsatzes geachtet. Es werden Bereiche beleuchtet, die gar nicht beleuchtet werden müssen. Wenn das Licht nicht gebündelt nach unten oder am Ziel vorbei in den Nachthimmel strahlt, wird es in der Atmosphäre gestreut. Dies führt zu einer Aufhellung des Himmels, die sich wie ein Schleier über den natürlichen Nachthimmel legt. Dadurch werden lichtschwächere Himmelskörper überstrahlt und verdeckt (Händel, 2014; s. Abb. 3).

Abb. 3: Exemplarisches Beispiel der Lichtverschmutzung durch eine nicht zielgerechte Beleuchtung einer Kirche in Fischbach bei Dahn (Quelle: Hänel, 2014).

Einfache Methoden, die Lichtverschmutzung zu reduzieren, sind zum einen eine genauere Ausrichtung des Scheinwerfers, eine Abschirmung zur Vermeidung von Streulicht oder die Montage des Scheinwerfers am Mast, so dass er nach unten strahlt. Zum anderen sollte aber auch überlegt werden, ob die Beleuchtung an dieser Stelle und zu dieser Zeit überhaupt noch notwendig ist, denn eine komplette Abschaltung kann neben dem Schutz der Umwelt auch Strom und Geld sparen.

Nicht nur die Beleuchtung von Gebäuden, sondern auch die normale Straßenbeleuchtung trägt zur Lichtverschmutzung bei. Wie bei der Gebäudebeleuchtung ist auch hier die Ausrichtung entscheidend – auch hier gibt es zahlreiche negative und positive Beispiele der Straßenbeleuchtung. Hierbei wird deutlich, dass Leuchten, die nicht oder nur teilweise nach oben abgeschirmt sind, ein Problem darstellen, da sie den Himmel übermäßig aufhellen.

Wie bei der Gebäudebeleuchtung sollte auch hier über die Lebensdauer nachgedacht und neue Technologien wie Bewegungsmelder in Betracht gezogen werden. Da insbesondere der Großteil der funktionalen Beleuchtung in deutschen, aber auch in europäischen Städten und Gemeinden im Allgemeinen noch aus den 1960er und 1970er Jahren stammt, sind in Ballungsräumen und über Großstädten sehr intensiv strahlende Lichtglocken zu beobachten. Zum Zeitpunkt der Errichtung dieser Beleuchtungen spielten der Umweltschutz und die gezielte Anstrahlung von Objekten eine sehr untergeordnete Rolle. Ziel war es in erster Linie, gut ausgeleuchtete Straßenräume zu schaffen. Hohe Lichtemissionen gehen auch von Flughäfen, Bahnhöfen, Flutlichtanlagen auf Sportplätzen, großen Parkplätzen oder Industrieanlagen aus. All diese Elemente kommen in Ballungsräumen zusammen, was die starke Aufhellung des Himmels in der Umgebung dieser Räume erklärt.

Die für den Menschen sichtbarste Auswirkung der Lichtverschmutzung ist der Verlust des Sternenhimmels über den Städten. Von etwa 3.000 mit bloßem Auge sichtbaren Himmelsobjekten sind über Großstädten

teilweise weniger als 100 sichtbar (Welt der Physik, 2023), was vor allem für die Astronomie ein großes Problem darstellt. Zumindest jedoch viel gravierender sind die Folgen für Flora und Fauna (s. dazu Kap. 3).

5 STAND DER FORSCHUNG

Eine Organisation, die sich für den Schutz der Nacht einsetzt, ist die International Dark Sky Association (IDA). Sie wurde 1988 in den USA als Vereinigung von Astronomen mit dem Ziel gegründet, die Lichtverschmutzung durch den Einsatz vollständig abgeschirmter Beleuchtungssysteme zu reduzieren (Darksky, 2023). Die IDA hat Partnerorganisationen in anderen Ländern und ist die Dachorganisation weiterer nationaler Vereinigungen. Sie zeichnet international Gebiete aus, in denen die Verantwortlichen einen wichtigen Beitrag zum Schutz der natürlichen Dunkelheit leisten. Damit will sie die Bevölkerung und die Öffentlichkeit für das Thema sensibilisieren. Ausgezeichnet werden "*Dark Sky Parks*", "*Dark Sky Reserves*", "*Dark Sky Communities*", "*Dark Sky Sanctuaries*", "*Urban Night Sky Places*" sowie "*Dark Sky Developments of Distinction*" (Darksky, 2023). Solche Sternenparks und Sternenreservate dienen in erster Linie dem Umweltschutz und der Erhaltung des Nachthimmels. Auch in Deutschland gibt es zwei solcher Schutzgebiete - im Westhavelland und in der Rhön. Sternenparks nutzen zusätzlich die touristische Attraktivität der besonderen Lage, während Sternenreservate noch strengere Regelungen zum Schutz von Flora und Fauna in Form von nächtlichen Beleuchtungsvorschriften haben und zudem deutlich größer sind als ein Dark Sky Park.

Dark Sky Communities sind von der IDA ausgezeichnete Städte, die sich besonders für den Schutz des Nachthimmels einsetzen und sich dem Problem der Lichtverschmutzung aktiv annehmen.

Das Biosphärenreservat Pfälzerwald wurde dahingehend untersucht, ob die notwendigen Voraussetzungen für eine Eignung als Dark Sky Park gegeben sind. Dazu wurden zunächst geeignete Mess- und Beobachtungsstandorte gesucht, die einen ausreichend großen Himmelsausschnitt zeigen. Dies erwies sich im dicht bewaldeten Pfälzerwald als besonders schwierig. Die von IDA geforderte Mindestanzahl von zwölf Standorten wurde jedoch ohne Probleme erreicht. Die Eignung der Flächen wurde durch eine Tagesbegehung festgestellt, bevor die Flächenhelligkeit (angegeben in mag arcsec⁻²) nachts vor Ort gemessen wurde. Der von der IDA festgelegte Mindestwert von 20,00 wurde meist erreicht, ebenso Werte über 21,00 (IDA, 2015). Zum Vergleich: Der dunkelste Ort Deutschlands im Westhavelland hat eine Flächenhelligkeit von 21,78. Eine Besonderheit ist, dass die Messungen in der Nähe der Sommersonnenwende durchgeführt wurden. Zu dieser Zeit werden die Nächte von Tag zu Tag kürzer und kurz vor der Wende sinkt die Sonne nicht mehr vollständig unter den Horizont.

Der zweite wichtige Faktor neben den natürlichen Bedingungen ist die Beteiligung der Öffentlichkeit und der Entscheidungsträger. In den IDA-Rahmenbedingungen für Sternenparks ist festgelegt, dass die Gemeinden bestimmte Anforderungen an die Beleuchtung erfüllen müssen. So muss z.B. die gesamte Straßenbeleuchtung innerhalb eines bestimmten Zeitraums an diese Richtlinien angepasst werden.

Es zeigte sich, dass die meisten der untersuchten Gebiete aufgrund ihrer örtlichen Gegebenheiten als Dark Sky Park geeignet sind. Diese Annahme wurde durch ausreichende bis gute Messergebnisse bestätigt. Das Monitoring dieser Gebiete wird derzeit fortgesetzt, um Veränderungen detailliert zu dokumentieren. Gleiches gilt für die Sensibilisierung der Gemeindeverantwortlichen und der Bevölkerung für das Thema Lichtverschmutzung. Denn ineffiziente Lichtquellen einfach abzuschalten, ist für Kommunen schon aus Sicherheitsgründen oft keine Option.. Gefragt sind vielmehr praktische Lösungen und ein innovatives Management des anthropogenen Lichtbedarfs, wie es beispielsweise durch die Einrichtung von Sternenparks bereits umgesetzt wird. Durch den aktiven Schutz natürlicher Nachtlandschaften ergeben sich positive Nebeneffekte, da nicht nur Energie, sondern auch monetäre Mittel eingespart werden.

6 THEORETISCHE HERLEITUNG DER PROBLEMSTELLUNG

Bei dem Versuch einer theoretischen Einordnung von Sternenparks als nachhaltiges informelles und kommunales Steuerungselement für den Natur- und Freiraumschutz kann die aktuelle klima- und umweltpolitische Diskussion sehr gut als übergeordneter Rahmen herangezogen werden. Der Lichtverschmutzung wird in diesem komplexen Wirkungsgefüge auf den ersten Blick keine entscheidende Rolle zugeschrieben. Es lassen sich jedoch sozioökonomische und sozioökologische Zusammenhänge herstellen, deren Bedeutung für die angesprochenen Teilbereiche verblüffend ist. Sternenparks können als ein Element angesehen werden, das die angesprochenen negativen Entwicklungen der unnatürlichen

Aufhellung des urbanen Raumes zwar nicht gänzlich umkehrt, aber in seinem Bemühen um den Schutz natürlicher Nachtlandschaften einen elementaren Beitrag zu einem nachhaltigen Natur- und Freiraumschutz leistet.

7 ZIELSETZUNG UND METHODIK

Die Ursachen der Lichtverschmutzung lassen sich klar benennen. Vor allem die ineffizient geschalteten Beleuchtungssysteme der Kommunen sind für die zunehmende Verschmutzung durch künstliches Licht verantwortlich. Ein Ziel der aktuellen Forschungsarbeit ist es, Sternenparks empirisch zu untersuchen und durch eine gezielte Analyse miteinander zu vergleichen. Der Vergleich soll Aufschluss darüber geben, ob Sternenparks als nachhaltiges informelles und kommunales Steuerungselement für den Natur- und Freiraumschutz in Deutschland und Europa in Frage kommen. Dies soll anhand konkreter Fallbeispiele geschehen. Die Fallbeispiele sollen Aufschluss darüber geben, wie detailliert die Projekte der Sternenparks gerade zu den Themen Lichtverschmutzung, Natur- und Freiraumschutz umgesetzt werden und welche Planungskultur darüber hinaus in den einzelnen Ländern gelebt wird. Die Forschungsarbeit soll damit einen Beitrag zur informellen Regionalentwicklung leisten und innovative Impulse für eine breite Vernetzung und einen Informationsaustausch der Akteure geben. Das Format des Sternenparks als informelles Steuerungselement für den Natur- und Freiraumschutz wird herausgearbeitet und als Grundlage für ein nachhaltiges Konzept einer ökonomisch und ökologisch orientierten Lichtkultur herangezogen. Ebenso soll durch eine gezielte Analyse untersucht werden, wie einzelne Regionen dieses informelle Instrument für Natur- und Freiraumschutzmaßnahmen nutzen, um z.B. die kommunale Straßenbeleuchtung ökonomisch und vor allem ökologisch umzurüsten oder ehemals genutzte Flächen zu rekultivieren, um der Natur wieder Ansiedlungsmöglichkeiten zu geben. Die Ergebnisse sollen am Ende der Forschungsarbeit durch erarbeitete Handlungsempfehlungen ergänzt werden, die für die Arbeit in den Sternenparks in den nächsten 10 bis 15 Jahren hilfreich sein können.

Im Rahmen des Projektes werden verschiedene Kategorien von Sternenparks, vor allem in Deutschland und Europa, aber auch einige ausgewählte internationale „Dark Sky Parks", die von der „International Dark Sky Association" anerkannt sind, identifiziert, beschrieben und bewertet. Darüber hinaus sollen aus der Analyse der unterschiedlichen Parkkonzepte (DSP, DSC, DSR; s. Kap. 5) Handlungsempfehlungen für die Praxis abgeleitet werden.

In diesem Zusammenhang ist es auch notwendig, die unterschiedlichen Planungssysteme und Planungskulturen der jeweiligen Länder, in denen sich die potentiell zu untersuchenden Sternenparks befinden, miteinander zu vergleichen. Es soll dargestellt werden, wie in den einzelnen Ländern die Planung speziell für den Bereich der Sternenparks zielgerichtet durchgeführt wird. Denn planungskulturelle Unterschiede ergeben sich vor allem aus den rechtlichen Rahmenbedingungen des jeweiligen Landes und den unterschiedlichen raumstrukturellen Gegebenheiten der jeweiligen Regionen. Der Schwerpunkt des Vergleichs, die spezifische planerische Identität, soll auf den Ländern der untersuchten Sternenparks liegen.

8 ERSTE ERKENNTNISSE

Die Einrichtung eines Sternenparks als informelles Steuerungselement für den Natur- und Freiraumschutz im Biosphärenreservat Pfälzerwald wäre theoretisch möglich. Die praktische Umsetzung ist jedoch mit erheblichem Aufwand verbunden, da viele Kommunen bereits vor einigen Jahren ihre kommunale Straßenbeleuchtung auf LED umgestellt haben, allerdings mit Leuchten, die eine Etablierung erschweren. Diese entsprechen in der Regel nicht den Anforderungen der IDA. Eine weitere Umstellung wird daher in den nächsten Jahren nicht ohne enormen finanziellen Aufwand möglich sein. Auch die Akzeptanz in der Bevölkerung wird kaum vorhanden sein, da diese den derzeitigen Bestand bereits durch Steuerbeiträge mitfinanziert hat. Dennoch sollten gerade diese Leuchten langfristig durch nachtsichttaugliche Beleuchtungssysteme ersetzt werden.

Es gibt jedoch Orte, an denen eine ökologisch und ökonomisch sinnvolle Umrüstung auf LED durchgeführt werden kann. Diese Orte sollen identifiziert und die Bevölkerung durch Fachvorträge über die Möglichkeiten einer sternenparkfreundlichen Umrüstung der Beleuchtung informiert werden. Nahegelegene Freiflächen, die eine Mindestgröße (etwa die Größe eines Fußballfeldes) aufweisen, werden anhand eines standardisierten Formulars nach den geforderten Kriterien auf ihre Eignung untersucht. Auf diese Weise können alle in Frage kommenden Flächen miteinander verglichen werden. Um eine zusammenfassende und objektive Aussage

treffen zu können, ist die Vergleichbarkeit der Datensätze von elementarer Bedeutung. Dementsprechend wurden im Projekt verschiedene Ansätze gebündelt und für alle vereinheitlicht.

Als Beispiel wird hier die Gemeinde Horbach (Pfalz) im Landkreis Südwestpfalz (Rheinland-Pfalz) betrachtet. Der Ort liegt am Übergang des Pfälzerwaldes zur Sickinger Höhe am westlichen Rand des Biosphärenreservats Pfälzerwald. Die Gemeinde ist derzeit dabei, die gesamte veraltete Straßenbeleuchtung planerisch umzustellen. Dieser Prozess soll aufgegriffen werden, jedoch nicht nur aus rein wirtschaftlichem Interesse, sondern vielmehr unter dem innovativen Aspekt des Einsatzes einer ökologisch modernisierten, „sternengemeindetauglichen" LED-Umstellung.

Im Zuge einer Ortsbegehung wurde eine potentielle Fläche zur Ausweisung als „Sternenbeobachtungsfläche" identifiziert. Sollte die Umrüstung nun erfolgen und der Antrag auf Anerkennung als „Dark Sky Community" durch die IDA erfolgreich sein, könnte hier bald ein Lichtschutzgebiet ausgewiesen werden, in dem ein aktiver Beitrag zum Natur- und Freiraumschutz geleistet werden kann (s. Abb. 4).
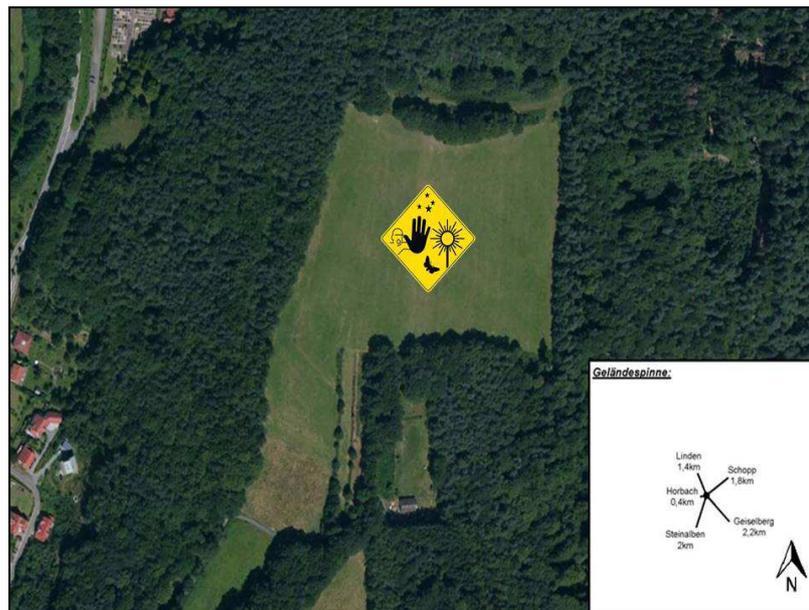
Abb. 4: Untersuchungsfläche in Horbach/ Pfalz (Quelle: Eigene Darstellung nach Google.de/maps, 2023).

Die Hürden der IDA sind mittlerweile sehr hoch. Es wird den Regionen sehr viel schwerer gemacht, eine entsprechende Anerkennung zu erhalten. Dennoch gibt es regionale Ideen zur Reduzierung von Lichtemissionen. Generell sollte jede Art von anthropogener Beleuchtung in dunklen Gebieten vermieden werden. Hier zeigt sich, dass es in den verschiedenen Regionen auch eigene, sehr heterogene Ansätze gibt. Eine Vielzahl unterschiedlicher Richtlinien und Vorgaben zur Erlangung der Zertifizierung als „Nachtfreundliche Gemeinde oder Region" sorgt für viel Verwirrung. So gibt es beispielsweise im Untersuchungsgebiet des Biosphärenreservats Pfälzerwald das Zertifikat „Gemeinde unter den Sternen" - unterteilt in die Kategorien Bronze, Silber und Gold (Pfälzerwald, 2023). Die Voraussetzungen für ein solches Zertifikat sind im Vergleich zu IDA weniger anspruchsvoll, dennoch gibt es derzeit nur eine „Gemeinde unter den Sternen" mit dem Status Silber - Rumbach. In der Gemeinde gibt es zwei Plätze, die zum Sternengucken einladen und somit im Zuge der Forschungsarbeit in den Fokus des aktiven Natur- und Freiraumschutzes gerückt sind.

Eine weitere Erkenntnis der Sternenparks bzw. des Forschungsprojektes zum Schutz der natürlichen Nacht ist die Multifunktionalität der natürlichen Dunkelheit. Die Interessen der vielen verschiedenen Akteure an der Reduzierung der Lichtverschmutzung und der Wiederherstellung bzw. Erhaltung der natürlichen Nachtlandschaft sind sehr unterschiedlich. Astronomen wünschen sich eine gute Sicht auf den Sternenhimmel, Umwelt- und Naturschützer versuchen, lichtempfindliche Tier- und Pflanzenarten vor anthropogenen Lichtquellen zu schützen, während Touristen Übernachtungsplätze mit möglichst geringem Lichteinfall suchen, um einen gesunden Schlaf und die Erholung des Körpers zu fördern. Unter Berücksichtigung dieser unterschiedlichen Interessen würde sich die Lage eines „Lichtschutzgebietes" von Fall zu Fall sehr unterschiedlich darstellen.

Im Idealfall überschneiden sich die Interessen der verschiedenen Akteure auf ein und derselben Fläche. So ist eine Fläche mit guter Sicht nach Süden für Astronomen zur Beobachtung des Sternenhimmels geeignet und gleichzeitig aus ökologischer Sicht eine Fläche, die vor Lichtverschmutzung geschützt werden muss.

9 FAZIT

Das Ausmaß der Umweltbelastung durch anthropogene Lichtemissionen wird durch eine Reihe schädlicher Umwelteinflüsse bestimmt. Lichtverschmutzung hat dabei einen starken Einfluss auf die Entwicklung von Fauna und Flora sowie auf die menschliche Gesundheit. Die bisherigen Erkenntnisse zeigen, dass es kumulative Zusammenhänge gibt, die sich in unterschiedlichem Ausmaß direkt auf einzelne Bereiche oder komplex auf mehrere Bereiche auswirken können. Die Tatsache, dass Licht in der modernen Architektur auch ein gestalterisches Element ist, wird bei der Betrachtung des Themas berücksichtigt. Der architekturgestalterische Aspekt des Lichts wird von Kommunen nicht nur touristisch genutzt, um Sehenswürdigkeiten marketingtechnisch ins „rechte" Licht zu rücken, sondern spielt auch für das individuelle Sicherheitsempfinden der Bevölkerung und die Ausleuchtung öffentlicher Plätze und Räume eine zentrale Rolle. Hier kann ein Ansatzpunkt für den Natur- und Freiraumschutz liegen, denn das vorhandene Potenzial sollte von den Kommunen bewusst gesteuert und genutzt werden.

Die derzeit angespannte finanzielle Situation vieler Kommunen erlaubt eine intensive Auseinandersetzung mit dem Thema „Sternenpark" und eine damit verbundene kontinuierliche planerische Bearbeitung. Der aktuelle russische Angriffskrieg veranlasst viele Kommunen, ihre noch aus den 60er und 70er Jahren stammende Straßenbeleuchtung zu überdenken und eine rasche Umrüstung auf LED vorzunehmen - einerseits aus rein wirtschaftlichen Gründen, andererseits aber auch mit dem positiven Nebeneffekt der Reduzierung der Lichtverschmutzung.

Die Sensibilisierung der breiten Öffentlichkeit für das Thema Lichtverschmutzung und den ressourcenschonenden Umgang mit Energie und natürlicher Dunkelheit wurde vor einigen Jahren noch mühsam durch Vorträge versucht. Durch die aufkommende Problematik der Energiekrise rücken die oben genannten Themen immer mehr in den Fokus, so dass u.a. Kommunen in Zukunft nicht mehr umhinkommen werden, den Energieverbrauch zu reduzieren. Denn ein wenig Verzicht wäre in vielen Bereichen gar nicht so schwer, da der Großteil der Bevölkerung diese Einschränkung gar nicht wahrnehmen würde, sondern sie einfach ignoriert.

10 LITERATURVERZEICHNIS

BIMSCHG (2021): §3 Abs. 2 BImSchG zu Immissionen und gemäß § 3 Abs. 3 BImSchG zu Emissionen.

DARKSKY (2023): http://darksky.org/light-pollution (letzter Zugriff: 22.05.2023).

FRANK, S. & SCHMIDT, M. (2015): Der Wert der Nacht für die Natur in Sternenpark Rhön – Warum der Schutz der Nacht Menschen und Natur so gut tut; Parzellers Buchverlag, pp. 22-23.

HÄNEL, A. (2014): Lichtverschmutzung im Osnabrücker Raum. In: Veröffentlichung des Naturwissenschaftlichen Vereins Osnabrück, Band 39/40, Strube Druck & Medien OHG, pp. 13-32.

IDA (2015): International Dark-Sky Association: Dark Sky Park Programm Guidelines.

LRC (2023): http://www.lrc.rpi.edu/programs/nlpip/lightinganswers/lightpollution/skyGlow.asp (letzter Zugriff: 22.05.2023).

NATUR – DAS MAGAZIN FÜR NATUR, UMWELT UND BESSERES LEBEN (2016): Nachtschicht im Körper, Ausg. März, pp. 72

PFÄLZERWALD (2023): https://www.pfaelzerwald.de/blog/sternenpark/das-zertifikat-gemeinde-unter-den-sternen/ (letzter Zugriff: 22.05.2023).

PORSCH, T., HÖLKER, F., UHLMANN, T. (2013): Das Ende der Nacht. Lichtsmog: Gefahren – Perspektiven – Lösungen, pp. 7.

SVENSSON, R.J. (1998): Mercury vapour lamps interfere with the bat defernce of tympanate moths (Operophtera spp.; Geometridae). In: Animal Behaviour, 55 (1), pp. 223-226.

WDR (2023): http://neuneinhalb.wdr.de

WELT DER PHYSIK (2023): https://www.weltderphysik.de/gebiet/erde/nachrichten/2023/lichtverschmutzung-die-sterne-am-nachthimmel-verschwinden/ (letzter Zugriff: 21.05.2023).

WISSEN (2023): http://www.wissen.de/medizin/zirkadianer-rhythmus (letzter Zugriff: 16.05.2023).

224

REAL CORP

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Digitales Parken der Zukunft – Planungen zu einem Reallabor auf dem Campus der Universität der Bundeswehr München

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1 ABSTRACT

Im Rahmen des dtec.bw -Forschungsprojekts MORE partizipiert die Professur für Raumplanung und Mobilität mit einem Destillat aller seiner infrastrukturellen und raumplanerischen Forschungsüberlegungen: Das Leuchtturmprojekt „digitales Parken der Zukunft", vorgesehen auf dem Campus der Universität der Bundeswehr München (UniBw M), um vor Ort am realen Objekt forschen zu können.

Dieser Reallabor-Demonstrator setzt sich aus den im Rahmen des dtec.bw-Forschungsprojekts MORE erforschten Komponenten der Professur zusammen:

- Nachhaltiges (Verkehrs-)Flächenmanagement, Flächeneffizienz und -gerechtigkeit

- Elektromobilität mit Sektorenkopplung

- Räumliche Implikationen der Digitalisierung von Mobilität und Verkehr/autonomes Fahren

- Multimodale Anknüpfungspunkte/Mobilitätshubs im urbanen Raum

- Emotionale Mobilität/gesellschaftlicher Wandel

- Beschleunigte Umsetzung von Baumaßnahmen der Bundeswehr

Die Erkenntnisse sollen dabei sowohl intern, durch weitere MORE-Forschungsaspekte, wie auch extern, durch Partner in Wirtschaft und Forschung, validiert und erweitert werden. Mit den im gemeinsamen Institut verankerten Professuren für Intelligente, multimodale Verkehrssysteme und Verkehrstechnik, den Professuren für Fahrzeugantriebe und für Elektrische Energieerzeugung & -verteilung sowie dem Institut für Technik autonomer Systeme demonstriert dieses wegweisende Reallabor die facettenreiche und engverzahnte Forschungsanwendung des MORE. Gemeinsam mit den Partnern aus der Wirtschaft, BwFuhrparkService (BwFPS) als Mobilitätsdienstleister der Bundeswehr, Daimler AG (Elektrifizierung, Automatisierung Pkw und Nfz), JACOB Elektronik GmbH (digitale Mess- und Leittechnik), SOPAGO GmbH (Solar Carports mit Ladeinfrastruktur) und VePa Vertical Parking GmbH (automatisch gesteuerte, kompakte Parksysteme) wird intensiv interdisziplinär kooperiert und eine weitgehende und umfangreiche detaillierte Planung mit mehreren Varianten erstellt. Weiterhin sollen zudem neueste und zum Teil zukunftweisende Technologien zum Einsatz gebracht und die Erkenntnisse unmittelbar im Demonstrator auf Alltagsfähigkeit erprobt werden. Den Anforderungen an flächensparendes Bauen und an die Anpassung an die Folgend es Klimawandels soll zudem Rechnung getragen werden, indem vorhandene versiegelte Flächen nachhaltig entwickelt werden.

Es wurden insgesamt vier Hauptvarianten entworfen, die an unterschiedlichen Stellen auf dem Campus Aufschluss zu den zahlreichen gemeinsamen grundsätzlichen Fragestellungen, aber auch individuellen Besonderheiten am jeweiligen Mikrostandort geben. Nachfolgend werden die vier Varianten mit ihren Gemeinsamkeiten und Unterschieden dargestellt.

Keywords: Nachhaltigkeit, Parkraum, Digitalisierung, Verkehrsmanagement, Verkehrsflächenmanagement

2 VARIANTE 1

In einem Innenhof karreeartig angeordneter Gebäude ist auf einer bisher extensiv genutzten Verkehrs-/Grünfläche (ca. 5.000 m²) ein neues Büro- und Verwaltungsgebäude entstanden. Die verbleibenden 3.000 m² Fläche (Abbildung 1, orange Markierung) soll aufgewertet und nach modernsten Erkenntnissen flächensparend zu einem digital-vernetzten Parkraum entwickelt werden. Im Sinne der Nachhaltigkeit soll der Versiegelungsgrad dabei minimiert und der Anteil an hochwertiger Grün-/Freifläche maximiert werden, sodass die Anrainer künftig nicht nur auf eine „Asphaltwüste mit Blechlawine" blicken müssen.

Abbildung 1: Standort des Demonstrators Variante 1 | Kartengrundlage: Google Maps (2020)

Der von Grund auf neu gestaltete, attraktive Innenhof liegt in unmittelbarer Nähe zur Hauptwache der Liegenschaft. Diese stellt den primären Zutrittspunkt für Gäste, Mitarbeitende und Studierende auf den Campus der Universität der Bundeswehr dar. Zusätzlich liegt der Gebäudeblock, der die zu entwickelnde Fläche umschließet, an der Schnittstelle vom Außenbereich der Liegenschaft, zu welchem alle Fahrzeuge Zufahrt haben, zum verkehrsberuhigten Innenbereich, zu dem leidglich ein beschränkter Kreis an Beschäftigten, Gästen sowie Liefer- und Dienstfahrzeugen Zufahrt mit Kraftfahrzeugen hat.

Ein geplanter Mobilitätshub ermöglicht an dieser exponierten Lage den Übergang von motorisiertem Individualverkehr zu den Microsharing- und Campusshuttle-Angeboten der letzten Meile auf dem Campus. Mit deren Hilfe lassen sich sowohl die zentral gelegenen Lehr-, Labor- und Verwaltungseinrichtungen wie auch randlich gelegene Sport- und Forschungsanlagen sowie Unterkunfts- und Stabsgebäude in Minutenschnelle erreichen. Beispielhaft seien an dieser Stelle genannt:

Campus-Destination	Entfernung
Bibliothek	700 m
Fahrbereitschaft/BwFPS (Abholpunkt für Dienst- und Leihfahrzeuge	650 m
Hauptwache	150 m
Hörsaalzentrum/Audimax	750 m
Laborgebäudekomplex 35	375 m
Laborgebäudekomplex 80	1.000 m
Mensa/Truppenküche/Restaurant	800 m
Präsidialbereich/Zentrale Verwaltung	450 m
Rechenzentrum	250 m
Schwimmhalle	550 m
Sportanlagen mit 400 m-Bahn, Groß- und Kleinspielfeldern u.v.m.	725 m
Sporthalle mit Kraftraum (Innenbereich)	300 m
Unterkunftsbereich/Stabsbereich	975 m
Offiziercasino	450 m

Tabelle 1: Entfernungen vom Demonstrator Variante 1 zu Campus-Destinationen (Fußwegebeziehung)

Insgesamt sollen auf der Fläche etwa 40 Stellplätze entstehen. Gemäß den aktuellen Vorgaben aus EU-Richtlinien und deutscher Gesetzgebung sollen min. 25 % der Stellplätze elektrifiziert werden, davon zwei Ladepunkte ausgebildet als Ultraschnelllader (HPC, min. 100 kW-Ladeleistung). Die übrigen Ladepunkte sollen aus einem Mix mit unterschiedlichen AC-/DC-Ladetechniken ausgestattet werden.
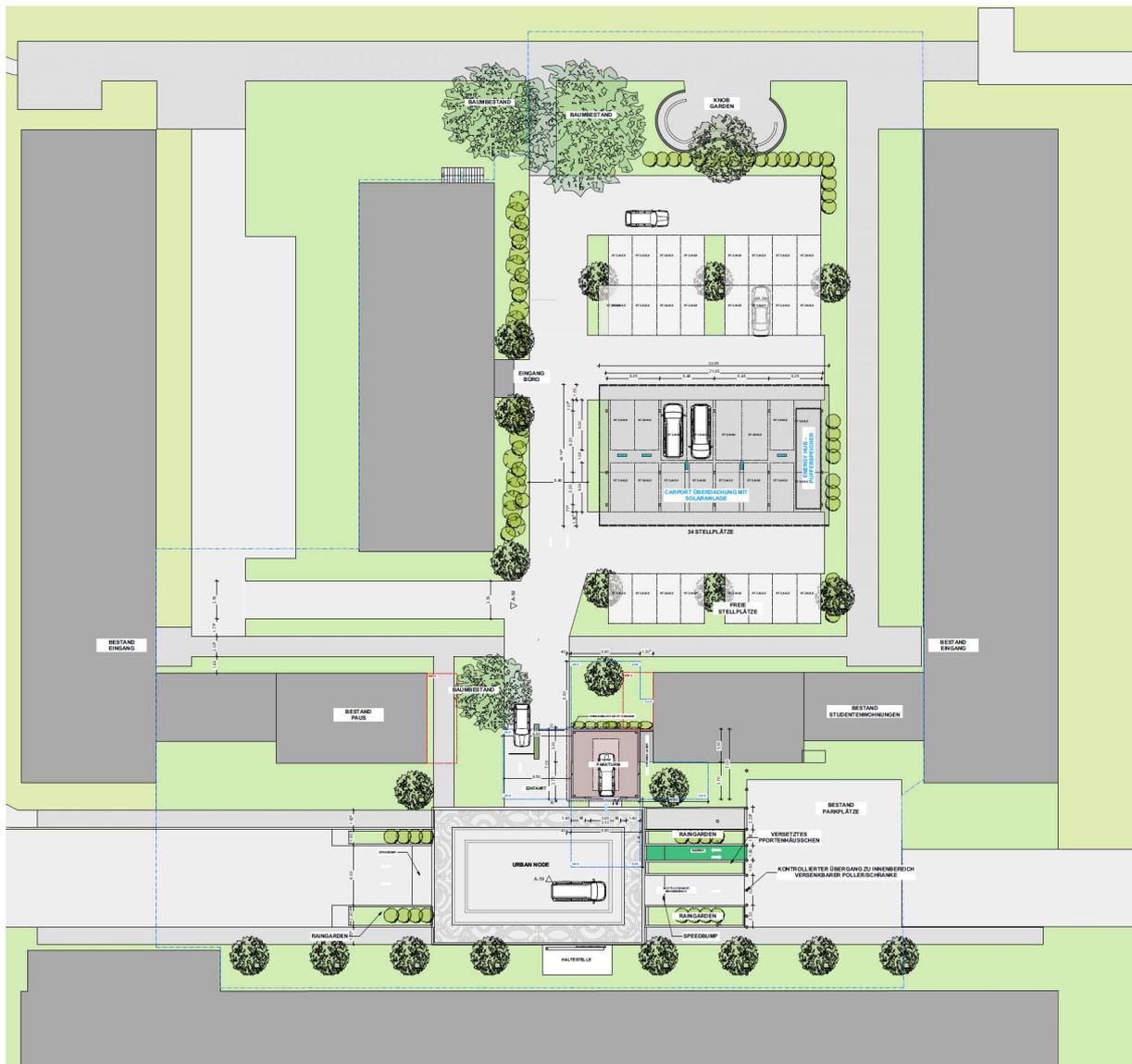
Abbildung 2: Entwurfsplanung Variante 1 (2021)

Besonderer Fokus soll auf zukunftsgewandte Technik und Schnittstellen gerichtet werden. Alle Ladepunkte werden mittels smartem Lastenmanagement vernetzt und erfüllen mindestens den Standard OCPP 1.6 (sofern verfügbar OCPP 2.0) und die Anforderungen der ISO 15118 (insb. bidirektionales Laden). Die gesamte Fläche wird ergänzend mit modernster Sensorik zur Erfassung von fließendem und ruhendem Verkehr überlagert, um Informationen zu freien Stellplätzen und Ladepunkten sowie Stromgewinnung/-speicherung zu liefern.

Neben Ladeinfrastruktur und regenerativer Stromerzeugung sind auch dezidierte Parkplätze für das Quartiers-Carsharing (gemeinschaftliche Langzeitnutzung) vorgesehen. Diese können in einem Parkturm weithin sichtbar sein (Verfügbarkeiten). Als architektonische Dominante des Demonstrators sind hier weitere zwölf Parkpaletten bzw. eine weitere, vertikal angeordnete Doppelparkreihe untergebracht. Ein automatisch gesteuertes Parksystem, ergänzt mit (automatisierter) Ladeinfrastruktur sitzt auf einem Übergabepunkt für autonomes Parken (vgl. Automated Valet Parking des Mercedes-Benz-Museum, Stuttgart).
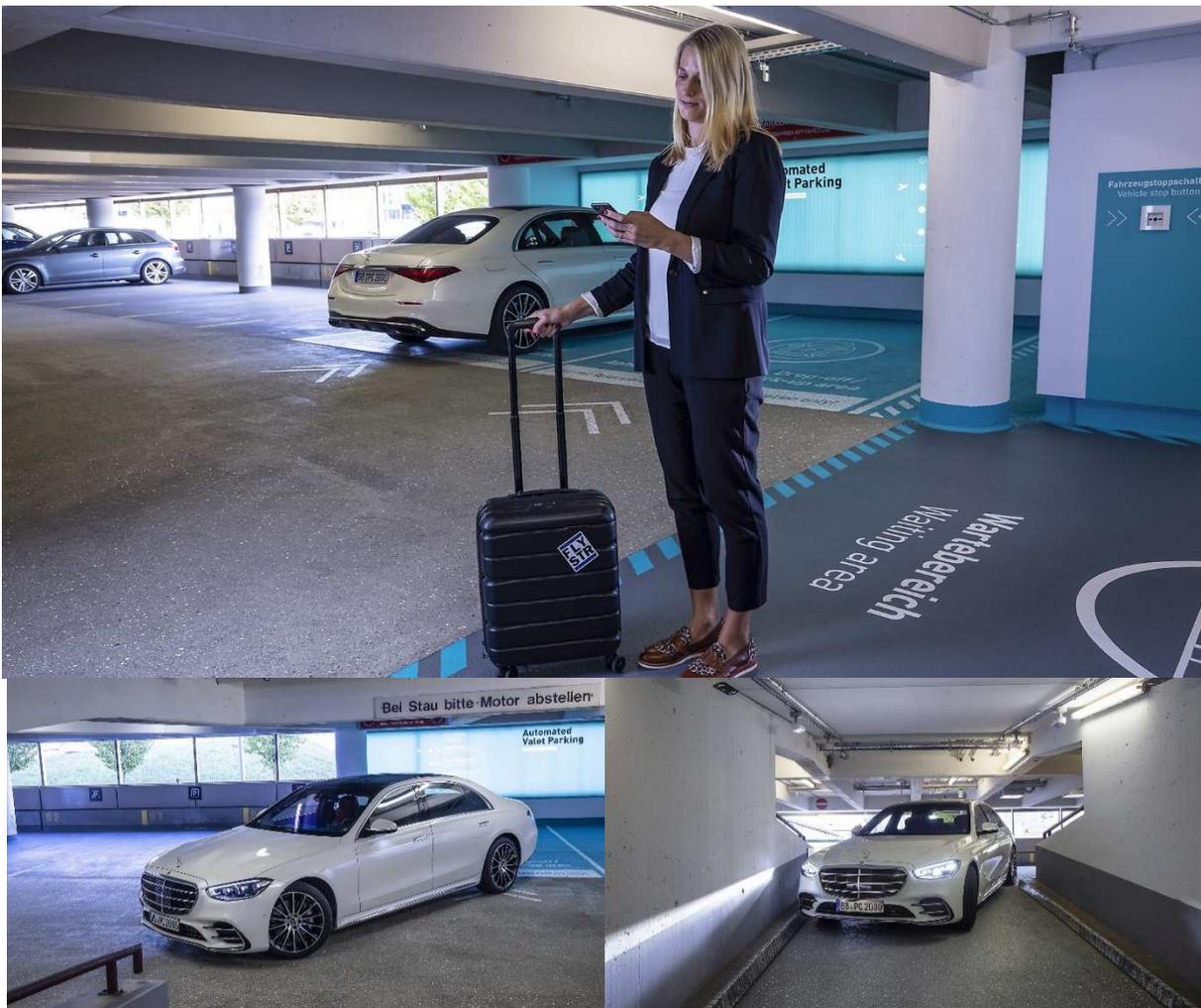
Abbildung 3: Mercedes-Benz Fahrzeug parkt aus und navigiert selbstständig durch ein Parkhaus | Quelle: Daimler AG (2021)

Ein Shared Space am Fuß des Turmes definiert einen Haltepunkt für das autonome Campusshuttle und den Mobilitätshub mit Übergang zur Micromobilität der letzten Meile (Fahrrad, Lastenrad, eBike, eScooter etc.).

Abbildung 4: Blick über den Shared Space mit Haltepunkt für autonomes Shuttle (Stand 2021)

228

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Abbildung 5: Ansicht Innenhof mit Carports (Stand 2021)

Zur Überbrückung von Strom-Angebots-/Nachfrageungleichgewichten wird die gesamte Anlage mit einem hochmodernen Stromspeicher ausgestattet. Dieser speichert überschüssigen Strom der Peakstunden und gibt diesen in Phasen niedriger Erträge (bedeckter Himmel, Nachtstunden) wieder ab.

3 VARIANTE 2

Nach der Festlegung des Standorts der Variante 1 wurde eine weitere Variante entwickelt, die sich einem bereits laufenden Genehmigungsprozess einer Baumaßnahme am Haupttor des Campus anschließen soll. Damit soll ein langer Verwaltungsakt vermieden und eine zeitnahe Realisierung gesichert werden.

Abbildung 6: Ansicht Haupteingang UniBw M, Universitätsstraße

Ein dafür aufgestelltes, neues Konzept sieht vor, die Stellplatzkapazität an der Hauptwache zu erhöhen, um den Besucher- und Lieferverkehr besser steuern zu können. Dazu wird die Variante 2 an der westlichen Seite des derzeit bestehenden Besucherparkplatzes, der 26 Stellplätze umfasst, geplant.
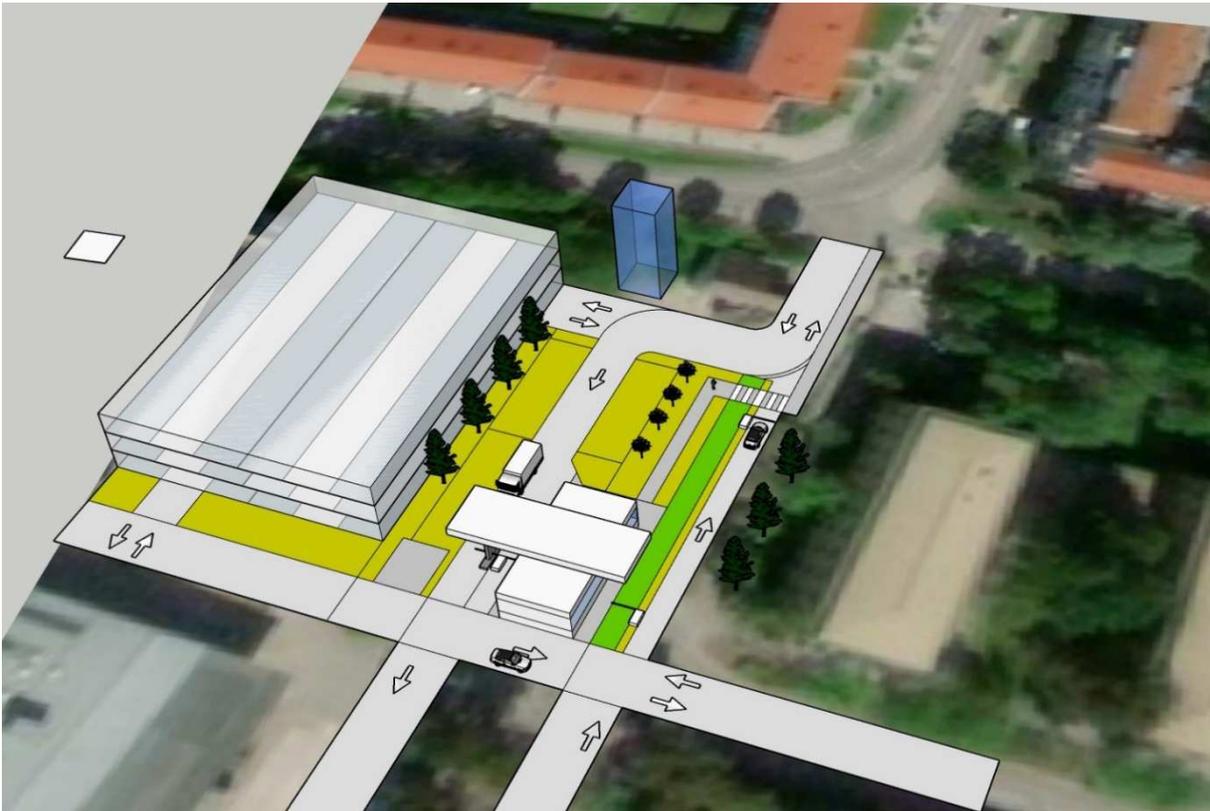
Abbildung 7: Planung für Demonstrator Version 2 am Haupteingang der UniBw M (Stand 2022)

- Um die temporäre Überlastung des Haupttors durch Liefer- und Besucherverkehr zu vermindern und um die verschiedenen Verkehrsströme zu entflechten, wurde durch das Team der Professur Raumplanung und Mobilität eine gesamtheitliche Umplanung des Haupttor-Areals durchgeführt. Wichtige Bausteine dieser Umplanung sind:

- Separate Verkehrsführung aus Richtung der Zubringerstraße für einfahrenden Verkehr

- Kontrollstelle der Hauptwache auf Fahrerseite, dadurch verbesserte Kontrollmöglichkeit

- Schaffung von mehr Kontrollkapazität zu Spitzenzeiten

- Trennung von Lieferverkehr und Personenverkehr durch separate Schranken und Fahrstreifen

- Separater Fahrradstreifen an der bisherigen Einfahrt für beidseitigen Verkehr (vgl. Abb. 7, grün dargestellt)

- Verminderung von Konfliktpunkten mit Schwerlastverkehr und Fahrrädern

- Neuer Fußgängerweg zur Hauptwache, der nur einen Radstreifen und den ausfahrenden Verkehr queren muss

- Weiterleitung des Verkehrs Richtung Liegenschaftsmitte/Hauptparkplatz parallel zur vorhanden Verkehrsachse zur Verminderung des bisherigen Konfliktpunkts unmittelbar nach dem Wachgebäude

- Parkturm (vgl. Abb. 7, blau dargestellt) am Rand der Liegenschaft als Leuchtturmprojekt schon von außen gut sichtbar

- Individuelle Anpassungsmöglichkeit der Parkturmfassade an Bedürfnisse und Gestaltungswünsche der Universität

- Symbolcharakter und Orientierungspunkt durch Höhe des Parkturms

Bei der Planung dieser Variante war auch der Parkturm-Hersteller VePa unterstützend wirksam und hat sofort auf die wechselnden Ansprüche reagieren können. Insbesondere Anforderungen an die militärische Sicherheit haben sich jedoch hemmend auf die bauliche Realisierung ausgewirkt.

4 VARIANTE 3

Durch den Beauftragten für Sonderinfrastruktur der UniBw M wurde an anderer (dezentraler) Stelle des Campus eine kompakte Lösung gesucht. Nach intensiver Planung und Schnittstellenkoordination mit den zuständigen Verwaltungs- und Baubehörden sollte ein Nachtrag zu einer bereits in der Ausführung befindlichen benachbarten Baumaßnahme umgesetzt werden.

Im zufahrtsbeschränkten Innenbereich der Liegenschaft steht ein kleines Baufeld zur Verfügung, welches mit einer stark reduzierten Version eines Demonstrators bebaut werden kann. Da der Umfang des Demonstrators Variante 3 baulich weniger anspruchsvoll ist als die beiden ersten Varianten, wurde großes Potenzial in einer zügigen Errichtung und Inbetriebnahme gesehen.
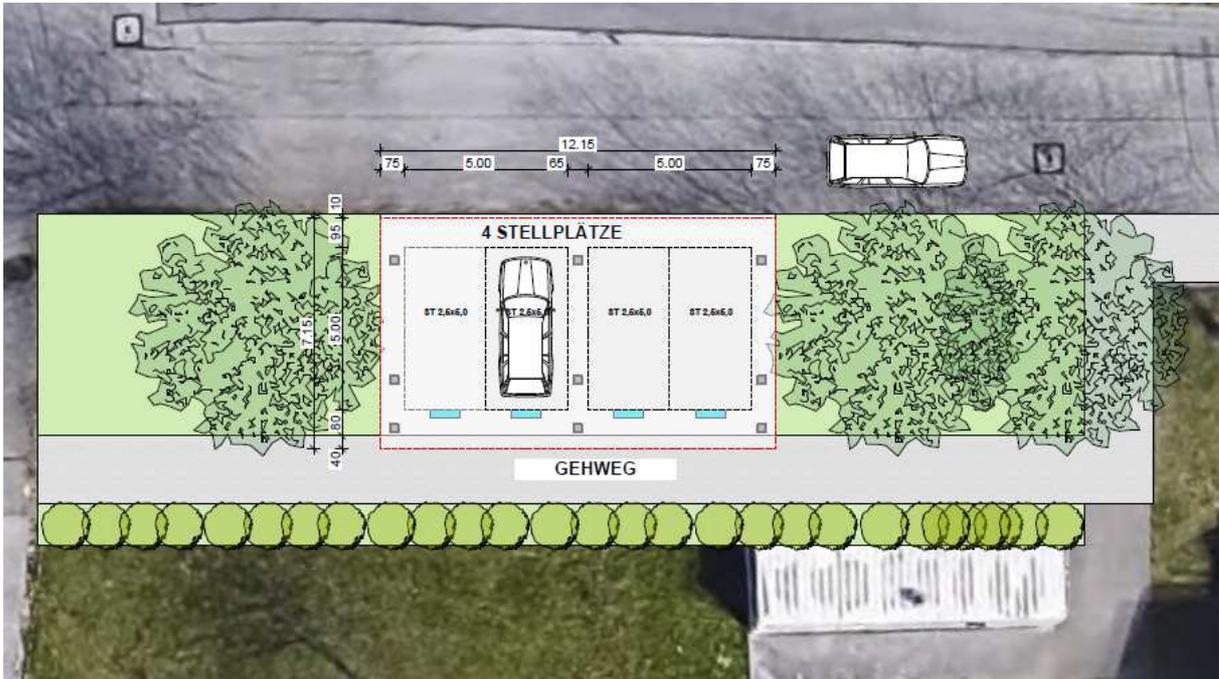
Abbildung 8: Vorplanung Demonstrator Variante 3 (Stand 2022)

Abbildung 9: SOPAGO Solar-Carport | Quelle: sopago.org, Abbildung verändert (Stand 2022)

Das Baufeld ermöglicht den Bau eines Solarcarports von vier bis maximal sechs Stellplätzen und bedient wichtige und zielbedeutsame Bausteine wie den vorgelagerten „Shared Space" und den vertikalen Parkturm nicht, solange die umgebende Flächennutzung nicht umfassend verändert wird. Um zumindest die Aspekte einer Ladeinfrastruktur mit eigenerzeugtem Ladestrom zu untersuchen, wurde nach einem Hersteller gesucht, der als Generalunternehmer eine Lösung für einen Solarcarport mit integrierter Ladeinfrastruktur anbieten bzw. liefern und errichten kann. Variante 3 ist somit als Minimallösung zu verstehen, die modular erweiterbar ist.

Das Münchner Unternehmen SOPAGO bietet ein System mit bifokalen Solarelementen mit Ost-West-Ausrichtung an und wäre dank smarter Materialketten auch binnen kurzer Frist liefer- und baufähig. Das umfangreich recherchierte modulare System steht in Drei- und Vier-Stellplatz-Modulen zur Verfügung, die ohne Linien- oder Flächenfundamente errichtet werden können. Das System wird mittels Schraubfundamenten im Boden verankert, welches auch bei einem möglichen Rückbau keinerlei bleibende Schäden im Erdreich hinterlässt. Lediglich elektrische Zuleitungsschächte und die gewünschte Parkplatzoberflächen müssen im Vorfeld erstellt werden. Zusätzlich wird so versickerungsfähiger Grund erhalten und durch die lichtdurchlässigen Solarelemente können auch extensiv begrünte und bewachsene Flächen überdacht werden.

Zu den Vorteilen dieser Variante gehören unter anderem:

- Keine Betonfundamente notwendig
- Modularer Aufbau als Drei- oder Vier-Stellplatz-Module möglich
- Mehr Tageslicht durch bifokale Solarelemente
- Teilversiegelter, wasserdurchlässiger Boden möglich
- Begrünung unter Carport möglich
- Durchfahrtshöhe für Forschungsvorhaben/Forschungsfahrzeuge kompatibel
- Integrierte Ladeinfrastruktur

5 VARIANTE 4

Das erarbeite Gesamtkonzept der Variante 3 wurde der Verwaltung zur Durchführung der Beschaffung vorgelegt. Nachdem dieses Konzept gut realisierbar schien, waren der räumlich weniger gut gelegen und kleiner als ursprünglich angedachte Standort erneut überdacht. Dafür wurde kurzfristig ein größeres Baufeld in rund 100 Metern Entfernung vorgeschlagen. Dabei handelt es sich um ein derzeit als unstrukturierte Parkplatzfläche genutzten, gepflasterten Bereich zwischen zwei Straßen im Innenbereich der Liegenschaft. Erneut wurde von Seiten der Professur für Raumplanung und Mobilität das bereits entwickelte und verfeinerte Planungskonzept über das neue potenzielle Baufeld gelegt und detailliert in 2D-Karten und 3D-Ansichten ausgearbeitet.

Ein besonderes (neues) Merkmal der Forschungsplanung lag dabei in der Beurteilung der am Standort vorhandenen Begrünung. Diese wurde als ökologisch wenig wertvoll klassifiziert. Durch den bei allen Varianten geplanten reduzierten Verkehrsflächenverbrauch kann der Verlust einzelner Grünelemente durch eine für die Forschung gleichsam große Betrachtungsdauer zu ermöglichen, wurde diese Variante 4 in drei Bauphasen ausgeplant. Dies erlaubt eine zeitversetzte Realisierung jeder einzelnen Phase mit den bereits aus Variante 3 bekannten modularen Solar-Carports.
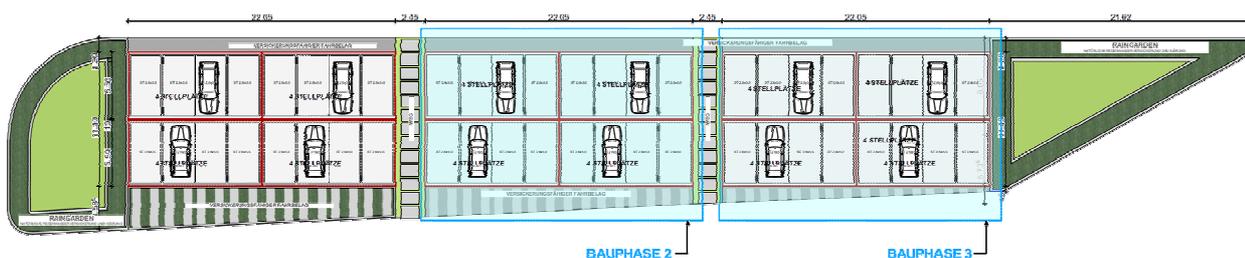
Abbildung 10: Vorplanung Demonstrator Variante 4 (Stand 2022)

Bauphase 1

- 16 Stellplätze mit vier Carport-Modulen à vier Stellplätzen
- Photovoltaik-Elemente auf dem Carport
- Ladeinfrastruktur für Elektrofahrzeuge inkl. intelligentem Lademanagement und Abrechnungssystem
- 32 Stellplätze auf teilversiegelter Parkplatzfläche als Vorbereitung für spätere Überdachung
- ortsnahe Niederschlagsversicherung in ökologisch aufgewerteten Randbereichen

Bauphase 2 und 3

- je 16 weitere Stellplätze mit Carport-Modulen (Überdachung der freien Bestandsstellplätze aus Bauphase 1 bzw. 1 und 2)

6 AUSBLICK

Da eine Solar-Carportanlage mit Elektroladeinfrastruktur auch unabhängig von den MORE-Forschungsinteressen als sinnvolle und notwendige Investition am Campus der UniBw M angesehen wird, bestehen große Chancen, dass sich diese Baumaßnahme auch in anderen Bundeswehr-Liegenschaften realisieren lassen. Die bisher geleisteten planerischen und wissenschaftlichen Untersuchungen zur Standortfindung und architektonischen Entwürfe haben eine hohe Wertigkeit für eine nachhaltige Verkehrs- und Raumplanung an der UniBw M. Mit den gewonnenen Erkenntnissen können auch zukünftig infrastrukturelle Maßnahmen der Bundeswehr planerisch unterstützt und ausgerollt werden. Da alle Entwurfsarbeiten als virtuelle Variante im VR-Labor der Professur zur Verfügung stehen, können gemeinsam mit der Professur für Verkehrspsychologie die Wirkung der geplanten Maßnahmen durch die künftigen Nutzer bereits vor dem Bau getestet und ggf. angepasst werden. Das Team der Professur Raumplanung und Mobilität wird den weiteren Verlauf des Infrastrukturprozesses aus eigenem Forschungsinteresse in enger Zusammenarbeit mit dem Bundesamt für Infrastruktur, Umweltschutz und Dienstleistungen der Bundeswehr begleiten. Darüber hinaus wird eine Planungshilfe für Gestaltung, Allokation und Nutzung eines digitalen Parkraums der Zukunft ausgearbeitet, die die Kernkomponenten der hier aufgezeigten Planungen idealtypisch miteinander kombiniert.

7 ABBILDUNGSVERZEICHNIS

Abbildung 1: Eigene Darstellung, Kartengrundlage: Google Maps (2020)
Abbildung 2: Eigene Darstellung (2021)
Abbildung 3: Mercedes-Benz Group AG,
https://group.mercedes-benz.com/innovation/case/autonomous/fahrerlos-geparkt.html (2020)
Abbildung 4: Eigene Darstellung (2021)
Abbildung 5: Eigene Darstellung (2021)
Abbildung 6: Pressestelle UniBw M (2013)
Abbildung 7: Eigene Darstellung, Kartengrundlage: Google Maps (2022)
Abbildung 8: Eigene Darstellung, Kartengrundlage: Google Maps (2022)
Abbildung 9: SOPAGO GmbH, https://sopago.org/unsere-loesung/ (2021)
Abbildung 10: Eigene Darstellung (2022)

"Energy WITH Spirit" Facing Nowadays Challenges by Generating Sustainbale Energy in Solidary Energy Communities: First Project Insights

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1 ABSTRACT

Our world faces multiple challenges: The energy crisis is one of them and must be addressed at a local and regional as well as national and global level. In this transformation process of phasing out fossil energy sources, technical and social innovation must work closely together to foster long-term and sustainable changes. Generating energy from solar sources is one of the key sustainable and resource-efficient options we presently have . As stipulated in the European Green Deal, the goal is to phase out fossil fuels by 2050 with no net greenhouse gas emissions (European Commission, 2019). Sun and renewable energy sources are therefore key drivers for resilient and livable cities, societies, and economies. Just as the challenges of global change processes are unevenly distributed across the world, so are financial resources. People who are threatened or affected by poverty are more likely to be affected by energy poverty. According to a study from 2021, low-income households are significantly more affected by the rising energy prices (Maier-Kubala, 2021). Measures for energy transition and climate change adaptation are often associated with high costs and are therefore more likely to be implemented by people with higher incomes.

To include vulnerable groups in the process of energy transition, the project "Energy WITH Spirit," solidarity-social energy communities, was established. The main aim of the project is for socially disadvantaged and poverty-affected households, as well as people in basic services and low-income earners , to benefit from the sustainable and solidary produced energy. 10 % of the energy produced in kWh or 10% of the profit generated in Euro will be donated to vulnerable groups. How this goal is implemented technically (e.g., smart metre rollout; photovoltaic systems and storage, optimal consumer mix), economically (e.g., billing modalities, digital billing), and organisationally (e.g., proof of household income and expenditure; selection of recipients of energy quotas) will be explored within the project.

- The following target groups are involved in the solidarity-social energy communities: producers invest in sustainable energy generation through photovoltaic systems and set them up on their own properties, prosumers produce and consume part of their produced energy themselves (production and use under one roof) and consumers receive part of the energy produced by photovoltaic systems in the form of electricity. As consumers only, the project addresses the following groups: Socially disadvantaged and/or low-income households, people in basic services and the in-work impoverished who do not receive any government grants.

- To better involve the target groups, knowledge-transfer and awareness-raising workshops are held to address and sensitise them to urban energy, environmental, and climate issues. According to the solidary approach, "Energy WITH Spirit" aims to overcome the challenges of the energy crisis by generating sustainable energy in a solidarity energy community by actively involving vulnerable groups in the energy transition process. The next steps of the project are the technical construction of the photovoltaic plants as well as the economic preparation of the solidary energy community. This process is accompanied by target group orientated and simple energy education workshops for the vulnerable groups.

Keywords: sustainability, transition, cooperation, energy communities, vulnerabilities

2 BASELINE

2.1 European Context

- The climate crisis highlights numerous challenges at the global, national, and local level. In response to this, the European Green Deal was formulated in 2019 by the European Commission (European Commission, 2019a). As a new growth strategy and transformative process, the Green Deal aims to facilitate the European Union and its member states' transition towards a fair society with a resource-efficient and competitive economy (European Parliament; European Council, 2018/2001). The European Green Deal, introduced by the European Commission in December 2019, is a comprehensive policy framework aimed at making Europe climate-neutral by 2050. It encompasses various initiatives to accelerate the transition to a sustainable and low-carbon economy. Energy communities align closely with the objectives of the European Green Deal by fostering renewable energy deployment, energy efficiency, and citizen engagement. The European Green Deal acknowledges the importance of energy communities as a key pillar in the transition to cleaner energy systems. It aims to facilitate the establishment and operation of energy communities across Europe through supportive policy measures, regulatory frameworks, and financial instruments. The overarching goal is to democratise the energy sector, empower local communities, and ensure a fair and inclusive energy transition.

- The ongoing energy crisis, particularly triggered by Russia's attack on Ukraine, has resulted in a rapid escalation of energy prices, impacting not only the economy and administration but also individuals and their daily lives. A study conducted in 2021 indicates that s low-income households are significantly more affected by the rising energy prices (Maier-Kubala, 2017).

- The Clean Energy for all Europeans Package (CEP) has incorporated energy communities into the European Union's legislation (European Commission, 2019b). The directive includes common provisions for the internal electricity market, enabling active participation of end-users in all markets by generating, consuming, sharing, or selling electricity (EU 2019/944).

- Alongside technological and digital advancements, social energy communities adopt a strong social approach. They encourage end-users to become part of the solution and foster an understanding for sustainable energy usage and behaviour.

2.2 Renewable Expansion Act (EAG Package) in Austria

- The Renewable Expansion Act (EAG Package) represents the implementation and execution of the European Green Deal and was passed by the Austrian National Council in 2021 (Republik Österreich, 2022). One of its goals is to transition Austria's electricity supply to 100% renewable energy sources by 2030. This law amendment allows individuals to collaborate across property boundaries to collectively produce, store, consume, and sell energy. The Renewable Expansion Act serves as the legal framework for energy communities in Austria.

2.3 And the social dimension

In the energy transition, a collaboration between technical and social innovations is necessary to bring about long-term and sustainable changes (Knoll, 2016). Measures for energy transition and climate change adaptation are often associated with high costs and are therefore implemented primarily by individuals who have sufficient income. It is known that a portion of the population (especially the elderly, migrants, students, job seekers/unemployed individuals, and low-income earners) or vulnerable groups (socially disadvantaged households, people living in poverty) are not fully involved in the energy transition due to a lack of resources (financial, spatial, knowledge-related) (Maier-Kubala, 2017; Räty, 2010). The experiences of existing energy communities demonstrate that standard communication and dissemination measures are important but insufficient. Technical terms need to be translated into understandable language for all population groups to effectively convey the benefits, meet expectations, and actively involve all demographic groups in the energy transition.

236

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3 HOW ENERGY COMMUNITIES EMPOWER SUSTAINABLE CHANGE

3.1 Roles within Energy Communities

In an energy community, at least two participants come together to achieve a collective production and utilisation of energy (Erneuerbaren-Ausbau-Gesetz, 2021). This is now possible beyond property boundaries. The electricity supply is provided by renewable energy sources, mostly photovoltaic systems. This is because the Renewable Expansion Act Package (EAG) aims to have Austria's electricity supply come 100% from renewable energy sources by 2030. Energy communities play an important role in this transition. By utilising renewable energy sources such as solar power, energy communities can help reduce our dependency on fossil fuels while ensuring a sustainable and clean energy supply. They promote a decentralised approach, where citizens actively participate in energy production and can collectively generate and utilise their energy. The concept of an energy community goes beyond mere electricity supply. It creates a closer community and promotes the exchange of know-how and resources. By pooling their efforts, people can collaboratively shape a sustainable future and make a positive contribution to climate protection.
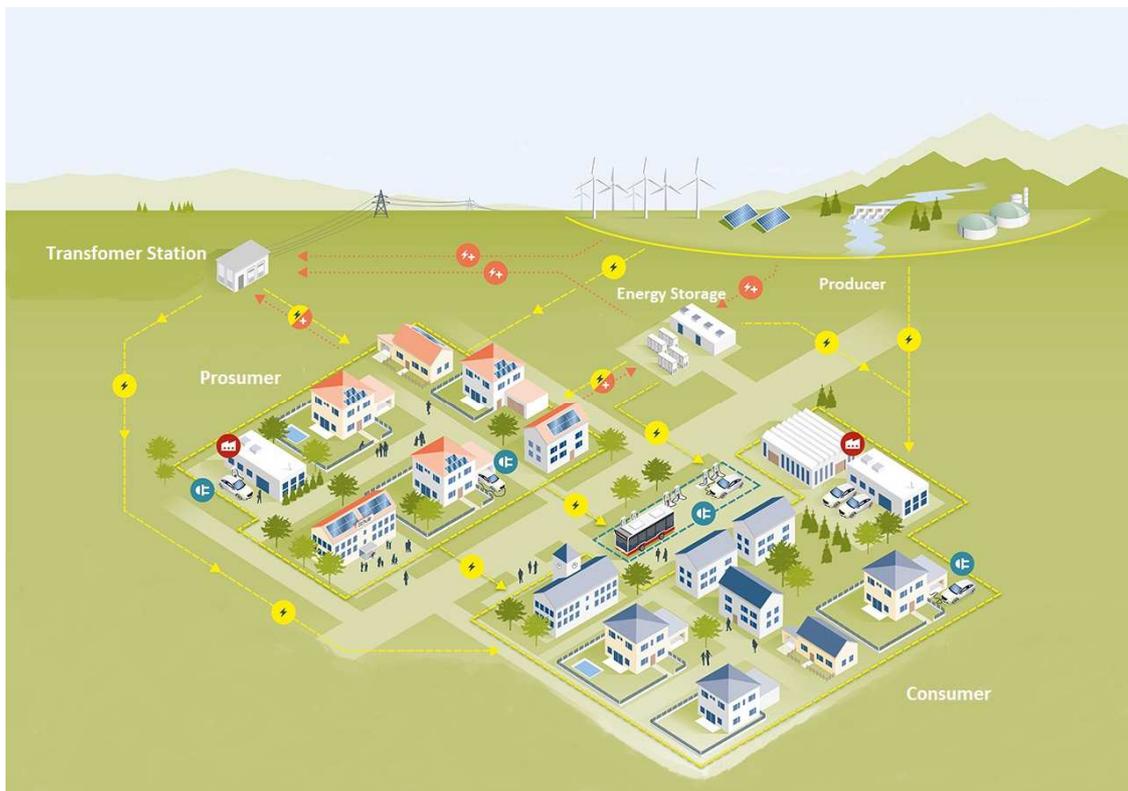
Fig. 1: Illustration of an Energy Community (https://energiegemeinschaften.gv.at/downloads/energiezukunft-gestalten/) (used with permission)

- Producers: Investing in sustainable energy generation, producers install photovoltaic systems on their own properties, contributing to the production of clean and renewable energy.

- Prosumers: Institutions acting as prosumers not only utilise the properties where photovoltaic systems are installed but also consume a portion of the energy produced on-site. This concept of production and consumption under one roof applies to various entities, including our two frontrunners the Protestant Boarding School Bad Goisern, catering to children with socio-pedagogical support needs and their caregivers, as well as the community of students, teachers, and non-teaching staff at the Protestant Secondary School Donaustadt.

- Consumers: Benefitting from sustainable energy practices, consumers receive a share of the electricity generated by photovoltaic systems, ensuring a cleaner and more sustainable energy supply.

3.2 Benefits of Energy Communities

The benefits of energy communities are numerous. According to legislation, the primary contribution of energy communities is the benefit they bring to the community (Erneuerbaren-Ausbau-Gesetz, 2021).

- Ecologically, energy communities provide advantages through localised energy generation. This eliminates the need for long-distance transmission, as energy is consumed in close proximity. Consequently, it reduces the carbon footprint not only for individuals but also for the region and the entire country. The proximity of energy generation also fosters a greater understanding and connection to the topic of electricity production.

- From an economic standpoint, energy communities offer several advantages. When the generated energy is sold or purchased, the energy community itself determines the price. Supporting local value creation helps minimise reliance on large imports of fossil fuels and leads to increased financial benefits for the region.

- Socially, energy communities contribute to increased awareness of climate and energy-related issues, by promoting renewable and sustainable energy sources. They enhance interaction and communication among community members and foster therefore a sense of social cohesion.

- Furthermore, sector coupling, achieved through the integration of electricity, heat, and mobility sectors, can elevate self-sufficiency levels. For instance, the utilization of a neighborhood storage system enables the use of self-generated electricity for charging electric vehicles at a later time.

4 THE LIGHTHOUSE PROJECT "ENERGY WITH SPIRIT"

To involve and actively engage vulnerable population groups in the energy transition, a consortium of 11 project partners from the business, scientific, research, and Protestant Church and its social welfare organisations came together for the project "Energy WITH Spirit. Pioneering implementation of a solidarity energy community in the Protestant Church Community Action sector in Austria." The project is led by B-NK GmbH Office for Sustainable Competence and involves the following organizations: AEE INTEC, akaryon GmbH, Diakonie Bildung gem. GmbH, Diakonie Eine Welt gem. GmbH, Diakonie Flüchtlingsdienst gem. GmbH, Dipl.-Ing. Ralf Dopheide e.U., Evangelische Superintendentur A.B. Wien, Evangelisches Haus Hadersdorf Wobes, Schülerheim Bad Goisern GmbH, and TRIGONplan Planning and Consulting Company for Landscape Ecology and Technical Environmental Protection. The three-year project started on March 1, 2023, and is funded by the Austrian Climate and Energy Fund under the "Lighthouses for Resilient Cities 2040" programme.

The project aims to ensure that the energy generated by the photovoltaic system not only meets the needs of the on-site facilities but also contributes to the well-being of socially disadvantaged and impoverished households, as well as individuals who rely on basic supplies and those who fall into the category of in-work poverty. This will be achieved through a solidarity-based approach, where approximately 10% of the energy produced in kilowatt-hours or 10% of the generated profit in euros will be allocated to these vulnerable groups. To address these objectives, first of all technical aspects, such as the implementation of smart metres, photovoltaic systems, and storage solutions, as well as different models for an optimised mix of different members and load profiles have to be examined. In addition, economic considerations will be considered, including billing methods and the implementation of digital invoicing systems. Organisational aspects, such as verifying the income and expenditure of households and selecting recipients for energy quotas, will also be carefully managed. By tackling these technical, economic, and organisational challenges, the project seeks to ensure that the benefits of the photovoltaic system extend beyond the immediate facilities and positively impact the lives of those in need, fostering a sense of solidarity within the community.

4.1 The Frontrunners

The project involves a pioneering implementation of a solidarity-based social energy community with two "fixed-starter buildings" (= "frontrunners") as prosumers, as well as the preparation for a nationwide roll-out.

As stated before, there are two frontrunners, one is the Protestant Boarding School in Bad Goisern.

The Protestant Boarding School Bad Goisern provides accommodation for 45 children (both girls and boys) aged 6 to 16, with a socio-pedagogical focus. The institution collaborates with child and youth services from

the provinces of Upper Austria, Salzburg, and Styria. Recently renovated in 2022, it is one of the most modern boarding schools in Austria. With the aim of embracing sustainability, the Protestant Boarding School Bad Goisern is in the process of installing a large-scale photovoltaic system. By holding both the "producer" and "prosumer" roles in the energy community, the boarding school seeks to meet its own energy demands while also demonstrating solidarity by allocating 10 % of its energy generation to support others in need. This endeavour not only enables the facility to become self-sufficient but also empowers it to contribute to the well-being of the wider community.

Fig. 2: Technical and Economic Pre-Dimensioning of the Photovoltaic System, Bad Goisern.

The second frontrunner is the Protestant Secondary School in Vienna Donaustadt.

The Protestant Secondary School Donaustadt is run by Diakonie Bildung gem. GmbH and is part of the Diakonie Eine Welt Group. The facilities of Diakonie Bildung are open to people of all denominations. In the Protestant educational institutions in Vienna and the surrounding area, Diakonie Bildung cares for around 3,800 children and young people in kindergartens, schools and after-school care centres.

The Protestant Secondary School Donaustadt already has an educational focus on "Ecology and Environment" and is certified with the eco-label "Österreischische Umweltzeichen Schule". The planning and installation of a photovoltaics system at the school is also an excellent opportunity for the students to learn in a practical on-site manner about renewable and sustainable energy production.

Fig. 3: Technical and Economic Pre-Dimensioning of the Photovoltaic System, Vienna Donaustadt.

4.2 The "Energy WITH Spirit" Real-Estate Database

To assess the potential for a rollout within the Protestant community, beyond the two frontrunners in the Energy WITH Spirit project, namely the Protestant Boarding School Bad Goisern and the Protestant Secondary School Donaustadt, Vienna, a survey will be conducted among Protestant institutions, congregations, organisations, and associations. The survey will address the following questions:

- What is the real estate inventory in Protestant institutions, and what are the potential factors related to photovoltaic installations (locations, climate factors, etc.) (= potential prosumers)?

- Where, and in what form, could solidarity energy communities be best established?

- Who could be additional prosumers of the energy community? Who could be additional consumers?

However, for the successful dissemination of the project, a detailed recording of relevant currentstate parameters of the potentially suitable properties in the Protestant church community is essential. This includes a database of its technical characteristics, equipment, and energy needs, as well as socio-structural input parameters within the framework of church and political communities. Methodologically, these surveys are based on both the traditional survey instrument and data from original sources regarding legal status, technical building documentation, and natural planning parameters, selected and based on the respective expertise of the project partners. The storage of the building and environmental data is managed through a database management system, for which the data model has already been developed in a draft version. The goal is to establish a web-based information system that supports project partners not only in the establishment of energy communities in the project, which is the main project objective but also in their ongoing operation by providing fundamental data.

4.3 The Context: Protestant Church in Austria

The Protestant Church A.B. in Austria has a three-tiered structure. The first level consists of 191 parish communities, which act autonomously in many matters towards the regional church through their representative bodies: the Community Council and the Presbytery. The parish community is led by a pastor and a curator who jointly fulfill their spiritual and secular leadership roles within the Presbytery of the parish community. The Community Council, from which the Presbytery is elected, serves as a supervisory body over this governing body.

The parish communities are grouped into seven dioceses, known as superintendencies, which generally correspond to the boundaries of the federalprovinces. The representative bodies of the superintendencies are the Superintendential Assembly and the Superintendential Committee. The superintendency is led by a superintendent and a superintendent's curator.

According to their own count in 2022, this church structure represents 252.233 individuals in Austria who are registered as active members of the Protestant Church A.B. (Evangelische Kirche in Österreich, 2022).

5 THE SOLIDARITY APPROACH: 10 % FOR THOSE WHO NEED IT

Diakonie is the social welfare organisation of Austria's Protestant churches. In its basic statement it is stated: "Church community action begins with the perception of need: Just as the first community in Jerusalem recognized the plight of Greek widows, Martin Luther addressed the impoverishment caused by currency devaluation, Johannes Calvin addressed the plight of refugees in Geneva, Countess de La Tour addressed the misery of illegitimate children, and the brothers Ernst and Ludwig Schwarz addressed social impoverishment, we too must concretely identify and name the general social situation and specific needs of certain groups and individuals. Church community action is directed to the poor and needy in our world. Poverty and social exclusion are often kept silent and ignored by society. In Christian communities, however, these specific problems are recognised, andlead to actions. These communities are places for all people, regardless of their origin and social situation, or their faith." (Diakonie, 2013).

Building upon this foundational statement and supported by a theological concept developed by the Faculty of Protestant Theology at the University of Vienna, the "Energy WITH Spirit" project aims to realise its fundamental objective: to share the energy produced in a spirit of solidarity. This entails allocating either 10% of the generated energy in kilowatt-hours or 10 % of the generated profits in euros to support socially disadvantaged households and individuals affected by poverty.

5.1 How to gain access to vulnerable groups

There are two primary approaches to accessing vulnerable groups: through the project consortium itself and through collaborations with charitable and social welfare institutions. For example, the Evangelischer Waisenversorgungsverein (Protestant Orphan Care Association) has implemented a scholarship model that considers not only financial income but also expenses and social circumstances.

In accordance with their charitable orientation, the Evangelischer Waisenversorgungsverein and Diakonie Bildung gem. GmbH provide financial resources for school fees to socially disadvantaged and/or impoverished families. As the oldest charitable association in Austria, founded in 1861, the Evangelischer Waisenversorgungsverein has supported approximately 900 children over a span of more than twenty years, often throughout their entire schooling period (Evangelischer Waisenversorgungsverein, 2023). The Evangelischer Waisenversorgungsverein, along with the institutions of Diakonie, as the social welfare organisation of Austria's Protestant churches, as part of the energy community, plays a key role in reaching out to socially disadvantaged households.

The solidary approach of the "Energy WITH Spirit" community is designed to benefit the following vulnerable groups:

- Socially disadvantaged and economically impoverished households. The Evangelischer Waisenversorgungsverein and Diakonie Bildung gem. GmbH specifically target these groups.

- Individuals in basic care or with subsidiary protection status, who have experienced displacement, are directly supported, and addressed by the Wohnberatung (Housing Counseling Service provided) by Diakonie Flüchtlingsdienst gem. GmbH.

- The in-work impoverished who do not receive state subsidies. It is the core competency of Diakonie to accompany such precarious living situations and mitigate their impact, particularly for children.

5.2 How to allocate the 10 %

The Faculty of Protestant Theology at the University of Vienna is currently working on the development of a theological concept, which is grounded in fundamental theological principles. By the end of 2023, this concept aims to establish a framework for sharing energy in a spirit of solidarity, specifically by allocating 10 % of the generated energy in kilowatt-hours or 10% of the generated profits in euros to support socially disadvantaged households and individuals affected by poverty.

The administrative procedures for implementing this allocation system will be devised and tested as part of the project. As a starting point, we will focus on two frontrunner buildings and energy communities in Bad Goisern and Vienna. These pilot projects will allow us to refine and validate the concept.

Once the concept has been thoroughly evaluated and proven effective, we plan to implement it on a larger scale across Austria by 2025. This nationwide rollout will enable us to extend the benefits of the solidarity-based energy sharing approach to a broader range of communities and individuals in need.

6 ENERGY EDUCATION WITH THE MOTTO "LEAVE NO ONE BEHIND"

The successful implementation of the two frontrunner energy communities relies heavily on the active engagement of staff members and users, including socially disadvantaged children and young people, students, and individuals in basic care. To enable these target groups to become fully integrated members of the energy community, communication and knowledge transfer processes are essential. Therefore, an integrated objective of the energy community is to provide accompanying "energy education" in the form of knowledge dissemination and awareness-building workshops. This is done to engage the target groups, raise awareness and sensitivity towards energy, environmental, and climate-related topics, and create awareness for the goals and measures surrounding "Energy WITH Spirit." In this regard, employees (social educators, therapists, counsellors, psychologists, teachers, facility technicians, administration) in the energy-producing facilities play an important role as multipliers. The project focuses on the inclusion of vulnerable individuals and equal opportunities.

Their participation is essential in the prosumer facilities, such as the Protestant Boarding School Bad Goisern and in the Protestant Secondary School Donaustadt, as well as in the Wohnberatung (Housing Advice) provided by the Diakonie Flüchtlingsdienst gem. GmbH. To achieve this engagement, the project will

develop and implement targeted knowledge transfer and "energy education" initiatives that are easily comprehensible for the respective target groups.

These initiatives will address various energy-related questions, covering topics such as

- the fundamental understanding of energy,
- the significance of sustainable and renewable energy production,
- the workings of photovoltaic systems,
- the implications of energy crises and rising prices,
- the importance of energy conservation,
- the concept of solidarity and energy communities,
- and the specific rationale behind installing photovoltaic systems.

The primary objective is to emphasise the value of energy as a precious resource and establish a clear connection between everyday life and energy-saving practices.

Through these educational activities, the "Energy WITH Spirit" project strives to raise awareness among staff members of the institutions and socially disadvantaged groups regarding the critical interplay between energy production and consumption. By fostering a deeper understanding of these dynamics, the project aims to empower individuals to make informed decisions and actively contribute to a more sustainable energy future.

7 CHALLENGES ENCOUNTERED THUS FAR

7.1 Equipping Buildings with Photovoltaic Systems: A Challenging Task

As "Energy WITH Spirit" is a research project focusing on energy communities in the Protestant-Community Action sector, church buildings and their annexed buildings are a significant portion of the Producers and Prosumers buildings. Religious communities often own rooftop spaces in urban areas where complex ownership structures of apartment buildings can make the installation of photovoltaic systems very difficult.

In Austria, churches and their roofs are subject to heritage protection regulations. The legal framework for heritage protection is established in the Denkmalschutzgesetz (= Heritage Protection Act) which serves as the basis for safeguarding cultural monuments and historic buildings throughout the country. Consequently, specific legal provisions and approval procedures must be followed when making alterations to these buildings. Currently, there is no unified statutory regulation specifically addressing the installation of photovoltaic systems on church roofs within the context of heritage protection. The legal situation can vary depending on the federal state, as heritage protection laws in Austria are governed at the regional level (Denkmalschutzgesetz, 2013).

While churches and their roofs are subject to heritage protection in Austria, the same does not apply to their annexes. We have already conducted initial exploratory discussions with representatives from the Federal Monuments Office regarding selecting "friendly customer" churches and Protestant religious communities aiming to install photovoltaic systems on their churches and establish a solidarity energy community involving their members, neighbours, municipalities, and other charitable institutions (Bundesdenkmalamt, 2022).

Currently, numerous factors are at play in the dynamic tension between climate protection and heritage preservation, necessitating the consideration of new parameters. As of now, there is no definitive decision from the Bundesdenkmalamt (Austrian Federal Monuments Office) that comprehensively addresses this issue. However, it is noteworthy that the year 2022 has been explicitly designated by the Federal Monuments Office as a focal year for the theme "Heritage Preservation = Climate Protection." This declaration underscores the growing awareness of the mutual significance and inseparable connection between these two spheres.

7.2 Legal Framework

According to the Erneuerbaren-Ausbau-Gesetz (EAG) (= Renewable Expansion Act) in Austria, large companies are not permitted to be members of energy communities (Erneuerbaren-Ausbau-Gesetz, 2021)

The EAG defines large companies as companies that meet the criteria of a large enterprise according to European law. The law stipulates that energy communities can only be formed by households, small businesses, small and medium-sized enterprises, and certain non-profit organisations. Large companies are excluded from participating in such communities. This regulation aims to ensure that energy communities align with the goals of decentralisation, democratisation, and participation of local communities. They are intended to enable citizens and smaller actors to actively participate in the generation and use of renewable energy and benefit from the associated advantages.

However, it should be noted that certain non-profit organisations, although primarily pursuing development and humanitarian objectives, may be classified as large companies according to European law based on criteria such as the number of employees and other factors. It is important to note that this specifically applies to the Austrian EAG. In other European countries, the regulations regarding the participation of large companies in energy communities may vary.

7.3 Dimensioning and Supply Chain Optimization for Photovoltaic Systems

Supply bottlenecks and extended delivery times have become a familiar topic of discussion. The demand for photovoltaic systems has significantly increased in the past year, driven by high energy prices and an unsettling sense of insecurity in the energy sector. Adding to the complexity is the vast array of photovoltaic modules, mounting systems, and storage solutions available. As a result, accurately estimating the kilowatt peak power to be achieved depends not only on the roof's surface area but also on the specific photovoltaic panel and mounting system employed. Proper sizing of photovoltaic systems and efficient management of the supply chain are crucial in the current market situation. Careful planning and coordination are necessary

7.4 Grid Membership

According to the Renewable Expansion Act, as of June 2023, two models for energy communities have been established. On one hand, there is the "renewable energy community" (EEG), which operates within local limitations, and on the other hand, the "citizen energy community" (BEG), which can operate without geographical restrictions. EEGs are limited to the "local area," requiring participants and their facilities to be located within the franchise area of a grid operator. A local EEG can be established when grid levels 6 and 7 (low-voltage grid) are interconnected, while a regional EEG encompasses grid levels 4 and 5. BEGs can operate across Austria, extending beyond the concession area of grid operators. Unlike EEGs, they are not restricted to renewable energy sources but are solely permitted to generate, store, consume, and sell electrical energy. However, economic benefits such as the elimination or substantial reduction of grid usage fees do not apply to BEGs. In rural areas, determining which neighborhoods belong to the same grid usage tier is often straightforward. However, in urban areas, this can be challenging. For instance, in Vienna, the closest transformer station (the boundary for local BEGs) is frequently located at the next street or apartment block boundary. As a result, the exchange of energy contingents within the EEGs can be severely limited in terms of space.

8 OUTLOOK

Based on the principles of solidarity, the "Energy WITH Spirit" research team is driven to address the challenges of the energy crisis. By establishing a solidarity energy community that generates sustainable energy, the project aims to actively involve vulnerable groups in the ongoing energy transition process. The next crucial steps of the project involve the technical implementation and construction of the photovoltaic plants. Simultaneously, the project team is undertaking economic and regulative preparations to ensure the smooth functioning of the solidarity energy community. This entails devising suitable billing and allocation systems, as well as developing strategies to encourage active participation and engagement from all members. In parallel with these technical and economic endeavours, the project recognizes the importance of energy education to empower and equip vulnerable groups with knowledge about sustainable energy practices. To achieve this, the initiative conducts targeted and easily understandable energy education workshops tailored to the specific needs and circumstances of the target groups. These workshops provide valuable insights into the benefits of renewable energy, energy-saving measures, and the overall importance of environmental sustainability. By fostering a deeper understanding of energy-related concepts, the project endeavors to empower vulnerable groups to make informed decisions, actively contribute to the energy transition, and contribute to climate protection.

9 REFERENCES

Bundesdenkmalamt: Denkmalschutz = Klimaschutz. Available online at: https://www.bda.gv.at/themen/denkmalschutz-ist-klimaschutz.html, checked on 6/13/2023.

Diakonie (Ed.): Diakonie – Standortbestimmung und Herausforderung. Kommission für Diakonie und soziale Fragen. Vienna, 2013. Available online at: https://www.diakonie.at/file/download/17607/file/standortbestimmung-und-herausforderungen-diakonie-2013.pdf, checked on 6/13/2023.

Denkmalschutzgesetz. BGBl. Nr. 92/2013. Gesamte Rechtsvorschrift für Denkmalschutzgesetz. Version of June 13,203 Available online at: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10009184, checked on 6/13/2023.

Erneuerbaren-Ausbau-Gesetz (EAG). Bundesgesetz über den Ausbau von Energie aus erneuerbaren Quellen. BGBl. Nr. 150/2021. Available online at: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10009184, checked on 6/13/2023.

European Commission (2019a): The European Green Deal. Communication from the commission to the European Parliament, the European Council, the European Economic and Social Committee, and the Committee of the Regions. Brussels.

European Commission (2019b): Clean energy for all Europeans package completed: good for consumers, good for growth and jobs, and good for the planet. Brussels, 2019b. Available online at: https://commission.europa.eu/news/clean-energy-all-europeans-package-completed-good-consumers-good-growth-and-jobs-and-good-planet-2019-05-22_en, checked on 4/30/2023.

European Parliament and European Council. Directive (EU) 2018/2001. Promotion of the Use of Energy from Renewable Sources 11.12.2018 (Recast). Brussels, 2018. Available online at: https://eur-lex.europa.eu/legal-content/DE/TXT/HTML/?uri=CELEX:02018L2001-20220607&qid=1682880962702, checked on 6/13/2023.

Evangelische Kirche in Österreich. Available online at: https://evang.at/, checked on 6/13/2023

Evangelischer Waisenversorgungsverein. Available online at: https://www.waisenversorgungsverein.org, checked on 6/13/2023.

Knoll, Bente; Spreitzer, Georg; Göbl, Christoph. "Tailor-made energy consulting for five different consumer groups. Learnings from the Austrian R&D project 'EnBe2.0' and the 'EnBe2.0-Toolbox'." In: ICT4S (Ed.). Proceedings. 4th International Conference on ICT for Sustainability (ICT4S 2016), pp. 202–208. Vienna, 2016. Available online at: http://www.atlantis-press.com/php/download_paper.php?id=25860384, checked on 6/13/2023.

Maier-Kubala, Sylvia / APA-Service. "Wo der Mensch ins Spiel kommt: Soziale Innovation in der Energiepolitik." June 30, 2017. Vienna, 2021.

Republik Österreich. Bundesgesetz über den Ausbau von Energie aus erneuerbaren Quellen. Erneuerbaren-Ausbau-Gesetz - EAG, dated 30.04.2023. Vienna, 2022. Available online at: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20011619, checked on 4/30/2023.

Räty, Riitta; Carlsson-Kanyama, Annika. Energy consumption by gender in some European countries. In: Energy Policy 38 (1), S. 646–649. DOI: 10.1016/j.enpol.2009.08.010. Sweden, 2010.

Evaluate the Socio-Economic Impact of the International Coastal Road (ICR) on Burg Elburullus City

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1 ABSTRACT

Communities are grappling with environmental, social, and economic challenges due to rapid urbanization and physical changes, with coastal slums bearing the brunt of the impact. Unplanned urban development worsens pollution, inequality, and disaster risk for low-income households. Specific sustainable development plans are vital for tailored solutions based on each community's distinct needs and views. This study examines the socio-economic impacts of the establishment of the International Coastal Road (ICR) in the city of BURJ AL-BURULLUS in Northern Egypt, which marked the beginning of major urbanization efforts in the region in 2002. The physical landscape of the city has undergone significant changes due to urban expansion, with the extension of the city having grown to almost twice the size of the original city. The expansion of the city due to the ICR has caused significant changes to the area's environment, communities, and economies. In particular, the separation of the city from the nearby lake, which was its primary source of income, has had diverse impacts on various aspects of people's lives. This study employed a narrative method to assess ICR's impacts on the area's environments, communities, and economies. Nine villagers with diverse incomes were selected and encouraged to freely share their detailed views. The study focused on the socioeconomic impacts of the changes on the city, but it had significant impacts on all economic, social, and environmental levels. Community participation enhances research outcomes regarding the challenges experienced by impoverished communities due to urbanization. It also assists in the creation of improvement strategies responsive to the distinct requirements of each community by incorporating important perspectives and first-hand experiences of those affected by urbanization.

Keywords: narrative method, Nile delta, physical changes, coastal cities, socio-economic impacts

2 INTRODUCTION

In 2008, half of the global population was located in urban areas, and this trend is expected to continue in the future. Projections indicate that the gradual shift of people from rural to urban areas, combined with population growth, could result in an additional 2.5 billion urban dwellers by the year 2050. This change is likely to accelerate in the coming years (Nations 2018). Urbanization has important implications for demographic changes and the physical landscape, but unplanned, unsystematic, and rapid urbanization can have profound impacts on social, economic, and environmental components. In Thailand, for example, population growth and increased migration have led to challenges experienced across various domains of life, while climate change and urbanization have affected urban governance. The usage of new technologies can also have worrying implications for the labor market and social welfare (United Nations 2020). Addressing the impacts of unplanned urbanization is crucial, as it violates children's rights and has negative effects on cultural diversity, environmental conservation, and urban greening. Effective land policies can play an important role in shaping society and controlling urbanization's character. (Patra et al. 2018).

Constructing new transportation routes is often viewed as the initial stage of urban development and progress. However, developing infrastructure without considering sustainability and environmental concerns can cause harm to natural ecosystems and lead to social and economic inequities (Singer 2018). Therefore, it is critical to adopt alternative approaches that take into account potential negative impacts and address them during the development of infrastructure and urban areas. Rapid and inadequate planning can generate harmful long-term effects, emphasizing the need to ensure positive outcomes for society and the natural world by achieving a balance between growth, sustainability, and environmental concerns (Song et al. 2016).

In response to rapid global urbanization, the Nile Delta Coast has been identified by Egyptian decision makers as a key region for substantial investment in various industries and the growth of existing projects. This coastal area spans approximately 240 km between Abu-Quir city in the west and Port-Said city in the east, situated along the central Mediterranean coast of Egypt ,as shown in Figure 1 (Masria et al. 2014). Thus, in recent years, the Nile Delta has undergone significant physical changes. Some of these are natural

and others human in origin(Future Earth Coasts 2009). These physical changes increase the vulnerability of the coastal zone regard to environmental, social and economic aspects (Iskander and Water 2017).

The state has focused on developing infrastructure along the central coast (delta region) to support mega-projects, including the creation of new cities, private universities, tourist beaches, various ports, and commercial and industrial areas. One of the most notable infrastructure projects is the ICR, established in 2002. Plans for a new train project to transport passengers and goods, with a line running parallel to the ICR, have been announced by Eng. Ashraf Raslan, who serves as the head of the Egyptian National Railways. Phase one of the project will involve an electric train that runs for a distance of 240 km, passing through the new cities of Damietta and Mansoura, and linking the West Port Said Port and Abu Qir Port in Alexandria. Due to the significant effects these developments may have on the environment, economy, and society of the region, responsible planning and management will be necessary to ensure positive outcomes.

Figure 1: The North coast of Egypt extended on the Mediterranean Sea as well as The Central Coast Region (Delta Region) is highlighted.

The northern coast of Egypt boasts several natural lakes, with three located in the Nile Delta region, which have become significant due to their crucial environmental, economic, and social functions(Chu and Karr 2017). These coastal lakes host a thriving ecosystem and possess a unique environmental status owing to their ability to connect saline and freshwater. However, the increase in development and human activities in the area has had a negative impact on the lakes, leading to their deterioration, as reported by Abayazid(Abayazid 2012). In 2018, Egypt achieved a total fish production of 373.3 tons from natural fisheries such as lakes, freshwater, and marine water. Elrazi (Elrazi 2020) reveals that the fish production from BURULLUS, MANZALA, and EDKO lakes and the Mediterranean Sea in Delta cities accounted for 54% of the state's production, with BURULLUS being the most productive lake.

Commercial fishing is a global activity that encompasses various social, economic, and environmental factors that are unique to different regions. In the ELBURLLUS area, for instance, the local population, including 17,000 licensed fishermen and their families, depend on these resources for their livelihoods. As such, fisheries are a crucial support system for the people in the area (Shaltout 2010). The livelihoods of artisanal fishermen depend on coastal environments, which can be greatly impacted by anthropogenic activities such as rapid urbanization(Andrews et al. 2021). This can pose a serious threat to this traditional fishing method. In addition, the primary and secondary buyers in the production chain result in low profit margins for the fishermen, sometimes forcing them to increase their fishing efforts to maintain their income(Charvet-Almeida, Góes de Araújo, and de Almeida 2005). Having fisheries located near their homes can help them save time and involve family members in fishing activities, making their livelihood more sustainable(Diegues 2008) (Granzotto et al. 2004). Fishing not only provides food but also employment opportunities for local communities (Hacohen-Domené et al. 2020).

The research problem arises from the need to understand the social and economic impacts experienced by fishermen in the northern delta region due to the establishment of the International Coastal Road (ICR). The cities located along the ICR route have been affected differently , particularly those that depend on fishing in the sea or lake as their source of income. With proposals to build a railway parallel to the ICR, the issue becomes even more significant, especially given the lack of research in addressing it and the complexity of problems that fishermen's villages may face in the absence of solutions to counteract the effects of the ICR.

246

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3 STUDY AREA

The construction of the International Coastal Road (ICR) in northern Egypt in 1995 was completed in 2002 with the aim of improving connectivity between Mediterranean countries of northern Africa and southern Europe (Eldeep and Elkady 2022) . Its route spans from Libya in the west to Palestine in the east. The coastal area, including six administrative units and four lagoons, is a crucial source of income for the region; it is renowned for its biodiversity, natural plant life, wetlands, and bird species. However, the region has faced multiple environmental challenges such as erosion, subsidence, water pollution, poor management, land encroachment, and sea-level rise. Tracking these changes and ensuring sustainable development is essential for the region's well-being (Dewidar 2004).

Figure 2: Burg elburllus city region is highlighted as well as the International Coastal Road also coloured (ICR), author.

The Burullus region is located on the eastern side of the Rosetta branch of the Nile River in the central zone of the Mediterranean Nile delta coast of Egypt. Burg Alburullus is a coastal city situated along the Mediterranean shore, bordered by the Alburullus lake to the south and connected to the sea via El Boghaz, v

ICR had established creating a triangular area that separates Burg ALBURULLUS city and lake called EL GOUNA its area is about 50% of the old city, so this extension of ELBURRULUS city was a big physical change as shoown in Figure 3 (Eldeep and Elkady 2022) . During the period of 2005 to 2021, El GOUNA underwent construction in four stages, which were solely dedicated to residential plots. Unfortunately, urban design elements and foundations were neglected during construction. These residential plots were sold via public auction, leading to a significant increase in land prices due to the limited availability and high demand. Although the first three phases have been entirely sold, the fourth stage is yet to be sold, and some plot owners are not yet to build on their land due to various administrative and financial reasons. Currently, only 55% of El GOUNA's land area has been built on, presenting a sizeable opportunity for further development.

Figure 3: EL GOUNA area is highlighted , (Eldeep and Elkady 2022)

4 RESEARCH QUESTION

- What is the impact of the International Coastal Road (ICR) on the socio-economic aspects of the community?

- How effective is community participation in solving problems related to the ICR's impact on the region's socio-economic conditions?

5   MATERIALS AND METHODS.

Conducting a socioeconomic impact (SEI) assessment can help understand the potential effects of physical changes and the reactions of those affected by the changes. Due to marginalization and lack of research on the subject, a case study of Elburullus, a city in Egypt that has undergone major physical changes, was selected to analyze the impacts of these changes on various socioeconomic aspects. The study aimed to provide an overview of all affected socioeconomic factors, rather than focusing on a single aspect. The study included in-depth interviews with nine residents, and thematic narrative analysis was used to obtain as much information as possible about the different socioeconomic effects of the changes. Based on the Socio-economic Impact Assessment Toolkit (Program 2005), seven categories with multiple topics were identified to cover socioeconomic indicators. Organizing these topics with narrators' stories provided insights into the type and magnitude of each impact. Each topic was then analyzed separately to assess the positive and negative views of the narrators.

based on Socio-economic Impact Assessment Toolkit(Program 2005), there are seven categories including many topics as subtitles to cover socio-economic indicators. scheduling these topics with narrators' stories led to knowing the weight and type of effect on every topic. After that, analyze each topic separately to discuss the positive and negative views of the narrators

5.1 Why Why and how narrative method

Narrative inquiry has developed as a research methodology over the last thirty years. It provides a way to collect, examine and analyse stories of experiences and events. (Riessman 2003) assert that storytelling is the most common form of human communication and that it is used to convey the elements of experiences that have influenced an individual or a larger group. Andrews, Squire, and Tamboukou (2008) also argue that storytelling is the universal way in which people make sense of their experiences. People communicate and reinterpret their life experiences through stories (Kohler Riessman 2002). (Hatchell and Aveling 2010) also believe that stories can be used to demonstrate the ways in which people make sense of their experiences through narratives, while illuminating common threads of understanding. They offer "a way of gaining insight into this complex relationship between individuals' particular experiences, meanings and strategies for action and their social and societal contexts" (Stroobants, 2005, p.49, cited in(Hatchell and Aveling 2010)).

The following table presents in a structured way the process of obtaining narrative interviews:

Phases of the Narrative interview	Rules for the interview Exploring
Preparation	Exploring the field Formulating exmanent questions.
Initialization	Formulation of the initial topic for narration. Use visual aids
Main narration	No interruptions. Only non-verbal or paralinguistic encouragement to continue telling the story Wait for signals the end of the ("coda").
Questioning phase	only question: What happened then? no opinion or attitude questions no arguing on contradictions do not ask: Why? Go from exmanent into immanent questions
Small talk	Stop recording. Only question allowed is why? Make note immediately after the interview.

Table 1: main phases of narrative interviews, JovcHElovicH E BauEr (2002)

Narrative development criteria should follow the following guidelines (Muylaert et al. 2014)

- Need to be an experiential part of the interviewee. This ensures his or her interest and lead to a richly detailed narrative.

- It should be personal, social or communal significance.

- The interest and investment in the topic of the informant should not be mentioned, in order to avoid taking positions or taking on roles from the beginning.

- The topic should be wide enough to allow the in- formant to develop a long history, from initial situations, going through past events, leading to the current situation.

- Avoid indexical formulations, ie by not referring explicitly to dates, names or places, which should be brought only by the informant, as part of his/ her relevant structure.

- Shutze(Bauer and Gaskell 2017) , outlines a form of analysis of narrative inter- view quite didactically:

- After transcription, we separate the indexed from the non-indexed material:
  - The first corresponds to the rational, scientific, concrete content of who does what, when, where, and why, ie, it is ordained (consequently, it is consensual order, collective)
  - The second, the non-indexed information goes beyond the events and expresses values, judgments, refers to the wisdom of life and therefore is subjective.
- In the next step, using the indexed content, events are ordered for each subject what is called trajectories.
- The next step is to investigate the dimensions that are not indexed in the text.
- Then, we group and compare individual trajectories.
- The last step is to compare and establish similarities among individual cases thus allowing the identification of collective trajectories.

5.2 The sample selecting

To gain a comprehensive understanding of the impact of a phenomenon, it's important to choose a diverse sample that includes all relevant variables. For the city of Burullus, two essential variables to consider are job and place of residence. Historically, fishing in the lake or sea, boat making, and fish trade have been the primary sources of income for families in the area. However, with the construction of the International Coastal Road, fishing has declined, leading to the rise of new income sources such as offshore fishing, furniture making, other types of trade, technical jobs, and higher education opportunities(Eldeep and Elkady 2022). The residents' place of residence is closely linked to their income level and to how much they have benefitted from the new road. Wealthier residents tend to live in El Gouna, while another group resides in the Old City. Poorer individuals migrated out of the city to live in villages close by where they can continue to practice fishing.
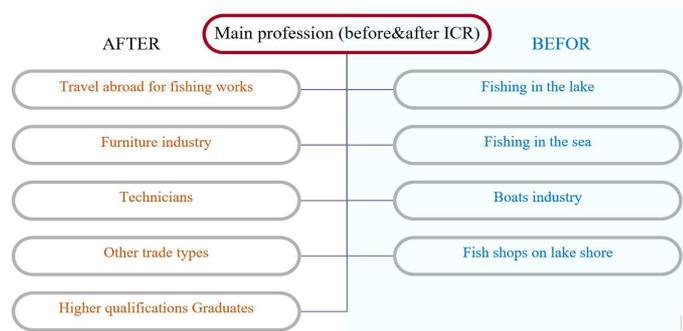
Figure 4: residents' profession after and befor the ICR construction

Figure 4 shows the diversification in the professions of the sample's narrators. Additionally, Figure 4 displays how the sample is distributed across the various regions of the city. This diversity is necessary to ensure that the study produces more comprehensive and realistic results.
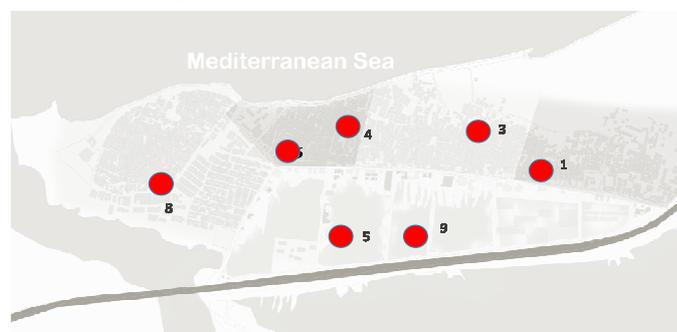
Figure 5: Accommodation distribution of the nine narrators in the city, author

Although it's important to consider the full range of impacts, including environmental and socioeconomic changes, studying specific socioeconomic changes in depth can be highly useful. For this reason, the study will focus solely on the impact of establishing EL GOUNA on socioeconomic aspects. The information

gathered from interviews will be analyzed to identify the main effects and any associated side effects, and to evaluate whether each effect is positive or negative depending on the group affected. Ultimately, the study aims to determine the advantages and disadvantages of establishing the international coastal road and building EL GOUNA in terms of their socioeconomic impacts.

6 DATA AND ANALYSIS

Based on the research program titled "A guide to assessing the socio-economic impacts of Marine Protected Areas in Australia" (Program 2005) from 2005, the topics covered in the residents' stories were categorized into seven main categories. The author added an eighth additional category for other topics that could not be subtitled under these seven categories. The main categories of socio-economic indicators were income, population, society, education, employment, main profession, industry structure, and firm performance as shown in Figure 6.

Figure 6: main categories of socio-economic impacts assessing according the mentioned research program, author

Residents	income					Population							Society					Education			Employment					Industry Structure			other mentioned topics							
	individual income	average income	family expenses	Mortgage/rent payments	high and low incomes gap	sex, age	dependency ratios	marital status	change in Youth proportion	ethnic origin	language skills	religion	Social unity	Quality and living conditions	Social equality	vulnerable groupss	health	Education levels	skills	Training	Employment type	Employment hours	Employment security	Employment rate	Unemployment	employment by industry structure	number of businesses	selected expenses	Immigration	crimes rate	divorcing ratio	city identity	begging	respecting the elderly	residents relationship	lake
1 th	N	P	N	P	N				N				N	p			N				P	P	P	N	N	N	N			N	N	N			N	N	
2 th	N	P	N	P	N				N														N							N							
3 th	N	N			N			N		N						N	N				P		P			N				N	N			N			
4 th	N	N	N	P	N		N		N		P		P	N			N				P	P	P				N		P		P		N				N
5 th			N	P	N		P									N	N																N				
6 th	P	P	N	P				P		N			P	P								P	N	P			P	P	P	N				P			
7 th	N	P			N											N			N	N	N						P			N		N				N
8 th	N	N	N	N	N												P						N													N
9 th	N	P	N	P	N		N		N				N	P					N		N		N		P		N	N								
N	7	3	7	1	8		2	1	5	1		0	3	2	3	2	3	1	0	0	1	2	4	1	4	0	0	0	5	5	2	1	1	2	3	
P	1	5	0	6	0		2	0	0	0		1	2	2	1	0	0	1	3	2	4	0	1	0	0	1	3	2	1	0	0	1	0	0	0	
sum of mentions	8	8	7	7	8	0	4	1	5	1	1	0	5	4	4	2	3	2	3	2	5	2	5	1	4	1	3	2	6	5	2	2	1	2	3	

Table 2: scheduling data and analysis for residents' stories.

These topics, along with other issues mentioned, were analyzed based on the stories of nine narrators. A symbol was used to depict a narrator's opinion on the type of effect of the physical change, which could be either negative or positive. A table 2 was also provided to assist in scheduling various data.

The chart (Figure 7) illustrates the results of interviews conducted with nine individuals regarding the topics they discussed, including the percentage of positive and negative mentions. The findings highlight income disparities, immigration, high crime rates, and living expenses as the most commonly cited negative issues. Conversely, access to housing, job quality, average per capita income, and multiple sources of income were the topics with the most positive feedback. Furthermore, the number of times a topic was mentioned serves as an indication of its importance to the population. Therefore, issues surrounding income, living expenses, migration, and social inequality were among the most pressing concerns for the residents.
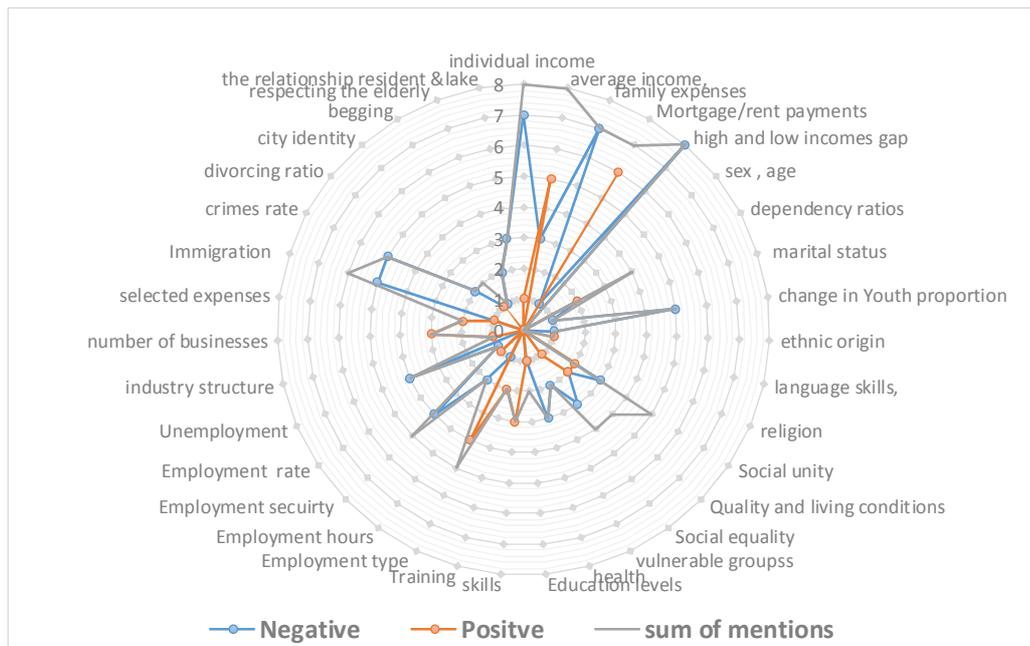
Figure 7: positve and negative opinions of resident about socio economic topics

6.1 Income

The issue of individual income was deemed significant by eight out of nine interviewees. Specifically, seven of them expressed negative sentiments toward the decline of basic professions, particularly fishing in the lake. This decline is attributed to various factors such as the increased distance between houses and boats, which range from 300 to 1500 meters once boats were anchored close to residences as shown in Figure 8 . Additionally, women's assistance in carrying fishing equipment became more difficult, as leaving them on the boat overnight made them vulnerable to theft. Some fishermen migrated to nearby villages along the lake's shore, while illegal fishing of small fish in AL-BAGHAZ became rampant, affecting profitability as criminals caught and sold them at high prices to fish farm owners.
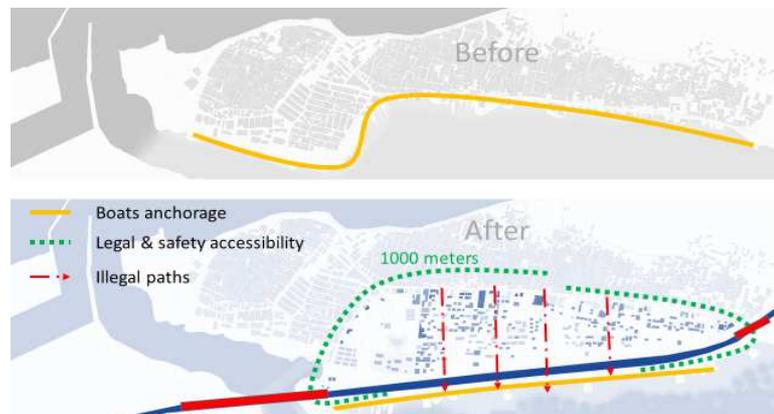
Figure 8: the distance between boats anchorage and homes. after and before the road costrucrion

Fish merchants faced challenges after the construction of the road as they had to move their operations to shops on the shore of the old city. To transport fishermen from the new docks to the store premises, they used cars, which proved to be expensive, particularly since the fishermen's return dates varied. As a result, some rich merchants purchased shops in the east of the city, while others went to other villages in BARBAHRI. However, the majority of fishmongers abandoned the trade and started working in different professions or went travelling. Due to the decline in sea fishermen employment, individuals began travelling to other Egyptian cities or even outside the country to find work. Five out of the nine interviewees stated that travelling increased average income despite being expensive and requiring procedures, physical ability, and suitable dates for children. In contrast, the seven individuals who talked about family expenses noted that it had become an enormous burden, unlike in the past when fish were readily available daily, and houses on the lake shore allowed for raising birds and storing rice annually as shown in Figure 9. Almost all of the speakers mentioned the widening income disparity as a significant issue. For instance, some residents owned multiple plots in EL GOUNA, which cost more than 30,000 EGP per square meter, compared to 4,000 EGP in the old city. In contrast, several families still reside in their father's house in the old city and face difficulties finding affordable housing, forcing many to consider emigration.
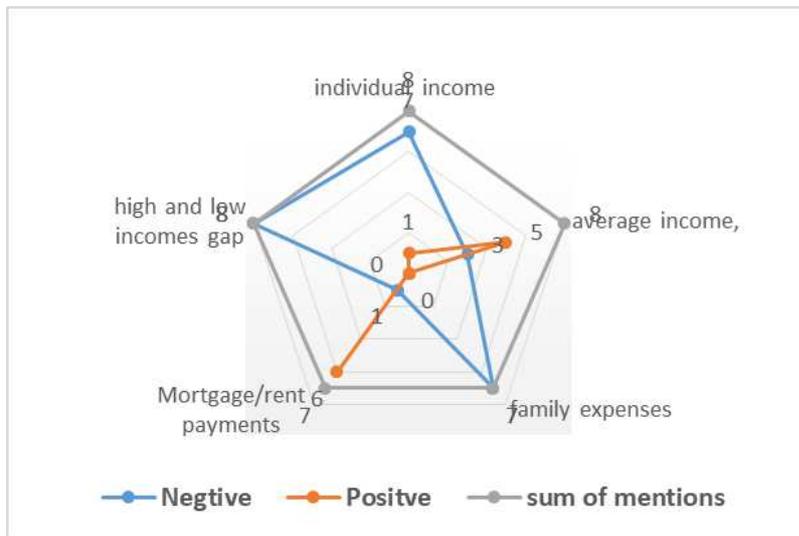
Figure 9: the percentage of negative and positive mentions to income topics

6.2 Population

The dependency ratios, which indicate the proportion of working-age individuals to the total population, have changed as the average family size has decreased from eight to four people. Some people view this positively as it has reduced household expenses, but others feel the opposite as having many children used to be an advantage for working in fishing and helping parents as shown Figure 10.

Figure 10: children help their fathers, film of behar elatash,19980

One resident mentions that young people are finding it difficult to marry early due to the high requirements, especially the cost of housing and construction in soft clay soil in ELGOUNA as shown Figure 11 , as well as the lack of funded housing for youth. This has led to a decrease in the percentage of young people in the city, and some have even migrated due to the lack of suitable job opportunities . The researcher notes that the number of elderly people and females dominates the city, with some residents stating that the city is no

longer attractive to young people. Fishing used to be an easy and fast way to earn a living, but now, due to changes such as the increase in land prices, many have turned to migration or other forms of work. Furthermore, the travel of residents abroad has led to the appearance of people from diverse ethnic backgrounds in the city. There has been an exchange of cultures, which has resulted in the learning of new languages and has had a positive impact on society.

Figure 11: long-term stages of building because of high cost, taken by author

6.3 Society

According to some residents, social unity between families has not strengthened due to various factors, including the exodus of fishermen and college graduates, as well as the widening income gap. However, others have a different perspective and argue that there are still some large families that remain socially and financially intact, even though at least one member from each family usually goes out to improve the family's income. Regarding living conditions, opinions vary as well. Some residents view it positively due to factors such as travel opportunities, good buildings, and easy accessibility by road. On the other hand, several fishermen from the lake in the old city suffer from difficult economic, environmental, and social challenges, with increasing disease rates, rising expenses, and decreasing income as shown in Figure 12. Regarding social equality, some residents in EL GOUNA have expressed concerns about the fairness of land ownership, given that it is based on an auction system that neglects the actual need for housing. Some argue that the rich tend to monopolize the land for real estate investment, leaving many undeveloped lots and unoccupied buildings. While most residents seem to share this sentiment, there are some who see the auction system as a fair way to own land.

One of the vulnerable groups in the area are the families of the lake's fishermen who are unable to travel for work and have limited employment opportunities. Unfortunately, the state has not provided sufficient support for them, especially in terms of housing. Moreover, social housing is inadequate and has been allocated illegally to undeserving individuals. Another resident has raised concerns over the lack of progress in improving services and infrastructure in the old town. Although a study by Elkady, Fikry, and Elsayad in 2018 (Elkady, Fikry, and Elsayad 2018)suggests that a minimum area of 46 m² is necessary for a family, many families are unable to obtain this amount due to the increasing number of families in the area.

Residents have noted a decline in overall health despite the presence of new hospitals and health centers. This is partially attributed to several factors, such as the city's environmental problems causing numerous diseases, the high cost of sea fish leading to increased consumption of preserved and unnatural foods, and the unhealthy habits of youth. Some residents have compared the current state of healthcare unfavorably to the past, when doctors such as MUHAMMAD GHALY and Dr. ARAFA treated all families and the general community enjoyed better health. Others have pointed out that the lake's pollution from car sewage and treatment plants has affected fish quality. Education rates have improved due to easier and safer travel opportunities after road construction, as well as the realization that a son's education and travel abroad is crucial for future financial stability. However, some residents have expressed concerns that fathers' frequent traveling may lead to some students dropping out of school. Nonetheless, the community has benefitted from technicians' transfer of skills and knowledge after traveling and training.

Figure 12: the gap between A) rich home and B) fisher home, taken by author.

6.4 Employment

The types of employment were traditional occupations and for the service of fishing, such as fish trade, boat industry, trade in boat fuel, trade in fishing tackle, manufacture and distribution of snow, spinning and trading...etc. But as people began to leave hunting and travel, they gained new experiences and were interested in education, so better and better jobs were created. However, some storytellers noted that "the working hours for travellers or technicians were not suitable for their families. Those who travelled abroad to fishing had an annual holiday that lasted no more than a month with their family. Fishing in Egypt's neighbouring cities also remains uninterrupted for twenty days a month.

According to residents, Job security has become too low for all professions saying "It is a great risk for the fisherman in the lake to cross the road, and a large number of young fishermen have already died, and also suffer constantly from the theft of their equipment. The fishermen on the sea outside the city spend a long time on the sea, which increases the risks". Although the nature of new jobs is better, the employment rate has dropped significantly, so the lake absorbs all the existing unemployment at the lowest cost, so the road is blamed for the increase in unemployment in the city as shown in

Figure 13: the percentage of negative and positive mentions to employment topics

6.5 Industry Structure and Firm Performance employment

The construction of an international road has improved mobility between cities, particularly industrial areas like DAMIETTA, GAMASA, BALTIM, MOTUBAS, EDCO and ALEXANDRIA. This has resulted in increased employment opportunities for young people in factories and companies in these areas. Moreover, families of these travelers are able to invest their money in the nearby areas, creating business opportunities. The involvement of their relatives also helps reduce labor costs.

6.6 Other mentioned topics

Immigration occurred in various locations and under different circumstances. For instance, fishermen from the city migrated to neighboring villages both east and west. College graduates also moved to other cities where they could find employment more easily. Presently, a significant number of people are migrating

because they are unable to afford daily expenses and do not own their own homes. During discussions with more than five individuals, high crime rates, particularly drug abuse, drug dealing, theft, murder, and earthquakes, were mentioned. Reasons cited for these crimes included unemployment due to the decline of the fishing industry, lack of supervision from traveling fathers, and large income disparities, which drove youth to resort to illegal activities to improve their income compared to travelers that obtained large amounts of money illegally and encouraged their children to do the same as shown in Figure 14 .
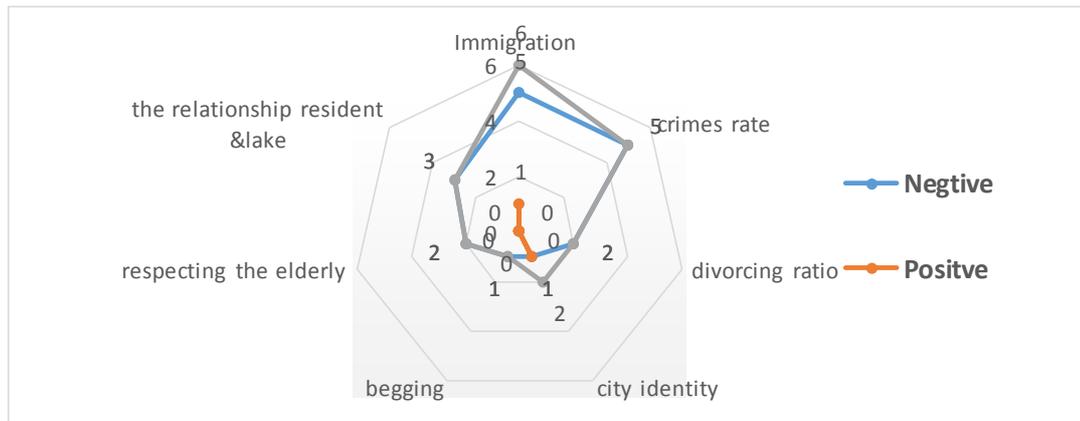
Figure 14: the percentage of negative and positive mentions to other mentioned topics.

According to some narrators, divorce rates in the city have increased significantly due to several reasons. Firstly, some women are unable to assist their husbands with fishing because boats are positioned too far away. Secondly, mothers prevent their children from fishing with their fathers due to concerns over traffic accidents. Thirdly, husbands traveling for long periods for work cause problems that lead to divorces. Fourthly, women find that their low income compared to the rich is insufficient to meet their needs. Lastly, some women refuse to migrate with their fishermen husbands. Rapid and unplanned urbanization has had a negative impact on the town's identity, although individual attempts have been made to preserve it. Due to the native population's constant migration, the identity of the town has begun to change at the people's level. Conversely, some people argue that the buildings and El GOUNA have enhanced the city's beauty in terms of urbanization.

During discussions, one person mentioned that begging, which is widespread nowadays, did not exist at all before. Additionally, the lack of respect among sons for their fathers was a frightening phenomenon in the BURULLUS community due to the distance between them while traveling.

Two individuals addressed an interesting topic in their narratives regarding the relationship between the inhabitants and the lake. According to one person, "the lake is like my daughter. Touching it, looking at it, and sitting next to it on the shore was a source of our happiness. The road blocked our view, but we protected it, and no one dared to harm it with sewage or by catching small fish." Another participant stated that the lake contributed greatly to their education and daily life. In addition to studying, they could earn money during limited hours and used the lake as the main spot for picnics with friends.

7 CONCLUSION

The research results were divided by the researcher into two distinct categories; one focused on the social and economic repercussions of these effects, while the other centered on utilizing social participation to tackle and solve these problems."

On a positive note, some of the residents in the new area (El Gouna) have the privilege of owning high-quality homes that are well-ventilated and have good lighting as well as wide roads. The existence of various industries and businesses in the city has also led to some individuals experiencing an increase in their income. Additionally, residents in El Gouna also have the benefit of having easy access to different cities, and through such exposure, they are exposed to a variety of ideas and cultures. Education is also easily accessible in the city, and there is also an increasing trend towards investment in the area. Certain types of work such as fishing away the city have also proven to be a significant source of income for some residents of El Gouna.On the flip side, there are several downsides to physical change in the city. The average income

of most individuals in the city is lower, making it difficult to meet the increasing household expenses. The income gap between different families has widened, consequently leading to unequal access to housing. As a result, a lot of fishermen have migrated from the city due to the challenges that come with fishing, as well as rising family expenses. Other issues that the city grapples with include a late marriage age and an unbalanced population of adults, which makes it difficult to maintain social bonds in families. Crime rates in El Gouna are also alarmingly high and have been linked to issues such as income inequality, unemployment rates, and travel. Finally, there is an increasing disparity in the level of services and opportunities available to different residents of the city, which makes things even more challenging.

The use of the narrative method in El Burllus city proved useful as it allowed inhabitants to speak freely and offer excellent suggestions towards resolving problems before the proposed railway project goes forward. Some of the suggestions are as follows:

- One inhabitant suggested that the fourth stage of El Gouna, which has not been sold yet, could be used differently to provide a significant opportunity. For example, the state could construct multistory towers to accommodate a large population. Then, it could improve the old city and create wider pathways and roads within it. Affected individuals could be compensated with apartments in the new towers.

- Another individual proposed creating a new village for the fishermen on the shore of the lake, to solve the issue of fishermen in the city. The new village could also protect AL-BOUGHAZ from local fishers engaging in illegal fishing. Furthermore, the establishment of this new village would help preserve the unity of families, preventing their dispersion into different areas.

- Some of the inhabitants suggested creating canals between houses in El Gouna, using the traditional method to facilitate fishing, prevent equipment theft, and overcome the danger of crossing the highway. This suggestion would also solve environmental problems, including the drainage of rainwater and its consequences.

- One narrator expressed that if the international road had passed from the north of the city, it would have been more beneficial as it could have preserved the beach from erosion. as well as It would have also protected the area from rising sea levels in the future.

- Additionally, one of the fishermen suggested that encouraging people to open fish shops on the beach could motivate most fishermen to work in the lake.

8 ACKNOWLEDGEMENTS

9 REFERENCES

Abayazid, Hala. 2012. "Coastal Lake Sustainability: Threats And Opportunities With Climate Change." IOSR Journal of Mechanical and Civil Engineering 1(5): 33–41.

Andrews, Nathan et al. 2021. "Oil, Fisheries and Coastal Communities: A Review of Impacts on the Environment, Livelihoods, Space and Governance." Energy Research & Social Science 75: 102009.

Bauer, Martin W, and George Gaskell. 2017. Pesquisa Qualitativa Com Texto, Imagem e Som: Um Manual Prático. Editora Vozes Limitada.

Charvet-Almeida, Patricia, Maria Lúcia Góes de Araújo, and Mauricio Pinto de Almeida. 2005. "Reproductive Aspects of Freshwater Stingrays (Chondrichthyes: Patamotrygonidae) in the Brazilian Amazon Basin." Journal of Northwest Atlantic Fishery Science 35(February): 165–71.

Chu, E W, and J R Karr. 2017. "Environmental Impact: Concept, Consequences, Measurement." Reference Module in Life Sciences.

Dewidar, KH M. 2004. "Detection of Land Use/Land Cover Changes for the Northern Part of the Nile Delta (Burullus Region), Egypt." International Journal of Remote Sensing 25(20): 4079–89.

Diegues, A. C. 2008. "Marine Protected Fisheries in Brazil Areas and Icsf." Samudra monographs.: 1–65. www.icsf.net.

Eldeep, Ahmed, and Ahmed Elkady. 2022. "Urbanization and Environmental Change: Local Effects of the International Coastal Road on Burg Elburullus City." SVU-International Journal of Engineering Sciences and Applications 3(1): 29–36.

Elkady, A.A., M.A. Fikry, and Z.T. Elsayad. 2018. "Developing an Optimized Strategy Achieving Design Flexibility in Small-Area Units: Case Study of Egyptian Economic Housing." Alexandria Engineering Journal 57(4).

Elrazi, Mohamed. 2020. "Annual Bulletin of Statistics Fish Production."

Future Earth Coasts, I P O. 2009. R&S 35. Dynamics and Vulnerability Of Delta Systems.

Granzotto, A et al. 2004. "Comparison between Artisanal and Industrial Fisheries Using Ecosystem Indicators." Chemistry and Ecology 20(sup1): 435–49. https://doi.org/10.1080/02757540310001629224.

Hacohen-Domené, Ana, Francisco Polanco-Vásquez, Colombo Estupiñan-Montaño, and Rachel T. Graham. 2020. "Description and Characterization of the Artisanal Elasmobranch Fishery on Guatemala's Caribbean Coast." PLoS ONE 15(1): 1–19.

Hatchell, Helen, and Nado Aveling. 2010. "Those Same Old Prejudices? Gendered Experiences in the Science Workplace." Journal of Workplace Rights 13(4): 355–75.

Iskander, Moheb, and National Water. 2017. "Environmental Friendly Methods for the Egyption." (July 2015).

Kohler Riessman, Catherine. 2002. "Illness Narratives: Positioned Identities." Health Communication Research Centre, Cardiff University (May): 1–35.

Masria, A., A. Negm, M. Iskander, and O. Saavedra. 2014. "Coastal Zone Issues: A Case Study (Egypt)." Procedia Engineering 70: 1102–11. http://dx.doi.org/10.1016/j.proeng.2014.02.122.

Muylaert, Camila Junqueira et al. 2014. "Narrative Interviews: An Important Resource in Qualitative Research." Revista da Escola de Enfermagem da USP 48(spe2): 184–89.

Nations, United. 2018. "Revision of World Urbanization Prospects." United Nations: New York, NY, USA.

Patra, Suman, Satiprasad Sahoo, Pulak Mishra, and Subhash Chandra Mahapatra. 2018. "Impacts of Urbanization on Land Use /Cover Changes and Its Probable Implications on Local Climate and Groundwater Level." Journal of Urban Management 7(2): 70–84. https://doi.org/10.1016/j.jum.2018.04.006.

Program, Social Sciences. 2005. "Socio-Economic Impact Assessment Toolkit." : 41.

Riessman, Catherine Kohler. 2003. "Performing Identities in Illness Narrative: Masculinity and Multiple Sclerosis." Qualitative Research 3(1): 5–33.

Shaltout, Kamal Hussien. 2010. "Towards Mainstreaming of Lake Burullus Biodiversity , North Egypt Kamal Hussien Shaltout." Ass. Univ. Bull. Environ. Res 13(1): 71–87.

Singer, Merrill. 2018. "Climate Change and Social Inequality: The Health and Social Costs of Global Warming." Climate Change and Social Inequality: The Health and Social Costs of Global Warming (152): 1–247.

Song, Jie et al. 2016. "Analyzing the Impact of Highways Associated with Farmland Loss under Rapid Urbanization." ISPRS International Journal of Geo-Information 5(6).

United Nations. 2020. World social report 2020 Inequality in a Rapidly Changing World.

EVAPO+ Transpiring Green Walls – a Demonstration on How to Maximise the Evapotranspiration Effect to Cool Down our Microclimate

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1 ABSTRACT

It is undeniable that climate change effects are impacting our daily lives and need to be considered when shaping our living environment and therefore also included in matters of spatial and landscape planning. Climate change adaptation measures mostly address climate change effects in large cities – such as overheating and urban heat islands. New approaches and solutions to improve liveability and to act against the consequences of climate change are required – not only in big cities but also in smaller towns and rural communities.

Nature-based-Solutions (NbS) can tackle some of the most pressing urban environmental and societal challenges such as urban heat islands and by fostering adaptation to climate, halting biodiversity loss and promoting public health and social cohesion. Green and blue infrastructures are considered to be a form of urban sustainability as they not only reduce temperatures and other urban environmental effects, but also improve air and water quality, reduce stormwater runoff, and attract pollinators. Vertical greening and green walls have many advantages and combine a positive effect on the environment and microclimate with an improvement in the quality of life in urban areas.

During the research project "Strasshof. Klimafit!" a concept for "EVAPO+ transpiring green walls" was developed. In comparison to other forms of vertical greening, the EVAPO+ transpiring green walls have a particularly high cooling effect and primarily serve as natural air conditioning in the outdoor area. The name "EVAPO+ transpiring green wall" is derived from the term evapotranspiration, which is the evaporation from plants, water, soil and substrates. EVAPO+ green walls increase and maximise evapotranspiration and thus contribute more effectively than other green wall systems to cooling the microclimate surrounding us.

With the EVAPO+ transpiring green walls which have been innovatively developed, the quality of stay can be improved at many locations in microclimatic areas. Essential functions of green infrastructure and nature-based solutions, such as creating shaded spaces as well as reducing the reflection of incoming solar radiation and cooling of the surrounding environment through evaporation can additionally be strengthened.

Keywords: urban heat island, example, green infrastructure, microclimate, evapotranspiration

2 BASELINE

2.1 Climate Change and Urban Heat Island Effect

It is undeniable that climate change effects are impacting our daily lives and need to be considered when shaping our living environment and therefore also included in matters of spatial and landscape planning. Climate change adaptation measures mostly address climate change effects in large cities – such as overheating and urban heat islands.

The urban heat island (UHI) effect is a phenomenon in which urban areas experience higher temperatures than surrounding rural areas due to urbanisation and human activities. It mainly occurs due to the high percentage of sealed surfaces, asphalt roads and the density of high buildings. These surfaces heat up a lot when exposed to sunlight, and the lack of plants, green areas and unsealed ground means that little water can evaporate to cool the surroundings. Due to the high percentage of sealed surfaces, evaporation is reduced while the solar irradiation on building and road surfaces is stored at the same time. With climate change, the number of very hot days (temperatures exceeding 30°C) increases, and the heat island effect additionally causes an increase in temperature. The UHI effect can cause significant warming of the local climate and can

be especially troubling during summer heatwaves when temperatures are particularly hot. It is therefore necessary that we adapt our urban construction methods to keep the UHI effect as low as possible. This can be achieved, among other things, through shading, planting and evaporative cooling.

Due to the fact that the population in communities surrounding large cities is constantly growing, small towns and rural communities are burdened with severe influx and, as a consequence, densification and a growing percentage of sealed surfaces to create housing and infrastructure. This causes a loss of green areas which in turn intensifies the consequences of climate change. For this reason, even, in small towns and rural communities, there is a need to take measures to counteract climate change effects, such as heat waves, drought and heavy rain.

New approaches and solutions to improve liveability and to act against the consequences of climate change are required – not only in big cities but also in smaller towns and rural communities.

2.2 Nature-based Solutions and Green Infrastructure

Nature-based solutions (NbS) and green infrastructure (GI) are both approaches used to address environmental challenges and promote sustainability. While there is some overlap between the two concepts, they have distinct characteristics and areas of focus.

Nature-based solutions (NbS) refer to the use of natural processes and ecosystems to tackle societal and environmental challenges. NbS leverage the power of nature to provide sustainable and cost-effective solutions. They involve the conservation, restoration, and management of ecosystems and biodiversity to deliver multiple benefits, including climate change mitigation, adaptation, and disaster risk reduction. NbS can take various forms, such as reforestation and afforestation projects, wetland restoration, coastal management initiatives, and urban greening efforts. These solutions often mimic or restore natural processes, enhancing ecosystem services like water purification, flood regulation, carbon sequestration, and habitat provision. NbS are designed to be resilient and adaptive to changing conditions, providing long-term benefits for both humans and the environment. NbS can tackle some of the most pressing urban environmental and societal challenges such as urban heat islands, fostering adaptation to climate, halting biodiversity loss and promoting public health and social cohesion. Over the last decade, NbS have increasingly been promoted as cost-efficient, no-regret solutions to address urban challenges in cities. The benefits nature delivers have been highlighted in European and international frameworks such as the EU Biodiversity Strategy for 2030, the Urban Agenda 2030 or others. The successful implementation of NbS depends on a sound knowledge and understanding of NbS, the complex processes of natural systems and NbS design features and options. Whilst scientific evidence of the multifunctional benefits of NbS is plentiful and well-documented, and technical knowledge on NbS design and implementation abundantly available, there is a lack of coherent, market-orientated and scalable models for local NbS design and implementation.

On the other hand, green infrastructure (GI) refers to a strategically planned network of natural and semi-natural spaces that conserve ecosystem values while also supporting human needs. It is a systematic approach to land use planning and design that incorporates natural elements into urban and rural areas. In the context of EU policies, GI is defined as "A strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity." (Directorate-General for Environment) GI aims to create a multifunctional network of green spaces that provide various environmental, social, and economic benefits. GI includes features like parks, forests, wetlands, green roofs, urban gardens, permeable pavements, and green corridors. These elements help manage stormwater, reduce urban heat island effects, enhance air quality, provide recreational opportunities, support biodiversity, and improve the overall quality of life in cities and regions. Green infrastructure is often integrated into urban planning processes to create more sustainable and resilient communities.

GI also includes vertical greening, such as complex façade-bound greening or ground-bound greening in outdoor areas, which are effective countermeasures. Because vertical greening hardly requires any additional space, it offers great potential for further application, especially against the background of urban densification. Green walls have many advantages: as a "natural air conditioning system", they cool the ambient temperature, absorb rainwater (water retention), improve air quality (pollutant filtering, fine dust binding, air purification, oxygen production, CO2 binding), reduce noise, create habitat for birds and insects

260

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(biodiversity), protect buildings from negative external influences (weathering, heat, cold, UV radiation, rain), energy costs for air conditioning in summer and heating in winter can be saved. In addition, the aesthetic value of green walls has multiple positive effects on our well-being. The quality of life and housing of the urban population in their direct living and working environment is increased. Vertical greening therefore combines a positive effect on the environment and microclimate with an improvement in the quality of life in urban areas.

Both – NbS and GI – are a form of urban sustainability as they not only reduce temperatures and other negative urban environmental effects, but also improve air and water quality, provide space for recreation, reduce stormwater runoff, and attract pollinators – all in all they help greatly with climate mitigation and adaptation. For the sake of completeness, blue infrastructures are infrastructures with visible "blue" in the form of water. This can be e.g., artificial, newly created ponds, water areas or water features. On the other hand, this also includes existing natural bodies of water. The connection of green (land) and blue (water) infrastructure has many advantages for the quality of the environment and natural areas and improves people's health and quality of life. In view of the constant loss of inner-city green spaces with increasing global climate change, which leads to urban heat islands, especially in cities, greening of buildings is becoming increasingly important. While nature-based solutions and green infrastructure share a common goal of utilising nature for environmental benefits, the main difference lies in their scope and focus. Nature-based solutions encompass a broader range of approaches that can address diverse environmental challenges, including climate change and disaster resilience. Green infrastructure, on the other hand, primarily focuses on urban and regional planning, emphasizing the integration of natural elements into human-made environments. Nature-based solutions and green infrastructure are complementary approaches that leverage the power of nature to promote sustainability. Nature-based solutions encompass a broader range of approaches for addressing environmental challenges, while green infrastructure primarily focuses on integrating natural elements into urban and regional planning to create sustainable and resilient communities.

3 STRASSHOF. KLIMAFIT! – A LIGHTHOUSE DEMONSTRATION PROJECT

3.1 About the project

"Strasshof. Klimafit! Strasshof as a lighthouse: EVAPO+ green walls, green infiltration troughs, empowerment and practical transfer" is a lighthouse demonstration project that stimulates processes for climate change measures by empowering other municipalities and small towns. The project aims to implement resilient, multifunctional and "climate-fit" solutions that respond to heat and heavy rain, improve the microclimate, increase the quality of life and living while promoting biodiversity in existing areas of the municipality Strasshof an der Nordbahn in Lower Austria. With these measures, the municipality of Strasshof can act against climate change consequences and improve the liveability of the population. The transferability of the demonstrations will be guaranteed with the help of various regional, national and international exchange forums. In cooperation with other Austrian municipalities, the lessons learned from Strasshof will be reflected and transferred to the regional network "Climate-Fit Small Towns and Municipalities" along with step-by-step instructions for climate-fit municipalities.

The project is funded by the Austrian Climate and Energy Fund, Klima- und Energiefonds, under the Smart Cities Initiative in Austria, from April 2022 to March 2025.

3.2 About the municipality

Strasshof an der Nordbahn is located about 25 km northeast of Vienna (Austria) in the political district of Gänserndorf and is part of the northern Marchfeld region in the province of Lower Austria. Originally planned and laid out as a Viennese suburb as a kind of "garden city", the settlement had only about 50 inhabitants around the year 1900. With the construction of a marshalling yard of the northern railroad in Strasshof, the economic upswing began in 1906. In recent decades, the town has developed rapidly, and, with 11,786 inhabitants (as of January 1, 2023), it is by far the largest town in the Marchfeld region. With an average population density of 1,012 inhabitants per square meter, the municipality has a compact settlement area. With the help of construction bans, Strasshof has already been taking on municipal tasks that have become pressing in recent years due to enormous population growth. Equally urgent still is the development of climate change-adapted strategies, through which the community can prepare for changing climatic conditions. Since 1999, Strasshof an der Nordbahn has been an active climate alliance municipality with the

goal of continuously reducing greenhouse gas emissions because it is becoming increasingly important for municipalities to improve the quality of life and standards for their citizens by running projects that fulfil their targets.

4 EVAPO+ TRANSPIRING GREEN WALLS IN STRASSHOF

In the course of the project Strasshof. Klimafit! a concept for "EVAPO+ transpiring green walls" was developed. In comparison to other forms of vertical greening, the EVAPO+ transpiring green walls have a particularly high cooling effect and primarily serve as natural air conditioning in outdoor areas. EVAPO+ transpiring green walls consist of a horizontal vegetation carrier with a continuous vertical substrate body that increases evaporation of the substrate, provides more root space for plants and thus more leaf mass and transpiration. The substrate in the vegetation carrier in addition to the plants causes higher evaporation rates. This technique in combination with automatic irrigation systems leads to greater leaf mass of the plants and therefore higher transpiration. Overall, they increase evapotranspiration, which serves to cool the surrounding area. The irrigation system of the vertical substrate level has a relatively high-water absorption capacity and releases the water slowly. Automatically weather-controlled, this level is watered more on warm and hot summer days. To reduce the top-bottom gradient of green walls, where top and side areas tend to be too dry, a special version of the automatic irrigation system is used. EVAPO+ transpiring green walls make a significant contribution to the adaptation of urban spaces to climate change.

The name "EVAPO+ transpiring green wall" is derived from the term evapotranspiration. Evapotranspiration is the transpiration from plants and evaporation from water, soil and substrates. EVAPO+ green walls increase and maximise evapotranspiration and thus contribute more effectively than other green wall systems to cooling the microclimate surrounding us.

The EVAPO+ transpiring green walls fulfil multifunctional effects on different levels. In addition to microclimatic effects, these effects are in particular:

- As a space-dividing element, the green wall (in a free-standing variation) can counteract conflicts of use at busy open spaces and create protected areas.
- Due to the continuous vertical substrate layer and plant cover, the green wall absorbs sound and can provide low conflict use and pleasant quality of stay as noise protection is provided along roads or playgrounds and sports fields.
- The plants and the moist substrate surface bind dust and harmful air particles and thus increase the quality of stay in the vicinity.
- Plants have a calming psychological influence on people and thus increase well-being and the quality of stay in the open space.

Three different types of EVAPO+ transpiring green walls have and will be implemented as demonstration objects in Strasshof an der Nordbahn as microclimate-improving measures which have been further optimised with regard to evapotranspiration cooling effects, leading to a better quality of life and supporting biodiversity:

- Public buildings: The first EVAPO+ green wall was implemented on the east-facing roof terrace of the municipal office in Strasshof.
- School/outdoor classroom: The implementation of another green wall is planned in combination with a pergola at a school site in Strasshof.
- Central public area: The implementation of a free-standing green wall in combination with seating in a central public area in Strasshof is currently being discussed.

4.1 Construction details

EVAPO+ transpiring green walls belong to the wall-bound façade greening categories. Compared to ground-based and trough-based vertical greening with climbing plants, wall-bound vertical greening can increase microclimatic effects.

The special characteristic of the innovative EVAPO+ transpiring green wall is a horizontal vegetation carrier with a continuous substrate body. This enormously increases the evaporation of the substrate. In addition, the

larger root spaces in EVAPO+ transpiring green walls allow for more developed plants, which leads to greater leaf mass and thus increases the transpiration of the vegetation. This results in the effect of an overall increased evapotranspiration, which cools the surrounding area.

To increase evaporation, the EVAPO+ transpiring green wall has a special design with two different substrate levels and two separate water circuits. The substrate, which runs vertically through the entire construction as a base for the greening, is designed like a gabion wall with a technical, structurally stable, and humus-free substrate in a grid structure and provided with its own irrigation circuit.

The actual plant and substrate level in front is lined with a knobbed layer made of HDPE plastic as constructive wood protection and a layer of geofleece on top. It is filled with a substrate mixture for intensive roof gardens. Watering is automatic via drip hoses running horizontally in the plant troughs.

The following visualisation shows in detail how the EVAPO+ transpiring green wall is constructed and layered. To highlight is the continuous substrate body at the back of the green wall.
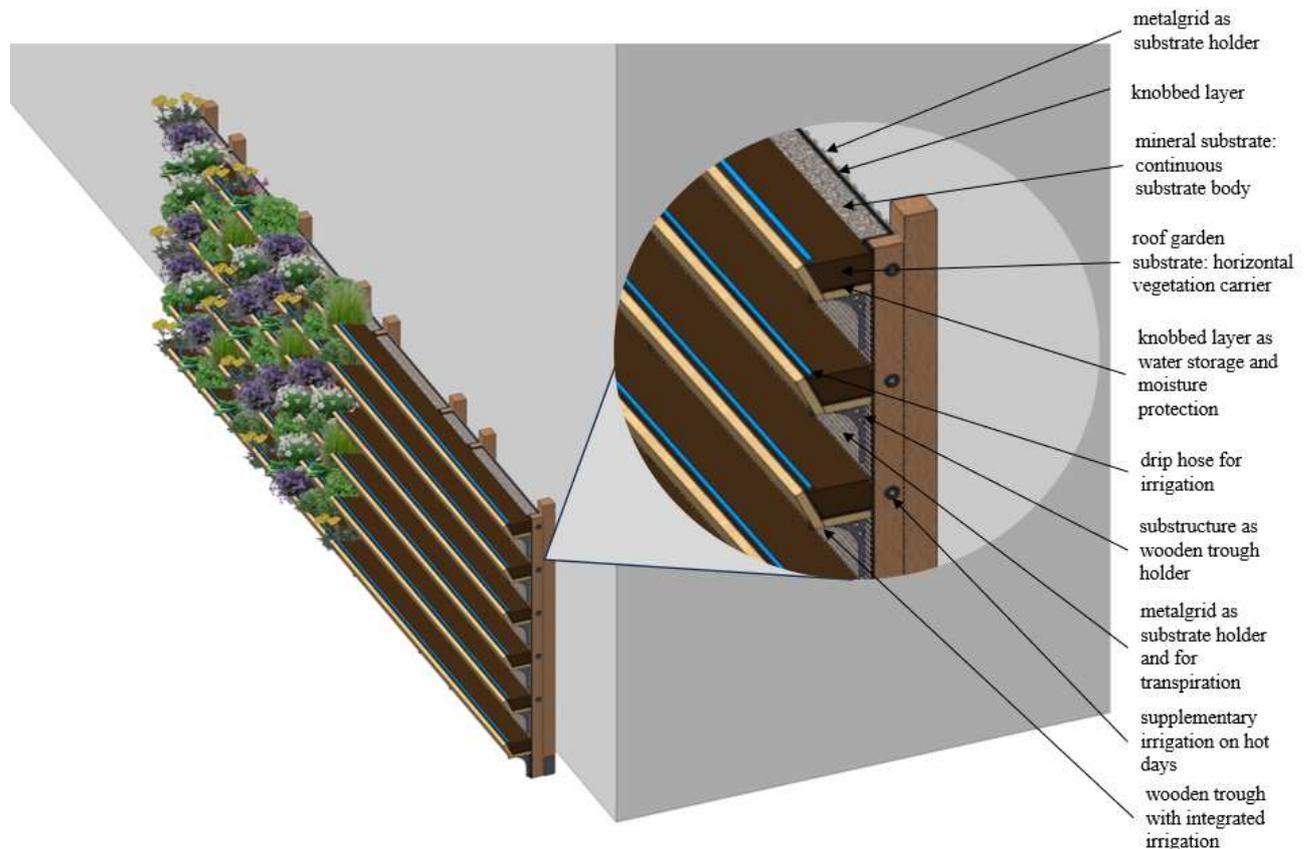
Fig. 1: Illustration of the EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office building

4.2 Plants and rhizosphere

The root area is a crucial growth criterion for the plant. The planting is carried out with robust, perennials and herbs. A root space of 1.5 litre of roof garden substrate is available per plant in the vegetation level with the plant troughs alone. In the underlying, vertically continuous substrate level, additional root space can be developed by the plants. According to the standard (ÖNORM L 1136) for full-surface wall-bound green roofs, the minimum dimensions of one litre of available root space per plant is required which is thus well surpassed. The plant substrate consists of a mixture of organic or mineral components that form the vegetation layer. A combination of ready-to-use materials such as crushed bricks and pumice, and filling materials such as sand and compost with an admixture of perlite, is applied.

4.3 Irrigation system

To optimise the performance of EVAPO+ transpiring green walls in dry periods and hot summer days two automatic irrigation systems for the rear substrate are designed. The first type of automatic irrigation system has a relatively high-water absorption capacity and releases the water slowly. The other type of irrigation

system is automatically weather-controlled. This means, the substrate is watered more on warm and hot summer days. This special irrigation system causes an increase in evaporation via the substrate surface on hot days and a reduction in the top-bottom gradient of green walls where top and side areas tend to be too dry on hot days. The substrate consists exclusively of mineral fractions with a grain size of 2 to 8mm, a maximum water capacity of 40% by volume and a water permeability mod. Kf of 0.68 cm/s.

The following illustration shows the two automatic irrigation systems: the main irrigation system for plantgrows in the horizontal vegetation carrier respectively the front substrate level and the additional irrigation system for hot summer days integrated in a continuous vertical substrate body (rear substrate level).

Fig. 2: Separate water circuits for watering the EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office building

4.4 Demonstration 1: EVAPO+ transpiring green at the terrace of the municipal office

The EVAPO+ transpiring green wall is built on the east-facing roof terrace of the Strasshof municipal office and attached to the façade. The green wall is 6m long and 2.40m high. The frame construction for the green wall is made of larch wood, which forms the substrate and plant carrier in the form of rows arranged one on top of the other. Over 300 plants were used. The following plant species (perennials and herbs) where planted in the Demonstration 1 EVAPO+ transpiring green wall: Alchemilla sericata, Allium schoenoprasum, Armeria maritima, Aster ageratoides, Bergenia cordifolia, Dianthus deltoides, Geranium wallichianum, Geranium x cantabrigiense, Geranium sanguineum, Geranium pratense, Iris x barbata-nana, Levisticum officinale, Melissa officinalis and Thymus x citriodorus.

Fig. 3 and 4: EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office

Most perennials are deciduous. About a third of the perennials are evergreen so that a relatively green wall can be seen, even in winter.

Fig. 5: EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office building

4.5 Demonstration 2: EVAPO+ transpiring green as part of a newly built outdoor classroom

In the Middle School in Strasshof, an outdoor classroom is currently under planning. This design will combine an EVAPO+ transpiring green wall with a pergola construction providing additional shade through climbing plants. The climbing plants form a ground-based vertical greening with climbing frames and aids.

Fig. 6 and 7: Construction details and visualisation of a draft of the outdoor classroom with EVAPO+ transpiring green wall

The EVAPO+ outdoor classroom will be set up near a south-east-facing large window area of the school building to produce shade and a cooling area for the school library, while creating a cool outdoor lounge for school lessons and breaks. In addition to the microclimatic advantages of the EVAPO+ green wall, climbing plants will be applied to the pergola on stainless steel cable elements and thus reduce the solar input into the school building. The deciduous climbing plants shade the library in summer and let the sun through in winter after the leaves have fallen.

Compared to the wall bound EVAPO+ transpiring green wall at the Strasshof municipal office, the EVAPO+ transpiring green wall within the outdoor classroom will be two-sided, meaning that both sides of the free-standing wall will be filled with plants. For that purpose, wide plant troughs are embedded in the pergola construction, which creates the possibility of two opposing vertical vegetation areas. Partitions with structurally stable technical substrates in grid structures are also installed in the middle of the plant troughs to increase evaporation.

The following visualisation shows in detail how the EVAPO+ transpiring green wall within the outdoor classroom at the Middle School in Strasshof is constructed and layered. To highlight is the double-sided design of the free standing wall.
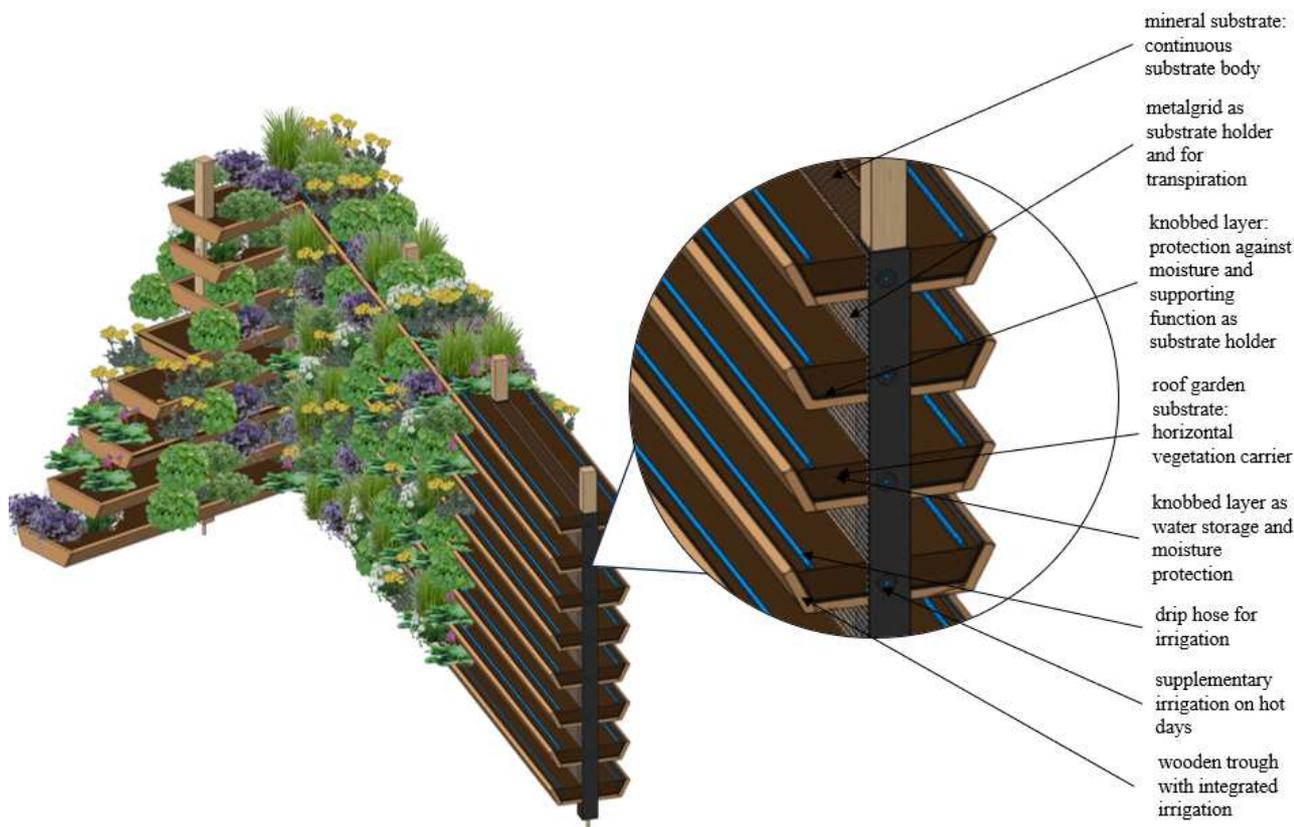
Fig. 8: Construction of the EVAPO+ transpiring green wall within the outdoor classroom at the Middle School in Strasshof

The EVAPO+ outdoor class will be designed using versatile perennial planting that will be home to a wide variety of flowering and fragrant perennials as well as herbs and, if desired, fruit or vegetables for cooking classes.

The outdoor classroom includes several categories of vertical greenery. The EVAPO+ transpiring green wall is a combination of wall-bound vertical greening with partial vegetation and wall-bound vertical greening with full-surface vegetation supports. The vertical greening with climbing plants is surrounded by a wooden border respectively a trough without a bottom. It is only recognisable as ground-based vertical greening at second glance.

The excess irrigation water of the EVAPO+ transpiring green wall is directed into the root area of the climbing plants via an underground supply pipe. Generally, there is a natural irrigation through rainwater and groundwater extraction in the case of ground-based vertical greenings.

The irrigation of the EVAPO+ transpiring green wall will be combined with rainwater harvesting (sustainable rainwater management, careful use of potable water). To save tap water for watering the EVAPO+ transpiring green wall, the installation of a rainwater tank is planned. The rainwater storage tank will receive the precipitation water from the roof of the school building. With the potential to use rainwater for irrigation, the goals of sustainable rainwater management and more careful use of drinking water can be achieved. Irrigation is carried out with low pressure and drip hoses and can thus also be fed with rainwater in public spaces.

266

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Construction work started during the school summer break 2023. With school starting again in September 2023, the plants will be added with the participation of students, so that the EVAPO+ outdoor class will be ready to use starting in autumn 2023.

Fig. 9 and 10: Ground construction/substructure of the EVAPO+ transpiring green wall within the outdoor classroom at the Middle School in Strasshof

5 CONCLUSION AND OUTLOOK

EVAPO+ transpiring green walls are a version of vertical green walls that can be seen as nature-based solutions and form a part of green infrastructures. Through the increased evapotranspiration, essential functions and benefits of green infrastructure and nature-based solutions are enhanced. EVAPO+ transpiring green walls are an easy solution to improve microclimates by cooling the surroundings, improving air quality and quality of stay for different users in urban open areas. They also lead to improvements in urban infrastructures, and in the settings of living and working spaces, etc. The innovatively developed EVAPO+ transpiring green walls can improve the quality of stay for many varying locations: they come in different shapes and sizes and can be combined with other built infrastructures (see outdoor classroom). EVAPO+ green walls can be used e.g., as wall-bound vertical greenery on buildings, in combination with pergola constructions to produce shade, or as free-standing room dividers, for example for terraces and seating areas. Furthermore, the choice of plants can be adapted to individual needs and situations. The evapotranspiration effect increases of course with the size of the EVAPO+ transpiring green wall. Generally, the team aims for construction heights of a maximum of 4 to 5 meters.

The developments around the EVAPO+ transpiring green walls aim to create the most robust, resilient vertical greenery possible in the immediate living and working environment and have exceptional microclimatic advantages. To prove these advantages, the EVAPO+ transpiring green walls will be monitored throughout the project. Measurable goals include microclimatic effects and positive effects regarding rainwater management. Further, it will be important to monitor the quality of stay for the immediate users. The following measurements will lead to a monitoring of the anticipated effects:

- Microclimatic effects through shading and evapotranspiration of the plants and the substrate body. Measurement sensors have been and will be installed and will measure temperature, humidity, and solar radiation through the entire duration of the project for monitoring. The results will be compared to reference measurements.

- To monitor the use and impact on the users, surveys will capture discernible effects of the EVAPO+ transpiring green walls on summer/heat days. Various needs and possible uses and applications of the green wall will be considered. Attention will also be paid to different needs and possible conflicts of use and interest.

Overall, the EVAPO+ transpiring green walls demonstrate an easy way to cool down microclimates with aesthetic effects. The increased and resilient transpiration effect of the plants, together with the evaporation over the extensive substrate surface, creates a particularly efficient evaporation coolness. Further, the vegetation develops much better and is many times more resilient than all wall-bound vertical green walls

available on the market, even in the event of disruptions or failure of the irrigation system. The demonstrations in Strasshof an der Nordbahn provide a good example for other municipalities or locations.

6 REFERENCES

DIRECTORATE-GENERAL FOR ENVIRONMENT: Green infrastructure. Available online at
https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en, checked on 06/23/2023.
FECHNER, Johannes; Mayr-Ebert, Michael (2020): Regenwasser in der Stadt. Technologie Report. Edited by Wirtschaftsagentur Wien. Wien. Available online at https://wirtschaftsagentur.at/fileadmin/user_upload/Technologie/Factsheets_T-Reports/Technologiereport_Regenwasser_in_der_Stadt_DE_WEB.pdf, checked on 10/13/2021.
KNOLL, Bente; Renkin, Agnes; Fleischmann, Michael; Knasmillner, Elisabeth; Hiller, Andreas; Dopheide, Ralf; Schiefermair, Fabian (2022): Spatial and Settlement Development Adapted to Climate Change in Strasshof an der Nordbahn (Lower Austria). In: 27th International Conference on Urban Planning and Regional Development in the Information Society GeoMultimedia. Unter Mitarbeit von Manfred Schrenk und Clemens Beyer. Real Corp. Airportcity Space Vienna International Airport, 14.-16.11.2022. Available online at https://www.corp.at/archive/CORP2022_140.pdf, checked on 06/23/2023.
KNOLL, Bente; Renkin, Agnes; Fleischmann, Michael; Knasmillner, Elisabeth; Sisko, Klaudia; Karner, Markus et al. (2022): Klimawandelangepasste Raum- und Bebauungsplanung. Am Beispiel der Marktgemeinde Strasshof an der Nordbahn. In: IBO - Österreichisches Institut für Bauen und Ökologie (Hg.): BauZ! Wiener Kongress für zukunftsfähiges Bauen. BauZ! Wien, 11.-12.05.2022.
KNOLL, Bente; Renkin, Agnes; Ralf Dopheide; Knasmillner, Elisabeth; Karner, Markus; Fleischmann, Michael et al. (2022): Raum & Grün. Möglichkeiten zur Integration von Begrünung ins Regelwerk der österreichischen Raumordnung. Edited by Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK) (Berichte aus Energie- und Umweltforschung, 45). Available online at https://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe-2022-45-raum-und-gruen.pdf, checked on 06/23/2023.
KRAUS, Florian; Fritthum, Roman; Robausch, Eva; Scharf, Bernhard; Preiss, Jürgen; Enzi, Vera et al. (2019): Leitfaden Fassadenbegrünung. Edited by MA 22 - Wiener Umweltschutzabteilung. Available online at https://www.wien.gv.at/umweltschutz/raum/pdf/fassadenbegruenung-leitfaden.pdf, checked on 1/30/2020.

268

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Exploring Nature-Based Solutions for Urban River Restoration: Insights from China's Sponge City Programme

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1 ABSTRACT

In cities, river restoration is widely recognised as an essential Nature-based Solution (NbS) that delivers a wide range of benefits. However, rapid urbanisation and economic growth over the past four decades have led to the degradation of Chinese rivers. In response, the Chinese government introduced the Sponge City (SC) concept in 2013 as part of the 'Ecological Civilisation' era. The SC, considered a hybrid NbS, was designed to foster urban resilience, particularly against severe disasters such as floods. The nationwide SC Program (SCP) commenced in 2014. Since then, the number of participating cities has continued to grow. As a result, a large number of Chinese cities have been transitioning from traditional grey infrastructure to green/blue infrastructure with substantial investments, leading to the restoration, redesign and revitalization of urban rivers. Despite these efforts, there is a noticeable lack of research that examines urban river restoration from a multi-beneficial NbS perspective, a current global research trend. To address this research gap, the present study adopted a mixed-methods approach, combining expert interviews with bibliometric analysis, to explore the specific role of urban rivers as an NbS within the SC framework. Our study revealed an increasing scientific interest in urban river restoration beginning in 2013, viewing them as elements of sponge construction. Alongside this, there's a progressively nuanced understanding of rivers as multifunctional NbS. In addition, we identified specific challenges that impede the successful implementation of these NbS in Chinese cities. To overcome these barriers, we formulated a set of recommendations that are in harmony with China's new River Chief System policy and the Ecology Oriented Development (EOD) model. The aim is to enhance the sustainable governance of urban rivers as an NbS in the long term, thus contributing to overall sustainable development in China.

Keywords: social-ecological system, interview analysis, bibliometric analysis, nature-based solution, urban river restoration

2 INTRODUCTION

In 2013, China first proposed the construction of an ecological civilization, which was later incorporated into the country's constitution in 2018. As part of this initiative, the Chinese government introduced the concept of Sponge City (SC) as a scalable NbS in 2012 and launched the nationwide SC Program (SCP) in 2014. SCP aims to develop a holistic urban water management system to adapt to climate change impacts, particularly in response to extreme weather events. This involves replacing traditional grey infrastructure with green/blue infrastructure capable of infiltrating, absorbing and storing excess rainfall during floods, as well as releasing it during droughts. Constructing SC infrastructures includes restoring rivers and floodplains, building artificial wetlands, installing sunken green spaces, rainwater tanks, and green roofs, transforming permeable pavements, and more (Song, 2022).

In 2015, 16 Chinese cities were selected for the first batch of pilot SCP, which expanded to include an additional 14 cities in 2016. The central government covers about 15-20% of the program costs, while the remainder is shared between local governments and the private sector through public-private partnerships (PPP). As of 2018, the fixed subsidy for pilot SC projects amounted to 600 million RMB per year (87.8 million USD) for municipalities, 500 million RMB (73.2 million USD) per year for provincial capitals and 400 million RMB (58.5 million USD) per year for other cities. The development of the SCP in China has been a rapid process; the number of pilot cities reached over 370 in 2018. By 2030, the national goal is anticipated that over 80% of municipal areas will recycle 70% of incident rainfall (Griffiths et al., 2020).

Research on river restoration in China emerged in the late 1990s with the introduction of the concept of „ecological hydraulic engineering" (Dong, 2013). Since 2015, efforts to eliminate black-odorous surface water bodies have significantly improved the water quality of rivers across the country (Cao et al., 2020). Many urban rivers have undergone restoration or rehabilitation under the SCP, attracting considerable investments and serving as integral components of green infrastructure within NbS. The creation of various

recreational riverfront parks in densely populated Chinese cities also provides urban green, open spaces and contributes to social well-being. While some research has focused on the role of urban river restoration within the SCP, it has not been thoroughly examined as an integrated NbS. Furthermore, the practical experiences of implementing restoration projects across various Chinese cities remain fragmented among practitioners and have not been in-depth documented or researched by scholars. To bridge this gap, this study endeavours to investigate the following research questions: 1) What is the research trend of studying river restoration within the SC concept? 2) What practical challenges does river restoration face while being implemented in sponge constructions? 3) What is the link between river restoration in China"s SCP and the global advancement of NbS research? The process involves analyzing research trends, identifying practical challenges, discussing findings from an intensive literature review, and providing recommendations for future efforts.

3 METHOD

The study adopted a mixed-methods approach, combining expert interviews with bibliometric analysis. Firstly, a bibliometric analysis was employed to identify research trends in river restoration under the SCP, as reflected in both Chinese and English literature. Subsequently, we carried out semi-structured interviews with SCP practitioners to gather information on the practical challenges associated with the design, implementation, and evaluation of restoration projects—challenges that scientific publications do not typically unveil. The bibliometric analysis was conducted using CiteSpace, a Java application for knowledge mapping, to examine scientific publications from 2012 to April 2023, through keyword frequency statistics and clustering. CiteSpace visualises the research structure within a specific domain by creating co-citation networks and keyword clustering (Chen, 2006). The Web of Science (WOS) was selected as the literature search engine, and both the WOS Core Collection (WOSCC) and the Chinese Science Citation Database (CSCD) were used as data sources, for their authoritative journals, publications, research field and time span, as well as for their compatibility with both Chinese and English literature. The CSCD contains Chinese literature with translated titles, authors, keywords and abstracts in English, facilitating a further examination in combination with English literature. We used a search query with the following criteria: TS=„Sponge City" AND TS=„river", DOP=all years (1900-2023), resulting in 333 pieces of literature published between 1999 and 2023. Of these, 210 were from the WOSCC, and 137 were from the CSCD, comprising various publication types such as articles, meetings, reviews, books, and early access. After eliminating duplicates and irrelevant documents, 272 relevant records were obtained, comprising 153 from the WOSCC and 119 from the CSCD. These records, published between 2013 and 2023, were extracted for bibliometric analysis.

In the second step, from 2020 to 2022, we conducted five semi-structured interviews with urban planners and landscape designers actively involved in the SCP. These individuals, based in Beijing, Guangdong, and Sichuan Provinces, provided their firsthand experiences related to specific urban river restoration projects. We thus gained insight into the challenges they encountered in the field through content analysis methods (Downe-Wamboldt, 1992). We then compared the findings from the interviews with the analysis of scientific literature, interpreting them through the lens of NbS. Finally, by synthesizing expert perspectives with the results of the bibliometric analysis, our study offered practical recommendations to bolster the future management of NbS for urban rivers.

4 RESULTS

4.1 Research Trend of River Restoration under SC

4.1.1 General Trend

Out of the total publications analysed, 228 were journal articles, 27 were conference proceedings, 17 were review articles, and 4 were early access publications (Table 1). From 2015 to 2020, there was a consistent growth in the number of publications, with the peak number (58) recorded in 2020, accounting for 21.3% of the total 272 articles. However, starting in 2021, there has been a decline in the number of publications. In 2021, the number of publications dropped to 40 (14.7% of the total), followed by a further decrease to 33 publications (12.1% of the total) in 2022. In 2023 (until April), there were only 3 publications (1.1% of the total), but this number is incomplete as the year is still ongoing.

270

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In summary, the trend shows a growing interest in 'river restoration' and 'SC' research from 2015 to 2020, followed by a decline in the number of publications from 2021 onwards (see Table 1 and Figure 1). The research domains related to 'river restoration' and 'SC' cover a wide range of disciplines, reflecting the interdisciplinary nature of these topics. The Science and Technology domain was the most dominant, with 263 publications (96.7% of the total). Within this domain, the research areas of Environmental Sciences and Ecology (39.3%), Construction and Building Technology (28.3%), Engineering (25%) and Water Resources (22.8%) were the most prominent. The Technology domain, accounting for 55.9% of the total publications, emphasised the importance of technological innovations in fields such as Construction and Building Technology (28.3%), Engineering (25%), Materials Science (2.6%) and Computer Science (2.2%). Life Sciences and Biomedicine involved 112 publications (41.2% of the total), indicating the connection between river restoration, SC construction and the living (primarily aquatic) environment. Research areas in this domain included Environmental Sciences and Ecology (39.3%), Biodiversity Conservation (1.5%), Marine and Freshwater Biology (0.7%) and Public Environmental and Occupational Health (0.7%). The Physical Sciences domain included 92 publications (33.8% of the total), highlighting the relevance of Geology (8.5%), Meteorology and Atmospheric Sciences (2.6%), Oceanography (1.1%) and Physical Geography (1.1%) in understanding the physical processes associated with river restoration. The domains of Arts and Humanities and Social Sciences accounted for 7 publications (2.6% of the total) and 4 publications (1.5% of the total), respectively, indicating relatively less consideration of social and cultural aspects in the literature.

Theme	Results
Year of study	72.1% were published from 2013 to 2020; 27.9% were published from 2021 to 2023
Article type	228 articles, 27 meetings, 17 review articles, 4 early access
Article language	153 in English (WOSCC); 119 in Chinese (CSCD)
Research domains	96.7% Science Technology, 55.9% Technology, 41.2% Life Sciences Biomedicine, 33.8% Physical Sciences, 2.6% Arts Humanities, 1.5% Social Sciences
Research areas (top 10)	39.3% Environmental Sciences Ecology, 28.3% Construction Building Technology, 25.0% Engineering, 22.8% Water Resources, 9.2% Science Technology Other Topics, 8.5% Geology, 4.0% Energy Fuels, 2.6% Architecture, 2.6% Materials Science, 2.6% Meteorology Atmospheric Sciences

Table 1: Summary of the filtered 272 literature
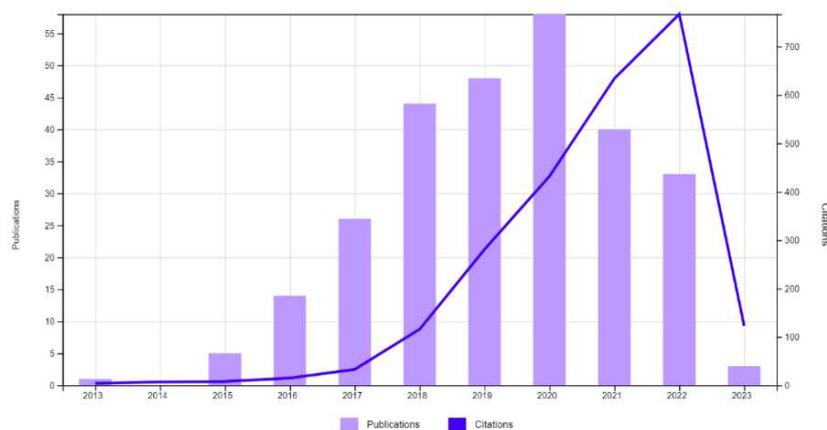
Fig. 1: Number of publications and citations per year from 2013 to 2023

4.1.2 Keyword Co-occurrence Analysis

A knowledge network was constructed based on keyword co-occurrence analysis using the top 36 calculated keywords. This network is visualised in Figure 2, where each node represents a keyword. The most frequently mentioned keyword was „SC", appearing in 129 articles. Other notable keywords included „climate change" (24 articles), „low impact development (LID, an approach to land design that uses natural features to manage stormwater runoff)" (29 articles), „urbanization" (22 articles), „model" (14 articles), „impact" (20 articles), „system" (19 articles), „stormwater management" (14 articles), „performance" (17 articles), „management" (24 articles), „runoff" (15 articles), „urban" (12 articles), „SC construction" (16 articles), „water quality" (10 articles), „challenge" (11 articles), „China" (11 articles) and „land use" (9 articles). These keywords suggest that the research focuses on the potential of restoring rivers to address challenges related to climate change, urbanization and stormwater management under the SCP. The prevalence of keywords such as „model", „impact", „system", „performance", and „management" indicates an understanding of the functioning, effectiveness and optimization of the river restoration process.

However, there seems to be less emphasis on the watershed perspective, as keywords such as „catchment" (7 articles) and „river basin" (6 articles) appeared less frequently (see Figure 2).

During the early stages of the research, particularly around 2015, the primary focus was on understanding the "SC" concept and controlling urban runoff, e.g., "LID". Between 2017 and 2018, several keywords gained prominence, reflecting a shift towards practical aspects of river restoration. These keywords included „impact", "SC construction", "stormwater management", "performance", "model" and "land use". This suggests an emphasis on understanding the real-world implications and practical considerations involved in implementing river restoration projects in SCP. As the field progressed, there was a growing interest in exploring the context of „climate change" and „urbanization". Around 2021, the emergence of the keywords „ecosystem service", „quality", and „green infrastructure" was observed, following "management" and "system", indicating the latest recognition of the regulating, supporting, provisioning, cultural ecosystem services that rivers provide and the aspect of their long-term governance. This shift highlights a deeper understanding of the social-ecological interactions of urban rivers and their potential to deliver multiple benefits as an NbS

Furthermore, the top 6 keywords with the strongest citation bursts (see Figure 3) provide additional insights into the temporal change trends of hot keywords:

- "Ecological restoration" (2016-2019, strength: 1.53) suggests a focus on the improvement of river ecosystems during this period, reflecting an emphasis on restoring the natural state of urban rivers.

- "Water ecology" (2017-2018, strength: 1.84) highlights the ecological dynamics of freshwater systems, indicating a growing interest in the interplay between hydrology and ecology.

- "Urban flooding" (2019-2020, strength: 2.15) emerged as a significant concern, reflecting the need to address flood risks in urban environments, in which river is often considered an infrastructure.

- "Challenge" (2021-2023, strength: 2.27) indicates that researchers are now focusing on identifying the difficulties and obstacles encountered in implementing river restoration initiatives under SCP.

- "Quality" (2021-2023, strength: 1.98) and „Ecosystem Service" (2021-2023, strength: 1.98) show increasing study numbers in the multi-dimensional outcomes of river restoration, such as improved water quality and the provision of multiple ecosystem services.

The analysis of citation bursts and the temporal change trend reveals a transformation in research focus over time. Initially, the emphasis was on flood risk mitigation, but there has been a subsequent shift towards a more comprehensive understanding of rivers as dynamic social-ecological systems. This shift further addresses the emerging practical challenges in river restoration projects and the need for sustainable management.

Fig. 2: High-frequency keyword map, based on the frequency and patterns of co-occurring keywords in the literature. The thickness of the rings within each circle reflects the number of papers within a given time frame. The colour of the rings corresponds to the publication time, as indicated by the time bar at the top of the figure. The links between different keywords indicate co-occurrence within the same papers.

Keywords	Year	Strength	Begin	End	2013 - 2023
ecological restoration	2016	1.53	2016	2019	
water ecology	2017	1.84	2017	2018	
urban flooding	2019	2.15	2019	2020	
challenge	2018	2.27	2021	2023	
quality	2021	1.98	2021	2023	
ecosystem service	2021	1.98	2021	2023	

Fig. 3: Top six keywords with the strongest citation bursts.

4.1.3 Cluster Analysis

We applied the log-likelihood ratio (LLR) algorithm to group the keywords which are closely related to one another and identified five distinct research clusters (Figure 4). The cluster modularity Q=0.6009 and weighted mean silhouette S=0.7885 indicate that the cluster structure is significant and effectively delineates the boundaries of research directions within these five clusters. The silhouette value provides a quantitative measure of the coherence and separation of the clusters. Keywords within different clusters are subsequently summarised into specific research themes (Table 2). Specifically, cluster 0 represented urban flooding, cluster 1 focused on SC, cluster 2 dealt with stormwater management, cluster 3 highlighted low-impact development and Cluster 4 addressed flood risk. The overlapping key terms indicate shared research topics, particularly in the domains of hydrology. This can be attributed to the interdisciplinary nature of the field and the need to address different aspects of river restoration simultaneously. Additionally, the citation network structure might have contributed to the overlapping themes, with influential papers shaping multiple clusters. The interconnectedness of the five clusters also suggests that they are part of a larger research framework tackling common objectives.

Cluster 0 (silhouette value=0.70), with an average publication year around 2016 (Figure 5), focused on urban flooding and the application of the Storm Water Management Model (SWMM; e.g., Kong et al., 2017; Luan et al., 2017) in SC. Key terms included „urban flooding" and „LID practices". The milestone papers by Xia, Zhang, et al. (2017) and Xia, Shi, et al. (2017) investigated urban water regulations facilitated by SC construction and proposed an integrated approach that combines green infrastructure, such as rivers, lakes and wetlands, with grey infrastructure. Seeing SC as a hybrid NbS, technical guidance was made (Jia et al., 2017), and the combined effectiveness was assessed (Kong et al., 2017). Luo et al. (2021) took the Shenzhen-Shantou Special Cooperation Zone (SSCZ) as a case study, identifying riparian areas as ecological buffer zones with higher flood risks and lower resilience to engineering solutions. They proposed restoring them to act as natural sponge bodies that could effectively mitigate urban floods (Luo et al., 2021).

Cluster 1 (silhouette value=0.81), with research papers published on average around 2016, focused on sponge techniques for sustainable urban development. Key terms included „SC", „LID", „total runoff control rate" and „water system". Zhang et al. (2016) analysed the SC concept from an urban hydrology perspective and proposed designing flood prevention measures at the river basin level and connecting rivers and lakes to enhance overall drainage capacity. However, Qiao et al. (2020) contended that the SC initiative should not be classified as a LID program since conventional grey infrastructure remains a significant component in its implementation, and there was limited space in compact Chinese cities and an absence of documented efficiency for green infrastructure (Qiao et al., 2020).

Cluster 2 (silhouette value=0.71), with an average publication year around 2018, focused on specific designs and impact evaluation for urban river systems in stormwater management. Key terms included „stormwater management", „uncertainty", „rainwater zone", „design ecology" and „stormwater quality and quantity". The article by Zhang et al. (2014) identified the effects of urbanization on the hydrological regime, including the degradation of river ecology, straightening and channelization of rivers and covering or transforming ponds and streams. Booth et al. (2016) and Walsh et al. (2005) further suggested identifying the Urban Stream Syndrome (Wantzen et al., 2019). Liu et al. (2017) explained SC construction guidelines, addressing the protection of natural ecological features, such as wetlands, the maintenance of natural flow regimes of rivers and the reduction of impervious surfaces in river beds. Li et al. (2019) proposed an evaluation system that quantifies the environmental, economic and social benefits of different combinations of LID units for SC

construction, incorporating indicators such as water quantity, water quality, landscape and ecological service functions. Using similar methods, Mei et al. (2018) evaluated the cost-effectiveness of GI in urbanised watersheds for flood mitigation under SCP using an SWMM.

Cluster 3 (silhouette value=0.79), with an average publication year around 2018, delved into the role of river restoration in adaptive urban development facing climate change effects. Key terms included „LID“, „town & city planning“, „urban rain island (a phenomenon in which precipitation levels in urban areas are higher than those in the surrounding suburban areas)“, „constant pipe drainage“ and „drainage ratio“. Jiang et al. (2018) examined the root causes of the vulnerability to urban pluvial flooding. Traditional approaches to managing urban rivers, such as channelization and dredging, were insufficient for tackling current challenges (Chan et al., 2018; Wang et al., 2018). Chan et al. (2018) suggested that the SCP offered opportunities to protect rivers and other inland water bodies while dealing with broader environmental issues. More integrated and localised (Nguyen et al., 2019) land-use guidance and assessment tools were recommended (Chan et al., 2018). River"s role in urban heat reduction in the SCP was underlined (Nguyen et al., 2019). Furthermore, developing urban drainage systems needed to consider factors at the watershed scale (Nguyen et al., 2019) and safeguard the watershed's integrity and the health of water resources (Li et al., 2017).

Cluster 4 (silhouette value=0.72), with an average publication year around 2016, emphasised an integrated flood risk management approach that included perspectives from society and decision-making processes. Key terms included „flood risk“, „perceptions of flooding“, „guideline“ and „integrated water management“. Using Wuhan as a case study, Shao et al. (2019) examined the impact of urban impervious surface coverage on hydrological processes and monitored interconnected urban watersheds by calculating impermeability ratios. It also highlighted the absence of integrated decision-support information. With a social survey, Wang et al. (2017) discovered that the public predominantly regarded incomplete drainage systems as the main cause of urban flooding, while impermeable surfaces were considered less significant factors.

By analyzing the characteristics of each cluster, we gain a general understanding of the temporal evolution of research topics related to river restoration and SC. Clusters with an average publication year around 2016 (Cluster 1 and 4) primarily concentrated on hydrological subjects, such as LID, flood risk management, urban runoff and water systems. In a contrasting shift, clusters with an average publication year around 2018 (Cluster 0, 2, and 3) redirected their focus towards more detailed issues, including river design in urban planning, drainage management, climate mitigation and specific case studies such as the SSCZ. Constructed wetlands were also discussed in relation to river restoration, and watershed scales started to receive attention.
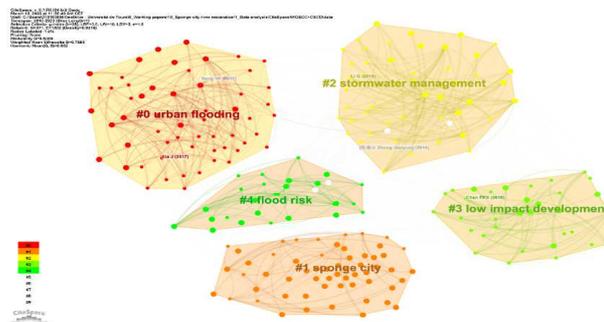

Fig. 4: 5 most significant clusters and the most active citer to each cluster, based on LLR clustering of keywords
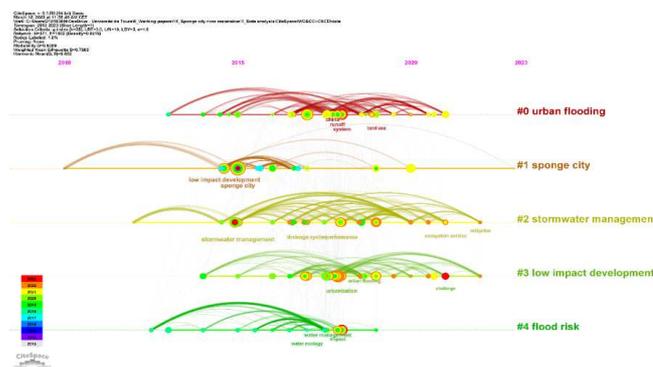

Fig. 5. Timeline of five clusters

274

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Cluster ID	Size	Sihouette Value	Average year	Top terms (LLR, p-value)
0	59	0.703	2018	urban flooding (4.32, 0.05); SWMM (4.32, 0.05); Shenzhen-Shantou special cooperation zone (3.77, 0.1); LID practices (3.77, 0.1)
1	58	0.808	2016	SC (16.17, 1.0E-4); LID (5.91, 0.05); total runoff control rate (5.75, 0.05); water system (5.75, 0.05)
2	50	0.709	2018	stormwater management (4.27, 0.05); uncertainty (4.2, 0.05); rainwater zone (4.2, 0.05); design ecology (4.2, 0.05); stormwater quality and quantity (4.2, 0.05)
3	33	0.788	2018	LID (4.6, 0.05); town & city planning (4.26, 0.05); urban rain island (4.26, 0.05); constant pipe drainage (4.26, 0.05); drainage ratio (4.26, 0.05)
4	27	0.724	2016	flood risk (6.02, 0.05); perceptions of flooding (4.81, 0.05); guideline (4.81, 0.05); integrated water management (4.81, 0.05)

Table 2: Summary of cluster size, silhouette value, average year and top terms of each cluster

4.2 Practical Challenges

4.2.1 Knowledge Gaps and Spatial Inequality

The bibliometric analysis indicated that the subjects related to ecological restoration had gained prominence since 2016 in scientific research. However, the findings from the interviews revealed a gap in practical knowledge, with conventional methods such as river channelization and dredging still being widely implemented in river restoration efforts, despite their inadequacy in addressing complex water management issues (Chan et al., 2018; Wang et al., 2018). Many river restoration projects simply dredged the river channel—removing sediments and debris from the riverbed—to tackle issues with black and odorous water bodies. This method is often implemented by the local Water Resource Bureaus, reflecting their engineering-centric tradition and lack of ecological knowledge, as river dredging can harm the ecosystems by disrupting aquatic life and destroying natural filtration layers that are essential for maintaining potable water reserves.

Furthermore, the interview analysis highlighted the challenge of convincing local government officials to allocate space for floodable riparian areas in cities, which would benefit biodiversity instead of building higher concrete embankments. This process can be time-consuming due to the knowledge gap among government officials regarding river-floodplain systems. An example is the „river restoration" project in Dali, Yunnan Province, China, in 2020. Despite its aim to control mudslides, the project resulted in the devastation of the natural riverbed and riverbank through the encasement of 18 small rivers in concrete. Although the project faced public criticism and had eventually been interrupted due to media pressure, these rivers in Dali remain channelised.

This phenomenon also presented a spatial inequality among Chinese cities. Practitioners widely believed that river restoration efforts under SC construction had made more progress in China's first and second-tier cities, primarily located in the eastern and southeastern coastal regions. These cities, such as Shenzhen, have superior economic performance and a higher standard of living, as evidenced in the case study by Luo et al. (2021). Conversely, third-tier cities, particularly those in less developed provinces such as Yunnan in the southwest, experienced more frequent channelization of rivers. These cities, with smaller populations and lower economic output, often rely on traditional engineering approaches to SC construction. This spatial inequality is also attributed to the knowledge gap and institutional path dependency of local governments.

4.2.2 Inadequate Evaluation of River Health and Failed PPP Models

River health assessment within the context of the SCP has not been a primary focus of scientific research. Rather, most scientific tools have been geared towards appraising the cost-effectiveness of green infrastructure, as evidenced by Mei et al. (2018). Similarly, investigations such as Li et al. (2019) have mainly focused on the various benefits of combinations of LID units rather than examining rivers in isolation. Regrettably, despite the pressing need for it, a proper evaluation of the health of rivers after restoration has yet to be established. China established standards for surface water environmental quality in 2002; however, the absence of biological indicators renders the current physical and chemical measuring methods insufficient for comprehensively assessing river ecosystem health (Cao & Wantzen, 2023).

In a groundbreaking move, the Chinese Ministry of Water Resources released the „River Health Evaluation Guide" in 2020, which united multiple performance indicators, including water quantity, quality and biology (such as invertebrates, fish and aquatic plants), as well as social service functions, to assess the overall health of river systems. This initiative was widely propagated to governments at all levels across the nation. Additionally, beginning in 2019, the notion of ecological flow was instituted into policy. The Yangtze River Commission has, therefore, established ecological flow targets for important rivers and lakes, and instituted an ecological flow rule platform to ensure those rivers do not dry up during droughts. However, urban streams are rarely addressed. The financial burden of conducting regular river health assessments has hindered progress; applying the „River Health Evaluation Guide" is not yet standard practice under the SCP.

Practitioners from the private sector also shed light on the dearth of a well-defined business strategy for the PPP model in SC funding (Wang et al., 2017), notwithstanding the endorsement of it by the central government. In recent years, private companies are gradually distancing themselves from investing in SCP due to the lack of immediate financial benefits. Local government investments and debt issuances become the only funding sources for current SC construction. The obstacles associated with the PPP model confirm those identified in prior research on obstacles to the Chinese PPP model, notably cost overruns, time overruns and wrong expected return (Bashar et al., 2021).

4.2.3 Fragmented River Management and Deficient River Basin Perspective

River restoration projects posed a challenge, which was not frequently mentioned in scientific papers but extensively observed in reality, on the collaboration and coordination between diverse departments involved in river management in Chinese cities. China follows a sectoral river management structure, where each department is only answerable for its tasks: The Environment and Ecology Bureau oversees water quality, the Water Resource Bureau looks after flood protection, the Planning and Natural Resources Bureau is responsible for land use and the Forestry and Parks Bureau is in charge of riparian vegetation, with little horizontal connections among them (Shen, 2021). This setup led to conflicts during the river restoration, with each department prioritizing its duties without any cooperation (Cao & Wantzen, 2023). Nevertheless, our interviews also confirmed the effectiveness of the newly introduced national policy in 2018, known as the River Chief System, as a crucial role in resolving inter-departmental conflicts and creating a shared vision for river management (Li et al., 2020; Wang & Chen, 2019). Integrated river basin management was also found to be a distant goal in China as the coordination mechanism at the basin level remains weak. Despite the existence of six river basin committees, including the Yangtze River Committee and the Yellow River Committee, they are still subordinate to the Ministry of Water Resources, leaving them with limited coordinative powers among the upstream and downstream provinces (Cao & Vazhayil, 2023). Administrative boundaries serve as the province and city's jurisdictional limit in managing rivers, with little motivation for co-managing transboundary rivers between administrative regions. This finding, in alignment with the bibliometric analysis, underscored the missing river basin perspective in current river restoration.

4.2.4 Limited Public Awareness and Participation

The final challenge lay in the public's limited awareness of rivers and restricted public participation in the river management process. The public sometimes failed to view the river as a 'sponge' entity, lacking an understanding of the river"s flood mitigation capacity. This finding was in line with the social survey results of Wang et al. (2017). Conversely, the public's expectations of SCP were found to be excessively idealistic, with many erroneously believing that it could entirely resolve urban flooding issues. When the Zhengzhou flood disaster struck in July 2021, the public thus criticised the Zhengzhou government"s sizable investment in SC construction, which still resulted in huge flood damage, leading to scepticism about the SC concept nationwide. However, as an NbS, SC needs time to demonstrate its effectiveness, and mitigating floods from intense rainfall events often requires hybrid measures (Vojinovic et al., 2021). As a relatively new policy, the application of SC in China is still underway. Lastly, due to the limited public participation in China's current river management scheme, many river restoration projects do not include societal stakeholders in decision-making. Public engagement is not only under-discussed in scientific studies, as revealed by the bibliometric analysis, but also overlooked by practitioners in SC design. On a positive note, the RCS has created opportunities for public involvement; despite being limited, the public can supervise RCs" work, thereby raising their awareness of urban rivers (Cao & Wantzen, 2023).

276

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5   DISCUSSION

Implementing on a national scale, SCP is a mainstream effort by the Chinese government to implement NbS with hybrid solutions, supported by continuous government investment. Similar to sustainable drainage systems (SuDS) and LID, the SC concept is developing with Chinese characteristics during rapid urbanization (Griffiths et al., 2020; Lashford et al., 2019). Urban rivers, often reflecting the historical water city design in ancient Chinese dynasties (Liu et al., 2015), are critical to managing flood risks under the SCP (Xia, Shi et al., 2017) and restored by SC construction (Wang et al., 2016). As revealed by keywords' temporal analysis (see Figure 3), a growing scientific understanding has shifted river restoration focus from solely hydrological control to a more holistic approach incorporating social-ecological consideration (Zhao et al., 2019) and microclimate effects (Jiang et al., 2018), such as heat island reduction (Wang et al., 2018). This shift emphasises the sustained benefits of urban river restoration, in accordance with the cross-sectoral multifunctionality of NbS for sustainable urban development (Nesshöver et al., 2017).

However, the successful implementation of NbS in urban settings faces many barriers (Ershad Sarabi et al., 2019). By combining the results of interviews with practitioners and bibliometric analysis, we have identified several challenges in urban river restoration within China's SCP. The identified knowledge gap confirms the need to enhance the cognitive capacities of local policymakers to integrate NbS into daily planning practices and associated governance (Wamsler et al., 2020). In terms of flood management, there is still a prevalence of engineering mindsets (Qiao et al., 2018) and prioritization of quantifiable objectives within short time frames (Qiao et al., 2020) in river restoration projects. This phenomenon manifests as spatial inequality in Chinese cities, where less-developed regions often struggle to overcome path dependency in organizational decision-making to adopt NbS, compared to their more-developed counterparts (Davies & Lafortezza, 2019).

Although aquatic ecology has been increasingly emphasised in the literature, in practice, ecological considerations are not always prioritised in river restoration under the SCP. In Chinese cities, the restoration of urban rivers is predominantly achieved through site-specific landscape design (Qi et al., 2021); selected river sites are strategically transformed to maximise their functions for human use, overwhelmingly serving as riparian public parks (Liu et al., 2019). This approach underlines the high recreational values of rivers (Durán Vian et al., 2021; Zingraff-Hamed et al., 2018), but the integrity of the river ecosystem, such as supporting biodiversity, is often not a priority and lacks proper monitoring and evaluation. In the long term, this may lead to potential trade-offs among the ecosystem services that NbS provide (Seddon et al., 2020).

This study also addresses the common barriers to NbS uptake concerning inadequate financial resources and uncertainty regarding the implementation process and effectiveness (Ershad Sarabi et al., 2019). While many studies have proved the role of private sector involvement in ensuring the financial viability of the SCP, our interviews revealed that the PPP model faces difficulties in the operation and maintenance of water projects (Liang, 2018). This might necessitate a change in the measurement technique of the cost-effectiveness of NbS compared to engineered alternatives, particularly in terms of valuing their significance in addressing societal challenges (Dick et al., 2019). In 2020, China's central government introduced the Ecology Oriented Development (EOD) model intending to address the critical issues of inadequate funding sources for ecological engineering projects and convert environmental benefits into economic gains (Wang & Han, 2022). The first list of pilot projects, launched nationwide in 2021, has extensively encouraged the PPP (Ministry of Ecology and Environment, 2021). This EOD model may offer fresh opportunities for refining the PPP in the context of river restoration in Chinese cities.

Employing NbS extends beyond a technical issue and presents a new governance challenge. In China, persistent obstacles arise from institutional fragmentation in river management (Cao & Wantzen, 2023; Ershad Sarabi et al., 2019). Moreover, while effective communication, involvement, and feedback are crucial for public participation in NbS (Ferreira et al., 2020), these elements are notably lacking in the river restoration under SCP (Dai et al., 2018). The limited representation of social science and governance research in this field also confirms this gap. Designing collaborative governance for NbS (Malekpour et al., 2021) that actively involves stakeholders and the wider society aids in understanding the complexity of urban rivers as social-ecological systems (Wantzen et al., 2016, 2019; Zingraff-Hamed et al., 2021). This is particularly important for restoring the social connectivity of rivers (Kondolf & Pinto, 2017; Wantzen, 2022). China's RCS plays a pivotal role in this respect by assigning stewardship to Civil RCs, who often include NGOs, experts, and local communities. These groups are involved in preserving the environmental quality of

rivers and providing feedback on the work of the official RCs. This cooperative model (dual RCS) should be effectively implemented across all types of urban river restoration projects in China (Cao & Wantzen, 2023).

6 CONCLUSION

In summary, the steady increase in scientific publications on river restoration under SCP from 2012 signalled a persistent interest in promoting NbS as a critical component of sustainable development in China, with restoring urban rivers serving as a multifaced NbS example for generating both environmental and social benefits. The bibliometric analysis highlighted the interdisciplinary nature of these combined topics and a research trend evolving from primarily managing flood risk towards an integrated focus on aspects such as ecology, urban planning, climate change adaptation, and methodology of modelling and evaluation. However, while there was a strong emphasis on engineering-led river restoration approaches, both the current research agenda and practical application displayed an absence of the social science field. Insights from SCP practitioners identified firsthand challenges in implementing river restoration projects under the SCP, including knowledge gaps, spatial inequality, a deficient evaluation of river health, unsuccessful PPP models, fragmented river management, and limited public participation. These issues conformed to the existing obstacles to NbS adoption and mainstreaming, particularly the limited acknowledgment of local policymakers, insufficient funding resources, potential ecosystem service trade-offs, institutional path dependency, insufficient cost-effectiveness evaluation, and collaborative governance. In China, the RCS policy fostered cross-departmental cooperation and opportunities for public involvement in protecting the river environment. Moreover, the newly established EOD model could potentially revive PPP models at a local level for investing in comprehensive river restoration. Consequently, future research and projects should pursue a more expansive, trans-disciplinary view, considering urban rivers as social-ecological systems and encouraging stakeholder and societal involvement in the long-term management of NbS.

7 REFERENCES

BASHAR, T., FUNG, I. W. H., JAILLON, L. C., & WANG, D. (2021). Major obstacles to public-private partnership (PPP)-financed infrastructure development in China. Sustainability, 13(12), 12. https://doi.org/10.3390/su13126718

BOOTH, D. B., ROY, A. H., SMITH, B., & CAPPS, K. A. (2016). Global perspectives on the urban stream syndrome. Freshwater Science, 35(1), 412–420. https://doi.org/10.1086/684940

CAO, J., SUN, Q., ZHAO, D., XU, M., SHEN, Q., WANG, D., WANG, Y., & DING, S. (2020). A critical review of the appearance of black-odorous waterbodies in China and treatment methods. Journal of Hazardous Materials, 385, 121511. https://doi.org/10.1016/j.jhazmat.2019.121511

CAO, Y., & VAZHAYIL, A. M. (2023). River culture in China and India, a comparative perspective on its origins, challenges, and applications. In K. M. Wantzen (Ed.), River cultures: Life as a dance to the rhythm of the waters (pp. 281–311). UNESCO Publishing. https://doi.org/10.54677/CVXL8810

CAO, Y., & WANTZEN, K. M. (2023). The river/lake chief system in China: A new policy to improve environmental quality in hydrosystems. In K. M. WANTZEN (Ed.), River cultures: Life as a dance to the rhythm of the waters (pp. 853–874). UNESCO Publishing. https://doi.org/10.54677/SAQI7606

CHAN, F. K. S., GRIFFITHS, J. A., HIGGITT, D., XU, S., ZHU, F., TANG, Y.-T., XU, Y., & THORNE, C. R. (2018). „Sponge city" in China—A breakthrough of planning and flood risk management in the urban context. Land Use Policy, 76, 772–778. https://doi.org/10.1016/j.landusepol.2018.03.005

CHEN, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. Journal of the American Society for Information Science and Technology, 57(3), 359–377. https://doi.org/10.1002/asi.20317

DAI, L., VAN RIJSWICK, H. F., DRIESSEN, P. P., & KEESSEN, A. M. (2018). Governance of the sponge city programme in China with wuhan as a case study. International Journal of Water Resources Development, 34(4), 578–596. https://doi.org/10.1080/07900627.2017.1373637

DAVIES, C., & LAFORTEZZA, R. (2019). Transitional path to the adoption of nature-based solutions. Land Use Policy, 80, 406–409. https://doi.org/10.1016/j.landusepol.2018.09.020

DICK, J., MILLER, J. D., CARRUTHERS-JONES, J., DOBEL, A. J., CARVER, S., GARBUTT, A., HESTER, A., HAILS, R., MAGREEHAN, V., & QUINN, M. (2019). How are nature based solutions contributing to priority societal challenges surrounding human well-being in the United Kingdom: A systematic map protocol. Environmental Evidence, 8, 37. https://doi.org/10.1186/s13750-019-0180-4

DONG, Z. R. (2013). River restoration. China Water & Power Press.

DOWNE-WAMBOLDT, B. (1992). Content analysis: method, applications, and issues. Health care for women international, 13(3), 313-321.

DURÁN VIAN, F., PONS IZQUIERDO, J. J., & SERRANO MARTÍNEZ, M. (2021). River-city recreational interaction: A classification of urban riverfront parks and walks. Urban Forestry & Urban Greening, 59, 127042. https://doi.org/10.1016/j.ufug.2021.127042

ERSHAD SARABI, S., HAN, Q., L. ROMME, A. G., DE VRIES, B., & WENDLING, L. (2019). Key enablers of and barriers to the uptake and implementation of nature-based solutions in urban settings: A review. Resources, 8(3), 3. https://doi.org/10.3390/resources8030121

FERREIRA, V., BARREIRA, A. P., LOURES, L., ANTUNES, D., & PANAGOPOULOS, T. (2020). Stakeholders" engagement on nature-based solutions: A systematic literature review. Sustainability, 12(2), 2. https://doi.org/10.3390/su12020640

GRIFFITHS, J., CHAN, F. K. S., SHAO, M., ZHU, F., & HIGGITT, D. L. (2020). Interpretation and application of sponge city guidelines in China. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 378(2168), 20190222. https://doi.org/10.1098/rsta.2019.0222

JIA, H., WANG, Z., ZHEN, X., CLAR, M., & YU, S. L. (2017). China"s sponge city construction: A discussion on technical approaches. Frontiers of Environmental Science & Engineering, 11(4), 18. https://doi.org/10.1007/s11783-017-0984-9

JIANG, Y., ZEVENBERGEN, C., & MA, Y. (2018). Urban pluvial flooding and stormwater management: A contemporary review of China"s challenges and „sponge cities" strategy. Environmental Science & Policy, 80, 132–143. https://doi.org/10.1016/j.envsci.2017.11.016

KONDOLF, G. M., & PINTO, P. J. (2017). The social connectivity of urban rivers. Geomorphology, 277, 182–196. https://doi.org/10.1016/j.geomorph.2016.09.028

KONG, F., BAN, Y., YIN, H., JAMES, P., & DRONOVA, I. (2017). Modeling stormwater management at the city district level in response to changes in land use and low impact development. Environmental Modelling & Software, 95, 132–142. https://doi.org/10.1016/j.envsoft.2017.06.021

LASHFORD, C., RUBINATO, M., CAI, Y., HOU, J., ABOLFATHI, S., COUPE, S., CHARLESWORTH, S., & TAIT, S. (2019). SuDS & sponge cities: A comparative analysis of the implementation of pluvial flood management in the UK and China. Sustainability, 11(1), 213. https://doi.org/10.3390/su11010213

LI, H., DING, L., REN, M., LI, C., & WANG, H. (2017). Sponge city construction in China: A survey of the challenges and opportunities. Water, 9(9), 594. https://doi.org/10.3390/w9090594

LI, Q., WANG, F., YU, Y., HUANG, Z., LI, M., & GUAN, Y. (2019). Comprehensive performance evaluation of LID practices for the sponge city construction: A case study in Guangxi, China. Journal of Environmental Management, 231, 10–20. https://doi.org/10.1016/j.jenvman.2018.10.024

LI, Y., TONG, J., & WANG, L. (2020). Full implementation of the river chief system in China: Outcome and weakness. Sustainability, 12(9), 3754. https://doi.org/10.3390/su12093754

LIANG, X. (2018). Integrated economic and financial analysis of China"s sponge city program for water-resilient urban development. Sustainability, 10(3), 3. https://doi.org/10.3390/su10030669

LIU, C., WANG, S., WANG, W., & WANG, E. (2015). Ancient chinese urban planning ideas on sponge city construction—A case study of Yixing City, Jiangsu Province. China Engineering Consulting, 7, 46–51. https://doi.org/10.3969/j.issn.1006-9607.2015.07.014

LIU, H., JIA, Y., & NIU, C. (2017). „Sponge city" concept helps solve China"s urban water problems. Environmental Earth Sciences, 76(14), 473. https://doi.org/10.1007/s12665-017-6652-3

LIU, Y., WANG, R., LU, W., & PENG, C. (2019). A social-economic-natural compound ecosystem constructed for urban rivers—planning and design for the remediation and ecological restoration of the guitang river watershed in Changsha City, China. Landscape Architecture Frontiers, 7(4), 114–127. https://doi.org/10.15302/J-LAF-1-040004

LUAN, Q., FU, X., SONG, C., WANG, H., LIU, J., & WANG, Y. (2017). Runoff effect evaluation of LID through SWMM in typical mountainous, low-lying urban areas: A case study in China. Water, 9(6), 439. https://doi.org/10.3390/w9060439

LUO, K., WANG, Z., SHA, W., WU, J., WANG, H., & ZHU, Q. (2021). Integrating sponge city concept and neural network into land suitability assessment: Evidence from a satellite town of shenzhen metropolitan area. Land, 10(8), 872. https://doi.org/10.3390/land10080872

MALEKPOUR, S., TAWFIK, S., & CHESTERFIELD, C. (2021). Designing collaborative governance for nature-based solutions. Urban Forestry & Urban Greening, 62, 127177. https://doi.org/10.1016/j.ufug.2021.127177

MEI, C., LIU, J., WANG, H., YANG, Z., DING, X., & SHAO, W. (2018). Integrated assessments of green infrastructure for flood mitigation to support robust decision-making for sponge city construction in an urbanised watershed. Science of the Total Environment, 639, 1394–1407. https://doi.org/10.1016/j.scitotenv.2018.05.199

MINISTRY OF ECOLOGY AND ENVIRONMENT. (2021, April 28). Notice on the approval of initiating the ecology-oriented development (EOD) pilots. https://www.mee.gov.cn/xxgk2018/xxgk/xxgk06/202104/t20210428_831153.html

NESSHÖVER, C., ASSMUTH, T., IRVINE, K. N., RUSCH, G. M., WAYLEN, K. A., DELBAERE, B., HAASE, D., JONES-WALTERS, L., KEUNE, H., & KOVACS, E. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of the Total Environment, 579, 1215–1227. https://doi.org/10.1016/j.scitotenv.2016.11.106

NGUYEN, T. T., NGO, H. H., GUO, W., WANG, X. C., REN, N., LI, G., DING, J., & LIANG, H. (2019). Implementation of a specific urban water management—Sponge City. Science of the Total Environment, 652, 147–162. https://doi.org/10.1016/j.scitotenv.2018.10.168

QI, Y., SHUN CHAN, F. K., GRIFFITHS, J., FENG, M., SANG, Y., O"DONNELL, E., HUTCHINS, M., THADANI, D. R., LI, G., SHAO, M., XIE, L., LIU, S., ZHANG, C., LI, X., LIU, L., & ZHONG, M. (2021). Sponge city program (SCP) and urban flood management (UFM)—the case of Guiyang, SW China. Water, 13(19), 2784. https://doi.org/10.3390/w13192784

QIAO, X.-J., KRISTOFFERSSON, A., & RANDRUP, T. B. (2018). Challenges to implementing urban sustainable stormwater management from a governance perspective: A literature review. Journal of Cleaner Production, 196, 943–952. https://doi.org/10.1016/j.jclepro.2018.06.049

QIAO, X.-J., LIAO, K.-H., & RANDRUP, T. B. (2020). Sustainable stormwater management: A qualitative case study of the Sponge Cities initiative in China. Sustainable Cities and Society, 53, 101963. https://doi.org/10.1016/j.scs.2019.101963

SEDDON, N., CHAUSSON, A., BERRY, P., GIRARDIN, C. A., SMITH, A., & TURNER, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120. https://doi.org/10.1098/rstb.2019.0120

SHAO, Z., FU, H., LI, D., ALTAN, O., & CHENG, T. (2019). Remote sensing monitoring of multi-scale watersheds impermeability for urban hydrological evaluation. Remote Sensing of Environment, 232, 111338. https://doi.org/10.1016/j.rse.2019.111338

SHEN, D. (2021). The river and lake chief system. In D. SHEN (Ed.), Water resources management of the people"s republic of China: Framework, reform and implementation (pp. 241–252). Springer International Publishing. https://doi.org/10.1007/978-3-030-61931-2_11

SONG, C. (2022). Application of nature-based measures in China"s sponge city initiative: Current trends and perspectives. Nature-Based Solutions, 2, 100010. https://doi.org/10.1016/j.nbsj.2022.100010

VOJINOVIC, Z., ALVES, A., GÓMEZ, J. P., WEESAKUL, S., KEERAKAMOLCHAI, W., MEESUK, V., & SANCHEZ, A. (2021). Effectiveness of small- and large-scale Nature-Based Solutions for flood mitigation: The case of Ayutthaya, Thailand. Science of The Total Environment, 789, 147725. https://doi.org/10.1016/j.scitotenv.2021.147725

WALSH, C. J., ROY, A. H., FEMINELLA, J. W., COTTINGHAM, P. D., GROFFMAN, P. M., & MORGAN, R. P. (2005). The urban stream syndrome: Current knowledge and the search for a cure. Journal of the North American Benthological Society, 24(3), 706–723. https://doi.org/10.1899/04-028.1

WAMSLER, C., WICKENBERG, B., HANSON, H., ALKAN OLSSON, J., STÅLHAMMAR, S., BJÖRN, H., FALCK, H., GERELL, D., OSKARSSON, T., SIMONSSON, E., TORFFVIT, F., & ZELMERLOW, F. (2020). Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation. Journal of Cleaner Production, 247, 119154. https://doi.org/10.1016/j.jclepro.2019.119154

WANG, H., MEI, C., LIU, J., & SHAO, W. (2018). A new strategy for integrated urban water management in China: Sponge city. Science China-Technological Sciences, 61(3), 317–329. https://doi.org/10.1007/s11431-017-9170-5

WANG, J., & HAN, Y. (2022). EOD mode oriented green low carbon circular development economic system tracked changes. https://www.researchgate.net/publication/362076131_EOD_mode_oriented_green_low_carbon_circular_development_economic_system_tracked_changes

WANG, X., ZHANG, Y., & ZHANG, P. (2016). Conservation and ecological restoration of lake and river in sponge city construction. Water Resources Protection, 32(1), 72–74,85. https://doi.org/10.3880/j.issn.1004-6933.2016.01.012

WANG, Y., & CHEN, X. (2019). River chief system as a collaborative water governance approach in China. International Journal of Water Resources Development, 36(4), 610–630. https://doi.org/10.1080/07900627.2019.1680351

WANG, Y., SUN, M., & SONG, B. (2017). Public perceptions of and willingness to pay for sponge city initiatives in China. Resources Conservation and Recycling, 122, 11–20. https://doi.org/10.1016/j.resconrec.2017.02.002

WANTZEN, K. M. (2022). River Culture: Socioecology of the rhythm of the waters. In F. Visentin & M. Kaaristo (Eds.), Geographies of inland waterscapes: Thinking with watery spaces and places. The Geographical Journal, 00, 1–16. https://doi.org/10.1111/geoj.12476

WANTZEN, K., ALVES, C., BADIANE, S., BALA, R., BLETTLER, M., CALLISTO, M., CAO, Y., KOLB, M., KONDOLF, G., LEITE, M., MACEDO, D., MAHDI, O., NEVES, M., PERALTA, M., ROTGÉ, V., RUEDA-DELGADO, G., SCHARAGER, A., SERRA-LLOBET, A., YENGUÉ, J. L., & ZINGRAFF-HAMED, A. (2019). Urban stream and wetland restoration in the global South—A DPSIR analysis. Sustainability, 11(18), 4975. https://doi.org/10.3390/su11184975

WANTZEN, K. M., BALLOUCHE, A., LONGUET, I., BAO, I., BOCOUM, H., CISSE, L., CHAUHAN, M., GIRARD, P., GOPAL, B., & KANE, A. (2016). River Culture: An eco-social approach to mitigate the biological and cultural diversity crisis in riverscapes. Ecohydrology & Hydrobiology, 16(1), 7–18. https://doi.org/10.1016/j.ecohyd.2015.12.003

XIA, J., ZHANG, Y., XIONG, L., HE, S., WANG, L., & YU, Z. (2017). Opportunities and challenges of the Sponge City construction related to urban water issues in China. Science China Earth Sciences, 60(4), 652–658.

XIA, J., SHI, W., WANG, Q., & ZOU, L. (2017). Discussion of several hydrological issues regarding sponge city construction. Water Resources Protection, 33(1), 1–8.

ZHANG, J., SONG, X., WANG, G., HE, R., & WANG, X. (2014). Development and challenges of urban hydrology in a changing environment：I：Hydrological response to urbanization. Advances in Water Science, 25(4), 594–605. http://skxjz.nhri.cn/cn/article/id/2443

ZHANG, J., WANG, Y., HU, Q., & HE, R. (2016). Discussion and views on some issues of the sponage city construction in China. Advances in Water Science, 27(6), 793–799. https://doi.org/10.14042/j.cnki.32.1309.2016.06.001

ZHAO, Y., CAI, T., SUN, R., NI, Z., & ZHANG, T. (2019). Review on sponge city research: From hydrological process to ecological restoration. Acta Ecologica Sinica, 39(13), 1–9. https://doi.org/10.5846/stxb201802090350

ZINGRAFF-HAMED, A., BONNEFOND, M., BONTHOUX, S., LEGAY, N., GREULICH, S., ROBERT, A., ROTGÉ, V., SERRANO, J., CAO, Y., & BALA, R. (2021). Human–river encounter sites: Looking for harmony between humans and nature in cities. Sustainability, 13(5), 2864. https://doi.org/10.3390/su13052864

ZINGRAFF-HAMED, A., NOACK, M., GREULICH, S., SCHWARZWÄLDER, K., WANTZEN, K. M., & PAULEIT, S. (2018). Model-based evaluation of urban river restoration: Conflicts between sensitive fish species and recreational users. Sustainability, 10(6), 6. https://doi.org/10.3390/su10061747

280

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Facades Solar Screens Impact on Daylighting Performance in Buildings

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1 ABSTRACT

Cities in hot climates feature clear skies most of the year, guarantting the provision of daylight into the interior. With the use of large glazed façades, controlling the penetration of solar radiation that contributes to thermal discomfort with passive solutions is acheived through the use of shading devices.These devices decrease energy loads of mechanical cooling. The facade solar screens is one of the shading strategies used and reported to be succeful in such hot climatic regions, blocking solar radiation while allowing visual access to external views. Such a strategy of screening the opennings with perforated surfaces has cultural and historical significance in multiple urban environmnets, demonstrated by the use of the traditional mashrabeya which are the inspiration for contemporary screens design. However, throughout the last decade, a large body of research has been concerned with the negative impact of solar screens on daylighting performance in internal spaces, leading to an increase in energy loads of artifical lighting.

This paper aims to review the current research body concerned with the correlation between solar screens design parameters and daylighting performance. 21 articles fall under this paper's realm. They are reviewed according to multiple comparison points, including: aims, spatial configuration of the test spaces, types and design of the tested solar screens, design parameters tackled, daylighting simulation tools, daylighting metrics, and finally, findings including parameters impact, empirical process methodolgy, and coorelation with other enviromental aspects. Thispaper discusses how the curent reviewed research body informs the design process for an environmentally conscious design of optimized solar screens with respect to daylight availability thereby promoting the use of passive design strategies towards greener cities and urban environments.

Keywords: Parametric design, Passive design, Daylighting performance, Facade solar screens, Optimizing performance

2 INTRODUCTION

Since the inception of early modernist archtiecture, the use of large glazed facades has been an integral part of worldwide modernist and contempray arhcitecture. In regions with a hot climate, building facades are being designed to western standards with the aim to have a contemporary look by using specifically large glazed façades (Etman et al., 2013; M. ElBatran & Ismaeel, 2021; Mayhoub & Labib, 2015). With clear skies most of the year, the provision of daylight into the interior is guaranteed as a passive design strategy.

Shading devices are also being implemented to control the penetration of solar radiation which contributes to thermal discomfort and over-heating (Wagdy & Fathy, 2015). Yet, in the scientific discourse of the balance between diffused daylighting and solar radiation, several reviews have proven that the different shading devices may negatively affect daylight availability.(Eltaweel & SU, 2017; Kirimtat et al., 2016; Yu et al., 2020).

2.1 Problem

The previously mentioned reviews stated that the research concerned with the impact of shading devices on daylighting produces only recommendations for specific hypothetical design cases.These articles present no methodologies to study the correlation between daylighting performance and the parameters of shading devices. Such insightsand design frameworks may assist architects and designers in their decision making process about the impact of the variations in the values of a specific parameter on daylighting performance.

2.2 Scope

Among the different shading devices,the research focuses on facade solar screens, as it can block solar radiation and at the same time keep the users more in contact with external views (Kirimtat et al., 2016; Wagdy & Fathy, 2015). The same refrences agreed as well that solar facade screens provide successful shading, specifically in hot climatic regions, despite reportinga negative impact on daylight availability. Such

features also have cultural and historical significance in hot climate regions through different traditional architectural vocabulary including the mashrabeya of Egypt, the moshabak of Iran, and the jali of India.

The research body concerned with the impact of facade solar screens on daylighting performance has been on the rise since the beginning of the last decade. This study reviews the literature concerned with this scope to assess if a methodology is developed to investigate the statistical correlation between different solar screens design paramaters and daylighting illuminance values in interal spaces.A brief introduction is conducted on daylight performance evaluation in architecture and research in order to understand how the impact of solar screens on daylighting is assessed. And then, the review of 21 selected papers is conducted and discussed to assess the presence of a methddology that investigates the correlation between solar screens parameters and daylighting.

3 DAYLIGHT ASSESSMENT IN ARCHITECTURE

In order to understand the impact of façade solar screens on daylighting, it is necessary to understand how daylighting performance is evaluated in architectural design and research. The first mention of a daylight evaluation method was proposed by (Trotter, 1911): a fraction between the illuminance at a point inside and the illuminance outside under an unobstructed overcast sky excluding sunlight. This was known later as the daylight factor DF and expressed as a percentage, whereby the internal illuminace at a point is divided by the external illuminace and multiplied by 100 (Lewis, 2017; P. Tregenza & Mardaljevic, 2018). The same references stated that for its ease of use the DF is adopted to date in multiple design guidelines and building regulations. Yet, its reliability is questioned by multiple references. One critical argument is that the DF is idealistic as it regards only the overcast sky and excludes varying factors, such as different sky luminances and solar radiation interference. Thus, its simplicity compromises its reliabiltiy in realistic conditions (Lewis, 2017; Lou et al., 2019; Mardaljevic et al., 2000; P. Tregenza & Mardaljevic, 2018; P. R. Tregenza, 1980).

Concerns about the DF led to the introduction of the Climate Based Daylight Modeling method into the development of computer software.The CBDM approach was introduced first hand by Mardaljevic et al., (2000); and Reinhart & Herkel (2000). In brief, CBDM considers long term assessment for daylighting performance in a space comprising the range of sky luminace conditions and solar radiation on an hourly basis for a full year. This process is conducted using daylight simulation software where different sky luminance values are modeled based on a weather data file for the site and processed by a calculation engine that produces output results. As the results comprise hourly illuminance values at a number of test points in a space for a full year, the CBDM relies on metrics developed to handle evaluating daylighting performance based on these results. These performance metrics assess the illuminance values at a point of specific minimum/maximum illuminance thresholds, based on research work concerning human comfort and daylighting functional requirements. The daylighting performance at that point is then assessed accordingly as being adequate or not regarding the percentage of hours throughout the year when it meets or falls short of the minimum/maximum illuminance thresholds. The commonly introduced metrics to date are: Daylight autonomy (DA) (Reinhart & Walkenhorst, 2001), Useful Daylight Illuminaces (UDI) (Nabil & Mardaljevic, 2006), Daylight Availability (DAv) (Reinhart & Wienold, 2010), Spatial Daylight Autonomy (sDA) (Heschong et al., 2012), and, Annual Sunlight Exposure (ASE) (Heschong et al., 2012).

4 FAÇADE SOLAR SCREENS AND DAYLIGHTING PERFORMANCE

This section tackles how the current research body investigates the impact of façade solar screen impact on daylighting, and whether a methodology to investigate a statistical correlation exists. First, the methodology of selecting papers is explained, and then a breakdown analysis is conducted for a number of aspects.

4.1 Paper selection

First, a search was done on several paper databases using a combination of the following keywords: solar screen, perforated facades, perforated panels, mashrabeya, jali, daylight availability, and daylight performance. The databases are: Science Direct, Taylor and Francis, Sage Journals, and Springer Link. There were no restrictions concerning the year of publication or the number of pages.

The search produced 386 papers, filtered to 14 relevant to this review's scope: 11 from Science Direct, 3 from Taylor and Francis, and none from Sage journals nor Springer link (table 1). The 14 papers are published in 9 journals as follows in (figure 1). The second step of selection was done by adding papers cited

282

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in the previous 14 papers found reliable to this review's scope. Seven conference proccedings papers were found relevant as follows in (figure 2).

Database	Results	Filtered Results
Science Direct	279	11
		(Chi, 2022; Chi et al., 2018; Chi, Moreno, & Navarro, 2017; Khidmat et al., 2022; Lavin & Fiorito, 2017; M. ElBatran & Ismaeel, 2021; Sabry et al., 2014; A. Sherif et al., 2012; A. H. Sherif et al., 2012; Srisamranrungruang & Hiyama, 2020; Wagdy & Fathy, 2015)
Taylor and Francis	73	3
		(Chi et al., 2021; Chi, Moreno, Esquivias, et al., 2017; Vazquez et al., 2021)
Sage Journals	34	0
Springer Link	0	0
Total	386	14

Table 1: Details of the search done in articles databases.
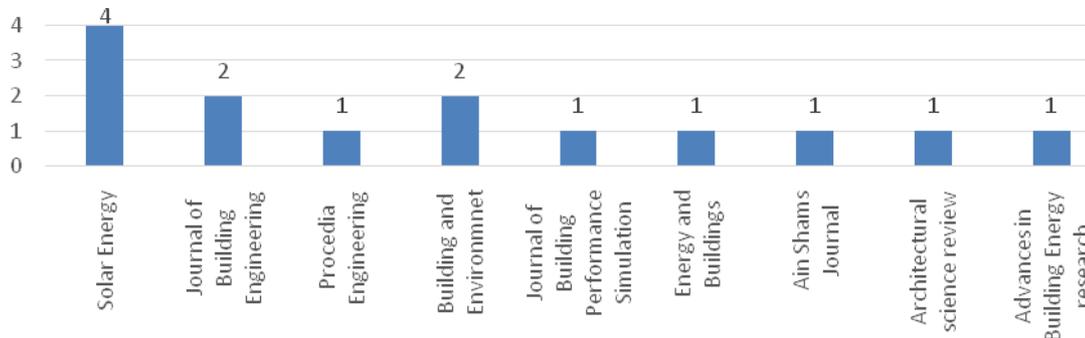
Fig. 1: Number of published papers per journal.
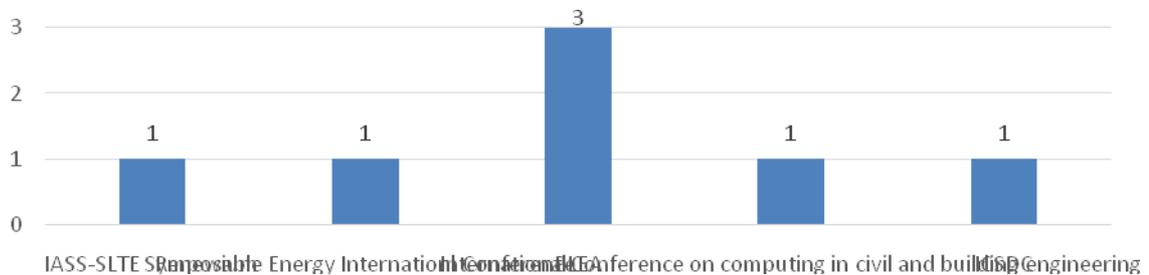
Fig. 2: Number of published papers per conference.

By reviewing the total selected 21 artilces, it is found that the first papers were published in 2010 by A. Sherif et al. (2010) in a conference proceeding. Since then until December 2022 a minimum of one paper was published each year except for years 2013, 2016, and 2019. Whereas 2017 marks the highest number of published papers proceeded by 2012, 2021, and finally 2022 (figure 3).
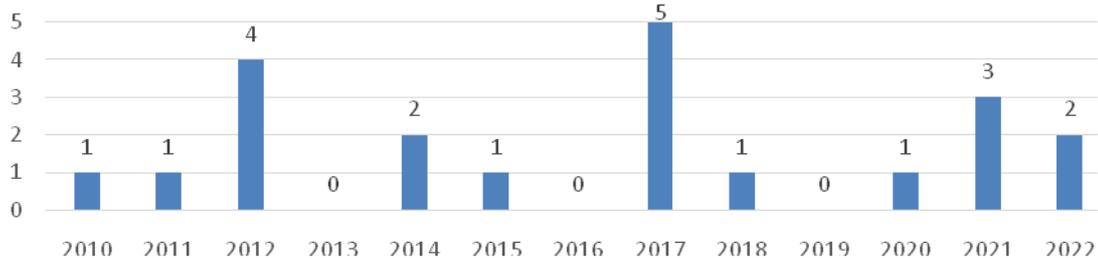
Fig. 3: Number of published papers per year.

The papers are investigating the impact of façade solar screens on either daylighting performance only, or combined with other environmnetal performance aspects, including: cooling loads, heating loads, artificial lighting loads, shading coefficient, solar radiation energy and finally natural ventilation. Daylighting is evaluated only in 12 papers, and combined dfferently with other environmental aspects as follows in (figure 4). The most combined environmental aspect with daylighting is the cooling load, followed by both heating and artificial lighting loads. Solar radiation was considered two times and only once for both natural ventilation and shading coefficient (figure 5).
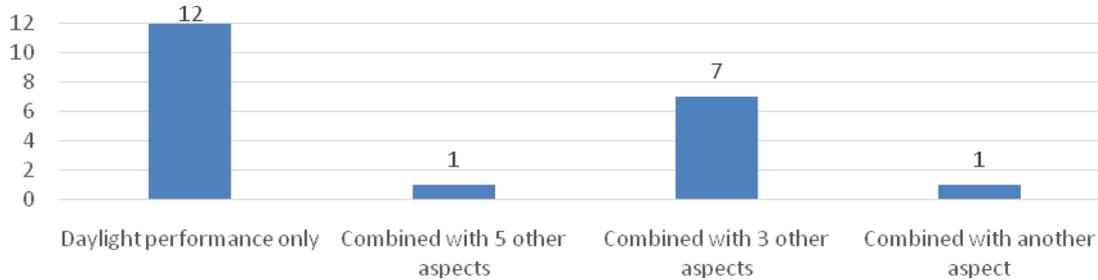
Fig. 4: number of papers testing other aspects performance with daylighting.
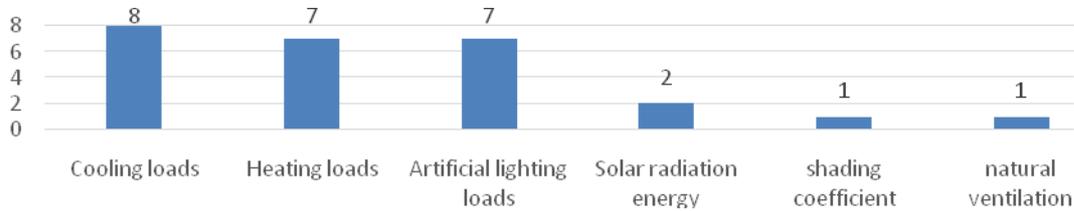
Fig. 5: Number of times specific aspects were tested with daylighting.

4.2 Review methodology

After selecting the papers, an analytical review was conducted. The selected methodology was related to the process in the reviewed papers of conducting their investigations about the impact of solar screens on daylighting performance. First, each paper proposes a space where the test is done, then, a solar screen type is selected along with variations in its paramters to generate test cases , finally a computer simulation is conducted and findings are deducted from the results. According to this process, the review methodology is conducted as follows (Figure 6):

(a) Review the test spaces: site, function, and physical configurations.

(b) Review the tested solar screens: types, parameters, and generated cases.

(c) Review the Simulation process: tools and performance metrics.

(d) Discuss the findings.

Fig. 6: Review methodology.

284

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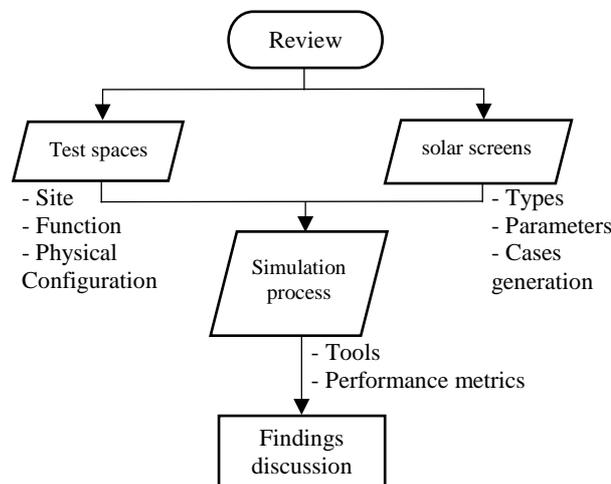
4.3 Test spaces

Each paper considered a space where the impact of the solar screenon daylight availability is evaluated. This section outlines these test spaces concerning site, function, and physical configurations.

4.3.1 Site

The methodologies of multiple papers reported that authors considered sites with clear and sunny skies most of the year, as shading screens were likely to be used. Egypt was the most common site with its cities Cairo, Al-Sadat and Alkharga Oasis, followed by Spain, mainly Seville. Saudi Arabia was next with its cities Jeddah and Riyadh, followed by Japan with Tokyo and Kitakyushu, and finally, there were single considerations in Australia (Sydney), Iran (Tehran), Paraguay (Asuncion), and USA (Phoenix) (figure 7).
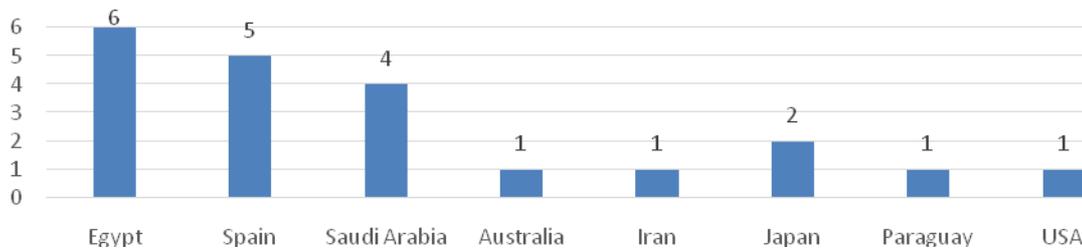
Fig. 7: Number of papers per chosen site.

4.3.2 Function

All test spaces are hypothetical, except one paper in which M. ElBatran & Ismaeel (2021) modelled the space after an office building in an administrative campus of the Smart Village campus in Cairo, Egypt. Three papers assigned no function to the test spaces and considered them as a test room. Administrative functions where adopted most in 9 papers, whereas 7 papers adopted residential functions, and finally educational functions were adopted in 2 papers (figure 8).
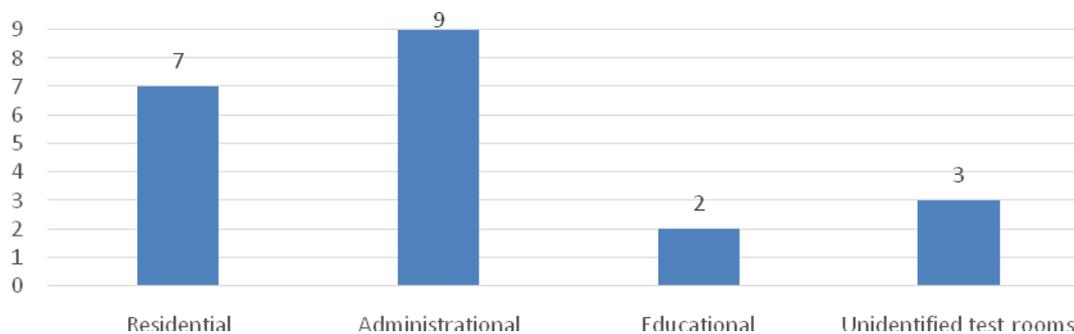
Fig. 8: Number of times a type of function was chosen the papers.

4.3.3 Physical configuration

The dimensions of the test spaces in all the papers were constant, as only one scenario was considered in each. The length of the spaces varied from a minimum of 3 meters to a maximum of 12 meters, and the widths varied from a minimum of 3.6 meters to a maximum of 12 meters, while the heights varied from a minimum of 2.6 meters to a maximum of 5.00 meters. Yet, only one space had a considerable difference in its physical configuration compared to the other 20 papers, namely the previously mentioned space modelled after an office building in Cairo, which had 42 meters length and 37.5 meters width. Apart from this space, the floor areas of the test spaces varied between a minimum of 10.8 m2 and a maximum of 144 m2.

Regarding the openings placement, 19 papers had a single façade opening, whereas 1 article had openings in adjacent facades and another had openings on all 4 facades. Concerning the opening design, 14 papers had singular continious openings, 6 papers had fully glazed facades, and finally one paper had patched windows along the façade. Each paper considered only one scenario, and no variations were adopted in the physical configurations. Yet, three articles (Chi et al., 2021; Oghazian, 2017; Wagdy & Fathy, 2015) conducted variations in the window to wall ratio WWR in their tests.

4.4 Solar screens

Each paper tested the impact of a solar screen on daylighting and other environmental aspects. This section reviews the types of solar screens chosen, the tested parameters, and the case generation process.

4.4.1   Types of solar screens

18 papers identified their solar screens as a perforated panel, sometimes as a specific design application, whereas for other cases the methodology was adopting a simple perforated plane to simplify the test and the modelling process. Three papers specified other façade solar screen types as follows: a screen of horizontal louvers (Wagdy & Fathy, 2015), a masonry brick wall (Vazquez et al., 2021), and an expanded metal mesh (Khidmat et al., 2022).

4.4.2   Tested parameters

A total number of 19 design parameters were tested in the 21 papers. Divided between the three types of tested solar screens, 8 parameters are related to the perforated panels, 4 parameters related to the screen of horizontal louvers, 5 related to the expanded metal mesh, and finally 2 related to the masonry brick wall.A description for each parameter is available in (table 2). Parameters are sorted by giving a code and a numbering for each indicating which type of screen it is related to:PP for perforated panels, HL for horizontal louvers., BW for masonry brick wall, and MM for expanded metal mesh.

Type/number of times tested		Code	Parameter / number of times tested		description
Perforated panel (PP)	18	PP01	Perforation percentage	11	Percentage of the panel's permeable surface area.
		PP02	Openings aspect ratio	5	Proportional relation between horizontal and vertical dimension of the openings/perforations.
		PP03	Screen axial rotation	4	Rotation angle of the whole panel.
		PP04	Screen depth	3	Identifies the panel's thickness.
		PP05	Matrix dimensions	6	Perforation distribution in horizontal and vertical directions.
		PP06	Geometry of openings	5	Indicates the geometrical shape of the openings/perforations.
		PP07	Non-uniform perforation	1	Targets the non-uniform distribution of the openings
		PP08	Gap screen and glazing	2	Distance between the glazing's plane and the perforated panel
Horizontal louvers (HL)	1	HL01	Louvers count	1	Identifies the number of louvers used to form the screen.
		HL02	Louvers tilt angle	1	Rotation angle of the louvers around its horizontal axis.
		HL03	Louvers depth	1	Louvers' depth in its horizontal plane.
		HL04	Louvers reflectivity	1	The finishing's reflectivity of the louvers.
Masonry brick wall (BW)	1	BW01	Bricks rotation angle	1	The rotation angle of each brick around its x,y and z axis.
		BW02	Bricks building pattern	1	The arrangement of bricks used to form the screen.
Expanded metal mesh (MM)	1	MM01	Diamond height	1	The dimensions of the diamond module.
		MM02	Diamond length	1	
		MM03	Diamond depth	1	
		MM04	Diamond angle	1	The tilt angle of the modules around its horizontal axis.
		MM05	Connecting bond length	1	length of bonds connecting the diamond modules

Table 2: coding, and description of tested parameters.

The parameters related to the horizonal louvers, masonry brick wall, and expanded metal mesh were tested each only once, as their types of screens were tested only once in the 21 papers. The perforation percentage PP01 was the highest tested parameter -11 times, followed by 6 times for the matrix dimensions PP05, 5 times for each of PP06 and PP02, 4 times for PP03, 3 times for PP04, 2 times for PP08, and finally once for PP07.The number of parameters tested in one study varies from one paper to another, 6 papers kept its testing limited to only one parameter, whereas the highest number of 7 paper tested on 2 parameters, 5 papers on 3 parameters, 2 papers on 2 parameters, and one article on 6 parameters (figure9).
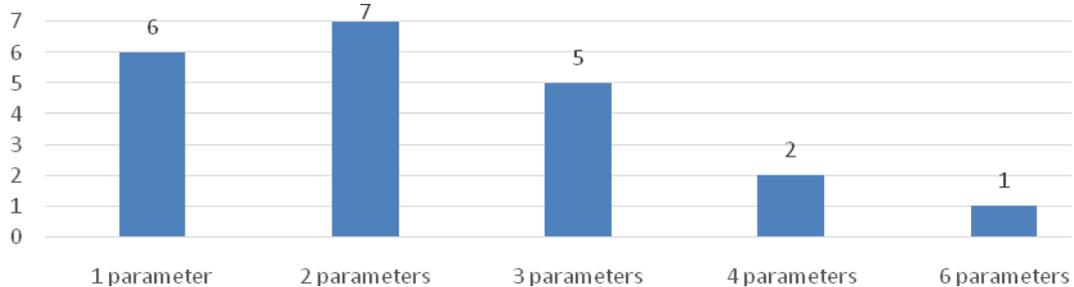
Fig. 9: Number of times several combined parameters have been tested together.

4.4.3 Cases generation

Each paper generated a number of cases through creating systematic variations in the parameter(s) (table 3). The range varies greatly between the maximum and the minimum number of case 3176 and 5 respectively.

	Reference	screen Design	Studied parameters	Cases
1	(A. Sherif et al., 2010)	Perforated panel	PP01	9
2	(A. Sherif et al., 2011)	Perforated panel	PP02	6
3	(A. Sherif et al., 2012)	Perforated panel	PP01	9
4	(Sabry, Sherif, & Rakha, 2012)	Perforated panel	PP03	10
5	(A. H. Sherif et al., 2012)	Perforated panel	PP02, PP03	12
6	(Sabry, Sherif, Gadelhak, et al., 2012)	Perforated panel	PP02, PP03	8
7	(Sabry et al., 2014)	Perforated panel	PP02, PP03	12
8	(Emami et al., 2014)	Perforated panel	PP01, PP04	5
9	(Wagdy & Fathy, 2015)	Horizontal Louvers	HL01, HL02, HL03, HL04	1600
10	(Lavin & Fiorito, 2017)	Perforated panel	PP01, PP05	10
11	(Chi, Moreno, & Navarro, 2017)	Perforated panel	PP01, PP05, PP06	16
12	(Chi, Moreno, Esquivias, et al., 2017)	Perforated panel	PP01, PP05, PP06	16
13	(Oghazian, 2017)	Perforated panel	PP06, PP07	22
14	(Kotbi & Ampatzi, 2017)	Perforated panel	PP02	36
15	(Chi et al., 2018)	Perforated panel	PP01, PP05, PP06	64
16	(Srisamranrungruang & Hiyama, 2020)	Perforated panel	PP01	5
17	(M. ElBatran & Ismaeel, 2021)	Perforated panel	PP01, PP04, PP08	36
18	(Vazquez et al., 2021)	Masonry brick wall.	BW01, BW02	12
19	(Chi et al., 2021)	Perforated panel	PP01, PP05` PP06	64
20	(Chi, 2022)	Perforated panel	PP01, PP05, PP08, PP04	72
21	(Khidmat et al., 2022)	Expanded Metal mesh	MM01,02,03, 04, 05	3176

Table 3: Summary of solar screen's types, parameters, and cases generated.

Moreover, 8 articles proposed other approaches to generate cases as part of their studies aims as follows. (Wagdy & Fathy, 2015) used a parametric exhaustive research method that enabled them to explore all possible scenarios that can be formed by different parameters values. 1600 cases were generated from this

method, and to handle the computational load of simulations they proposed a "parallel computational algorithm" that uses all PC cores to run multiple simulations at the same time. (Chi, 2022; Chi et al., 2018, 2021; Chi, Moreno, & Navarro, 2017) used the "orthogonal arrays", a statistical method to find optimized solutions. It allows to test with the least number of experiments/simulations multiple variables; thus, the computational load is reduced while giving an insight into the impact of the variation in each parameter. Finally, (Khidmat et al., 2022; Lavin & Fiorito, 2017; Vazquez et al., 2021) used a genetic algorithm method. It is a process that mimics the natural process of selection where the fittest prevails. It requires defining genes (variables with values) and a fitness value. In the study case the fitness value is a daylighting performance metric, and the genes are the studied screen parameters.

4.5 Simulation process

Daylighting simulation tools are being used in all the 21 papers to test the impact of solar screens on daylighting. This section reviews the used tools, and the adopted daylighting metrics (table 4).

	Reference	Daylight simulation engine - Interface	Daylighting performance metric
1	(A. Sherif et al., 2010)	Radiance	Point in time illuminances
2	(A. Sherif et al., 2011)	Radiance - DIVA for Rhino	Point in time illuminances
3	(A. Sherif et al., 2012)	Radiance - DIVA for Rhino	Point in time illuminances
4	(Sabry, Sherif, & Rakha, 2012)	Radiance	Point in time illuminances
5	(A. H. Sherif et al., 2012)	Radiance - DIVA for Rhino	DAv, DGP
6	(Sabry, Sherif, Gadelhak, et al., 2012)	Radiance - DIVA for Rhino	DAv, DGP
7	(Sabry et al., 2014)	Radiance/Daysim - DIVA for Rhino	DA
8	(Emami et al., 2014)	Radiance/Daysim - DIVA for Rhino	DA DF
9	(Wagdy & Fathy, 2015)	Radiance/Daysim - DIVA for Rhino	sDA, DAv, ASE, DGP
10	(Lavin & Fiorito, 2017)	Radiance/Daysim - Ladybug and honeybee for Grasshopper/Rhino	UDI, DF
11	(Chi, Moreno, & Navarro, 2017)	Radiance/Daysim - DIVA for Grasshopper/Rhino	DAv, UDI
12	(Chi, Moreno, Esquivias, et al., 2017)	Radiance/Daysim	DA, DAv, UDI
13	(Oghazian, 2017)	Radiance	sDA,DGP
14	(Kotbi & Ampatzi, 2017)	Radiance/Daysim - DIVA for Grasshopper/Rhino	DAv
15	(Chi et al., 2018)	Radiance/Daysim - Honeybee and ladybug for Grasshopper	DAv
16	(Srisamranrungruang & Hiyama, 2020)	Radiance – DIVA for Grasshopper	DAv, UDI
17	(M. ElBatran & Ismaeel, 2021)	Radiance/Daysim - DIVA for Rhino	sDA, ASE
18	(Vazquez et al., 2021)	Radiance - DIVA for Grasshopper	sDA, ASE
19	(Chi et al., 2021)	Radiance - DIVA for Grasshopper	DAv
20	(Chi, 2022)	Radiance, Daysim / DIVA for Rhino	DAv
21	(Khidmat et al., 2022)	Radiance, Ladybug and honeybee for Grasshopper	UDI, sDA, ASE

Table 4: Summary of daylight simulation: tools and metrics.

4.5.1 Metrics

Each paper uses one or multiple performance metric(s). The DF is used in only 2 papers coupled with another CBDM metric. The DA. and rough points in time illuminance values were used to explore the impact

288

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in 4 papers. The authors of these papers decided their own minimum and maximum thresholds during the methodology phase, thus none of these articles used any CBDM metric. Finally, 17 papers used different CBDM metrics, either one or multiple per paper. The DAv was the most used metric followed by the sDA (figure 10).
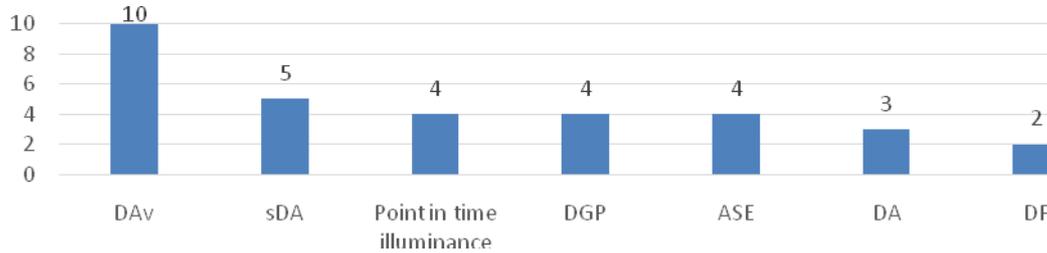

Fig. 10: Number of times a daylighting metric was used in the articles.

4.5.2 Tools

The Radiance simulation engine (and its method Daysim) is the only engine used in all of the 21 papers. The most used plugin/interface is DIVA for Rhino/Grasshopper to control Radiance in 14 articles. Honeybee and Ladybug for Grasshopper are used in 4 articles, and 3 articles did not identify the used interface (figure 11).
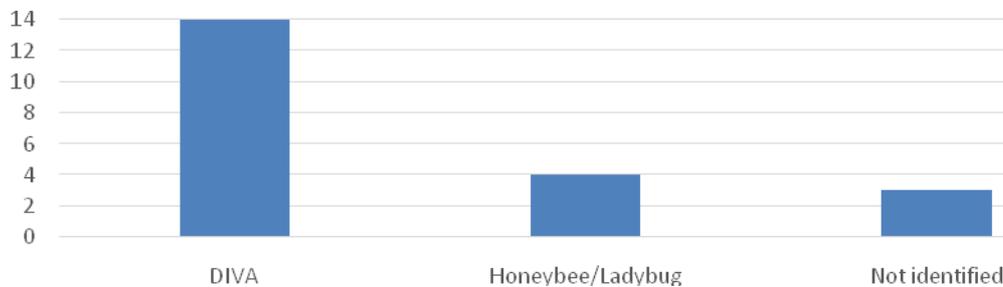
Fig. 11: Number of times an interface was used in the simulation process.

5 FINDINGS DISCUSSION

This section aims to discuss how the previously mentioned points of analysis impacted the findings of the papers, and whether they are relevant or not to the question of this study: whethere there is an investigation of the statistical correlation between daylighting performance and screens paramters. When the investigation of the daylighting performance was combined with other environmental performance aspects the aim shifted towards discovering optimized solution for screen design in specific cases. Such an approach led to the lack of in-depth insights concerning the targeted correlation, as the process was driven by a tradeoff between the different parameter values towards best case scenario for the overall environmental performance targeted. This approach to the optimization process was adopted in 9 papers.

The other 12 papers, concerned only with daylighting performance had more in-depth findings concerning the correlation between daylighting and design parameters. 11 papers targeted the perforated panels while only one paper targeted the screen of horizontal louvers. Five of these papers tested the impact of one parameter, and another five tested the impact of 2 parameters, only one article tested 3 parameters, and one article tested the impact of 4 parameters. The impact of the parameters on daylighting performance was addressed as follows:

(a) First, findings exploring the minimum and maximum parameter(s) value to achieve adequate daylighting. For example, A. Sherif et al., (2010) stated a minimum value of perforation percentage that can produce adequate daylighting. A. Sherif et al. (2012)stated that to achieve adequate daylighting in the depth of the test space higher values of perforation percentage is required, recommending the use of non-uniform values to achieve it. In another study, Oghazian, (2017)stated that different geometries of perforations with the same area affect daylighting performance differently. Such findings do not observe the presence of a statistical correlation between the parameter's values and daylighting. Moreover, the results are bonded to a specific physical configuration of a test space. Sabry, Sherif, Gadelhak, et al., (2012) and A. H. Sherif et al.

(2012)agreed on this,mentioning that other spatial configurations of test spaces may affect the concluded results.

(b) Regardless of the previously mentioned concern, Sabry, Sherif, & Rakha, (2012) is the onlypaper that observed the statistical correlation,they found an increasing linear relationship between average illuminance values and axial rotation angles. They suggested that such a correlation could be used by architects as a guide to choose suitable axial rotation angles knowing their impact on daylighting availability.

(c) The orientation and solar radiation impact was addressed in a number of findings. A. Sherif et al. (2012)observed that the impact of screens in the north with the absence of solar radiationis more effective. Similar findings were stated by Oghazian, (2017) who claimed that non-uniform perforation could deal with the efficiency/deficiency of other screen parameters when daylighting values are influenced by solar radiation. Sabry, Sherif, Gadelhak, et al. (2012) and A. H. Sherif et al. (2012) found that the aspect ratio of openings can improve daylighting while taking into consideration that it may cause over-lighting due to solar radiation for southern and eastern orientations.

(d) The previously mentioned findings prove that adopting solar radiation into the simulation process affects the insight of how the diffused daylight is impacted by tested parameters. Emami et al. (2014)agreed and stated that it is important to consider the DF in such a process as an indication of the percentage of diffused daylight blocked by the solar screen rather than CBDM metrics that considers solar radiation.

(e) Such insights put the finding of Kotbi&Ampatzi (2017)in question, who suggested a table for architects to use which indicates how several perforation aspect ratio values impact daylighting performance according to the DAv thresholds. Such a table is only valid when using the CBDM metric and when it is related to a specific spatial configuration.

(f) Several other findings relate to both studies which had the highest number of tested parameters (M. ElBatran& Ismaeel, 2021; Wagdy & Fathy, 2015). These papers addressed the impact of the trade-off between the different values of parameters on daylighting performance. Whereas the higher number of cases may give statistically a better insight for a correlation, the high number of addressed parameters makes the singular impact of each parameter unclear to observe.

6 CONCLUSION

This review of papers aims to observe how the impact of façade solar screen design parameters on daylighting is interpreted in research, and assessing if there is a methodolgy to fnd a statistical correlation between parameters of solar screens and daylighting levels. The topic relevance has been proven throughout the last decade, as an average of one to two papers per year are being published on it in journals or conferences proceedings. The tests in the 21 studies have been conducted on sites in different hot zones with hot climate, which proves awareness of the research community and their interest in the scope of this study.

Although there was only one study that observed and described the correlation between the variation in design parameters and daylighting levels, there is no reliable attempt towards devising a methodology to investigate the statistical correlation between a specific solar screen design parameter and daylighting levels. This failure could be related to the following:

(a) Using metrics that adopt the interferance of solar radiation which impacts the results of diffused daylight.

(b) Introducing no variations in the spatial configuration of test spaces, which renders the results relatingto only one specific spatial configuration.

(c) The combination of a large number of parameters in one study and the testing on other environmnetal aspects which leads to shifting the paper's aim into creating trade-offs and investigating a number of best-case scenarios.

However, the reviewed papers provide insight about what could be recommended to propose such a methodology in further research work, for example: adopting point in time illuminace values rather than CBDM metrics to exclude the interferance of solar radiation and have a clear judgmnet about the direct impact of solar screens on diffused daylight. Also, considering only one paramater with its variations per study, whereas introducing multiple cases in the test space's spatial configurations and compare their results to each other, thus any coorelation suggested would not be related to one specific spatial configuration case.

Finally, the reported ease of its modelling and manipulation made the perforated panel the most tested type of solar screen, together with its parameters. This conclusion may denote a lack in covering the reported growing number of screen types and morphologies. This leads to the need of reviewing a pool of international examples to create a catalogue to categorize screen morphologies into families and types with their respective design parameters.

7 REFERENCES

Chi, D. A. (2022). Solar energy density as a benchmark to improve daylight availability and energy performance in buildings: A single metric for a single-objective optimization. Solar Energy, 234, 304–318. https://doi.org/10.1016/j.solener.2022.01.068

Chi, D. A., Moreno, D., Esquivias, P. M., & Navarro, J. (2017). Optimization method for perforated solar screen design to improve daylighting using orthogonal arrays and climate-based daylight modelling. Journal of Building Performance Simulation, 10(2), 144–160. https://doi.org/10.1080/19401493.2016.1197969

Chi, D. A., Moreno, D., & Navarro, J. (2017). Design optimisation of perforated solar façades in order to balance daylighting with thermal performance. Building and Environment, 125, 383–400. https://doi.org/10.1016/j.buildenv.2017.09.007

Chi, D. A., Moreno, D., & Navarro, J. (2018). Correlating daylight availability metric with lighting, heating and cooling energy consumptions. Building and Environment, 132, 170–180. https://doi.org/10.1016/j.buildenv.2018.01.048

Chi, D. A., Moreno, D., & Navarro, J. (2021). Impact of perforated solar screens on daylight availability and low energy use in offices. Advances in Building Energy Research, 15(1), 117–141. https://doi.org/10.1080/17512549.2018.1550439

Eltaweel, A., & SU, Y. (2017). Parametric design and daylighting: A literature review. Renewable and Sustainable Energy Reviews, 73, 1086–1103. https://doi.org/10.1016/j.rser.2017.02.011

Emami, N., Khodadadi, A., & Von Buelow, P. (2014). Design of Shading Screens Inspired by Persian Geometric Patterns: An Integrated Structural and Daylighting Performance Evaluation. Proceedings of the IASS-SLTE Symposium "Shells, Membranes and Spatial Structures: Footprints." https://www.researchgate.net/publication/265844273

Etman, O., Tolba, O., & Ezzeldin, S. (2013). Double-Skin Façades in Egypt between Parametric and Climatic Approaches. Computation & Performance: Proceedings of the 31st International Conference on Education and Research in Computer Aided Architectural Design in Europe, 459–466. www.aast.edu

Heschong, L., Wymelenberg, V. Den, Andersen, M., Digert, N., Fernandes, L., Keller, A., Loveland, J., Mckay, H., Mistrick, R., Mosher, B., Reinhart, C., Rogers, Z., & Tanteri, M. (2012). Approved method : IES spatial daylight autonomy (sDA) and annual sunlight exposure (ASE).

Khidmat, R. P., Fukuda, H., Kustiani, Paramita, B., Qingsong, M., & Hariyadi, A. (2022). Investigation into the daylight performance of expanded-metal shading through parametric design and multi-objective optimisation in Japan. Journal of Building Engineering, 51. https://doi.org/10.1016/j.jobe.2022.104241

Kirimtat, A., Koyunbaba, B. K., Chatzikonstantinou, I., & Sariyildiz, S. (2016). Review of simulation modeling for shading devices in buildings. Renewable and Sustainable Energy Reviews, 53, 23–49. https://doi.org/10.1016/j.rser.2015.08.020

Kotbi, A., & Ampatzi, E. (2017). USING SOLAR SCREENS IN SCHOOL CLASSROOMS IN HOT ARID AREAS: THE EFFECT OF DIFFERENT ASPECT RATIOS ON DAYLIGHTING LEVELS Investigating the parameters of perforated solar screens View project. Design to Thrive, Proceedings Vol. 2, PLEA 2017 Conference. https://www.researchgate.net/publication/319904145

Lavin, C., & Fiorito, F. (2017). Optimization of an External Perforated Screen for Improved Daylighting and Thermal Performance of an Office Space. Procedia Engineering, 180, 571–581. https://doi.org/10.1016/j.proeng.2017.04.216

Lewis, A. (2017). The mathematisation of daylighting: A history of British architects' use of the daylight factor. Journal of Architecture, 22(7), 1155–1177. https://doi.org/10.1080/13602365.2017.1376342

Lou, S., Li, D. H. W., & Chen, W. (2019). Identifying overcast, partly cloudy and clear skies by illuminance fluctuations. Renewable Energy, 138, 198–211. https://doi.org/10.1016/j.renene.2019.01.080

M. ElBatran, R., & Ismaeel, W. S. E. (2021). Applying a parametric design approach for optimizing daylighting and visual comfort in office buildings. Ain Shams Engineering Journal, 12(3), 3275–3284. https://doi.org/10.1016/j.asej.2021.02.014

Mardaljevic, J., Mphil, B., & Mardaljevic, J. (2000). The Simulation of Annual Daylighting Profiles for Internal Illuminance. In Lighting Research and Technology (Vol. 32, Issue 3). http://www.lboro.ac.uk/departments/civil-building/staff/mardaljevicjohn

Mayhoub, M., & Labib, R. (2015). Towards A Solution for the Inevitable Use of Glazed Facades in the Arid Regions via a Parametric Design Approach. CIE 2015. https://doi.org/10.13140/RG.2.2.22687.76963

Nabil, A., & Mardaljevic, J. (2006). Useful daylight illuminances: A replacement for daylight factors. Energy and Buildings, 38(7), 905–913. https://doi.org/10.1016/j.enbuild.2006.03.013

Oghazian, F. (2017). The role of geometry and non-uniform distribution of openings in daylighting performance of solar screens Future Architecture and Planning View project. Design to Thrive, Proceedings Vol. 2, PLEA 2017 Conference. https://www.researchgate.net/publication/321361768

Reinhart, C. F., & Herkel, S. (2000). The simulation of annual daylight illuminance distributions-a state-of-the-art comparison of six RADIANCE-based methods. In Energy and Buildings (Vol. 32). www.elsevier.comrlocaterenbuild

Reinhart, C. F., & Walkenhorst, O. (2001). Validation of dynamic RADIANCE-based daylight simulations for a test office with external blinds. Energy and Buildings, 33, 683–697. http://radsite.lbl.gov/radiance/.

Reinhart, C. F., & Wienold, J. (2010). THE DAYLIGHTING DASHBOARD-A SIMULATION-BASED DESIGN ANALYSIS FOR DAYLIT SPACES. SimBuild 2010 - Fourth National Conference of IBPSA-USA, 410–418.

Sabry, H., Sherif, A., Gadelhak, M., & Aly, M. (2014). Balancing the daylighting and energy performance of solar screens in residential desert buildings: Examination of screen axial rotation and opening aspect ratio. Solar Energy, 103, 364–377. https://doi.org/10.1016/j.solener.2014.02.025

Sabry, H., Sherif, A., Gadelhak, M. I., & Rakha, T. (2012). External Perforated Solar Screen Parameters and Configurations: Daylighting Performance of Screen Axial Rotation and Opening Proportion in Residential Desert Buildings. 14th International Conference on Computing in Civil and Building Engineering. www.salem-art.com

Sabry, H., Sherif, A., & Rakha, T. (2012). Daylighting Efficiency of External Perforated Solar Screens: Effect of Screen Axial Rotation under Clear Skies. ICSDC 2011: Integrating Sustainability Practices in the Construction Industry.

Sherif, A. H., Sabry, H. M., & Gadelhak, M. I. (2012). The impact of changing solar screen rotation angle and its opening aspect ratios on Daylight Availability in residential desert buildings. Solar Energy, 86(11), 3353–3363. https://doi.org/10.1016/j.solener.2012.09.006

Sherif, A., Sabry, H., Elzafarany, A., Rasha, A., Rakha, T., & Anees, M. (2011). Balancing the energy savings and daylighting performance of external perforated solar screens: Evaluation of screen opening proportions. Architecture and Sustainable Development, Proceedings of PLEA 2011. https://www.researchgate.net/publication/290260237

Sherif, A., Sabry, H., & Rakha, T. (2010). DAYLIGHTING FOR PRIVACY: EVALUATING EXTERNAL PERFORATED SOLAR SCREENS IN DESERT CLEAR SKY CONDITIONS. Renewable Energy 2010 International Conference.

Sherif, A., Sabry, H., & Rakha, T. (2012). External perforated Solar Screens for daylighting in residential desert buildings: Identification of minimum perforation percentages. Solar Energy, 86(6), 1929–1940. https://doi.org/10.1016/j.solener.2012.02.029

Srisamranrungruang, T., & Hiyama, K. (2020). Balancing of natural ventilation, daylight, thermal effect for a building with double-skin perforated facade (DSPF). Energy and Buildings, 210. https://doi.org/10.1016/j.enbuild.2020.109765

Tregenza, P., & Mardaljevic, J. (2018). Daylighting buildings: Standards and the needs of the designer. Lighting Research and Technology, 50(1), 63–79. https://doi.org/10.1177/1477153517740611

Tregenza, P. R. (1980). The daylight factor and actual illuminance ratios. Lighting Research and Technology, 12(2), 64–68.

Trotter, A. P. (1911). illumination - its distribution and measurement. Macmillian and Co., Limited.

Vazquez, E., Duarte, J., & Poerschke, U. (2021). Masonry screen walls: a digital framework for design generation and environmental performance optimization. Architectural Science Review, 64(3), 262–274. https://doi.org/10.1080/00038628.2020.1749552

Wagdy, A., & Fathy, F. (2015). A parametric approach for achieving optimum daylighting performance through solar screens in desert climates. Journal of Building Engineering, 3, 155–170. https://doi.org/10.1016/j.jobe.2015.07.007

Yu, F., Wennersten, R., & Leng, J. (2020). A state-of-art review on concepts, criteria, methods and factors for reaching 'thermal-daylighting balance.' Building and Environment, 186. https://doi.org/10.1016/j.buildenv.2020.107330

292

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FTN – Frequent Transit Network: Transit Strategies towards Achieving Transit-Oriented Development in Alexandria City, Egypt

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1 ABSTRACT

Land use policy and transport policy are normally integrated through transit-oriented development (TOD) strategies. (TOD) is a "mixed-use community", that encourages people to live near transit services and to decrease dependence on their driving. Instead of requiring riders to consult a timetable or wait for extended periods of time, transit service is most appealing when it is frequent enough that riders can arrive at a stop knowing that a bus or train will arrive soon. Frequent Transit Networks (FTNs) aim to deliver services in high-demand areas in a convenient, connected, and memorable. (FTNs) are intended to serve the locations that the majority of people want to visit most frequently and to make service convenient by operating at least every 15 minutes from early morning until at least mid-afternoon. This paper discusses, evaluates, and looks into the possibility of implementing TOD and FTNs in Alexandria, Egypt. Alexandria is experiencing a sharp increase in transport demand as a result of its rapid urbanisation. With the narrow streets and limited spaces the rapid urbanisation process has led to a significant increase in traffic volume. This paper adopts the Frequent Transit Network (FTNs) strategies in identifying corridors linking the city's urban centers and the nodes where these corridors intersect. The main purpose is to direct growth , development and to create a proposal for a "System Backbone" that provides a structure for other services. Expected findings from this study is to perform a framework that identify potential (FTN) solutions for the city. It also proposes a "Key Corridor Network" for the bus routes and light rail transit, emphasising corridors in which combined transport services could provide a more efficient operation of the city's public transport.

Keywords: Key Corridor Network, Convenient, Frequent Transit Network, Mixed-Use Community, Transit Oriented Development

2 INTRODUCTION

2.1 A brief overview

Frequent Transit Networks (FTNs) and Transit-Oriented Development (TOD) are related ideas with the same goal of enhancing urban areas' liveability and sustainability of transportation. An FTN is a high-frequency bus, train, or metro network that puts accessibility and dependability first and makes it easy for people to get around the city. TOD is a land-use strategy that encourages mixed-use, pedestrian-friendly, and compact urban development around transit stations in order to maximise the potential of FTNs. By reducing reliance on automobiles and fostering sustainable mobility, FTNs and TOD provide an all-encompassing solution to urban transportation issues that also improves livability, economic vitality, and social equity. Therefore, any city seeking to create a more sustainable and equitable future should prioritise planning and implementing FTNs and TOD.

2.2 The Essential Elements of Frequent Transit Networks

Frequent Transit Networks are intended to deliver service in highly populated areas in a convenient, connected, and memorable way.

2.2.1 Convenient

Frequent Transit Networks operate at least every 15 minutes from early in the morning until at least mid-afternoon, making service more convenient. The most direct route possible is planned for each route.

For example: Seattle's Frequent Transit Network (FTN), which was first mentioned in the Transit Master Plan, offers a long-term vision of connected bus routes crisscrossing the city, offering high-quality and frequent transit service to all residents, employees, and visitors of Seattle. This network aids in directing the service investments made by (Stock Tank Barrel per Day) STBD.

Three categories of routes are established by Seattle's FTN: Local, Frequent, and Very Frequentas shown in Fig 1. The FTN emphasises frequent service that is available every day of the week (18 to 24 hours). All Seattle residents now have more transport options thanks to this interconnected network of routes. The FTN actively develops a transit network for the Seattle of the future while adjusting frequency around times of the day when transit demand is at its highest.

Fig. 1: FTN Frequency Targets.(Source: Seattle's Frequent Transit Network)

2.2.2 Connected

Frequent Transit Networks are made to take passengers to the places they want to go most frequently, including downtowns, urban neighbourhoods, mixed-use corridors, employment centres, and significant institutions like universities. Additionally, they can establish a de facto "system backbone" that acts as a framework for other services. Frequent Service Networks can offer a similar framework for smaller systems, with lower frequency routes and specialised services acting as connections to the Frequent Transit Network, much like how large urban systems are built around the backbone that their rapid transit systems provide.

2.2.3 Memorable

Four main strategies are used by frequent transit networks to make their services memorable: distinctive branding, frequent transit network maps, straightforward service models, and simple schedules.

Distinctive Branding: To increase awareness of the services offered, many transit systems brand their frequent transit networks. Unique branding and clever marketing can help bring new users into the system, decreasing reliance on cars overall.

Frequent Transit Network Maps: Numerous systems create unique Frequent Transit Network maps that are intended to draw attention to and distinguish frequent services from other services.

Straightforward Service Models: Frequent Transit Networks have straightforward service structures that are made to be simpler to remember. They usually travel as directly as possible along the main roads.

Simple Schedules: Frequent Transit Networks also frequently have simple schedules, with scheduled transit services operating at regular intervals (clockface headways) that are simple for passengers to remember.

3 LITERATURE REVIEW

By analysing related scientific studies to determine the research gap that is most likely to be true between them, a meta-analysis of the literature is used. It was determined that:

3.1 Problem definition

Planning guidelines for sustainable mobility have gaps from the perspective of sustainability principles. While issues like strategic land use and impacts on non-motorized travel are frequently overlooked unless they are a part of integrated land use and transportation studies (TOD) (Transit Oriented Development) or comprehensive urban development plans,transportation planning traditionally addresses various issues related to vehicles, safety, maintenanceand infrastructurerelated environmental impacts. Which led to the

294

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observation that there is a general trend, "Modal shift from public transport to private transport" which is described below as shown in Fig 2. The challenge at the spot is to use a frequent transit network strategy to achieve transit-oriented development while directing the opposite "Modal shift from private to public transport" direction.

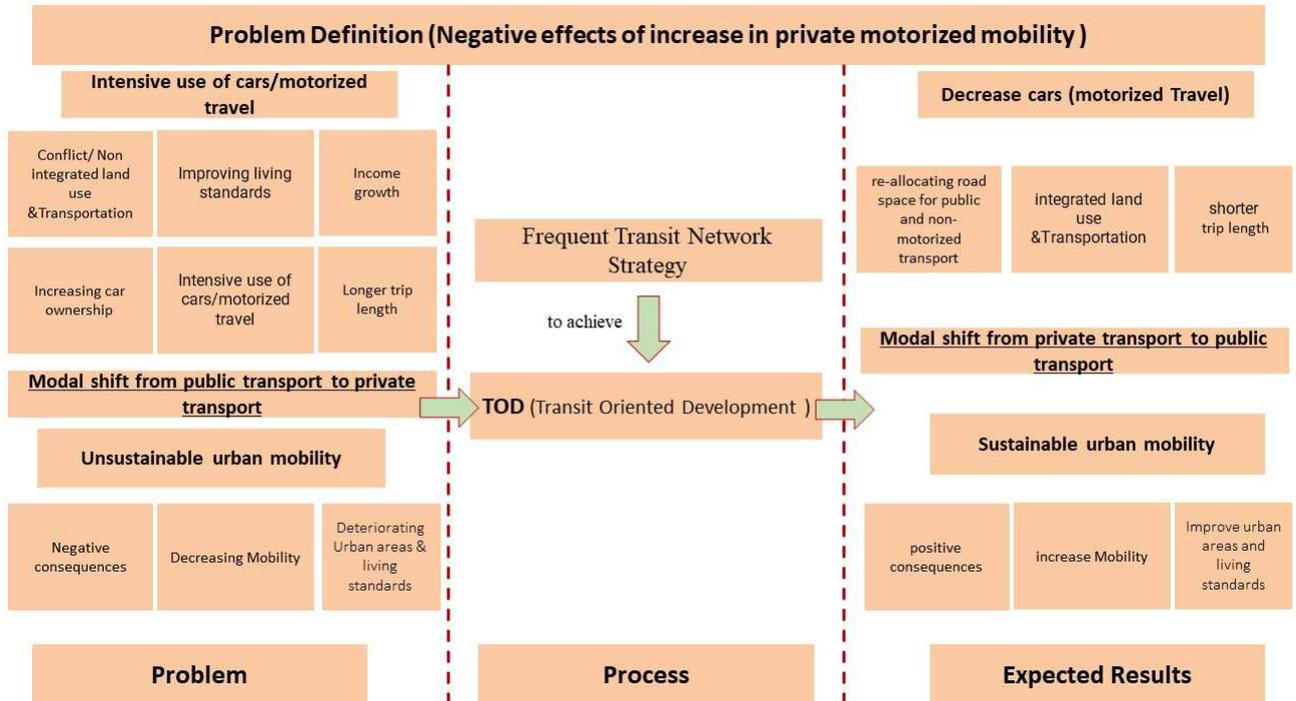Fig. 2: Problem Definition (Negative effects of the increase in private motorized mobility). (Source:authers)
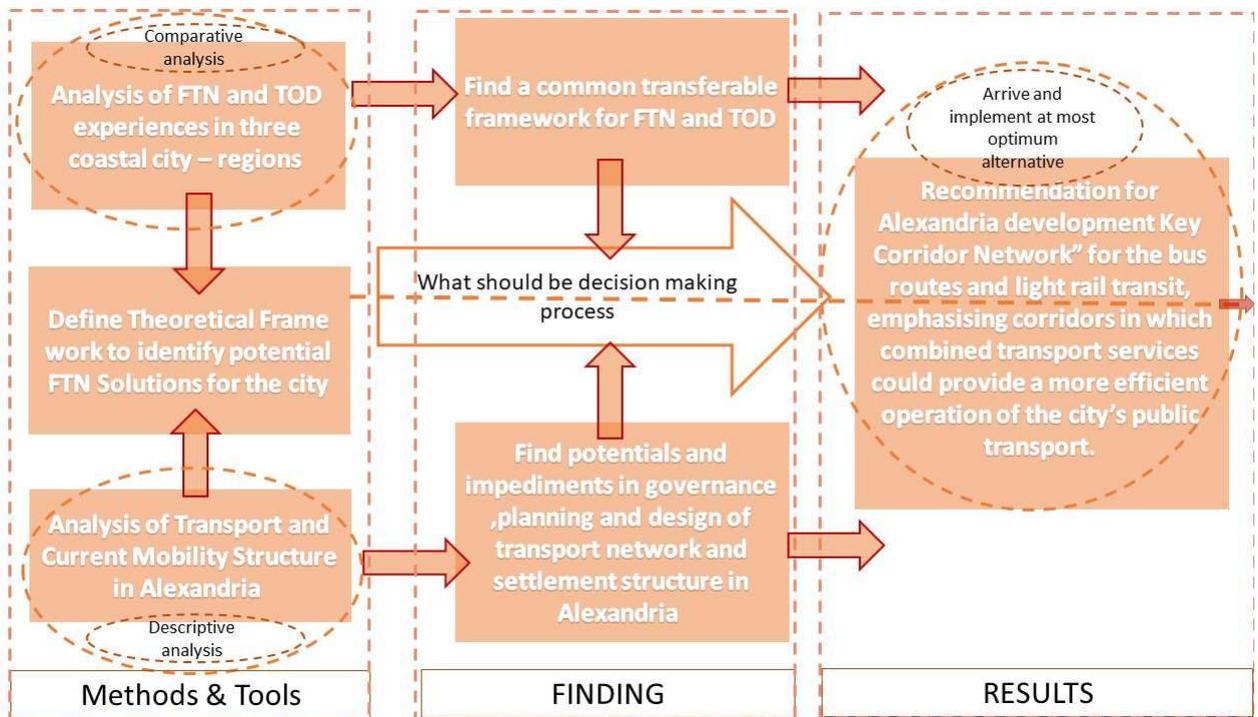
4 METHODS AND TOOLS

Fig. 3: Chart showing the sequence of work in paper (Methods &Tools – Finding – Results) constantly. (Source:authors)

4.1 Comparative analysis

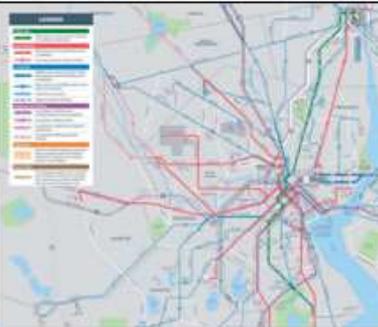Comparisons are made of the selected case studies through analysis of FTN and TOD experiences in three city regions.

NO	Name/ Description	Map	Service /Used Techniques
	Portland, OR: By enhancing infrastructure and increasing frequencies, TriMet developed its frequent service network. The regional hubs where many riders live and work are intended to be connected by lines of the frequent service network. For transportation to and from Portland International Airport in the wee hours of the morning and late at night, TriMet is adding a new bus line. In order to reduce wait times, TriMet is also splitting its longest bus line and increasing frequency in East Portland. Increased access to dependable, safe transport throughout the region, better connections to jobs and other destinations, and more service are all benefits of the expansion.	 Fig. 3: Map of Trimet Frequent service (Portland ,OR)	**Services:** • Every 15 minutes or better most of the day, every day • five light rail lines • 24-hour service • Later trips on MAX and all-night bus service to PDX • A new frequent service line • Serving the suburbs • Splitting our longest bus line • A more comfortable ride **Used Techniques:** 1. New shelters and sign poles with service information a(nd stop identification numbers . 2. Bus stop re-spacing and curb extensions . 3.Better pedestrian access . 4.Traffic signal priority . 5.Bus-only lanes .
2	**Austin, TX:** Capital Metro's "High Frequency Transit Routes" network is brand-new, and it serves Austin. The bus system in Austin underwent a redesign in June 2018. Since then, Capital Metro has seen a 4.5% increase in ridership, making it one of the few transit systems in the country to see rising ridership. With a focus on frequent service, Capital Metro launched its Cap Remap bus network redesign in 2018. There are 15 routes in the new extensive transit system.	 Fig. 4: Map of Austin's bus network (old - New) (Austin ,TX)	**Services:** - every 15 minutes from 6:00 AM to 8:00 PM, seven days a week. - 13 metro bus routes - 15 routes -Thirteen MetroBus routes that run every 15 minutes from 6:00 AM to 8:00 PM, seven days a week. -Two MetroRapid BRT routes that operate every 10 minutes during peak hours on weekdays **Used Techniques:** •Prioritize transit and walking. •Redesigning of its bus network . •Transit Joint Development
3	**Rhode Island:** (Potential Rhode Island Frequent Transit System) A "Key Corridor Network" consisting of the Rapid Bus line (the R-Line), key corridor bus routes and transit emphasis corridors where combined services on multiple routes provide frequent service was created by RIPTA for the Providence Metro area as part of its 2013 system redesign.	 Fig. 5: Map of Rhode Island Transit Master Plan (Rhode Island)	**Services:** • every 15 minutes. • the Providence Metro area • Rapid Bus line (the R-Line), key corridor bus routes **Used Techniques:** •Developping a "Key Corridor Network" . •Crosstown routes that connect service outside of downtown . •Additional radial routes to provide frequent service to additional areas.

Table. 1: Comparison of strategies that were used in three cities to applyFrequent Transit Network (FTNs). Source: authors after Tri-Met's Frequent Service Network Capital Metro's new frequent transit network -RIPTA's Key Corridor service

4.2 Descriptive analysis:

Analysis of transport and current mobility structure in case study (Alexandria):

With 35% of trips and a portion of the 40% of trips that are internal to the East zone, the "east - city centre" represents the main ridership potentialwhich is described below as illustrated in Fig 6. The city center's north and south corridors exhibit a moderate flow that is clearly on a different scale from the "east-city centre" flow. Today, the "west - city centre" is less significant. It may change in line with anticipated western development, but most likely in the medium- to long-term..

296

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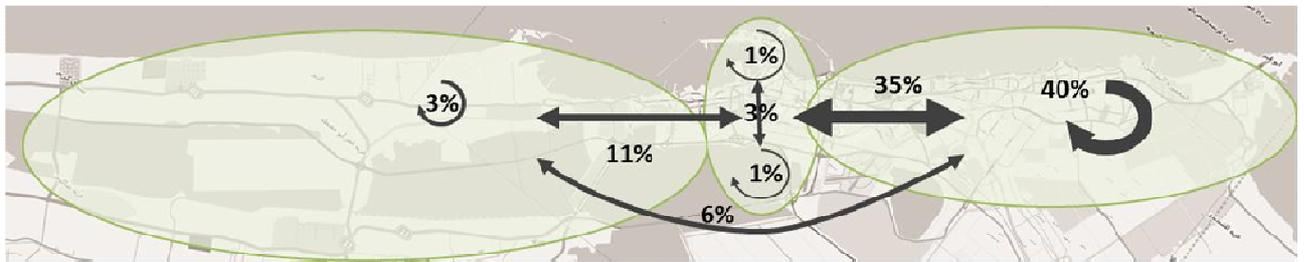
Fig. 6: Main public transport flows in Alexandria (Source: Egis 2014 surveys)

The sketch belowas illustrated in Fig 7 shows how the internal journeys of the eastern zone are represented. It demonstrates that the primary demand is also in an east-west direction there.This comprehensive analysis leads to the conclusion that the "East - City Centre" connection should be given priority (the scope of work) .
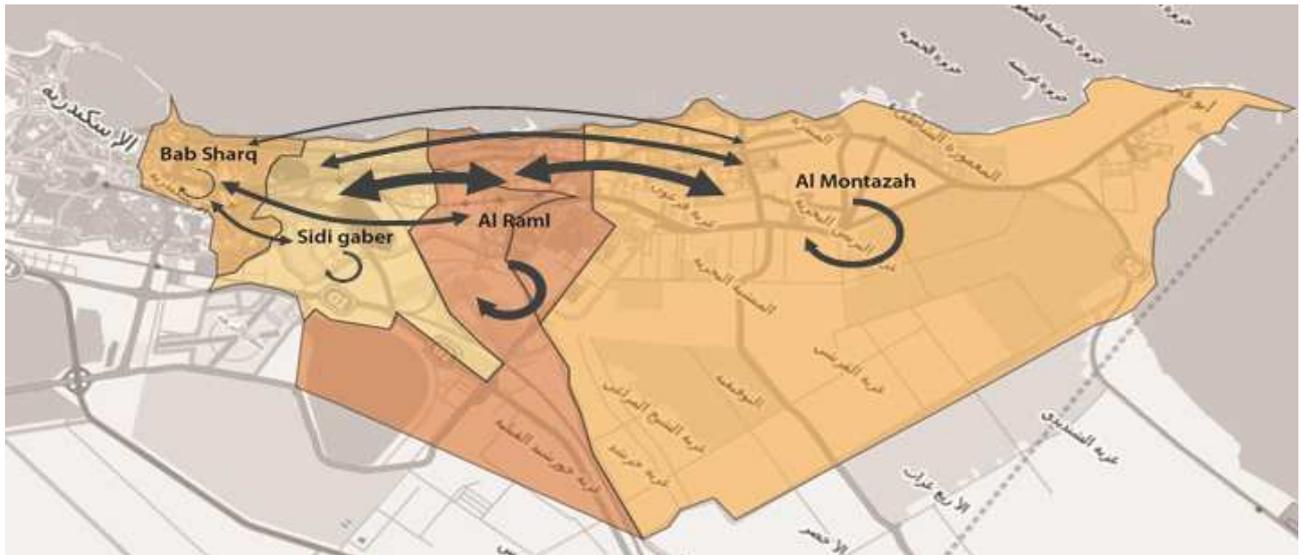
Fig. 7: Main public Transport flows in the east of Alexandria. Source: Egis 2014 Survey.

4.3 Define Theoretical frame work: to find potential FTN Solutions for the Alexandria case study
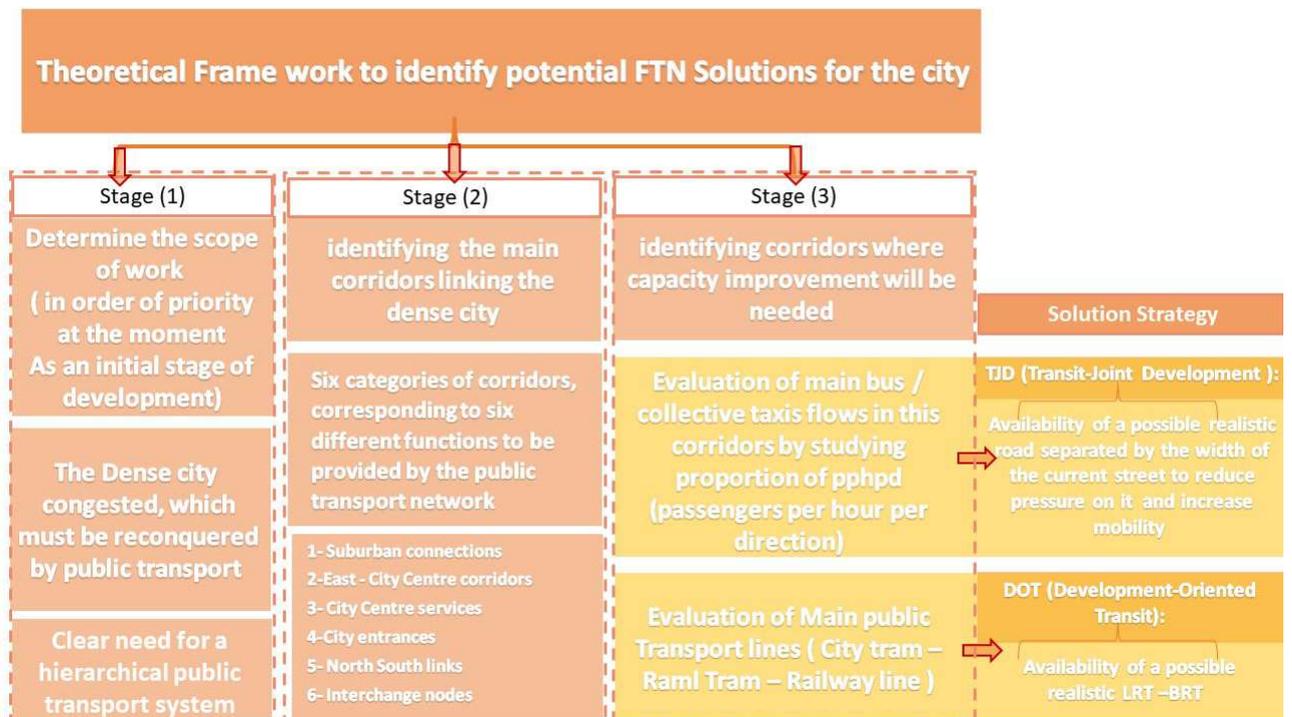
Fig. 8: Theoretical Frame work to identify potential FTN Solutions for the city (Source: authors)

4.3.1 Determine the scope of work

Alexandria dense city : there is a clear need for a hierarchical public transport system. The dense City, congested, which must be reconquered by public transport.In Alexandria, due to the linear structure of the city, the structure will naturally be based on one or several east-west axis combined with south-north feeding lines.

1	Road to Rashyd	~ 17 000pphpd
2	Corniche Road	~ 15 000 to 20 000 pphpd
3	Al-Muhammadiyah Canal axis / Alexandria entrance road from Muharram Bey	~ 18 000 pphpd
4	Cairo-Alexandria Agricultural Road (regional road)	~ 10 000 pphpd
5	Suez Canal Street (main road)	~ 20 000 pphpd
6	Al-Max Street (Main Road)	~ 15 000 pphpd
7	Malak Hefni Road - Abu Qir Road	~ 18 000 pphpd
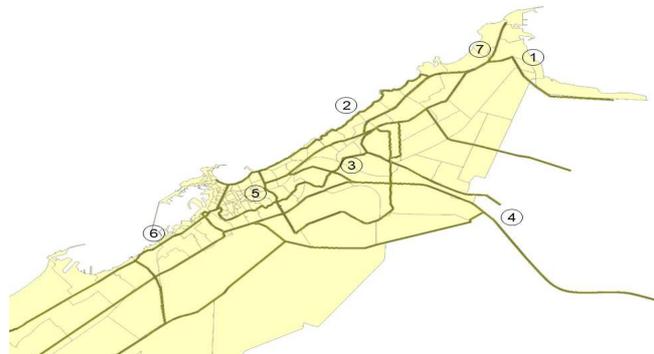
Fig. 9: Map of Alexandria dense cityMain bus/collective taxis flows (Current total publicridership-Passengers per hour per direction pphpd. Source: authors after French Development AgencyAlexandria Urban Transport StudyReport Phase 1.

4.3.2 Identifying the main corridors linking the dense city:

Through the diagnosis, six categories of corridors were discovered, each of which corresponds to a different service that the public transport system will offer.

4.3.3 Identifying corridors where capacity improvement will be needed

Evaluation of main bus/collective taxis flows in this corridors by studying proportion of pphpd (passengers per hour per direction):

by layering mapon top of each other in order (Network of arterial ways and main roads + number of lanes of main roads + flow of main bus/collective taxis + interchange nodes) to produce a mapidentifying corridors where capacity improvement is required.
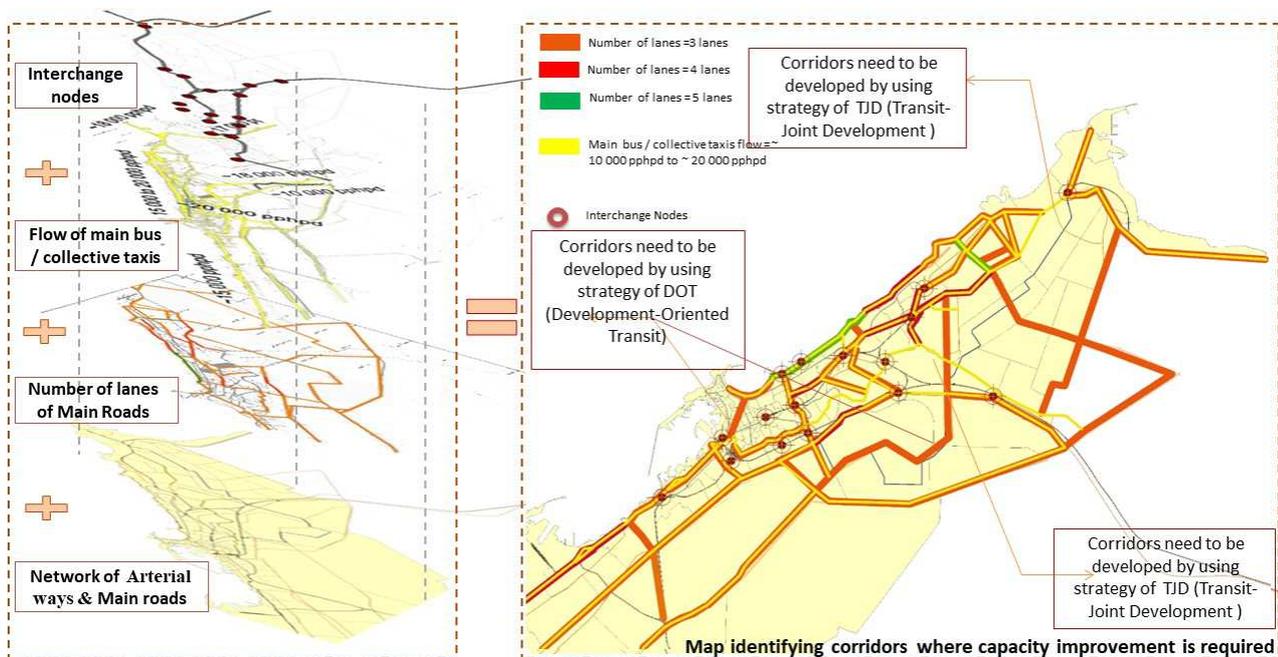
Fig.10: Proposed Digramatic Map of Alexandria dense city identifying corridors where capacity improvement is required. Source: authors.

Function	Map	Road /Rail /Tunnel /Tram	Area Served	Current pphpd
1- Suburban connections		1- Abu Kir	City center, Sporting facilities, commercial centers	20 000pphpd
		2- Borg El Arab Rail line	City Centre, El Max, Almeriyah, Borg El Arab	7000pphpd
		3- North Costal Line	Dekheila port	15000pphpd
		4- Rail Connection from East to South		
		5- Abu Kir Line extention by Tunnel under city center	CityCenter	
2- East - City Centre corridors		6- Raml tram (existing right of way)	CityCentre, AlexandriaUniversity, tworailStations, Sportingfacilities, commercialcentre	12000pphpd
		7- Corniche	City centre, Alexandria University, Touristic Area (beach), commercial centres	20 000 pphpd
		8- Mahmoudeya Canal	Pharos University, Moharram bey, city centre	15000pphpd
		9- Mostafa Kamal to El Sa'aa	East New urbanized areas	8000pphpd
3- City Centre services		10- El sabaa Banat Road (Raml Tram extension or Corniche Line extension)	City centre	
		11- Sherif Street / Abdel Moneim Road	City centre	
		12- City Center North South tunnel	City centre, Misr Station	
		13- City Tram	City centre, Misr station, Alexandria Port, industrial Area	Vary from one line to the other
4- City Entraces		14- Road to Rashyd		17 000 pphpd
		15- Entrance of Alexandria from theAgricultural Road		18 000 pphpd
		16- City entrance through Moharram Bey		20 000 pphpd
5- North South links		17- Suer Canal Road	Citycenter	20 000 pphpd
		18- El Galaa – El Sa'aa	Victoria station, El Nokrashy	
6- Interchange nodes		19- Main interchange Nodes / P+R • El Max • Moharram Bek • Sidi Gaber • Victoria		
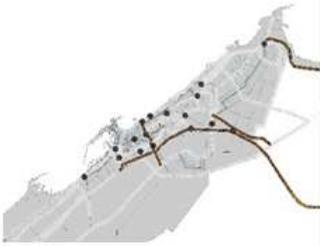
Table. 2: Identifying the main corridors linking the dense city. Source: authors after French Development AgencyAlexandria Urban Transport StudyReport Phase 1.

Evaluation of Main public Transport lines (City tram – Raml Tram – Railway line)

(a) City Tram : is currently completely jammed in traffic, but could regain an important role if car traffic could be limited in the city center, and with an important renovation work. It could be the same also for walking, if increased space and safety was given to pedestrians.

(b) Raml Tram : where demand is high (more than 10 000 pphpd) and where the existing tramway could be upgraded into a modern tramway system with an improved right of way segregation. The existing line could be extended towards Mansheya Square or even Kabbary if it is possible to cross the city center.

(c) Railway Line / Regional lines : will also be the main structure for the public transport network and offer a possibility for quick move inside the city.)Jérémie Simon et al. , 2015(

5 RESEARCH FRAMEWORK

Common transferable framework for applying FTN Strategies towards achieving Transit-Oriented Development as shown in fig. 11.
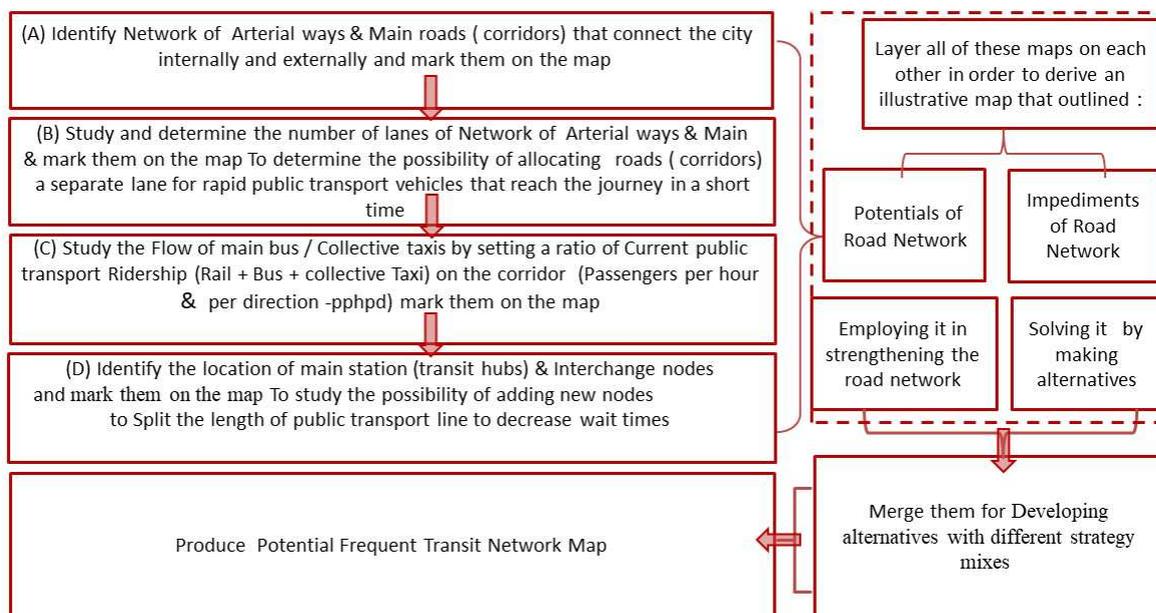
Fig. 11: diagram show Common transferable framework for applying FTN (Source: authors)

5.1 Results

Recommendation for Alexandria development Key Corridor Network" for the bus routes and light rail transit, emphasising corridors in which combined transport services could provide a more efficient operation of the city's public transport as shown in fig. 12.
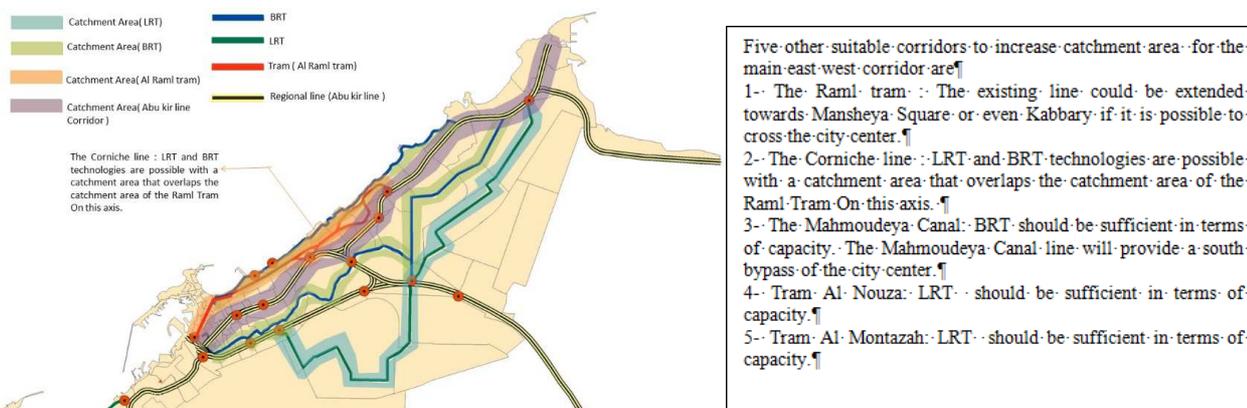
Fig. 12: Proposed Digramatic Map of Alexandria dense city framework development Key Corridor Network. Source: authors after French Development Agency Alexandria Urban Transport StudyReport Phase 1.

The main east west corridor: a mass public transport line such as a heavy metro or a LRT with high capacity to implement such a line is on the Abu Kir line corridor will operate as the backbone of public transport on the area; its stations will be fed by bus and collective taxis to improve the accessibility of the line and the attractivity of the whole public transport network. Those stations could also be used as nodal points for transport oriented development.

6 DISCUSSION
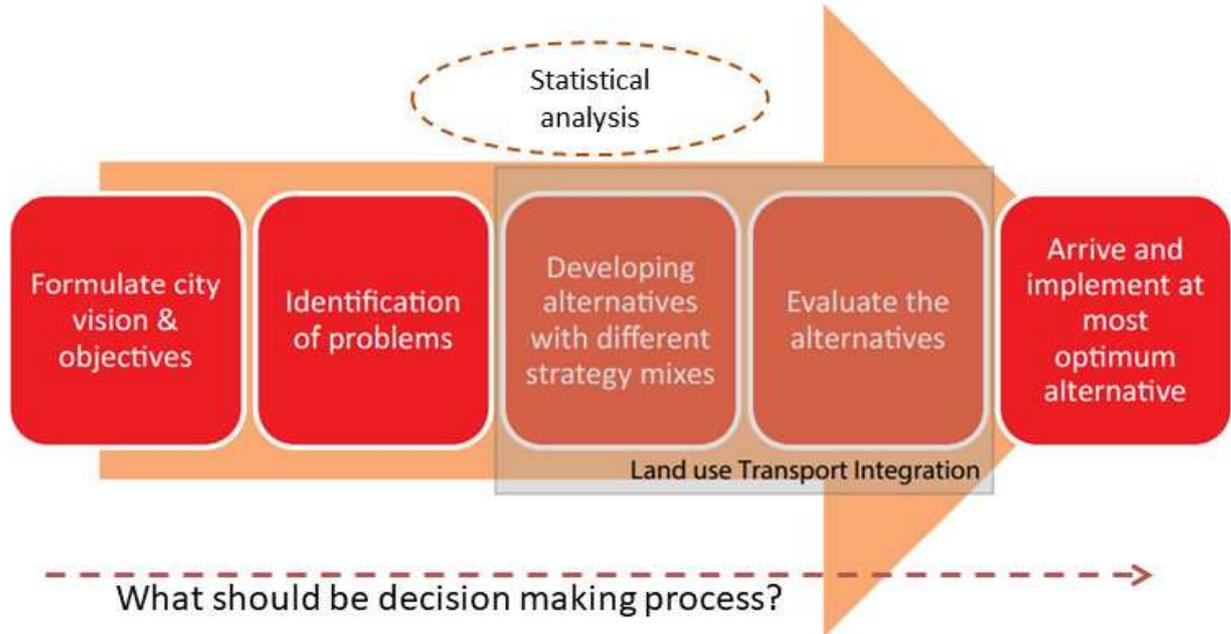
Fig. 12: Diagram show steps of decision making process as part of fig. 3.

6.1 Formualte city vision and objectives

6.1.1 City Vision

The strategic Urban Plan 2032 describes the "city vision" in six modules:
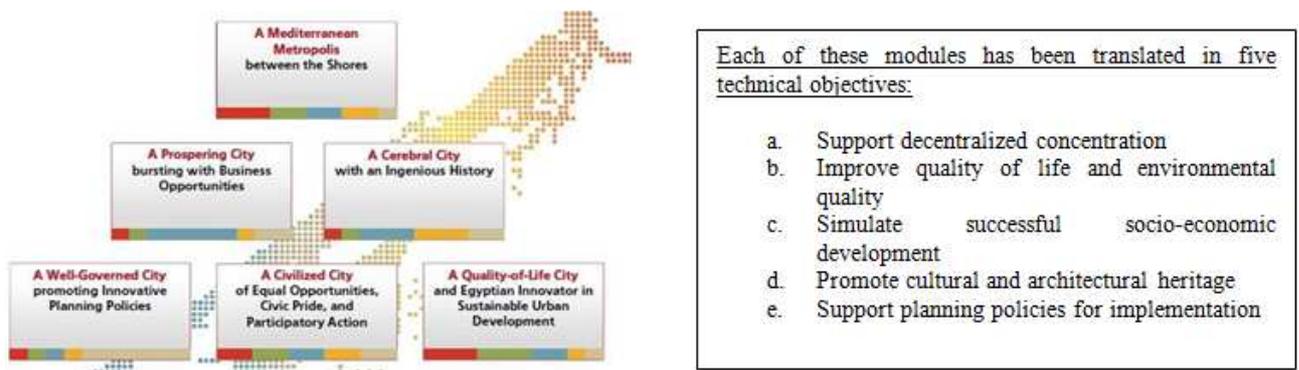
6.1.2 Objectives

the Strategic Urban Plan 2032 identifies some priority objectives to improve the existing public transport system, which is currently not sufficient to deal with the large demand. These objectives are:

(a) Expand capacity: provide public mass transit along the primary communication axes.

(b) Prioritize public transport: in terms of space (dedicated lanes, priority at crossings) or finances, to show that public transport is faster and more convenient than driving.

(c) Connect subsystems and form a hierarchic public transport system.

(d) Make heavy maintenance on existing network: Raml tram line and Abu Kir railway line.

6.2 Identification of problems

No	Diagnosis	Problem	Strategic tools to be a dopted
1	Transportation	overall congestion; un-attractive public transport; limited catchment area	Limit car congestion, with higher performances of public transport lines increase catchment areas
2	Urban and economic development	un-sustainable urban development	develop a consistent planning between urban planning and transport Improve economic and touristic attractivity of the city – example of the Corniche
3	Environmental and social	there are major disturbances due to heavy traffic: air pollution, noise, unsafety.	Improve the quality of life, safety in the dense city
4	Financial	funds are lacking to develop and even maintain the public transport system	enhance the financial sustainability of new projects
5	Institutional diagnosis	coordination between public transport stakeholders is lacking	Integration, or at least coordination, between stakeholders in Alexandria

Developing alternatives with different strategy mixes: Strategy used: (1) Employment of potentials of existing road network, (2) Developing solutions for Impediments of existing road network.

Fig. 12 Proposed Digramatic Map of Alexandria dense city highlighting the potential of existing roads network by showing the direction of the main axes that were deduced from the traffic movement of the city's residents (source :authers)

Fig. 13 Proposed Digramatic Map of Alexandria dense city highlighting the Impediments of Existing Road Network by identifying corridors where capacity improvement is required (source :authers)

Fig. 14 Proposed Digramatic Map of Alexandria dense city by layering two maps over each other map identifying employment of potentials of road network over map identifying corridors where capacity improvement is required (source : authers)

Fig. 15 Proposed Digramatic Map of Alexandria dense city by layering two maps over each other map identifying main roads that collective vehicles will pass frequently over map identifying corridors where capacity improvement is required

7   CONCLUSION

The research deal with the problem of "Modal shift from public transport to private transport" and how to apply a Transit Strategies towards achieving Transit-Oriented Development .The challenge here is to steer the opposite "Modal shift from private transport to public transport direction" by using a strategy of Frequent Transit Network through Comparative analysis of (FTNs) and (TOD) experiences in three city – regions & Analysis of Transport and Current Mobility Structure in Alexandria conclude from it Theoretical Frame work to identify potential (FTNs) Solutions for the city. The research has finally arrived Recommendation for Alexandria development " Key Corridor Network" for the bus routes and light rail transit, emphasising corridors in which combined transport services could provide a more efficient operation of the city's public transport.

Fig. 16 FTN Frequency Map of Alexandria dense city by Merging alternatives showed in fig 14, fig 15 By classifying the routes into three categories (very frequent routes – frequent routes – local routes) suggestion three lines BRT (The Mahmoudeya Canal - The Corniche line – Mustafa kamal) three lines lines LRT (Tram Al Nouzza - Tram Al Montazah)口
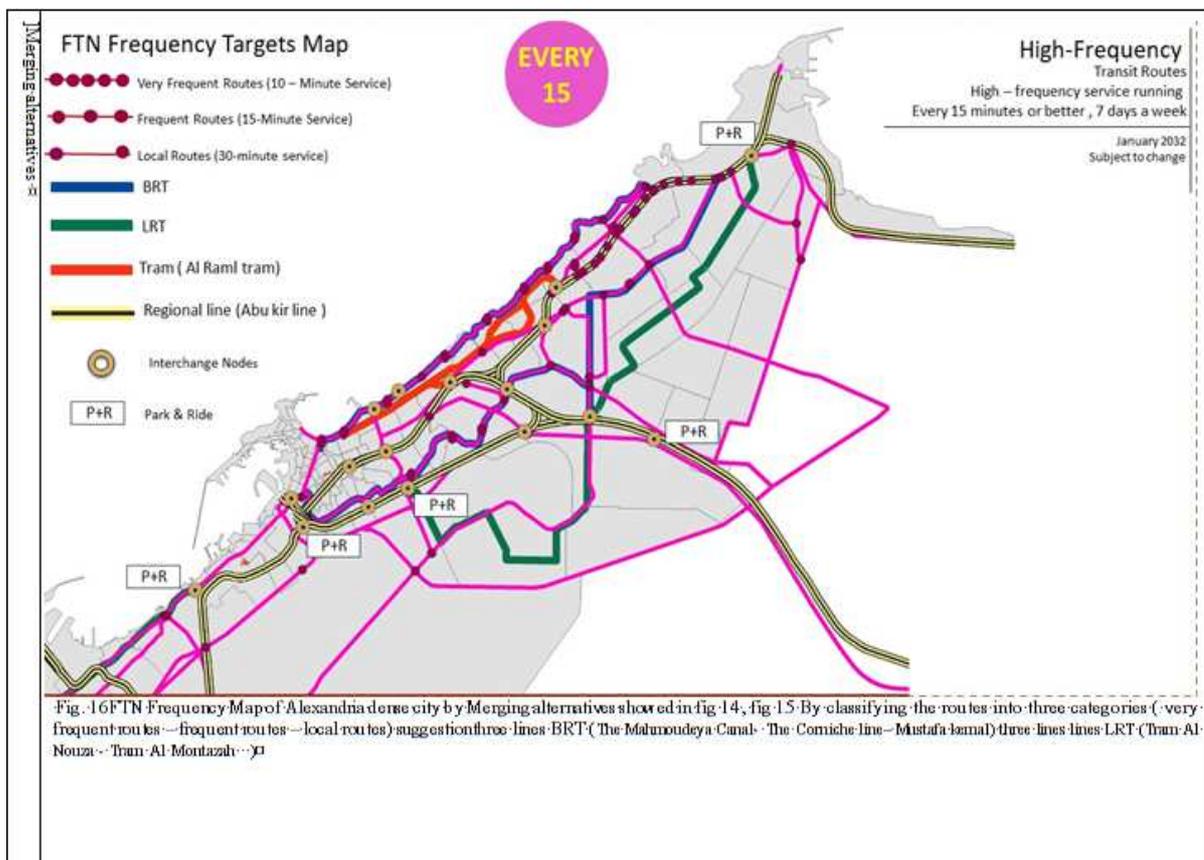
8 REFERENCES

Baylis, M.L., 2017. Transit-oriented development: a case study of Rosebank, City of Johannesburg (Master's thesis, University of Cape Town).

Walker, L., Garnett, L., Kan, R. and Klitz, P., 2009. Integrating Frequent Transit Service and Corridor-Based Transit Supportive Environments inteh Metro Vancouver Region. In 2009 Annual conference and exhibition of the transportation association of Canacda Transportation in a climate of change.

Boubezari, M., Which urban development for Algiers far from oil dependency? Towards TOD solutions.

Arts, J., Hanekamp, T. and Dijkstra, A., 2014, April. Integrating land-use and transport infrastructure planning: Towards adaptive and sustainable transport infrastructure. In Transport Research Arena (TRA) 5th Conference: Transport Solutions from Research to DeploymentEuropean CommissionConference of European Directors of Roads (CEDR) European Road Transport Research Advisory Council (ERTRAC) Waterborne European Rail Research Advisory Council (ERRAC) Institut Francais des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR) Ministère de l'Écologie, du Développement Durable et de l'Énergie.

Mukhopadhyay, C. and MIT (Massachusetts INstitute of Technology), 2017. Public Transport and Bus Rapid Transit as a Tool of Decarbonization in Malaysia. MIR-UTM Malaysia Sustainable Cities Program, Working Paper Series.

Lindquist, J.D. ed., 2015. Proceedings of the 1984 Academy of Marketing Science (AMS) Annual Conference. Springer.

Olayode, I.O., Tartibu, L.K., Okwu, M.O. and Uchechi, D.U., 2020. Intelligent transportation systems, un-signalized road intersections and traffic congestion in Johannesburg: A systematic review. Procedia CIRP, 91, pp.844-850.

Dong, C., Clarke, D.B., Richards, S.H. and Huang, B., 2014. Differences in passenger car and large truck involved crash frequencies at urban signalized intersections: An exploratory analysis. Accident Analysis & Prevention, 62, pp.87-94.

Marzo, J.L., Maryni, P. and Vilà, P., 2001. Towards QoS in IP-based core networks. A survey on performance management, MPLS case. In Proceedings of International Symposium on Performance Evaluation of Computer and Telecommunication Systems, SPECTS.

Yuan, Y., Li, S., Yang, L. and Gao, Z., 2022. Real-time optimization of train regulation and passenger flow control for urban rail transit network under frequent disturbances. Transportation Research Part E: Logistics and Transportation Review, 168, p.102942.

Hu, Y., 2014. Developing a program organization framework for the success of construction megaprojects in China.

Authority, S.C.B.C.T., 2009. Integrating Frequent Transit Service & Corridor-based Transit Supportive Environments in the Metro Vancouver Region.

Hammermeister, J.P., 1987. The co-ordination of light rapid transit and land-use: an examination of the institutional framework in Edmonton (Doctoral dissertation, University of British Columbia).

Chen, J., Liu, J., Du, B., Peng, Q. and Yin, Y., 2022. Resilience Assessment of an Urban Rail Transit Network Under Short-Term Operational Disturbances. IEEE Transactions on Intelligent Transportation Systems, 23(12), pp.24841-24853.

Trifunovic, A. and Friedrich, B., Transit network design augmented with shared vehicles acting as feeders on short distances.

Wang, J., Liu, H. and Xie, C., 2016. Transit network design with exclusive bus lanes (No. 16-3513).

French development agency, 2015

Albert Speer & Partner International GmbH et al, 2015

Functional Applications of Unmanned Aerial Vehicle Technology in Urban Planning Practice: A PRISMA systematic Review

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1 ABSTRACT

Covid-19 pandemic has arguablely created an opportunity for urban planners to create cities that are more resilient and sustainable. This systematic review was aimed at analysing the potential of Unmanned Aerial Vehicle (UAV) technology as a tool for post-covid-19 urban planning and design. Specifically, the study reviewed the functional application areas that have leveraged the existence of UAV technology since its inclusion in non-military sectors in 2006. PRISMA method was used to retrieve journal articles that were published between 2006 and 2022 from scopus database and a total of 48 journal articles were included in the study. The results of the literature analysis revealed that there is a growing application of UAV technology in urban disaster managemnert, smartcities development initiatives, urban landscape management and urban road transportation management. The study also revealed that there is already a research increase on UAV integration in urban planning from 2019 which signifies the contribution of the pandemic towards UAV adoption. It has also been established that there is an increasing application of Machine Leaning (ML) and Computer Vision (CV) models for UAV data analysis. The study concludes that UAV technology has a lot of potential for improving urban planning processes with regard to time, cost, and safety and hence can be regarded as one of the sustainable tools in post-covid-19 urban planning efforts. Therefore, there is need for robust research to explore its potential in other application areas such as municipal waste management, urban developement control, and urban drainage systems among others. The study also recommends that basic courses on Artificial Intelligence (AI) be introduced in urban planning education to equip urban planners on the emerging AI applications.

Keywords: Unnamed Aerial Vehicles, Urban Planning, Artificial Intelligence, Machine Learning, Computer Vision

2 INTRODUCTION

2.1 Study Background

The impact of the covid-19 global pandemic has generally been seen as two-fold. While a significant proportion of the global population perceived the pandemic as a huge threat, some studies have revealed that the pandemic is an opportunity in some respect (Aboagye et al., 2021; Sharifi & Khavarian-Garmsir, 2020). One of the notable positive contributions of the pandemic is the increase in the invention of new digital technologies or at least an increase in the adoption of the already existing ones across different sectors whose impact has been far more positive in terms of production efficiency and cost-effectiveness. For example, Bukovska et al., (2021) investigated the impact of Covid-19 on technological adoption in the meeting and event industry and established that about 69 percent of the investigated events migrated to virtual or hybrid format and therefore increased the adoption of conferencing technologies. Similarly, Serbulova et al., (2020) and Farrugia et al., (2020) established similar findings in the business and the health sectors respectively.

In cities, Covid-19 pandemic has arguably created a new landscape that some scholars have deemed an opportunity for urban planners to create cities that are more resilient and sustainable (Sharifi, 2020). However, as history suggests, this new landscape is significantly parallel to the crises that gave birth to urban planning profession about two centuries ago (Smith, 2007, 2012; Smith & Lobo, 2019). It therefore implies that achieving the new dream of a sustainable cities calls for new planning techniques that match the current urban challenges. In this study, a systematic literature review was employed to assess the potential of Unmanned Aerial Vehicles (UAV) technology (popularly known as drones) in urban planning practice as

planning solution for the development of new sustainable cities. Specifically, the study intended to identify and analyse the functional application areas that have leveraged the existence of UAV technology since its inclusion in the civilian sectors and to understand its prospects for post-covid-19 urban planning and design. Additionally, we also analysed commonly used supporting technologies for performing UAV-based data analysis from the retrieved articles.

2.2 Background of UAV Technology

UAV technology is one of the state-of-the-art innovations that was invented in the 1800s. History indicates that in the past, the application of UAV technology was only limited to military purposes. For example, the first usage of drones was recorded in 1849 during the first Italian war of independence when Australian Empire devised a system of unmanned hot air balloons to drop bombs in Venice (Rakha and Gorodetsky, 2018). Later, the hot air balloons were also used during the American civil war and the Spanish-American war to gather and telegraph reconnaissance. Over time, however, UAV technology has gone through a series of evolutions to accommodate civilian applications. The major turnaround appeared recently in the 21st century when Frank Wang and his colleagues established DJI Technology company in 2006 which started producing drones for personal and commercial use (Mac, 2015). Since then, a lot of sectors including commerce, engineering, mining, and health, have all adopted this technology to improve operational efficiency among other things.

Similarly, the built environment sector has also leveraged the existence of UAV technology. Many studies documenting the application of UAVs in the built environment have shown that this technology can be successfully applied in building inspections, construction project monitoring, and infrastructure crack detection among others. For example, Patel et al., (2021) investigated the potential application of remotely Unmanned Aerial vehicles in construction management. In their study, they used a mobile-piloted drone to capture digital images of a seven-floored building that was under construction. Using a Pix4D software, they analysed the images and concluded that UAVs have the capability to capture building information like slab length, column dimension, and building area. UAVs also have secondary capabilities such as monitoring construction progress and updating project schedules. Again, Rakha & Gorodetsky, (2018) investigated how UAVs can be used to remotely detect cracks in buildings to facilitate maintenance planning. Drone-mounted cameras were used in the study to capture infrared images of a buildings. After analysing the infrared images, they concluded that UAV technology has the capability to effectively detect building cracks of all kinds and magnitude. Generally, the built environment sector is primed for growth in UAV applications, (Albeaino et al., 2019).

3 RESEARCH METHODS

To achieve the study objectives, the we adopted a systematic review approach. PRISMA protocol was used to retrieve journal articles related to UAV technology and urban planning from Scopus database. Scopus database was preferred, on one hand, for its wide coverage which guarantees comprehensiveness in the search results on the targeted subject (Onososen and Musonda, 2022). On the other hand, PRISMA protocol was preferred for its widespread acceptance, comprehensiveness, and wide variety of applications in numerous academic disciplines as well as for its ability to improve the accuracy and transparency of academic literature reviews (Samuel Adeyinka-Ojo, 2021; Shahruddin and Zairul, 2020).

To obtain comprehensive results from the literature search, the following search combination was used: "Drones OR unmanned aerial vehicles OR unmanned aerial systems AND urban planning" AND "Drones OR unmanned aerial vehicles OR unmanned aerial systems AND city planning" AND "Drones OR unmanned aerial vehicles OR unmanned aerial systems AND town planning". A total of 664 papers were identified and 48 journal articles were included in the study after applying various screening criteria. Figure 1 shows the PRISMA flow diagram which summarises the search process. The 48 journal articles were classified into three research categories: application research, process optimisation research and mixed research. In the results and discussion section, we focused on the papers under the "application research" category.
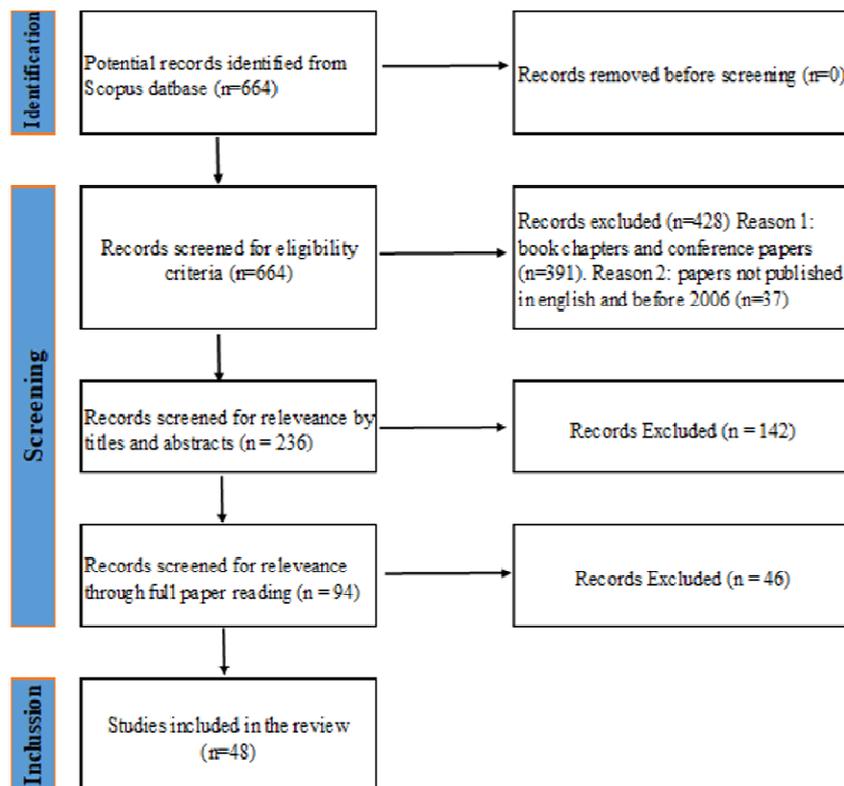
Fig. 1: The PRISMA flow diagram.

4 RESULTS AND DISCUSSION

4.1 Publications by Year

Scopus Analyst tool was used to analyse the 48 sampled journal articles to understand their distribution in terms of year of publication. Figure 2 summarizes the results. According to figure 2, about 92% of the sampled articles were published within the last five years between 2018 and 2022. From 2006 to 2017, only four studies (8%) related to UAVs and urban planning were published. This shows that UAV technology adoption for urban planning purposes is still a novel development. However, the trend shows a growth in the sense that from the year 2017, the publications have been increasing at a steady rate. If this trend continues, the technology might be widely adopted in few years to come. This aligns with the predictions by CIO Tech Outlook, (2020) that adoption of UAV technology across various industries such as agriculture, logistics, photography, mining, construction, and surveillance is going to increase at a rapid pace in the years to come. The steady boom of publications between 2019 and 2021 might also be attributed to the Covid-19 pandemic which necessitated minimization of physical contact between people.
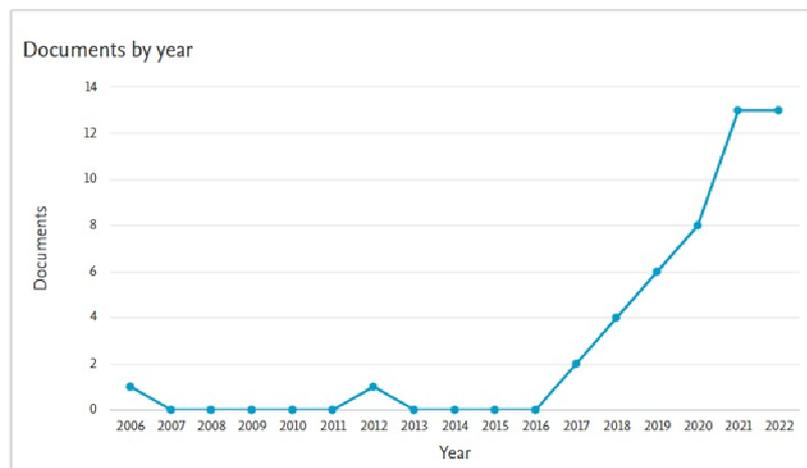
Fig. 2: Distribution of the sampled articles by year of publication. Source: Author, 2023.

4.2 Emerging Research Categories

A comprehensive thematic analysis of the sampled papers was conducted to understand the key research categories relating to UAV technology and urban planning. The study derived that UAV research in urban planning can be categorized into three main groups: process optimization research; application research; and mixed research. Process optimization relates to all studies that are aimed at optimizing or improving the efficiency in the processes of integrating UAV technology in urban planning and management. For examples, some studies focused on developing algorithms or models for UAV flight path planning to ensure efficiency in energy consumption and increase flight time of UAVs in big cities; or algorithms for collision avoidance such as tall buildings in cities; or algorithms for multi-UAV communication when the targeted flight area is wide. Some process optimization studies have also focused on developing algorithms for post data (image/video) processing such as image segmentation or feature extraction (Boonpook et al., 2021; Pilinja Subrahmanya et al., 2021; Vazquez-Carmona et al., 2022). On the other hand, application research includes studies that relate to the actual usege of UAV technology to solve real-life urban problems. For example, Ullah et al., (2021) applied UAVs to map the extent of bushfire disaster to inform policy formulation for post-disaster recovery initiatives. Saputra et al., (2022) also employed UAV technology to simulate a flooding event and model the potential impact on vulnerable communities Indonesia to inform policy formulation for disaster prevention preparedness strategies. Lastly, the mixed research category includes those studies that involve the development of process optimization tools such as flight path or image processing algorithms but also involve the testing of the developed toolkits to solve real-life urban problems and ascertain their performance (Aljehani and Inoue, 2019; Escobar-Silva et al., 2022; Zhao et al., 2022).

Figure 3 summarizes the classification of the sampled articles based on their thematic categories. The figure shows that the majority (48%) of UAV research in urban planning deals with process optimization. This means that the technology is still developing, and full integration has not been achieved yet. However, a significant proportion (42%) of application research was also recorded meaning that there is concurrency between research and application. The remaining 10% of the sampled studies were classified as mixed research.
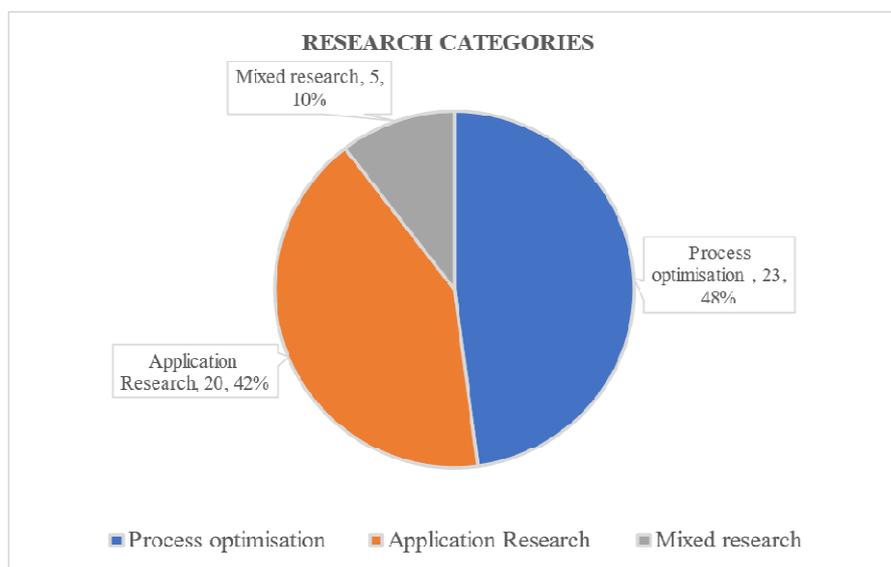
Fig. 3: Emerging Research Categories in UAV Application in Urban Planning

4.3 Functional Application Areas of UAV Technology in Urban Planning Practice

As stated earlier, the study also intended to uncover the common functional areas of UAV technology application in urban planning discipline to derive its prospects in post-covid-19 urban planning and design. It has been established that the major areas of application include Urban disaster management (23%), smart cities development initiatives (19%), urban landscape management (15%), and urban road transportation management (13%). Landcover change analysis and Urban Heat Island (UHI) mapping are the least exploited application areas with a 2% score each. These results imply that there are still a lot more functional areas within the urban planning domain where UAV technology has not been explored yet. Therefore, further research is necessary to explore more application areas. Table 1 summarises the identified areas of

application and the major ones are expounded in subsequent sections focusing only on those studies that involve practical usage of drones rather than optimizing the process of UAV integration.

GENERAL AREA OF APPLICATION	SPECIFIC TOPICS TACKLED	NUMBER AND PERCENTAGE OF SAMPLED ARTICLES	SOURCES
Urban Disaster Management	Earthquakes, Flash floods, Volcanos, landslides, gully erosion, typhoons, bushfires,	11, 23%	(Aljehani and Inoue, 2019; Assis et al., 2020; Gudino-Elizondo et al., 2018; Huang et al., 2017; Li et al., 2012; Qadir et al., 2021; Saputra et al., 2022; Ullah et al., 2021; Wang et al., 2018; Wu et al., 2020; Zhan et al., 2018)
Smart Cities Development Initiatives	Smart Health; Smart transportation; smart energy; smart governance;	9, 19%	(Ahmed Hamza et al., 2022; Aloqaily et al., 2022; Dudek and Kujawski, 2022; Liu, Zhu, et al., 2022; Nelson and Grubesic, 2020; Sultonov et al., 2022; Templin and Popielarczyk, 2020; Teng et al., 2021; Vazquez-Carmona et al., 2022)
Urban Landscape Management	Monitoring urban vegetation cover	7, 15%	(Alvarado-Robles et al., 2022; Behera et al., 2022; Escobar-Silva et al., 2022; Feng and Li, 2019; Lee et al., 2021; Wu et al., 2021; Zhao et al., 2022)
Urban Road Transportation Management	Road traffic management; road infrastructure management; parking spaces management	6, 13%	(Coifman et al., n.d.; Jalayer et al., n.d.; Javadi et al., 2021; Li et al., 2019; Liu and Zhang, 2021; Luo et al., 2019)
Building Data Inventory	Identification and extraction of buildings and building attribute data from UAV images using various algorithms	4, 8%	(Ahmed et al., 2020; Boonpook et al., 2021; Pilinja Subrahmanya et al., 2021; Vacca et al., 2017)
Urban Security and Safety	Urban surveillance and security patrol	3, 6%	(Huang and Savkin, 2020, 2021; Liu, Bao, et al., 2022)
Urban Recreation	Parks and other public open spaces management	2, 4%	(Park, 2020; Rodríguez et al., 2022)
Urban Environmental Monitoring	Environmental quality monitoring; chemical pollution mapping	2, 4%	(He et al., 2019; Zhao et al., 2018)
Landcover Change Analysis	Mapping urban landcover changes overtime	1, 2%	(Hassan et al., 2020)
Urban Heat Island Mapping	Mapping urban surface temperatures	1, 2%	(Dimitrov et al., 2021)
Others	Cadastral data verification; energy optimization in built environments	2, 4%	(Arjoune et al., 2021; Cienciała et al., 2021)

4.3.1 UAV Technology in Urban Disaster Management

The nexus between cities and disasters is unequivocal. In general, urban areas tend to suffer more fatalities and economic losses from disasters than rural areas, possibly due to the aggregation of people, infrastructure and assets, urban expansion, and inadequate management. According to UNDES (2019), more than half (58%) of the world cities have a high level of exposure to at least one type of natural disaster such as cyclones, floods, droughts, earthquakes, landslides, and volcanic eruptions. With 68% of the global population projected to live in cities by 2050 (UN-Habitat, 2022), it transpires that cities or urban areas in general remain the central focus of disaster risk management. Besides, the rapid and often unplanned expansion of cities is exposing more people and economic assets to the risk of disasters and the effects of climate change (World Bank, 2012).

When it comes to urban disaster management, the current study has revealed that UAV technology has been used in managing different kinds of both natural and man-made urban disasters such as urban flooding (Gudino-Elizondo et al., 2018; Li et al., 2012; Saputra et al., 2022); typhoons (Wu et al., 2020); earthquakes (Assis et al., 2020); landslides (Huang et al., 2017; Wang et al., 2018); and bushfires (Ullah et al., 2021) among others. Aditya et al, (2022) applied UAV technology in urban flooding modelling in the small town of Java in Indonesia. Images from drones were used to create landcover maps and generate Digital Elevation Models (DEM) for simulating flood impact and predict the probability and the gravity of flooding events. Similarly, Li et al., (2012) used UAV images to simulate the potential level of impact that a dam break disaster from mass movement would have caused in Xiaojiaqiao city in China to inform future disaster preparedness strategies. Wua et al., (2020) used drone images to assess the level of damage from typhoon

disaster in Xiamen city in China. From the images, they were able to map and compute the extent of disaster damage for recovery planning purposes. The study concluded that drones could provide technical and decision-making support for urban disaster emergency rescue, ecological restoration, environmental monitoring and for urban planning in general. Furthermore, Gudino-Elizondo et al., (2018) applied drone technology to quantify and measure the attributes of gullies in urban areas after a storm event in Los-Laureles Canyon Watershed, in Tijuana, Mexico. Using various image analysis techniques, they were able to map the gully network extent and estimate different gully parameters such as gully heads. This informed the planning of recovery actions by various urban stakeholders.

4.3.2   UAV Technology and Urban Landscape Design and Management

Urban landscape management is defined as the management of open spaces and greenspaces, like residential green spaces, parks, playgrounds, etc. (Anguluri & Narayanan, 2017). Modern urban landscape management approaches incorporate various technologies to achieve sustainability goals and UAV technology is one of them. Research has shown that UAV technology can be successfully applied to estimate vegetation growth in urban green spaces, classify vegetation cover in an urban area, and map the distribution and trends in landcover changes. In this regard, Escobar-Silva et al., (2022) used drones to estimate grass growth in urban green spaces. The study involved integrating UAV technology and GIS to model and predict the growth of Bahia grass in Southeastern Brazil to facilitate the planning of grass cutting and mowing by city managers. Besides predicting growth, UAV technology was also able to capture vegetation parameters such as Leaf Area Index (LAI), soil water content, biomass, and evapotranspiration rate. It was also established that using this model would have a cost-cutting effect on landscaping processes.

Lee et al., (2021) developed vegetation detection model using UAV images. In this study drones were used to capture multispectral images that were then used to classify urban landcover to identify and analyse the distribution of vegetation in urban areas to support decision making in urban regeneration programs. The results showed that the model was able to differentiate real vegetation from other vegetation-like features such as green roofs and artificial grass. Related studies were also conducted by Feng & Li (2019); Zhao et al., (2022); and Robles et al., (2022). In their approach, they integrated UAV capabilities with other supporting technologies such as photogrammetry and Machine Learning models to reinforce UAV capabilities to identify, map the distribution, and compute vegetation parameters in urban green spaces.

4.3.3   UAV Technology and Urban Recreation

UAV technology has also been successfully applied in urban recreation. Rodríguez et al., (2022) applied drone technology to measure thermal comfort in an urban public space in Huelva, Spain. Thermal comfort simply means the level of comfort by public space users with park heat levels. Drones mounted with thermal cameras and sensors were used to collect infrared images of a public open space to measure thermal comfort. The estimated figures of mean radiant temperatures from the images were verified with the ones collected in real-time and the results showed high accuracy. It was then concluded that, this aerial thermography can be adopted as a way of measuring thermal comfort. Another drone technology application in urban recreation was conducted by Park, (2020). In this application case, drones were used to assess the level of park use in terms of number of people who use urban parks and their characteristics such as gender and age group at different times of the day and different days of the week. Drones were used to collect High Definition (HD) videos of the selected parks which were later assessed by a professional video assessor. By using this method, park use related information were collected at a lower cost compared to physical observation.

4.4 UAV Data Processing Tools and Techniques

A thorough analysis of the commonly used UAV data (Images and videos) processing techniques was also conducted in this study. An initial assessment revealed that about 90% (43 articles) of the sampled studies involved some sort of images/ video processing to achieve the intended objectives. The remaining 10% (8 articles) did not involve any data processing mainly because they are optimization research and their main study objective was merely to develop algorithms to improve some processes for UAV integration such as flight path planning (Qadir et al., 2021; Vazquez-Carmona et al., 2022) or to improve multi-UAV communication in urban an environment (Liu, Bao, et al., 2022; Teng et al., 2021). For the former, it has been established that to achieve maximum efficiency, the adoption and use of UAV technology in urban planning discipline is constantly fused with other supporting technologies. Out of the 43 studies that

involved processing of UAV images and/ or videos, only 5% (2 articles) involved the use of human intelligence for the analysis. In one study, Park, (2020) assessed the level of park use in terms of number of people who use parks and their characteristics such as gender and age group at different times of the day and different days of the week. He used UAVs to collect High-Definition videos of the selected publics parks which were later analysed by a professional video assessor to extract the park use related information. Further analyses were also conducted to assess the correlation of park use and the attributes of the surrounding environments or neighbourhoods. In the other study, Jalayer et al., (2019) used UAVs to capture images for inspecting and inventorying interchanges assets as a way of minimizing Wrong Way Driving (WWD) crashes on road interchanges. A visual analysis of the UAV images was used to identify the presence or absence interchange assets such as installed road signs, pavement markings, and geometric features and their condition.

However, for the rest of the studies (95%) various supporting technologies, other than human intelligence, were used. These technologies have been classified into five main groups: GIS-related technologies; Machine Learning (ML)/ Computer Vision (CV) technologies; Photogrammetry technologies; mixed technologies; and Others. Figure 4 summarizes the results.

GIS related technologies involve the use of Geographic Information Systems software to process UAV images to achieve research objectives. The commonly used software under this category was the Esri ArcMap. Only one study (Wu et al., 2021) applied a different GIS software, ENVI 5.3 Version, to analyse UAV images. Studies that used GIS related technologies accounted for 19% of the total articles.

Machine leaning/ computer vision technology involve the utilization of ML/ CV algorithms or models to perform image/ video analysis such as object segmentation, and feature extraction. In this study, it has been established that 44% of the total studies utilized ML/ CV algorithms to perform UAV image analysis. Deep learning algorithms such as You Only Look Once (YOLO), and Artificial Neural Networks (ANN) are the commonly used algorithms that were identified in most studies.

Photogrammetry technologies were classified as those technologies that support the pre-processing of UAV images such as image alignment and generation of orthophotos for further analysis. In this study, only 12% (5 articles) relied entirely on photogrammetry technologies for UAV image analysis. Agisoft Photoscan, Agisoft Metashape, and Pix4 Desktop Mapper software were commonly used under this category.

The mixed category involved an integration of multiple technologies to perform image/video processing. For example, Boonpook et al., (2021) integrated photogrammetry technology (Pix4 Desktop Mapper) and ML/CV based technologies (Deep Learning) to automatically extract buildings data from UAV collected images. On the other hand, Assis et al., (2020); Gudino-Elizondo et al., (2018); Lee et al., (2021); Nelson & Grubesic, (2020); and Wu et al., (2020) integrated various photogrammetry technologies with GIS technologies to analyse UAV images and videos in their respective studies.

From the analysis, it can be concluded that ML/CV is the most used processing technique in modern urban planning research and practice. Although Machine Learning is relatively a new branch of technology, its growth in application is rapid and has more potential for a technological takeover.
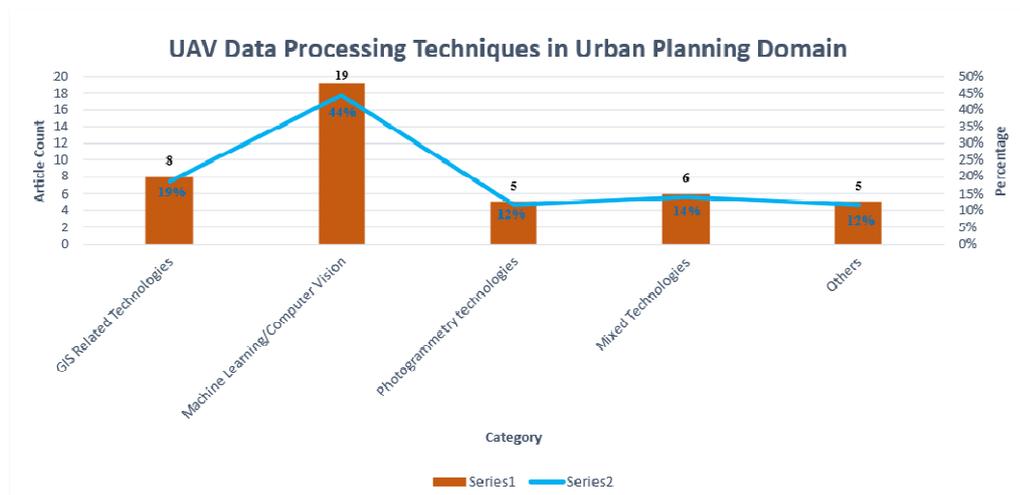

Fig. 4: Common UAV Data Processing Techniques in Urban Planning Research.

5 CONCLUSION

This study intended to review functional applications of UAV technology in Urban planning practice and understand its potential for post Covid-19 urban planning and design by using a systematic literature review approach. The results have shown that there are many success stories of UAV technology in different urban planning related area so far. Among the common areas discovered include urban disaster management, smart cities development initiatives, urban landscape management, and urban recreation. The study has also shown that there is a growing trend in UAV research in urban planning, including process optimization research, which signals high potential for future adoption of the technology in urban planning sector. The study has also revealed that there is a growing integration of Machine Learning models alongside Geographical Information Systems as the major techniques for UAV data analysis. Therefore, this study concludes that, UAV technology has a lot of potential and can be adopted as one of the sustainable tools for post covid-19 urban planning and design to carter for the increasing need for less physical contact between planning officials and city residents when executing planning roles.

6 REFERENCES

M. Ahmed Hamza, H. Alqahtani, D.H. Elkamchouchi, H. Alshahrani, J.S. Alzahrani, M. Maray, M. Ahmed Elfaki, and A.S.A. Aziz, "Hyperparameter Tuned Deep Autoencoder Model for Road Classification Model in Intelligent Transportation Systems," Applied Sciences (Switzerland) 12: 20 (2022).

N. Ahmed, R. Bin Mahbub, and R.M. Rahman, "Learning to extract buildings from ultra-high-resolution drone images and noisy labels," International Journal of Remote Sensing 41: 21 (2020) 8216–8237.

G. Albeaino, M. Gheisari, and B.W. Franz, A Systematic Review of Unmanned Aerial Vehicle Application Areas and Technologies in the AEC Domain Journal of Information Technology in Construction (ITcon) (2019) <https://www.itcon.org/2019/20> Accessed.

M. Aljehani and M. Inoue, "Performance evaluation of multi-UAV system in post-disaster application: Validated by HITL simulator," IEEE Access 7 (2019) 64386–64400.

M. Aloqaily, O. Bouachir, I. Al Ridhawi, and A. Tzes, "An adaptive UAV positioning model for sustainable smart transportation," Sustainable Cities and Society 78 (2022).

G. Alvarado-Robles, M.A. Garduño-Ramón, R.A. Osornio-Ríos, and L.A. Morales-Hernandez, "Methodology for urban vegetation segmentation based on cartesian hue and saturation characteristics using UAV images," Urban Forestry and Urban Greening 78 (2022).

Y. Arjoune, S. Peri, N. Sugunaraj, A. Biswas, D. Sadhukhan, and P. Ranganathan, "An instance segmentation and clustering model for energy audit assessments in built environments: A multi-stage approach," Sensors 21: 13 (2021).

L.E. Assis, E.A.G. Marques, C.A. Lima, S.J.M.C. Menezes, and L.A. Roque, "Mapping of Geological-Geotechnical Risk of Mass Movement in an Urban Area in Rio Piracicaba, MG, Brazil," Soils and Rocks 43: 1 (2020) 57–70.

T.K. Behera, S. Bakshi, and P.K. Sa, "Vegetation Extraction from UAV-based Aerial Images through Deep Learning," Computers and Electronics in Agriculture 198 (2022).

W. Boonpook, Y. Tan, and B. Xu, "Deep learning-based multi-feature semantic segmentation in building extraction from images of UAV photogrammetry," International Journal of Remote Sensing 42: 1 (2021) 1–19.

A. Cienciała, K. Sobolewska-Mikulska, and S. Sobura, "Credibility of the cadastral data on land use and the methodology for their verification and update," Land Use Policy 102 (2021).

CIO Tech Outlook, "Three Emerging Trends Accelerating the Adoption of Drones," March 17, 2020.

B. Coifman, M. Mccord, R.G. Mishalani, M. Iswalt, Y. Ji, and G.R. Assistant, Roadway Traffic Monitoring from an Unmanned Aerial Vehicle.

S. Dimitrov, A. Popov, and M. Iliev, "An application of the LCZ approach in surface urban heat island mapping in Sofia, Bulgaria," Atmosphere 12: 11 (2021).

T. Dudek and A. Kujawski, "The Concept of Big Data Management with Various Transportation Systems Sources as a Key Role in Smart Cities Development," Energies 15: 24 (2022).

E.V. Escobar-Silva, V. Bourscheidt, C.S.T. Daughtry, J.R. Kiniry, A.R. Backes, and M.E.D. Chaves, "A general grass growth model for urban green spaces management in tropical regions: A case study with bahiagrass in southeastern Brazil," Urban Forestry and Urban Greening 73 (2022).

X. Feng and P. Li, "A tree species mapping method from UAV images over urban area using similarity in tree-crown object histograms," Remote Sensing 11: 17 (2019).

N. Gudino-Elizondo, T.W. Biggs, C. Castillo, R.L. Bingner, E.J. Langendoen, K.T. Taniguchi, T. Kretzschmar, Y. Yuan, and D. Liden, "Measuring ephemeral gully erosion rates and topographical thresholds in an urban watershed using unmanned aerial systems and structure from motion photogrammetric techniques," Land Degradation and Development 29: 6 (2018) 1896–1905.

A. Hassan, M.G. Almatar, M. Torab, and C.D. Allen, "Environmental urban plan for Failaka Island, Kuwait: A study in urban geomorphology," Sustainability (Switzerland) 12: 17 (2020).

X. He, J.R. Bourne, J.A. Steiner, C. Mortensen, K.C. Hoffman, C.J. Dudley, B. Rogers, D.M. Cropek, and K.K. Leang, "Autonomous Chemical-Sensing Aerial Robot for Urban/Suburban Environmental Monitoring," IEEE Systems Journal 13: 3 (2019) 3524–3535.

H. Huang and A. V. Savkin, "Energy-efficient autonomous navigation of solar-powered UAVs for surveillance of mobile ground targets in urban environments," Energies 13: 21 (2020).

H. Huang and A. V. Savkin, "Energy-efficient decentralized navigation of a team of solar-powered UAVs for collaborative eavesdropping on a mobile ground target in urban environments," Ad Hoc Networks 117 (2021).

T. Huang, M. tao Ding, T. She, S. jun Tian, and J. tao Yang, "Numerical simulation of a high-speed landslide in Chenjiaba, Beichuan, China," Journal of Mountain Science 14: 11 (2017) 2137–2149.

M. Jalayer, H. Zhou, and S. Das, Application of Unmanned Aerial Vehicles to Inspect and Inventory Interchange Assets to Mitigate Wrong-Way Entries Directional Rumble Strips for Reducing Wrong-Way Driving View project Safety Performance of Pavement Marking Retroreflectivity in Alabama View project <https://www.researchgate.net/publication/334138965> Accessed.

S. Javadi, M. Dahl, and M.I. Pettersson, "Vehicle Detection in Aerial Images Based on 3D Depth Maps and Deep Neural Networks," IEEE Access 9 (2021) 8381–8391.

G. Lee, J. Hwang, and S. Cho, "A novel index to detect vegetation in urban areas using uav-based multispectral images," Applied Sciences (Switzerland) 11: 8 (2021).

W. Li, H. Li, Q. Wu, X. Chen, and K.N. Ngan, "Simultaneously detecting and counting dense vehicles from drone images," IEEE Transactions on Industrial Electronics 66: 12 (2019) 9651–9662.

Y. Li, J.H. Gong, J. Zhu, L. Ye, Y.Q. Song, and Y.J. Yue, "Efficient dam break flood simulation methods for developing a preliminary evacuation plan after the Wenchuan Earthquake," Natural Hazards and Earth System Science 12: 1 (2012) 97–106.

D. Liu, W. Bao, X. Zhu, B. Fei, T. Men, and Z. Xiao, "Cooperative Path Optimization for Multiple UAVs Surveillance in Uncertain Environment," IEEE Internet of Things Journal 9: 13 (2022) 10676–10692.

D. Liu, X. Zhu, W. Bao, B. Fei, and J. Wu, "SMART: Vision-Based Method of Cooperative Surveillance and Tracking by Multiple UAVs in the Urban Environment," IEEE Transactions on Intelligent Transportation Systems 23: 12 (2022) 24941–24956.

X. Liu and Z. Zhang, "A Vision-Based Target Detection, Tracking, and Positioning Algorithm for Unmanned Aerial Vehicle," Wireless Communications and Mobile Computing 2021 (2021).

H. Luo, P. Zhang, J. Wang, G. Wang, and F. Meng, "Traffic patrolling routing problem with drones in an urban road system," Sensors (Switzerland) 19: 23 (2019).

R. Mac, Bow To Your Billionaire Drone Overlord: Frank Wang's Quest To Put DJI Robots Into The Sky (2015) <https://www.forbes.com/sites/ryanmac/2015/05/06/dji-drones-frank-wang-china-billionaire/?sh=494265eb48f2> Accessed April 7, 2022.

J.R. Nelson and T.H. Grubesic, "The use of LiDAR versus unmanned aerial systems (UAS) to assess rooftop solar energy potential," Sustainable Cities and Society 61 (2020).

A.O. Onososen and I. Musonda, "Research focus for construction robotics and human-robot teams towards resilience in construction: scientometric review," Journal of Engineering, Design and Technology (Emerald Group Holdings Ltd., 2022).

K. Park, "Park and Neighborhood Attributes Associated With Park Use: An Observational Study Using Unmanned Aerial Vehicles," Environment and Behavior 52: 5 (2020) 518–543.

T. Patel, V. Suthar, and N. Bhatt, "Application of Remotely Piloted Unmanned Aerial Vehicle in Construction Management," in 77 (Springer Science and Business Media Deutschland GmbH, 2021).

P. Pilinja Subrahmanya, B. Haridas Aithal, and S. Mitra, "Automatic Extraction of Buildings from UAV-Based Imagery Using Artificial Neural Networks," Journal of the Indian Society of Remote Sensing 49: 3 (2021) 681–687.

Z. Qadir, F. Ullah, H.S. Munawar, and F. Al-Turjman, "Addressing disasters in smart cities through UAVs path planning and 5G communications: A systematic review," Computer Communications 168 (2021) 114–135.

T. Rakha and A. Gorodetsky, "Review of Unmanned Aerial System (UAS) Applications in the Built Environment: Towards Automated Building Inspection Procedures Using Drones," Automation in Construction (Elsevier B.V., 2018).

M.V. Rodríguez, S.G. Melgar, and J.M.A. Márquez, "Assessment of aerial thermography as a method of in situ measurement of radiant heat transfer in urban public spaces," Sustainable Cities and Society 87 (2022).

Samuel Adeyinka-Ojo, PRISMA Statement and Thematic Analysis Framework in Hospitality and Tourism Research Advances in global services and retail management: Volume 2 (Anahei Publishing, 2021).

A. Saputra, A.A. Sigit, Y. Priyana, A.M. Abror, A. Noor, L. Sari, and O. Nursetiyani, "A low-cost drone mapping and simple participatory GIS to support the urban flood modelling", Geographia Technica 17 (2022) 46.

S. Shahruddin and M. Zairul, BIM Requirements across a Construction Project Lifecycle: A PRISMA-Compliant Systematic Review and Meta-Analysis (2020) <www.ijicc.net> Accessed.

F. Sultonov, J.H. Park, S. Yun, D.W. Lim, and J.M. Kang, "Mixer U-Net: An Improved Automatic Road Extraction from UAV Imagery," Applied Sciences (Switzerland) 12: 4 (2022).

T. Templin and D. Popielarczyk, "The use of low-cost unmanned aerial vehicles in the process of building models for cultural tourism, 3D web and augmented/mixed reality applications," Sensors (Switzerland) 20: 19 (2020) 1–26.

H. Teng, M. Dong, Y. Liu, W. Tian, and X. Liu, "A low-cost physical location discovery scheme for large-scale Internet of Things in smart city through joint use of vehicles and UAVs," Future Generation Computer Systems 118 (2021) 310–326.

F. Ullah, S.I. Khan, H.S. Munawar, Z. Qadir, and S. Qayyum, "Uav based spatiotemporal analysis of the 2019–2020 new south wales bushfires," Sustainability (Switzerland) 13: 18 (2021).

G. Vacca, A. Dessì, and A. Sacco, "The use of nadir and oblique UAV images for building knowledge," ISPRS International Journal of Geo-Information 6: 12 (2017).

E.V. Vazquez-Carmona, J.I. Vasquez-Gomez, J.C. Herrera-Lozada, and M. Antonio-Cruz, "Coverage path planning for spraying drones," Computers and Industrial Engineering 168 (2022).

Y. Wang, M. sheng Zhang, Q. Xue, and S. duo Wu, "Risk-based evaluation on geological environment carrying capacity of mountain city - A case study in Suide County, Shaanxi Province, China," Journal of Mountain Science 15: 12 (2018) 2730–2740.

K.S. Wu, Y. rong He, Q. jin Chen, and Y. mao Zheng, "Analysis on the damage and recovery of typhoon disaster based on UAV orthograph," Microelectronics Reliability 107 (2020).

Z. Wu, Q. Lu, S. Lei, and Q. Yan, "Study on landscape ecological classification and landscape types evolution: A case study of a mining city in semi-arid steppe," Sustainability (Switzerland) 13: 17 (2021).

Q. Zhan, W. Zhang, and Y. Xiao, "Research and Practice on Disaster Prevention Planning in Villages based on Planning Support System," 6: 4 (2018) 110–127 <http://dx.doi.org/10.14246/irspsda.6.4_110> Accessed.

K. Zhao, T. He, S. Wu, S. Wang, B. Dai, Q. Yang, and Y. Lei, "Application research of image recognition technology based on CNN in image location of environmental monitoring UAV," Eurasip Journal on Image and Video Processing 2018: 1 (2018).

T. Zhao, L. Huang, J. Wang, B. Cui, X. Li, and X. Zhu, "Effective Screening and Texture Segmentation of Green Vegetation Cover Based on UAV Images," Traitement du Signal 39: 4 (2022) 1435–1442.

314

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Gender-Sensitive Use and Development of (Digital) Participation and Analysis Tools for Equal Access to Open Spaces

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1 ABSTRACT

In view of the growing threat posed by the effects of climate change on cities and regions, politicians and the public administration are increasingly called upon to create environmentally and climate-friendly as well as just framework conditions in urban spaces (IPCC 2022). The Covid-19 pandemic has underlined that urban green infrastructuresnot only benefit biodiversity, but arealso socially significant. In addition to providing a range of ecosystem services (MEA 2005), they equally support the diverse usability of urban landscapes, thus affirming the right to the (climate-just) city for all (Heindl 2022). Especially in denser settlement areas, where green and open spaces with important social and recreational functions are only available to a limited extent, different, sometimes contradictory needs of diverse social groups can lead to conflicts of use. Thereby, "vulnerable" persons or groups[1], who on average already have less access to high-quality green and open spaces anyway (Honey-Rosés et al. 2020), often give way to the more dominant user groups. In this context, approaches such as gender-sensitive planning and design (Terraza et al. 2020, Tummers et al. 2019) as well as attempts to design and manage public spaces sensitively according todiverse everydayneeds of the heterogenous urban populationare becoming increasingly important.

The research project "DraussenDaheim"[2](DDH) [German for: "At Home Outside"] is therefore developing a methodology and toolbox from a gender- and group-specific perspective, which serves not only the participatory evaluation of urban public spaces, but also the simulation-based development of different planning scenarios,which can, for example, be incorporated into space-time management concepts. Digital participation and simulation tools as well as tailor-made workshop designs are applied in the context of two Austrian use cases(Vienna, Zell am See) to identify spatio-temporal use patterns and group-specific requirements for the multifunctional use of space. In addition, the usability of the compiled tools (on the part of usersand process facilitators) is tested. The methodology to be developed also builds on knowledge from a well-tested target group segmentation approach with a special focus on active mobility (Markvica et al. 2020) to more accurately capturethe mobility and information needs of the (vulnerable) groups involved.

This contribution gives a comprehensive insight into the project, its conceptual and methodological approach, and provides first results of use case specific surveys and tool-tests. From this, key findings are derived that address the potentialof the gender-sensitive use and developmentof(digital) participation and analysis tools to supportequal and environmentally friendly access to open spaces in residential environments.

Keywords: gender groups, open space, participation, digital tools, urban planning

2 INTRODUCTION

In the ever louder demand for more ecological and social justice, public space in cities plays a central role. It is considered the space of action of public life and as such is constantlyre-produced through diverse social practices and relationships. It is social, political and material space at the same time, the importance of which became clear in the course of the Covid-19 pandemic (Reinwald et al. 2021).

Social justice in this context of spatial planning and development is influenced by three different aspects: distributive, procedural, and recognition-based conceptions of justice (Schlosberg 2007). Distributive justice

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[1] Vulnerability refers to one or more aspects of people's everyday lives and draws attention to the needs of those groups of people who are often forgotten in planning decisions, and/or who are particularly locally bound and dependent on planning for everyday life due to low time or financial resources and low mobility. "Vulnerable" groups thus include persons with care responsibilities (more likely to be female), as well as younger and older or mobility-impaired persons who are care-dependent.

[2] Project website (in German): DraussenDaheim | ProjektWebseite (ait.ac.at), or DraussenDaheim Promoting climate-neutral mobility - AIT Austrian Institute Of Technology (for englich readers)

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follows the principle of equity and refers to the fair distribution and access of urban amenities (Rawls 2005). Procedural justice refers to the planning processes and fair opportunities to engage in these processes. The third aspect of social justice is that of recognitional justice. This is the recognition and appreciation of different interests and needs and thus inclusion of different social groups (Nussbaum 2013).

The focus of this article is procedural justice,i.e. the possibilities to participate - with the support of digital tools - in specific phases of the planning processes (see Chapter 4). Similarly, the use of different tools and methods also supports the needs of different groups of people in a better and more differentiated way and thus also promotes the aspect of recognitional justice.

The accessibility and usability of public spaces such as green and open spaces in the residential environment not only determine the quality of life of different social groups, but also have significant influence on mobility habits. This is due to the possibly limited right to green and open space.If public spaces are designed in such a way that they are more accessible to all socialgroups, encourage more active mobility and reduce the need for longer recreational traffic, they can make a significant contribution to environmental and climate protection.Furthermore, public space reflects the social coexistence and culture of a city, which in the case of the City of Vienna leads to commitments such as increasing the quality of stay for all and contributing to unrestricted use for children, older persons and persons providing care (Fachkonzept Öffentlicher Raum 2018). As a constant space of negotiation and appropriation, public space is also a potentially conflictual space that must accommodate contradictory needs. Urban gender equality policy (e.g. Vienna City Administration 2014) addresses this by striving to create equal living conditions for women and men and by using gender-sensitive planning methods to specifically take into account different interests.

The use of innovative digital approaches in urban planning opens up new possibilities for evaluating open spaces, developing them in a participatory manner and achieving a gender-responsive design in the planning process and use of public space.Since digital analysis tools, as already emphasised in the previous project SMTG+[3], usually lack the integration of gender and group-specific aspects, a special focus is placed on this in the two use cases, starting with the gender-, age- and care-specific disaggregated survey up to the differentiated evaluation of the investigated space-time use patterns. Finally, the concepts of gender (mainstreaming) and gender planning from a care-perspective (Tummers/Wankiewicz 2021) are also applied in the actual process design and tool development.

3 DRAUSSENDAHEIM PROJECT AND RELATED CASE STUDIES

In view of the democratic relevance of open spaces as well as their recreational factor (as an important health aspect), a right to a good living environment can be stated in the urban planning context (Heindl 2022). It is derived from the human right to housing, which includes public space. According to this, all groups should be able to feel "at home outside"[German: "draussen daheim"].

This is the starting point and at the same time the objective of the project "DraussenDaheim". Based on the analysis of cycles of use of urban spaces and the identification of specific spatio-temporal patterns of use and requirements of different social groups, a methodology is developed that supports the design of gender-responsive open spaces.This methodology, which is applied and further developed in exemplary use cases, is intended to support the spatio-temporal organisation of open spaces (see corp paper Wankiewicz et al. 2023)andto help makingthem accessible to groups in vulnerable situations without displacing others at the same time.The development of this new methodology as a result of the gender-sensitive use of digital participation and analysis tools draws on tailored toolsets consisting of survey tools (using analogue questionnaires as well as an online survey tool), a digital participation platformusing the tool "Smarticipate"[4] (see Khan et al. 2017)and simulation and visualisation toolsusing the tool "Simulate[5]", "SUMO[6]" (see Lopez

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[3] Project website (in German): SmartThroughGender+ (ait.ac.at)

[4] "Smarticipate" is an interoperable and expandable platform for interactive urban planning for a more transparent, democratic and inclusive implementation of urban transformation processes. Using the online smarticipate service platform, different stakeholders including citizens can interact with the system to initiate new proposals using inputs on a map and obtain automated feedback on any proposed changes based on Open Government Data (OGD) layers. The platform provides a carefully selected list of features, which enhance the ability of citizens to co-create, collaborate and participate in city decision making: https://www.smarticipate.eu/

[5] "Simulation, analysis and optimisation of customer and pedestrian flows": https://www.ait.ac.at/en/solutions/analysis-and-optimization-of-pedestrian-flows/simulate

et al. 2018) and a parametric design tool called Rhinoceros3D/Grasshopper[7].Within the framework of online surveys and co-creative workshop formats used in the use casesAumannplatz (Vienna) and Sonnengarten Limberg (Zell am See), group-specific spatio-temporal use patterns are collected and analisedin a first step. In a second step, further analyses (e.g. by means of WebGIS applications and simulation tools) will be carried out and user-friendly visualisation possibilities tested (e.g. heat maps on the group-specific use of open space during the day and week) in order to be able to feed the results back to the participants and thus stimulate further discussions on equal access to . Providing such possibilities can not only contribute to a more just balance in the use of open space, but also increase the acceptance of the respective needs of the different groups. As the project will continue until February 2024, we will focus in this paper on the already developed methodology based on the digitally supported analysis of spatio-temporal use patterns of different groups (rather than on the simulation and visualisation of results) as well as on first results and findings from the tool applications in the respective use cases.Finally, the learnings mainly refer to the (further) development of the tools, especially to the improved usability of the compiled tools from the perspective of the users and process facilitators, as well as to the design of participatory processes that enable a gender-sensitive use of (digital) participation and analysis tools.

3.1 Use case: Aumannplatz (Vienna)

The Aumannplatz, a central square in Vienna's 18th district, which represents one of the research project's use cases, no longer meets the multidimensional demands of its users due to its problematic traffic situation and poor design. Based on a functional and socio-spatial analysis carried out by the District Service of the City of Vienna [GebietsbetreuungStadterneuerung], which roughly outlines the main user groups (e.g. schoolchildren and older people), a large-scale participation process was therefore initiated with the aim of redesigning the square. The project "DraussenDaheim" was involved in the extensive process of collecting ideas and supported the identification of the spatial qualities of the square and the actual as well as future target group-specific possibilities of use. The participatory evaluation of the public square and its usability (e.g. crossing possibilities and quality of stay), and the simulation-based development of different planning scenarios (square with different spatial boundaries and elements) relied in particular on the successful interplay of the tools "Smarticipate" and "Simulate".

Fig. 1: Participation phases: use case Aumannplatz, Vienna, Austria, © Photo credits (from left to right): GB* – GebietsbetreuungStadterneuerung, Bezirksmuseum Währing, Bezirksvorstehung Währing, Markus Hießleitner, AIT

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[6] "Simulation of Urban Mobility": https://eclipse.dev/sumo/
[7] https://www.rhino3d.com/

3.2 Use case: Sonnengarten Limberg (Zell am See)

Compared to the use case Aumannplatz, the starting point of the use case Sonnengarten Limberg is different in some fundamental factors: Sonnengarten Limberg, known as the "settlement of short distances", is not so much embedded in the urban fabric but is rather located on the outer municipal area and is therefore also less intrastructurally interwoven with the town of Zell am See.Even though basic infrastructure is provided within the settlement area most people living there (about 70% younger than 47 years) are using cars as their dominant means of transport. Furthermore, since the housing project has already been developed and implemented, monitoring and evaluation is carried out within the framework of the research projectby using the digital participation tool "Smarticipate" to investigate the use of open spaces close to or further away from the settlement and thus draw a first conclusion about the spatio-temporal use patterns of the residents. This was achieved with the combined use of an online survey and the creation of an open space use diary using "Smarticipate".

4   DIGITAL METHODS AND TOOLS FOR PARTICIPATORY PLANNING PROCESSES

Forms of participation can be categorised according to different criteria (Schoßböck et. al. 2018). We follow the classification according to the form of communication or type of information flow of Rowe and Frewer (2000).

We listed digital tools for information, consultation and collaboration that can be used in each of these phases(see Figure 2). The result is that digital tools are used for different purposes in several phases of participation Processes, and they are usually combined by none-digital methods and tools.
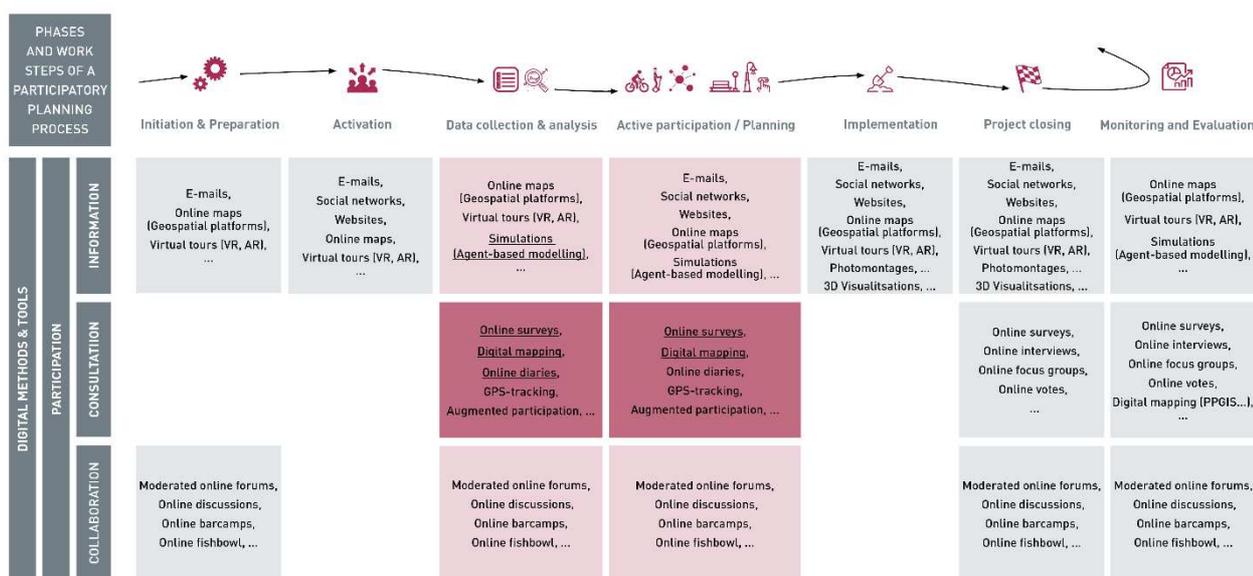
Fig. 2: Digital methods and tools for the different phases of participatory planning processes, © BOKU & AIT

Since the use case Aumannplatz was in the phase of data collection and analysis accompanied by active participation, the focus was set on tools which support gathering information from the residents (consultation tools). For the co-creation processes, we chose an online survey tool (LimeSurvey) and a digital participation tool ("Smarticipate") and combined it with a simulation tool ("Simulate") to show the impact of workshop participants' suggestions and ideas on pedestrian flows. In the Sonnengarten Limberg use case, the same online survey tool as well as digital participation platform (this time over a longer period of time) were used, and later more detailed analyses will be carried out using a mobility simulation tool ("SUMO").

4.1 Combined assessment using the toolchain

An important step within the project is the thorough development of interfaces (APIs) to combine the differnet participatory tools.For example, the results of the online survey for the use case Sonnengarten Limberg were subjected to a detailed analysis before the actual tool workshop in order to be able to segment the surveyed target groups. With the help of a person ID ensuring the anonymity of users, the respondents could be clustered in the further use of the digital participation platform according to their mobility

behaviour (allocation to groups via pro:motion types, see chapter 5) and their use of open spaces could thus be better analysed. Likewise, conclusions could be drawn about the group-specific use of the tools themselves.Furthermore, in combination with other factors, such as care obligations, preferences of the different groups reached (DDH profiles) can be derived and qualified for the gender-sensitive use and development of the tools.

4.2 Toolchain evaluation

As part of the DDH project a toolchain evaluation by users and process facilitators is performed to understand the needs of the different groups regarding tool usability and visualisation of results. This ultimately helps to find out how they can be used most efficiently during the different participatory phases. Within the first half of the project tool tests with focus groups have already been performed and will be further extended till the end of the project (February 2024). The results of the first tool evaluation process already enabled to improve the tool usability during first and second use case application.

5 DDH PROFILES: TARGET GROUP IDENTIFICATION BASED ON SPATIO-TEMPORALUSE TYPES

To, first by means of use case -specific questionnaires, collect gender+[8] differentiated data in the selected case studies Aumannplatz (n=46) and Sonnengarten Limberg (n=59), specially developed spatio-temporal use types (DDH profiles) are identified. Their design is based on theoretical and practical considerations on different dimensions of spatio-temporal constraint as well as on the pro:motion typology (Markvica et al. 2020), which comprises a total of six mobility and information types: *Spontaneous – On the Go, High Informed Sustainability*, *Efficiency-oriented Information Pickers*, *Interested Conservatives*, *Low Demand and Digital Illiterates*. We also draw on the knowledge from the previous project Smart through Gender+ (Damyanovic et al. 2021, Tummers/Wankiewicz 2021) and the gender+ groups[9] defined therein.

The following dimensions of spatio-temporal constraint are considered:

- dependence on care
- obligation to care
- mobility restriction
- employment

The spatio-temporal use types were surveyed in that the question sets contained in the surveys for both use cases included demographic and care- or gender-related questions on the one hand, and mobility-specific and open space use-related questions as well as spatio-temporal questions which draw on practical experiential knowledge on the other. In the use case of Sonnengarten Limberg, the indicator statements from the pro:motion study[10] (Brauner et. al. 2016) were additionally asked in order to be able to cluster the respondents according to their pro:motion type. As a result of the survey with 46 participants, the following Figure shows the pro:motion types represented according to their care obligations. Only the pro:motion type *High Informed Sustainability* shows a significant lower rate of care obligation.

While the cross-sectional evaluation of the survey allows each pro:motion type to be considered from the perspective of a specific care focus, there is already general knowledge about their type-specific mobility behaviour (including willingness to switch to cycling or walking) as well as underlying motivations, values and attitudes (regarding efficiency, environmental protection and sustainability, costs, time factor, etc.).In addition, type-specific information needs and communication demands (e.g. on style or medium of communication - analogue, digital, personal) are known, which subsequently makes it easier to select and target suitable communication and participation methods (e.g. classic analogue vs. playful digital campaigns).The major advantage of this approach is that with the existing knowledge about the groups

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[8] "The term "Gender+" describes an expanded concept of gender. It signals that gender is always overlaid with other characteristics on which structural inequality is based, such as age, origin, skin color, education, profession, disability, sexual orientation or religion (intersectionality)" (Verloo 2009)

[9] These groups are not only determined by sex, but also by further factors which are considered to shape a person's urban routines, such as age, household size, employment and country of origin.

[10] https://www.ait.ac.at/themen/integrated-mobility-systems/projects/promotion

reached, the requirements for the methods and tools used in the project can be specified. With the help of this target group segmentation based on mobility and information behaviour, people with similar needs and values were finally divided into focus groups for the tool workshop. Moreover, for the future derivation of action scenarios, it is possible, for example, to work in the same way with the assumptions on group-specific attitudes such as the willingness to switch to a climate-friendly means of transport.
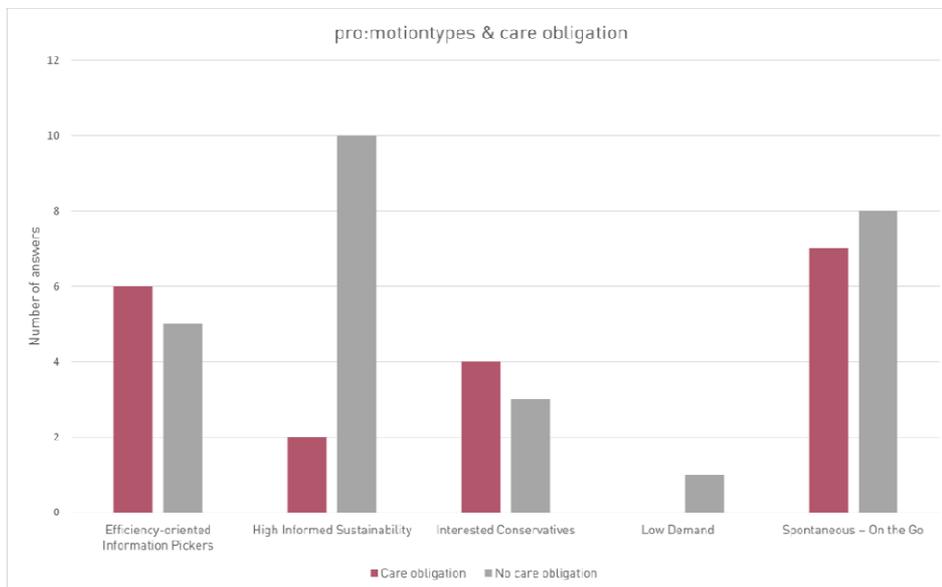
Fig. 3: Survey result use case Sonnengarten Limberg: pro:motion types by care obligation (n=46).

While the tool test in the Aumannplatz use case was conducted with mixed groups, not clustered by pro:motion types, thus enforcing an exchange beyond their own interests, the intention of the homogeneous group formation according to pro:motion types in the Limberg use case was a mutual reinforcement of the participants as well as the promotion of motivation and collective engagement potential. Finally, the evaluation according to pro:motion types and care obligation also allowed conclusions to be drawn about the open space use of the surveyed groups (see Figure 4).
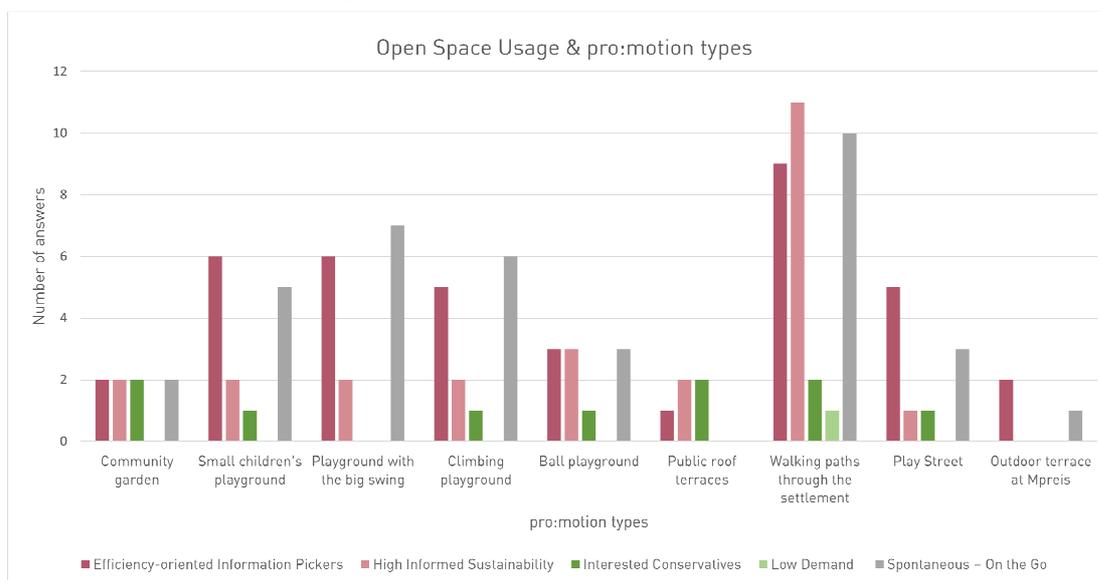
Fig. 4: Survey result use case Sonnengarten Limberg: open space use according to pro:motion types (n=46)

Moreover, as can be seen in Figure 5, which compares the rate of use of open spaces inside the settlement or outside, participants with care responsibilities use open spaces inside the area almost as often as outside.
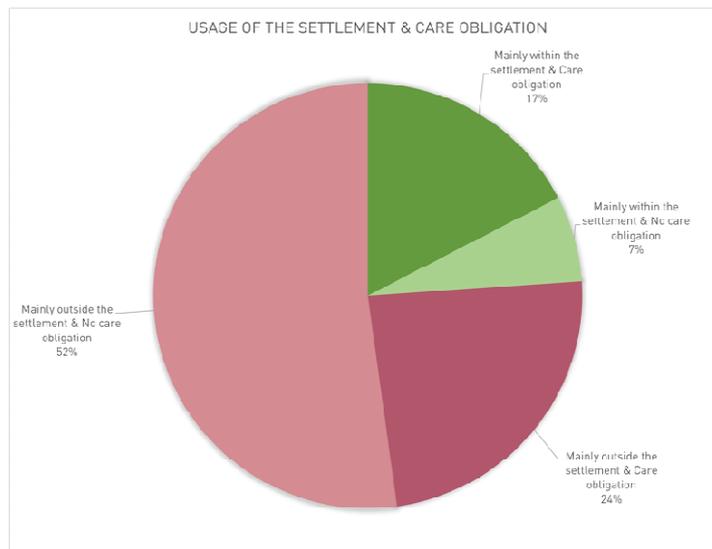
Fig. 5: Survey result use case Sonnengarten Limberg: open space use inside and outside the settlement according to care obligation (n=46)

Through the gender perspective, which takes into account group-specific needs and demands, it can be seen that "vulnerable" groups due to their age, mobility, income or everyday situation related to care are precisely those who have a small radius of movement, are locally oriented or bound and thus depend on a high-quality living environment. This includes, for example: children, senior citizens, people with limited mobility and disabilities, and precisely people with care obligations (Zibell et. al. 2019).

Also a very significant difference is seen between full-time and part-time employed as the full-time mainly use open-spaces outside of the area. One reason for this might be that during the week this people often use their private gardens due to time restrictions and on the weekend they use the private car to visit locations outside.
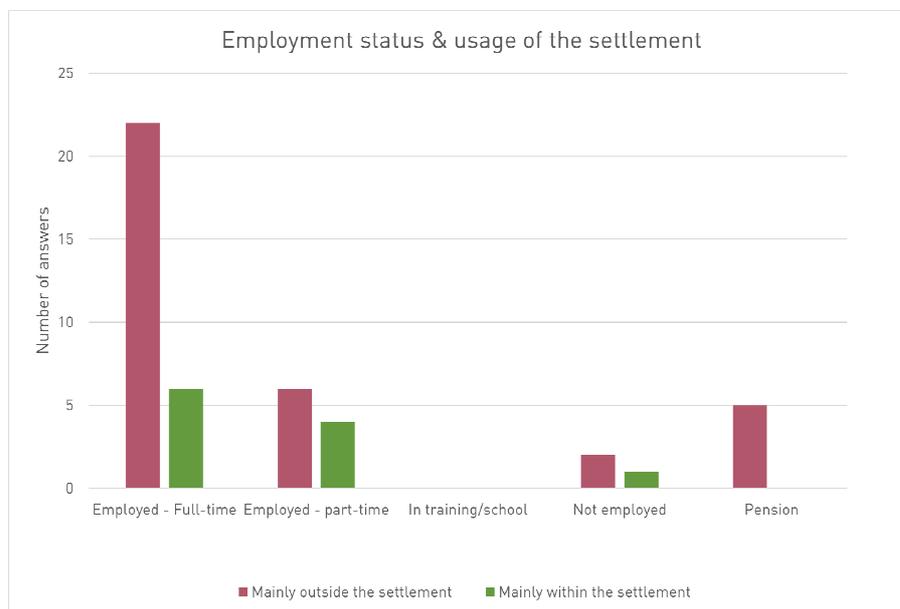
Fig. 6: Survey result use case Sonnengarten Limberg: open space use inside and outside the settlement according to employment status (n=46)

In order to be able to develop a digitally supported methodology in the long term that supports the research and design of gender-responsive open spaces, the pro:motion types identified in the initial survey need to be further embedded in different gender contexts. By combining them with the above mentioned dimensions of spatio-temporal constraints in the cross-sectional evaluation of the survey and evaluating them in a differentiated group-specific manner (according to gender, age etc.), a further refinement of the DDH profiles is made possible. The spatio-temporal use types will thus be enriched with the latest findings on

gender- and life-stage-specific spatio-temporal use patterns as well as type-specific disadvantages/vulnerabilities.

6 PARTICIPATORY IDENTIFICATION AND ANALYSIS OF SPATIO-TEMPORAL USE PATTERNS

Although the selected use cases considered here have different starting points and objectives in their participation processes, similar overall goals are pursued in the research. This concerns both the methodological approach for the participatory identification and analysis of spatio-temporal use patterns as well as the process design for the toolset applications in a co-creative workshop setting.

In a first step, the initial involvement and activation of different target groups for each use case was carried out with special attention to gender relevance and dimensions of spatio-temporal constraints (see DDH profiles).Accordingly, the target groups range from people with care dependencies (children or adults who are dependent on support in everyday life) and care responsibilities (care givers who support children or adults in coping with everyday life) to people with mobility impairments (physical, sensory or cognitive impairments) and people with limited spatial, temporal and financial resources (due to e.g. available living space, extent of employment, income). All these groups face different constraints and vulnerabilities due to their specific everyday situations and more or less flexible or rigid daily routines. With the basic aim of reaching as many different people as possible by means of various communication strategies, different ways of approaching them have been used. In both use cases, Aumannplatz (Vienna) and Sonnengarten Limberg (Zell am See), already established analogue and digital communication structures and channels (newsletters, mail shots, flyers, WhatsApp groups, etc.) have proven effective in promoting the research project and increase its reach. By approaching people personally (with great support from local partners and multipliers such as the District Service or Housing Coordination) and conducting on-site surveys in addition to the online survey, it was possible to question various (even less digitally affine) groups of people and recruit them for subsequent tool workshops. Nevertheless, the digital pre-surveys are at the heart of the preparatory process (before the actual tool applications), as they provide information on the socio-demographics as well as the mobility and leisure behaviour of the local population. Since the surveys also included questions on care obligations or dependencies, a more accurate picture of the current need and the people reached could be given.

As the first broad online survey conducted at Aumannplatz shows, the results not only provide insights into complex spatio-temporal use patterns (e.g., the use of space over the course of the day during the week and at weekends) as well as mobility behaviour (e.g., preferred mode of transport), but they also give information on the socio-demographic background and care obligations of respondents. For example, with the help of an interactive analysis of complex correlations from a gender perspective, it was possible to show that although almost 70 % of the respondents have care responsibilities, they hardly use the open space (Aumannplatz) with children or senior citizens in need of care.
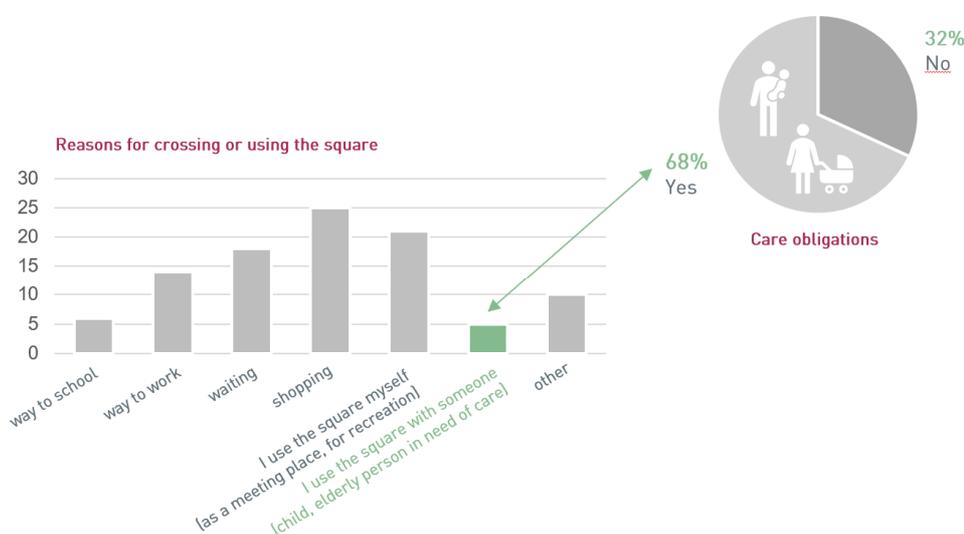
Fig. 7: Survey results use case Aumannplatz, reasons for crossing or using the square and care obligations (n=47)

In Sonnengarten Limberg, an online survey was conducted on their leisure and mobility behaviour of the residents of the settlement, which was promoted via the e-mail distribution list and the private WhatsApp group of the housing coordination as well as in personal conversations. By also asking for information on the social background (gender, age group, employment status, care obligations towards children and elderly persons) and the housing situation (household and flat size) as well as information behaviour, it was possible to gain a first insight into the composition of the group, who committed to participate in the workshop with the digital participation tool "Smarticipate" and the following playful creation of the open space use diary. As expected, the playgrounds within the settlement are used a lot by people with care obligations (see Figure 8) and are thus extremely important for this group due to their spatiodiary-temporal constraints.
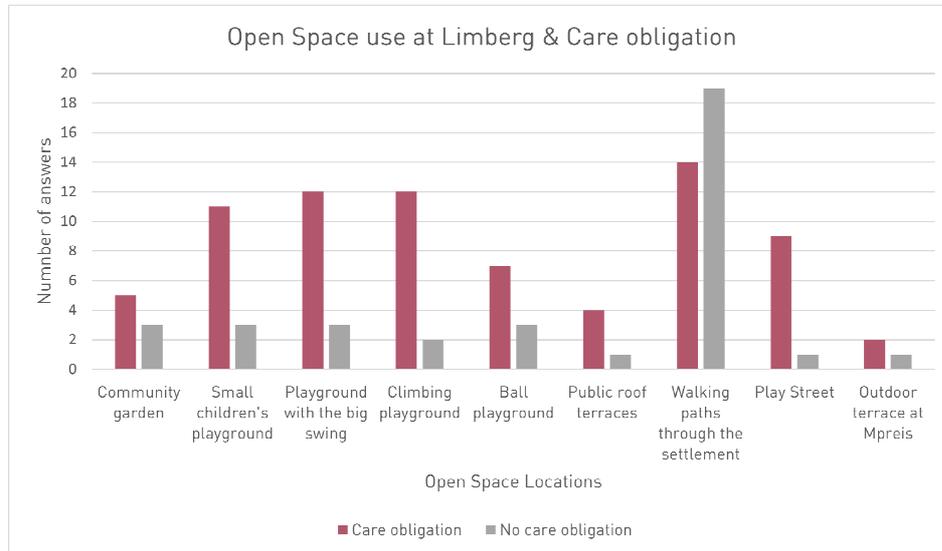
Fig. 8: Survey results use case Limberg, open space use in view of care obligations (n=46)

In a second step during the active participation phase using digital tools, the main focus of the Aumannplatz tool test was on the crossing possibilities and the function of the square as a place to stay and play. By discussing and mapping current footpaths in small groups of mixed age and gender (partly also with visual impairment), complex temporalities and rhythms emerged as can be seen in Figure 9.A dozen interested persons participated in the tool-supported identification of spatio-temporal use patterns and group-specific needs. In the process, different combinations of tool applications were used, the core of which was always the digital participation platform "Smarticipate".
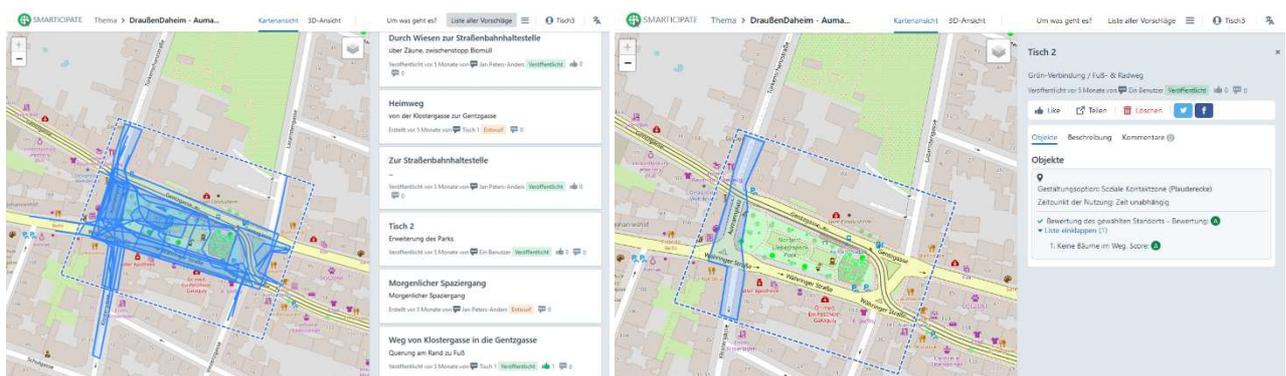
Fig. 9: Mapping spatio-temporal use patterns with the help of the participation platform "Smarticipate", © AIT

In the second half of the co-creative tool workshop, the participants had the opportunity to draw desired paths and make new design proposals for the square in a joint negotiation process. For this, a square without spatial boundaries was assumed. However, existing green spaces were always included in the considerations. Afterwards, a pedestrian simulation was shown using the tool "Simulate" to see how these new design objects would affect movement flows in real time (morning, midday and evening)(see Figure 10). This considered the status quo of movements of people getting off the tram (at the nearby station), going to work or school, etc., which gave the participants an idea of the current dynamics of the square at different times. The result was various scenarios for the square with newly implemented design objects (e.g., a new water

playground) that take on new spatial boundaries and thus simultaneously change path-time relations, patterns of use and behaviour on the square.

Fig. 10: Simulation-based design of different planning scenarios with the help of "Simulate"

While the tool workshop at Aumannplatz took place in a local shop bordering the square, the on-site participation in Sonnengarten Limberg was organised directly in the premises of the Housing Coordination. This communal space provided the ideal setting to introduce the participants to the "Smarticipate" tool, which they were to use during two weeks to create an online diary on the use of open spaces. The target group-specific evaluation of the survey and allocation of the participants according to specific information behaviour types enabled the formation of heterogeneous focus groups (see chapter 5). Thus, for example, in addition to a young mother with a digital affinity, a childless couple interested in sustainability issues and an older lady with little technical expertise took part in the tool workshop. In preparation for working independently with the diary, the daily routines of a classic weekday and weekend day (use of open spaces and destinations inside and outside the settlement as well as additional information such as time, duration, purpose of use and the means of transport used) were reconstructed and entered into the "Smarticipate" tool (see Figure 11).
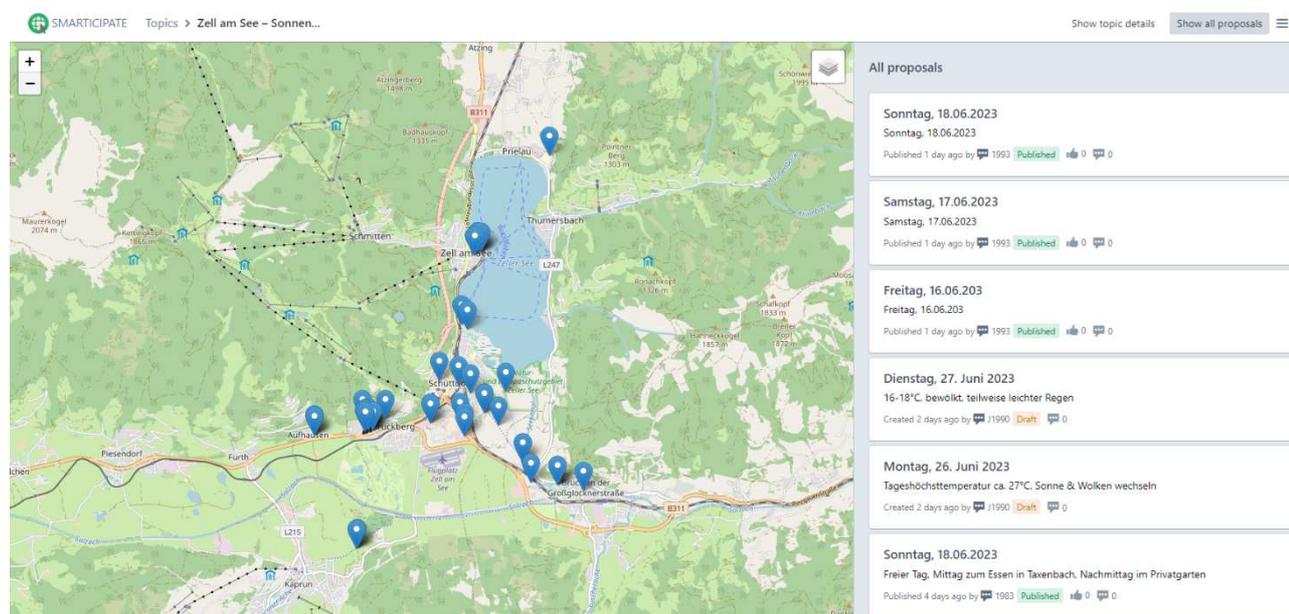
Fig. 11: Recording spatio-temporal uses of open spaces in the form of a diary with the help of "Smarticipate"

The group-specific differentiation will allow the presentation of different rhythms and possible overlaps of use patterns in specific open spaces. The result can therefore provide assumptions on the optimisation of the (semi-)public open spaces within the settlement and thereby shows potential to contribute to an inclusive (as e.g., conflicts of use are avoided) and gender-equitable as well as CO_2-avoiding (as e.g., longer recreational traffic is avoided) urban transition.

324

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7 LEARNINGS AND OUTLOOK ON THE GENDER-SENSITIVE USE AND DEVELOPMENT OF AN INTEGRATED DIGITAL TOOL CHAIN

The extensive process documentation as well as the evaluation by means of a test and evaluation framework to check the gender-sensitive use of digital tools resulted in several learnings for (further) gender-sensitice tool use and development. In order to assess the possibilities and limitations of developing an integrated digital tool chain, the tool applications were meticulously observed and documented by the process facilitators.In addition, the participants were asked about the usability of the tools. In the course of reflection workshops, the results were then reflected on together with the tool developers in order to further improve them.

As a follow-up survey and analysis on the comprehensibility and usability of the tools showed, the "Smarticipate" tool increased the understanding of how the space works for most participants. This advantage of visualisation tools has already been confirmed in various research projects (e.g. Reinwald et al. 2014). The extension of this approach- the combination with the pedestrian simulation tool ("Simulate") - reinforced this effect, as in addition the impact of potential planning proposals by the participants is presented to them. Furthermore, a better understanding of the (sometimes competing) demands of different groups on the space could be achieved. The use of the toolchain consisting of several instruments (e.g. survey,"Smarticipate" and "Simulate"), especially the direct coupling (via technical interface development and target group segmentation), supports gender- and group-specific data collection and analysis and at the same time helps laypersons in participatory processes to reflect and classify their own proposals.

The evaluation by the process facilitators confirmed the importance of participatory negotiation processes in terms of awareness raising and strengthening the "Design for All" concept for the planning and design of urban infrastructures. It also provided valuable input for the further development of the tools and toolchain (especially regarding usability and target group-specific handling).

Summarising these learnings concerning the tool development, it can be said that the participants were very interested in the application and open to try new things, but also pointed out the weaknesses in the handling of the tool "Smarticipate". Especially the (mostly older) digitally inexperienced participants had to be taken by the hand, which is an argument for simplified applications to increase their inclusion. Moreover, recommendations were made regarding simple design, the preferred scale and layout of the used basic maps.

Looking at the learnings related to the specific design of participation process, it can be concluded that the case-specific application of tools must not only be very well linked to specific planning and design questions, but also be low-threshold (in terms of spatial and temporal accessibility).It also became apparent that the careful embedding of the tools in participatory formats is crucial, as it influences both the group dynamics and the results. For example, the direct pedestrian simulation feedback using "Simulate" connected to "Smarticipate" supported consensus-oriented discussions and negotiation processes within the workshop group, but also had to be explained in an understandable way. Finally, the thoughtful composition and representation of the different target groups also plays a key role in the successful promotion of the different views.

In summary, it can be deduced that through the use of different communication strategies and the use of a mix of (analogue and) different digital tools more groups can be reached in participation processes. Especially young people (who are usually not very involved in "normal" participation processes) and digital affine groups could be reached by the use of these tools. The use of digital tools can also help to involve groups that cannot come to "usual" participation events due to lack of time - e.g. people with care obligations. For this, however, the usability and low-threshold nature of the tools must be further improved so that they can be used independently (e.g., user-guides or webinars should assist this). The advantage for people with (mobility or visual) impairments still needs to be analysed in more detail. However, the possibilities of differentiating the specific requirements of these groups in participation processes as well as for the opening up of new perspectives on their use of time and space became clear. With these approaches and the gender-sensitive use of digital tools, procedural justice - as a part of social justice - can be promoted.

This approach also leads to an improvement in the downstream planning processes, as the different requirements are recorded in a differentiated manner. By incorporating and reflect different life worlds and space-time patterns, it can also contribute to recognitional justice. In the context of the research project, it is recognised that there are gender-specific differences in the use of space (and time) and in dependence on care

obligations, which is why great importance is attributed to the representation of caregivers (in many cases women), their achievements and activities in public space.

8 ACKNOWLEDGEMENT

Heidrun Wankiewicz, Lidewij Tummers and Flora Fessler will present another project paper: "Time-based solutions for gender just low carbon, sustainable urban transformation" at REAL CORP 2023 in Ljubljana.

9 REFERENCES

DAMYANOVIC, D., FINK, T., GEBETSROITHER-GERINGER, E., GRIMM-PRETNER, D., KOZLOWSKA, A., REINWALD, F., STOLLNBERGER, R., TUMMERS, L., UNTNER, S., WANKIEWICZ, H., WEICHSELBAUMER, R.: Ein Tool-Set zur Unterstützung einer Gender+-gerechten Stadtplanung. Ergebnisbericht des Forschungsprojekts SmartThroughGender+ – Integration von Gender+ in digitale Stadtplanungs-Tools und Entwicklung eines Tool-Sets für Gender+-gerechte Stadtplanung, Wien, 2021.

HEINDL, G.: Gerechte Stadt muss sein. Studie zur Bestandsanalyse und Zukunftsorientierung einer gerecht(er)en Stadtplanung mit Schwerpunkt Wien. Standpunkte Nr. 42, Kammer für Arbeiter und Angestellte für Wien. Wien, 2022.
https://emedien.arbeiterkammer.at/viewer/ppnresolver?id=AC16732301

HONEY-ROSÉS, J., ANGUELOVSKI, I., CHIREH, V.K., DAHER, C., KONIJNENDIJK VAN DEN BOSCH, C., LITT, J.S., MAWANI, V., MCCALL, M.K., ORELLANA, A., OSCILOWICZ, E., SÁNCHEZ, U., SENBEL, M., TAN, X., VILLAGOMEZ, E., ZAPATA, O.,NIEU-WENHUIJSEN, M.J.: The impact of COVID-19 on public space: an early review of the emerging questions – design, perceptions and inequities. In: Cities Health, pp. 1-17,2020.

IPCC (Intergovernmental Panel on Climate Change): Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 2022.

KHAN, Z., DAMBRUCH, J., PETERS-ANDERS, J., SACKL, A., STRASSER, A., FRÖHLICH, P., TEMPLER, S., SOOMRO, K.: Developing Knowledge-based Citizen Participation Platform to Support Smart City Decision Making: The Smarticipate Case Study. In: Information, 8, 47, 2017.doi:10.3390/info8020047

LOPEZ, P.A., BEHRISCH, M., BIEKER-WALZ, L., ERDMANN, J., FLÖTTERÖD, J.-P., HILBRICH, R., LÜCKEN, L., RUMMEL, J., WAGNER, P., WIESSNER, E.: Microscopic Traffic Simulation using SUMO. In: 21st International Conference on Intelligent Transportation Systems (ITSC), 2575–2582, 2018.
https://doi.org/10.1109/ITSC.2018.8569938

MA 18 und MA 19: STEP 2025 - Fachkonzept Öffentlicher Raum, 2018.

MAGISTRAT DER STADT WIEN: Wiener Hitzeaktionsplan. Für ein cooles Wien der Zukunft. Wien, 2022.

MARKVICA, K., MILLONIG, A., HAUFE, N., LEODOLTER, M.: Promoting active mobility behavior by addressing information target groups: The case of Austria. In: Journal of Transport Geography, Vol. 83, pp. 1-13. 2020.

MEA - Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC, 2005. Accessed 10 May 2023: www.maweb.org/documents/document.354.aspx.pdf

NUSSBAUM, M.C.: Creating Capabilities. Harvard University Press, 2013.

RAWLS, J.: A theory of justice. Harvard University Press, Cambridge, 2005.

REINWALD, F.; BERGER, M., STOIK, C.; PLATZER M.; DAMYANOVIC D.: Augmented Reality at the Service of Participatory Urban Planning and Community Informatics – a case study from Vienna. Journal of Community Informatics, Vol. 10, No 3, 1-26; ISSN 1712-4441, 2014.

REINWALD, F., HALUZA, D., PITHA, U., STANGL, R.: Urban Green Infrastructure and Green Open Spaces: An Issue of Social Fairness in Times of COVID-19 Crisis. In: SUSTAINABILITY-BASEL, Vol 13, Issue 19, 10606, pp.Vienna, 2021.

ROWE, G., & FREWER, L. J.: Public Participation Methods: A Framework for Evaluation. Science, Technology, & Human Values, Vol 25, Issue 1, pp. 3–29, 2000.

SCHLOSBERG, D.: Defining environmental justice: Theories, movements, and nature. Oxford University Press, Oxford, New York, 2007.

SCHOßBÖCK, J., RINNERBAUER, B., & PARYCEK, P.: Digitale Bürgerbeteiligung und Elektronische Demokratie. In M. Leitner (Ed.), Digitale Bürgerbeteiligung, Vol. 10, pp. 11–40, Springer, 2018.

TERRAZA, H., ORLANDO, M. B., LAKOVITS, C., LOPES JANIK, V., & KALASHYAN, A.: Handbook for gender-inclusive urban planning and design. © World Bank, Washington, DC, 2020.
http://hdl.handle.net/10986/33197 License: CC BY 3.0 IGO.

TUMMERS, L., DENÈFLE, S., & WANKIEWICZ, H.:Gender mainstreaming and spatial development: Contradictions and challenges. In B. Zibell, D. Damyanovic, & U. Sturm (Eds.), Gendered Approaches to Spatial Development in Europe: Perspectives, Similarities, Differences (1 ed., Vol. 1, pp. 78-98), 2019.
doi:10.4324/9780429503818-7

TUMMERS, L., WANKIEWICZ, H.: Rethinking planning and spatial assessment from a care-perspective. Incorporating diversity of use-patterns in planning instruments. In: REAL CORP 2021 Proceedings/ 202, 2021.

326

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

VIENNA CITY ADMINISTRATION, MUNICIPAL DEPARTMENT 18 (MA 18) -Urban Development and Planning: STEP 2025 - Urban Development Plan Vienna, City of Vienna, 2014.

VERLOO, M., WALBY, S., ARMSTRONG, J., & STRID, S.: QUING – Quality in Gender+ Equality Policies.: Deliverable No.62: Final STRIQ report, 2009.

https://cps.ceu.edu/sites/cps.ceu.edu/files/quing-striq-report-2009.pdf

WANKIEWICZ, H., TUMMERS, L., FESSLER, F.:Time-based solutions for gender just low carbon, sustainable urban transformation. In: REAL CORP 2023 Proceedings, 2023.

ZIBELL, B., DAMYANOVIC, D., STURM, U. (Eds.): Gendered approaches to spatial development in Europe: Perspectives, similarities, differences. Routledge, London, 2020.https://doi.org/10.1007/978-3-658-21621-4_2

Gendersensibles Carsharing – Nutzungsbarrieren und Maßnahmen

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1 ABSTRACT

Carsharing gilt als wichtiger Baustein einer multimodalen nachhaltigen Mobilität und besitzt eine große Bedeutung für die Verkehrswende. Carsharing hat das Potenzial den Gesamtfahrzeugbestand und die Autonutzung zu reduzieren sowie Ressourcen einzusparen. Allerdings wird (E-)Carsharing derzeit von einer recht homogenen, männlich dominierten Nutzerinnen- und Nutzergruppe genutzt und die Systeme sind meist an deren Bedürfnisse angepasst. Mobilität und somit auch Carsharing sind in die bestehende Geschlechterverhältnisse hinsichtlich strukturellen Rollenzuweisungen eingebettet. Beispielsweise legen Frauen im statistischen Durchschnitt gegenüber Männern mehr, aber kürzere Wege und längere Wegeketten zurück – und oftmals weniger Wege aus eigennützigen Gründen. Weiters zeigt sich, dass Frauen seltener einen Pkw, dafür häufiger den Umweltverbund nutzen. Die Schwierigkeiten, mit denen Frauen im Hinblick auf ihre Mobilität konfrontiert sind, machen Carsharing für sie weniger attraktiv bzw. leistbar. Dies führt in weiterer Folge zur zusätzlichen Benachteiligung und Ungleichheit. Diese ergeben sich nicht nur aus dem Geschlecht, sondern aus mehreren Aspekten wie dem Alter (passgenaue Planung für ältere Personen kommt überproportional Frauen zugute), dem Leben mit und ohne Kinder, finanzielle Ressourcen oder kulturelle oder auch milieuspezifische Einflüsse.

Dieser Beitrag setzt sich daher mit genderspezifischen Anwendungs- und (Nicht-)Nutzungsverhalten, Nutzungserfahrungen und Nutzungshemmnisse von verschiedenen E-Carsharing Angeboten in Österreich auseinander. Im Rahmen von Fokusgruppen wurden genderspezifische Nutzungsbedürfnisse eruiert, Verbesserungsmaßnahmen ko-kreativ erarbeitet und Frauen in unterschiedlichen Lebenslagen in den Mittelpunkt des Erkenntnisinteresses gestellt. Die ersten Erkenntnisse aus den Gruppen in Wien und Bregenz werden mit verschiedenen Fokussen als zwei Fallbeispiele dargelegt. Zum einen handelt es sich um Angebotsverbesserungen eines bestehenden Carsharing-Systems in Wien mit flankierenden Veranstaltungen, um mehr Frauen zur Carsharing-Nutzung zu motivieren und zum anderen um die Etablierung von privaten, nicht-kommerziellen Carsharing-Gruppen, um den Bedürfnissen (wie Vertrauen und gegenseitiges Kennen) von Frauen gerecht zu werden.

Keywords: Mobility planning, Focus groups, Co-Creation, Carsharing, Gendersensitive

2 HINTERGRUND UND STATE OF THE ART

Die Genderthematik rückt immer mehr in den Diskurs der Mobilitätsplanung. Gender als soziales Konstrukt geht davon aus, dass Frauen wie auch Männer sich in unterschiedlichen Lebensbedingungen wiederfinden und somit jeweils verschiedene Chancen vorfinden. Ist von Mobilität im Zusammenhang mit Gender die Rede, kommen meist die benachteiligten Mobilitätchancen und Ungleichzeit von Frauen zur Sprache, die der damit verbunden Rollen begründet ist. Dass Frauen vermehrt Versorgungsarbeit (Kindererziehung, Betreuung alter Menschen, Einkäufe erledigen etc.) leisten, in geringerem Ausmaß an Erwerbsarbeit beteiligt sind und in weiterer Folge über geringere finanzielle Ressourcen verfügen (Wetterer 2002), hat auch Einfluss auf ihren Zugang zu Mobilität sowie ihre Ansprüche und Bedürfnisse hinsichtlich Mobilitätsangeboten. Häufig wird die Debatte auf Frauen fokussiert und vernachlässigt weitere Diversitätsdimensionen wie Alter, körperliche Beeinträchtigung, sexuelle Orientierung, Hautfarbe, Nationalität, Religion etc. (Knapp & Wetterer 2007, Bersch & Osswald 2021). Es ist daher wichtig die vielfältigen Lebensrealitäten sowie Rollen und persönliche Bedürfnisse in die Betrachtung mit zu integrieren, was auch zunehmend passiert (Bersch, Osswald 2021)

2.1 Gender und Mobilitätsverhalten

Die soziale Rolle einer Person in der Gesellschaft beeinflusst die Mobilität (Kawgan-Kagan 2015). So ist Mobilität in bestehende Geschlechterverhältnisse (mit den strukturellen Rollenzuweisungen von Versorgungs-, Haus- und Reproduktionsarbeit) der Gesellschaft eingebettet (Knoll & Szalai 2005, Nobis &

Lenz 2005). Obwohl Frauen in den westlichen Gesellschaften, wie die Statistiken zeigen, überwiegend am Arbeitsmarkt teilnehmen (in Österreich Frauen mit 68,1 % gegenüber Männer mit 76,7 % - Erhöhung seit 2011 um 3,1 % bei den Frauen, aber hoher Anteil der Teilzeitarbeit), übernehmen sie nach wie vor eher Haushaltpflichten und kümmern sich um Kinder und (pflegebedürftige) Verwandte (Bundeskanzleramt 2021; Schneebaum & Mader 2013, Dribe & Stanfors 2007). Daher zeigt sich (vor allem im Rahmen von Elternschaft) ein sogenanntes „Gender Mobility Gap": Gründe dafür sind u.a. soziodemografische Aspekte (z.B. geringeres Einkommen durch vermehrte Teilzeitarbeit bei Frauen) und der Verantwortung für Begleit- und Versorgungsaufgaben, die in unterschiedliche weisen Männer und Frauen unterschiedliche Mobilitätsmuster von Männer und Frauen resultieren (Kawagan-Kagan & Popp 2018). In der Litartur werden folgende Aspekt gehäuft gennant:

- Frauen haben im statistischen Durchschnitt gegenüber Männern häufigere, aber kürzere Wege und längere Wegeketten (Gauvin et al. 2022, Kawgan-Kagan & Popp 2018, Nobis & Lenz 2005, McGuckin & Nakamoto 2005).

- Frauen verfügen seltener über einen Pkw. Dafür nutzen sie häufiger den Umweltverbund (Stiewe & Krause 2012, VCÖ 2014), wobei eine gewisse geschlechterspezifische Konvergenz über die letzten Jahrzehnte zu beobachten ist (Konrad 2014).

- Frauen haben gegenüber Männern mehr Versorgungswege und weniger Arbeitswege (VCÖ 2022).

- Wichtige Faktoren für den Besitz eines eigenen Pkws bei Frauen sind Routinen und die Verantwortung für andere (Kinder, ältere Personen) (Kawgan-Kagan & Popp 2018).

- Indirekt hat auch die Umwelteinstellung einen Einfluss auf die Verkehrsmittelwahl: Frauen sind vorallem in städtischen Umgebungen umweltbewusster als Männer (Hinkeldein et al. 2015).

Genderthemen sind aber auch im Verkehrs- und Verkehrsforschungssektor relevant und dieser ist nach wie vor stark von Männern dominiert. Der Frauenanteil beträgt 22 % (BMK Infothek 2020). Diese männliche Dominanz manifestiert sich bis heute im öffentlichen Raum, welcher zugunsten des motoriserten Verkehrs angelegt ist (Hennicke et al 2022).

2.2 Gender und Mobility Sharing – ungleicher Zugang?

Besonders evident wird die Ungleichheit beim Blick auf die Nutzung von Carsharing. Carsharing als Teil der Shared Mobility gilt als wichtiger Baustein einer multimodalen nachhaltigen Mobilität. Ein Carsharing-Fahrzeug kann mehrere private PKWs ersetzen und somit Platz im öffentlichen Raum und Ressourcen einsparen. Ausgehend von kleinen oder elektrisch betriebenen Fahrzeugen, können auch Emissionen reduziert werden (Rid et al 2018).

Unterschiedliche Studien belegen, dass sich die Nutzerinnen und Nutzer diverser (E-)Carsharing-Angebote aktuell auf bestimmte soziodemografische Bevölkerungsgruppen bzw. soziale Milieus konzentrieren und damit den „klassischen" Early Adopter repräsentieren:

- Mehrzahl an männlichen Nutzern (Amirnazmiafshar & Diana 2022, Stadt Wien 2015) – zum Teil starke Unterschiede bei den Raumkategorien. Wobei offen bleibt, ob die Daten lediglich die Mitgliedschaft und nicht wirklich die Nutzung widerspiegeln (Hummer 2019).

- Überdurchschnittliches Bildungsniveau (Amirnazmiafshar & Diana 2022, Hülsmann et al. 2018, Gugg 2015, Stadt Wien 2015)

- Eher jüngere Nutzerinnen und Nutzer (Amirnazmiafshar & Diana 2022) mit Zugang zum Internet (Gugg 2015)

- Kleine Haushaltsgröße (meist 1-2 Personen) (Hülsmann et al. 2018, Gugg 2015, Stadt Wien 2015), minderjährige Kinder im Haushalt abhängig von konkreter Angebotsform, aber durchschnittlich etwa bei einem Drittel oder weniger der Nutzerinnen und Nutzer (Bundesverband CarSharing 2018)

- Keine Kinderbetreuungspflichten (Hülsmann et al. 2018)

- Milieus: Junge-adaptive Milieus, kritisch-kreative Milieus und gehobene Milieus überrepräsentiert (Hülsmann et al. 2018)

- Umweltbewusstsein, Technik- und Innovationsaffinität (Hummer 2019)

Auch beim Einsatz von (E-)Carsharing lassen sich geschlechtsspezifische und räumliche Unterschiede feststellen, beispielsweise in Bezug auf die zurückgelegte Strecke, die Fahrtzeit oder die zeitlichen Nutzungsmuster (Hummer 2019). In urbanen Gebieten nutzen Frauen beispielsweise E-Carsharing eher ab 15 Uhr bis in die Abendstunden, während in ländlichen Gebieten Frauen um 11 Uhr vormittags die höchste Fahrzeugnutzung aufweisen (Hummer 2019). Das resultiert darin, dass die aktiven Nutzer von Free-Floating Carsharing-Systemen überwiegend Männer 70-80 % ausmachen (Amirnazmiafshar & Diana 2022).

2.3 Nutzungshürden und -chancen

In der Literatur zeigen sich verschiedenen Nutzungshemmnisse. Beispielsweise haben ältere Altersgruppen tendenziell eine negative Einstellung gegenüber Carsharing (Gugg 2015). Neben der individuellen Einstellung und dem Festhalten an Gewohnten, spielt auch die tatsächliche Kostentransparenz eine Rolle (Hummer 2019). Die Wahrscheinlichkeit für (E-)Carsharing Nutzung hängt an (Riegler et al. 2016):

- Personeneigenschaften (z.B. Alter, Geschlecht, Mobilitätseinschränkungen, Bildungsabschluss, Führerscheinbesitz)

- Kontext des Haushalts, da Entscheidungen zum Pkw-Besitz und deren Nutzung meistens im Haushaltskontext in Abhängigkeit verschiedener Kriterien getroffen werden

- Angebotsentwicklung (räumlich und strukturell) als wichtige Rahmenbedingung für die Nachfrageentwicklung: Ausbau des Angebots generiert zusätzlich Nachfrage, weshalb es wichtig ist, dass das Angebot passgenau für diverse Nutzerinnen- und Nutzergruppen entwickelt wird.

Entscheidend für die Beitrittsabsicht von Nicht-Nutzerinnen und Nicht-Nutzern ist neben der positiven Einstellung zu Carsharing auch die subjektive Überzeugung, dass Carsharing die eigenen Mobilitätsbedürfnisse abdecken kann, leicht zugänglich ist und im sozialen Umfeld als Mobilitätsform anerkannt wird (Riegler et al. 2016). Kawgan-Kagan & Popp (2018) untersuchten mittels mixed-methods Ansatz (GPS-Tracker, Fragebogen, teilstrukturierte narrative Interviews) das Mobilitätsverhalten von Frauen mit Fokus auf E-Carsharing und fanden einige Nutzungshürden für E-Carsharing. Zum Beispiel die Nicht-Eignung von Carsharing für Familienausflügen und komplexeren Wegeketten, die fehlende Routinen bei wechselnden Fahrzeugtypen, die fehlende Ausstattung für Kinder oder die Distanz zum nächsten Carsharing Auto. Diese decken sich auch mit den in Kapitel 3.2. identifizierten Hürden und Herausforderungen in der Nutzung, welche allerdings noch etwas weiter gefasst werden.

Es wird deutlich, dass derzeitige Angebote verschiedene spezifischen Anforderungen an Mobilität (z.B. von Personen mit komplexen Betreuungspflichten) nicht nachkommen. Trotz einer Relevanz von umweltfreundlicher Fortbewegung wird eine Nutzung des Systems nicht angestrebt, da selbst finanzielle Vorteile die subjektiv erlebten Nachteile nicht ausgleichen (Kawgan-Kagan & Popp 2018). Deswegen ist es essentiell Nutzungshemmnisse noch tiefgehender zu erforschen, sodass eine passende Alternative zum Autobesitz entwickelt werden kann.

2.4 Carsharing-Landschaft in Wien und Bregenz

Da im Rahmen des Forschungsvorhabens die Workshops in Wien und Bregenz stattfanden und Unterschiede auch Einfluss auf die Ausrichtung der nachfolgenden Workshops hatten, wird die Carsharing-Landschaft im Folgenden kurz skizziert.

In der Stadt Wien gibt es zum einen Freefloating-Angebote wie ShareNow und Eloop. Die Fahrzeuge sind im öffentlichen Raum des Stadtgebiets zu finden. Zum anderen existieren stationsbasierte Angebote zum (E-)Carsharing wie u.a. Mo.Point und ÖBB Rail & Drive. Das Angebot wird kontinuierlich ausgebaut – hinzu kommen aktuell 100 stationsbasierte E-Fahrzeuge der Wiener Linien an Mobilitätsknoten (Stadt Wien 2023).

In der Stadt Bregenz bietet ein Betreiber stationsbasiertes (E-)Carsharing. Beim Bahnhof stehen vier Autos von ÖBB Rail & Drive zur Verfügung (ÖBB Rail & Drive 2023). Freefloating-Carsharing gibt es in Bregenz nicht, da dazu das Einzugsgebiet einer Kleinstadt zu klein ist. Der dritte Carsharing-Anbieter ist der als Verein organisierte Maronihof – mit dem Haupteinzugsgebiet von Bewohnerinnen und Bewohnern einer bestimmten Wohnumgebung. Der Maronihof umfasst rund 40 Familien und verfügt über vier sehr unterschiedliche Autos, von denen drei von Privatbesitzerinnen und Privatbesitzern zur Verfügung gestellt

werden. Viele der Userinnen und User des Maronihofs sind Frauen (Quelle: Workshops im Rahmen des Forschungsvorhabens).

3 FORSCHUNGSINTERESSE UND METHODISCHES VORGEHEN

3.1 Ziel des Forschungsvorhabens

Im Forschungsvorhaben „Gendersensibles (E-)Carsharing sollen genderspezifisches Anwendungs- und (Nicht-)Nutzungsverhalten, Nutzungserfahrungen und Nutzungshemmnisse von verschiedenen E-Carsharing Angeboten in Österreich eruiert werden. Das Projekt legt dabei den Fokus auf die potenziellen künftigen Zielgruppen von E-Carsharing, die das Angebot derzeit noch nicht nutzen, aber die grundsätzlichen Voraussetzungen erfüllen, E-Carsharing im Alltag nutzen zu können. In Hinblick auf genderspezifische Nutzungsbedürfnisse sollen Frauen in unterschiedlichen Lebenslagen in den Mittelpunkt des Erkenntnisinteresses rücken. Abgeleitet aus diesen Erkenntnissen werden anschließend gendersensible Maßnahmen für verschiedene (E-)Carsharing Angebote gemeinsam mit (Nicht-)Nutzerinnen, Nicht-(Nutzern), Betreiberinnen und Betreibern entwickelt.

3.2 Methodisches Vorgehen

Im Rahmen des Forschungsprojekts GECAR – Gendersensibles E-Carsharing wurden vom Projektteam in Wien wie auch in Bregenz Co-Creation-Begleitgruppen aufgebaut, die das Forschungsvorhaben die gesamte Projektlaufzeit über im Rahmen von Fokusgruppen-Workshops begleiteten. Hier konnten sie ihr Wissen, ihre Erfahrungen und ihre Ideen hinsichtlich Verbesserungsvorschläge rund ums Thema E-Carsharing einbringen sowie Feedback zu den Angeboten der Projektpartner MO.Point und Maronihof geben. In den letzten Jahren ist ein deutlicher Trend zu beobachten, dass Nutzerinnen und Nutzer verstärkt in Innovationsprozesse im Bereich der (technologischen) Forschung und Entwicklung eingebunden werden. Dieses Potenzial wurde auch in der Wissenschaft erkannt, indem das "versteckte Anwendungswissen" der Nutzerinnen und Nutzer bereits in einer frühen Phase des Innovationsprozesses genutzt wird (Dörrzapf et al 2019, von Hippel, 1986). Unter dem Begriff Co-Creation wird jegliche Form kollektiver Kreativität verstanden, bei der mehr als zwei Personen oder Parteien involviert sind (Sanders and Stappers, 2008). Dieser Co-Creation ist ein grundlegender methodischer Ansatz für dieses Vorhaben.

Die insgesamt drei Begleitgruppen – zwei in Wien und eine in Bregenz – bestanden aus Nutzerinnen und Nicht-Nutzerinnen von E-Carsharing-Angeboten und umfassten Frauen in unterschiedlichen Lebenslagen – mit und ohne Kinder im Haushalt, unterschiedliche Altersgruppen, verschiedene Haushaltsgrößen etc.

Die Akquise der Teilnehmerinnen in Wien erfolgte über das Projektteam in Wien. Es wurden zum einen Interessierte über den Verteiler von MO.Point sowie über Plattformen für Allein- und Getrennterziehende, Sharing-Netzwerke oder auch spezifische Wohnprojekte (Frauenwohnprojekte, fahrradzentriertes Wohnen u. ä.) zur Teilnahme eingeladen. Zum anderen auch Kontakte im persönlichen wie auch privaten Umfeld genutzt, um Teilnehmerinnen zu motivieren. Die Akquise in Bregenz erfolgte über den Kooperationspartner Maronihof und umfasst einerseits Frauen, die bereits das Carsharing des Maronihofs nutzten, andererseits weitere Interessierte, die Erfahrungen mit dem Angebot von Caruso oder auch noch keine Erfahrungen mit (E-)Carsharing hatten. Auffallend war, dass die Rückmeldungen insgesamt sehr gering waren. Trotz persönlicher Ansprache ist es auch nicht gelungen, Frauen mit Migrationserfahrung für die Teilnahme an den Begleitgruppen zu interessieren. Dies lag unter anderem auch daran, dass angefragte Personen z. B. über keinen Führerschein oder in ihren Augen zu wenig Fahrpraxis verfügten.

Die Begleitgruppen umfassten insgesamt 21 Frauen, von denen die jüngste 28 Jahre und die älteste 61 Jahre alt war. Etwas weniger als die Hälfte der Frauen war zwischen 28 und 40 Jahren alt, etwas mehr als die Hälfte zwischen 41 und 61 Jahren. Die meisten Teilnehmerinnen lebten allein oder zu zweit mit Partnerin oder Partner im Haushalt, neun der Frauen lebten mit Kindern unterschiedlichen Alters zusammen. Etwas mehr als die Hälfte der Teilnehmerinnen verfügte über ein eigenes Auto im Haushalt. Von der Teilnahme im Rahmen der GECAR-Begleitgruppen erwarteten sich die Teilnehmerinnen mehr Infos rund um das Thema Carsharing wie auch zu den Hintergründen des Forschungsprojekts. Sie wollten selbst dazu beitragen, fundierte Daten zur Fragestellung und in weiterer Folge bessere Bedingungen für Frauen zu schaffen und waren gespannt auf den Austausch mit den anderen Teilnehmerinnen.

332

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Die Co-Creation Workshops mit den drei Begleitgruppen erfolgten in vier „Runden", zum jetzigen Zeitpunkt haben bereits drei Runden stattgefunden. Die drei bereits erfolgten Workshop-Runden hatten folgende inhaltlichen Schwerpunkte:

1. Runde: Kennenlernen der Teilnehmerinnen untereinander und Erwartungen an die Workshops, Vorstellung des Forschungsprojekts und der Rahmenbedingungen für die Begleitgruppen, Beschäftigung mit den eigenen Mobilitätsbedürfnissen und den bereits gemachten Erfahrungen mit (E-)Carsharing, Registrierung für einen Carsharing-Anbieter für die folgende Phase der Erprobung von E-Carsharing. Zwei Workshops fanden in Wien und einer in Bregenz im Herbst 2022 statt. Im Anschluss an die erste Runde der Workshops waren die Teilnehmerinnen eingeladen, mit einem Guthaben der Kooperationspartner MO.Point und Maronihof bis zum jeweils nächsten Workshop im Zeitraum von ungefähr einem Monat E-Carsharing auszutesten, um sich in der zweiten Workshoprunde über die gesammelten Erfahrungen mit den anderen Teilnehmerinnen auszutauschen.
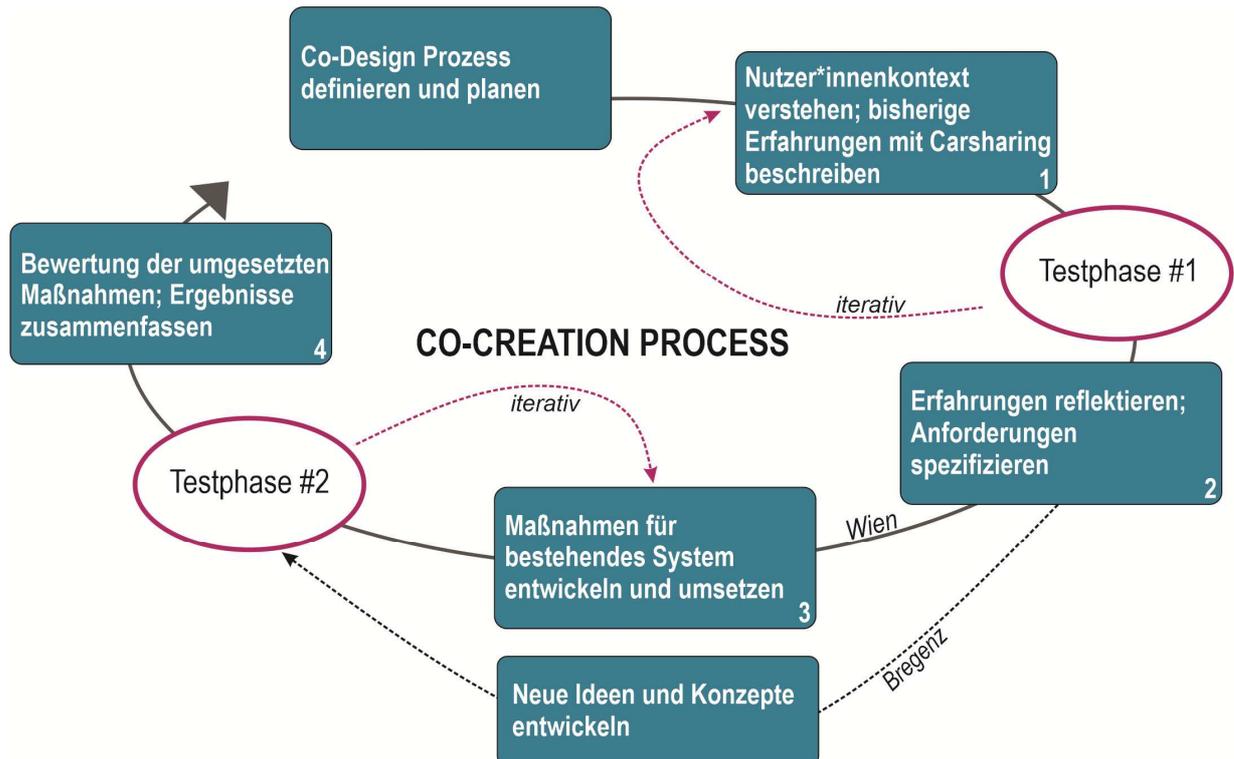
Abbildung 1: Iterativer Co-Designprozess nach ISO 9241-210, eigene Darstellung

2. Runde: Austausch der Erfahrungen mit dem in der Zwischenzeit erprobten E-Carsharing sowie darauf aufbauend die Sammlung von konkreten Ideen für (gendersensible) Verbesserungsvorschläge für das E-Carsharing wie auch zur Frage, wie Carsharing insgesamt für Frauen interessanter (gemacht) werden könnte. Im Winter 2022 fanden zwei Workshops in Wien und einer in Bregenz statt. Die von den Teilnehmerinnen gesammelten Ideen und Verbesserungsvorschläge wurden im nächsten Schritt vom Projektteam thematisch gegliedert, strukturiert und dahingehend bearbeitet, welche im Rahmen des Forschungsprojekts konkret weiterverfolgt werden können und sollen.

3. Runde Fokusgruppen: Die dritte Fokusgruppen-Runde gestaltete sich in den Wiener Begleitgruppen und der Bregenzer Begleitgruppe sehr unterschiedlich. In den beiden Wiener Begleitgruppen wurde zum einen vorgestellt, wie die Inputs und Ideen der Teilnehmerinnen seitens des Projektteams und insbesondere des Sharing-Anbieters MO.Point aufbereitet worden sind, welche Maßnahmen bereits umgesetzt worden sind oder sich gerade in Umsetzung befinden und welche nicht umgesetzt werden können (z. B. da sie nicht im Entscheidungsspielraum des Sharing-Anbieters liegen etc.). Im Anschluss an die beiden Wiener Fokusgruppen gab es eine zweite Testphase, in der die Teilnehmerinnen gebeten wurden, nochmals E-Autos auszuborgen, um in der für Frühherbst anvisierten vierten und letzten Fokusgruppen-Runde nochmals Rückmeldungen zu den Veränderungen zu geben. Da die meisten bereits in der ersten Testphase die ersten Startschwierigkeiten hinter sich gebracht hatten, waren die eingeführten Hilfestellungen meist nicht relevant.

Jedoch wurden einige Maßnahmen (verbesserte Beschilderung, Etui mit Bedienungsanleitungen etc., s. 4.2.) als hilfreich empfunden. In Bregenz hingegeben war die zentrale Erkenntnis nach der zweiten Fokusgruppe, dass das Carsharing des Vereins Maronihofs sehr gut und zur Zufriedenheit aller Teilnehmerinnen funktioniert, so dass kein Veränderungsbedarf gesehen wurde. Da der Maronihof nicht plant zu wachsen, wurden gemeinsam mit der Gruppe erste Überlegungen angestellt, wie Carsharing über den Maronihof hinaus z. B. im privaten Umfeld vorangetrieben werden kann. Die Teilnehmerinnen testeten daher eine bereits existierende Sharing-App hinsichtlich ihrer Tauglichkeit für privates Carsharing. Credo war, dass die existierende App für privates Carsharing nicht übersichtlich ist und eine intuitivere Lösung benötigt wird, die in diesem oder im Folgeprojekt weiter verfolgt werden soll.

4. Runde Fokusgruppen: Die vierte Fokusgruppen-Runde ist für Frühherbst 2023 geplant. Ziel ist es, die umgesetzten Maßnahmen zu reflektieren und Ergebnisse mit den Teilnehmerinnen zusammenzufassen, um einen gemeinsamen Abschluss zu finden.

4 ERGEBNISSE UND MASSNAHMEN AUS DER BEGLEITGRUPPE

Die Fokusgruppen wurden je Runde inhaltsanalytisch ausgewertet und aufbauend auf den Erkenntnissen wurde die jeweils nächste Workshop-Runde konzipiert. Schon in der ersten Workshop-Runde zeigte sich, dass sich die Carsharing-Landschaften in Bregenz und Wien unter anderem aufgrund der unterschiedlichen Größendimensionen – Kleinstadt versus Großstadt – in ihrem Angebot wesentlich voneinander unterscheiden (siehe auch 2.4.).

4.1 Ergebnisse aus den Co-Creation-Workshops

Als strukturierende Momente für die Nutzung von (E-)Carsharing ließen sich sowohl Themen vor der ersten Nutzungserfahrung als auch Themen, die sich erst durch die Registrierung und Nutzung ergaben, ausmachen.

4.1.1 Vorannahmen und Vorwissen rund ums (E-)Carsharing

• Bei den Teilnehmerinnen bestand ein sehr hoher Informationsbedarf rund um Carsharing und das Fahren mit Automatikautos und E-Autos (Was ist stationsbasiertes Carsharing, was freefloating Carsharing? Kann ich mit dem Auto auch über die Stadtgrenze fahren? Wer darf fahren? Wie starte ich das Auto? Wie funktioniert der Scheibenwischer? Wie funktioniert das Laden? Wie lange dauert der Ladevorgang? Etc.). Das Bedürfnis, im Vorhinein über alles ganz genau Bescheid zu wissen, kann als sehr hoch beschrieben werden.

- Ein Großteil der Teilnehmerinnen und vor allem auch diejenigen, die noch keine Erfahrung mit Carsharing hatten, schätzten dieses von der Zugänglichkeit her als sehr kompliziert und sehr zeitaufwändig – in Hinblick auf die Registrierung, den Überblick über die Angebote, die Zahlungsoptionen etc. – ein. Carsharing setzt in ihren Augen Internetaffinität voraus und erfordert einen hohen Grad an Organisation und Planung im Voraus. Von vielen wurde der Wunsch nach persönlicher und niederschwelliger Ansprache, Unterstützung und Einschulung geäußert, da die Nutzungshemmschwelle als sehr hoch empfunden wurde.

- Die Teilnehmerinnen schätzten die (E-)Carsharing-Landschaft vor allem auch in Wien als sehr unübersichtlich ein, so dass die Orientierung und eine Entscheidung schwerfällt oder auch (zu) viel Zeit in Anspruch nimmt. Eine Folge der vergleichsweisen hohen Anzahl an Anbietern in Wien ist eine mangelnde Kostentransparenz und Kostenvergleichbarkeit.

- Allgemein kann die Haltung der Teilnehmerinnen gegenüber Autos in der Stadt als sehr kritisch bezeichnet werden – insbesondere oberirdische Standorte verstellen in ihren Augen den so dringend benötigten öffentlichen Raum. Die Teilnehmerinnen der Begleitgruppen sind bemüht, Autos u. a. aus ökologischen Gründen in ihrem Mobilitätsverhalten so wenig wie möglich zu nutzen. Viele sahen nach den Testphasen in ihrem Alltag nur wenige Situationen, in denen sie tatsächlich ein Auto benötigten – z. B. für größere Einkäufe oder Transporte zu tätigen oder die Brücke Stadt/Land zu überwinden. Auch bei konkreten Überlegungen, ein altes eigenes Auto aufzugeben, wird Carsharing interessant.

4.1.2 Registrierung und Buchung eines (E-)Carsharing-Fahrzeugs

- Bezüglich des Registrierungs- und Validierungsprozesses kamen seitens der Teilnehmerinnen sehr viele Anregungen, von denen wiederum sehr viele von der Wiener Kooperationsfirma MO.Point im Laufe des Prozesses mit den Begleitgruppen umgesetzt worden sind. Ein möglichst einfacher, intuitiver und niederschwelliger Zugang fördert hier die Zugänglichkeit von (E-)Carsharing für Frauen.

- Die Buchung eines (E-)Carsharing-Autos wurde – inklusive Umbuchungen oder Verlängerungen während der Fahrt – vom Großteil der Teilnehmerinnen als einfach, unkompliziert und selbsterklärend erlebt.

4.1.3 Die Bedienung des (E-)Carsharing-Fahrzeugs:

- Die erste Fahrt mit einem E-Carsharing-Auto bedeutete für nicht wenige der Teilnehmerinnen, das erste Mal mit einem Sharing-Auto, das erste Mal mit einem E-Auto und das erste Mal mit einem Automatikauto unterwegs zu sein. Dies stellte einen recht großen Teil der Frauen vor kleinere und größere Herausforderungen. Zwar wurden die Erklärungen in der App, die Schritt für Schritt das Starten und Fahren erklärt, als gut eingestuft, doch nichtsdestotrotz benötigten alle einige Zeit, um sich zu orientieren.

- Auch das Laden von E-Autos stellte viele der Teilnehmerinnen vor Herausforderungen – diese reichten von Schwierigkeiten mit dem Ab- und Anstecken, keine Information, wie lange ein Ladevorgang dauert und wo sich öffentliche Ladestationen finden lassen bis zur Reichweite von E-Autos, die sich bei höherer Geschwindigkeit und Kälte drastisch reduzierte. Es zeigte sich, dass das diesbezügliche allgemeine Wissen zu E-Autos eher vage war und hier auf jeden Fall Informationsbedarf besteht.

- Schließlich gestaltete sich die Rückgabe der E-Carsharing-Autos in vielen Fällen als nicht reibungslos, da es immer wieder zu Fehlermeldungen durch die App kam (z. B. sei die Zündung noch eingeschalten, das Auto sei noch zu laden; gleichzeitig kam aber die Aufforderung das Ladekabel rauszuziehen u. ä.). Die Sorge, dass möglicherweise nicht alles ordnungsgemäß funktioniert hat, stand für einige der Teilnehmerinnen länger im Raum und sorgte für Stress.

- Für die Teilnehmerinnen wäre es sehr wichtig, dass im Rahmen von (E-)Carsharing möglichst viele unterschiedliche Fahrzeugmodelle für eine Bandbreite an unterschiedlichen Bedürfnissen und Anlässen zur Verfügung stehen.

4.1.4 (E-)Carsharing mit Kindern

- Prinzipiell wird Carsharing vor allem für Alleinstehende oder Paare ohne Kinder als interessant eingeschätzt. Wirklich erleichternd und zeitsparend für den komplexen Alltag mit Kindern werden Sharing-Fahrzeuge im Vergleich zu einem eigenen Auto weniger eingeschätzt. Familiengründung war für einige der Teilnehmerinnen der Zeitpunkt, an dem das eigene Mobilitätsverhalten geändert und z. B. ein Auto angeschafft wurde.

- Wichtig für (E-)Carsharing mit Kindern und allgemein für eine unkomplizierte Nutzung ist auf jeden Fall, dass im Rahmen einer Fahrt unterschiedliche erwachsene Personen ein Sharing-Auto lenken dürfen.

4.1.5 (E-)Carsharing-Standorte

- Ein weiterer wesentlicher Aspekt für die Nutzung von (E-)Carsharing stellte für die Teilnehmerinnen die Nähe einer Carsharing-Station zum Wohnort dar. Gab es keinen Standort im näheren Umfeld, wurde das als zentrale Hemmschwelle für die Nutzung von Carsharing benannt. Carsharing muss sich unkompliziert und einfach in den eigenen Tagesablauf integrieren lassen, damit es den Frauen sinnvoll erscheint.

- Carsharing-Stationen in Tiefgaragen wurde von Teilnehmerinnen, vor allem der Wiener Begleitgruppen, immer wieder als etwas schwerer und zeitaufwändiger im Hinblick auf die Zugänglichkeit beschrieben. Der Zugang zur Garage sowie das Auffinden des Fahrzeugs braucht in

den meisten Fällen bei erstmaliger Nutzung etwas Zeit – bei häufigerer Nutzung fällt diese Hürde jedoch weg.

4.2 Abgeleitete Maßnahmen

Nach Abschluss der Testphase 1, die die erstmalige Erprobung der Fahrzeuge umfasste, reichte die Begleitgruppe sowohl mündliches als auch schriftliches Feedback bei dem Projektteam ein. Das Feedback wurde eingehend analysiert und anhand der aufgetretenen Probleme und Herausforderungen in fünf Kategorien klassifiziert:

- Registrierung
- Fahrzeugbetrieb und Nutzungsprozess
- Ladevorgang
- Zutritt und Rückgabe
- Tarife und Zahlung

Kategorie	Messen	Implementierung (begrifflich)	Form der Umsetzung (Begründung)	Status
Registrierung	Anweisungen zum Rabattcode	kurzfristig	FAQs zur Website + Verlinkung im Fahrzeug & App + Info-E-Mail	umgesetzt
	Infos zur Anzahlung	kurzfristig	FAQs zur Website + Verlinkung im Fahrzeug &; App	umgesetzt
	Beachten Sie die nächsten Schritte nach der Registrierung (Guide)	langfristig	Automatisierte E-Mail	Im Gange (Plattformbetreiber)
	Schritt-für-Schritt-Anleitung Registrierung	mittelfristig	Erweiterung &; Aktualisierung der Website	Im Gange (intern)
	andere Zahlungsmittel einführen / aktivieren		(Aus geschäftlichen Gründen nicht erwünscht)	Nicht umsetzbar
Fahrzeugbetrieb/ Nutzungsprozess	Home Garage als Privatadresse festlegen	kurzfristig	Im Fahrzeug	umgesetzt
	Handbuch für den Fahrzeugbetrieb	mittelfristig	Im Fahrzeug als Koffer	umgesetzt
	Video zur Fahrzeugbedienung	-	(Aus Kostengründen)	Nicht umsetzbar
	Details zur Fahrzeugausstattung	kurzfristig	Auf der Website und in der App	Umgesetzt
	Transparente Kommunikation der "15 Minuten vor Buchungsbeginn, die nicht verrechnet werden"	kurzfristig	FAQs auf der Website + Link im Fahrzeug &; App	Umgesetzt
	Markieren Sie das Öffnen des Handschuhfachs	-	(Vom Betreiber nicht gewollt)	nicht umsetzbar
Ladevorgang	Hinweis zu Ladezeiten & Reichweite	kurzfristig	FAQs auf der Website + Link im Fahrzeug &; App + Hinweis im Fahrzeug	umgesetzt
	Anleitung für den Ladevorgang	mittelfristig	Im Fahrzeug als Koffer	umgesetzt
	Ladestationen im Navigationssystem anzeigen	-	(Abhängig vom Fahrzeugmodell, nicht beeinflussbar oder veränderbar)	nicht umsetzbar
Anfahrt & Rückgabe	QR-Codes an Eingängen vergrößern	Langfristig	Berücksichtigen Sie zukünftige Standorte	Im Gange
	in der App bei Parkinfo exakte Lieferung an den Standort in der Garage	kurzfristig	In der App	umgesetzt
	Nutzen Sie den Parkplatz 2 am Standort Schwarzenbergplatz	Kurzfristig	Vor Ort	umgesetzt
	Entfernen von Beschilderungen in Garagen	-	(Kommt auf den Betreiber an, nicht erwünscht)	nicht umsetzbar
Tarife & Bezahlung	Zusätzliche Fahrten für längere Buchungen → Teilen von Fahrten unter Benutzern	Kurzfristig	FAQs auf der Website + Link im Fahrzeug &; App + Newsletter	umgesetzt
	Klare Informationen zur Abrechnung, wie sich die Kosten zusammensetzen	Kurzfristig	FAQs auf der Website + Link im Fahrzeug &; App + Newsletter	umgesetzt

Tabelle 1: Maßnahmen zur Verbesserung des Services

In einem weiteren Schritt wurden den identifizierten Problemen geeignete Maßnahmen zugeordnet. Es ist anzumerken, dass ein erheblicher Teil dieser Maßnahmen von den Teilnehmerinnen der Begleitgruppe stammt. Eine interne Diskussion erfolgte, um die Umsetzbarkeit der Maßnahmen zu bewerten. Anschließend wurden sie in einen zeitlichen Rahmen eingeordnet, um zu bestimmen, ob sie kurz-, mittel- oder langfristig umgesetzt werden können. Maßnahmen, die aufgrund technischer oder betriebswirtschaftlicher Gründe nicht

umgesetzt werden konnten, wurden entsprechend begründet. Das Projektteam legte großen Wert darauf, für jedes Feedback der Teilnehmerinnen eine angemessene Begründung zu geben.

Zusätzlich zur Verbesserung des Carsharing-Angebots von MO.Point wurde in den Workshop-Gruppen auch die Fragestellung "Wie kann die Teilnahme von Frauen am Carsharing erhöht werden?" erörtert. Zahlreiche Vorschläge wurden gemacht und wiederum vom Projektteam in verschiedene Kategorien eingeteilt, darunter Veranstaltungen, Marketing und Goodies.

Durch den systematischen Prozess der Feedback-Einholung von den Teilnehmerinnen und der darauffolgenden Zuordnung von geeigneten Maßnahmen konnten zielgerichtete Verbesserungsmaßnahmen für das Carsharing-Angebot entwickelt werden. Des Weiteren wurden konkrete Maßnahmen erarbeitet, um die Beteiligung von Frauen am Carsharing zu steigern.

Bei der Arbeit an den Maßnahmen zur Verbesserung des Services war es wichtig, Informationen auf verschiedenen Kanälen (Website, App, E-Mail, im Fahrzeug) zu platzieren. Ziel ist es, so viele Menschen wie möglich zu erreichen.

Die entwickelten Maßnahmen zur Überwindung der Hindernisse für die Nutzung von Carsharing und zur gezielten Ansprache von Frauen lauten wie folgt:

- Veranstaltungen: Durch die Durchführung von Veranstaltungen soll das Carsharing-Angebot auf niederschwellige Weise vorgestellt und getestet werden. Idealerweise sollten diese Veranstaltungen an Orten stattfinden, die von Frauen besonders häufig besucht werden. Aufgrund der Standortbeschränkungen von MO.Point wurden bestimmte Rahmenbedingungen festgelegt. Daher wurde der Karmelitermarkt als Veranstaltungsort ausgewählt, an dem im Juni ein Event stattfinden soll. Dabei wird das Thema Carsharing durch interaktive Methoden behandelt.

- Marketing & Information: Die Überwachungsgruppe betonte, dass bei Marketingmaßnahmen darauf geachtet werden sollte, zu komplexe technische Begriffe zu vermeiden und eine einfache und ansprechende Sprache zu verwenden, die bei vielen Frauen besser ankommt. Die Farbgestaltung und Bilder auf potenziellen Plakaten sollten Frauen ansprechen, ohne dabei Klischees zu bedienen. Die Werbung sollte alltägliche Anwendungsfälle zeigen und die Einfachheit des Carsharings hervorheben. Ein aussagekräftiges Statement wäre, dass Carsharing das Leben erleichtert, anstatt es komplizierter zu machen.

- Goodies (in Form von Rabattcodes bei Empfehlungen): Als zusätzliche Maßnahme wurden Goodies in Form von Rabattcodes eingeführt, die beim Teilen des Carsharing-Angebots mit Freundinnen verwendet werden können. Im Workshop wurde deutlich, dass Frauen gerne jemanden dabeihaben möchten, wenn sie Carsharing zum ersten Mal ausprobieren. Dies bietet eine gute Gelegenheit, ihre Erfahrungen mit der Carsharing-Nutzung an andere Frauen weiterzugeben.

5 FAZIT UND AUSBLICK

Im Forschungsvorhaben "Gendersensibles (E-)Carsharing" werden genderspezifisches Anwendungs- und (Nicht-)Nutzungsverhalten, Nutzungserfahrungen und Nutzungshemmnisse von verschiedenen E-Carsharing-Angeboten in Österreich untersucht. Im Hinblick auf die Genderthematik in der Mobilitätsplanung wird darauf hingewiesen, dass Frauen aufgrund ihrer Rollenzuweisungen oft benachteiligte Mobilitätschancen haben. Sie sind vermehrt in Versorgungsarbeit engagiert, haben seltener einen eigenen Pkw und legen häufiger, aber kürzere Wege zurück. Carsharing ist deshalb eine wesentliche Mobilitätsoption, die nutzerinnen- und nutzerfreundlich gestaltet werden muss. Im Rahmen der Co-Creation Begleitgruppe konnten verschiedene Anforderungen identifiziert werden, die sich teilweise mit der Literatur decken. Des Weiteren konnten aber viele neue, detaillierte Einblicke in die Nutzungshürden und -bedürfnisse von Frauen gewonnen werden. Zu nennen sind der hohe Informationsbedarf der Teilnehmerinnen bezüglich Carsharings und dem Fahren mit Automatik- und E-Autos sowie das Bedürfnis den Ausleihprozesse weniger kompliziert und zeitaufwändig zu gestalten. Persönliche Unterstützung und niederschwellige Ansprache spielen ebenso eine Rolle. Abgeleitet von den Bedürfnissen wurden Maßnahmen entwickelt, die allerdings intern nach ihrer Realisierbarkeit und ihrem Zeithorizont priorisiert wurden. Diese Maßnahmen sind noch ein „work in progress". In einer letzten Workshop-Runde werden umgesetzte Maßnahmen mit den Teilnehmerinnen diskutiert und gegebenenfalls weiter geschärft.

Es ist wichtig darüber hinaus, das Wissen und die Erkenntnisse aus diesem Projekt für andere Sharing-Anbieter verfügbar zu machen. Insbesondere im free-floating Bereich als marktstärkster Sharing-Service besteht hinsichtlich ausgewogener Nutzerinnen- und Nutzerzahlen noch Aufholbedarf. Die Berücksichtigung von gendersensiblen Angeboten kommt dabei allen zu Gute: Für Nutzerinnen und Nutzer wird zum einen der gleichberechtigte Zugang zum Mobilitätssystem verbessert und zum anderen aus gesellschaftlicher Sicht die Nutzung nachhaltiger Verkehrslösungen forciert. Auch aus Betreibersicht können dadurch die Nutzerinnen- und Nutzerzahlen von Carsharing erhöht werden, was die Auslastungen und Effizienz der Carsharing-Flotten maßgeblich erhöht. Dennoch ist darauf zu achten, dass nicht zur sehr zwischen männlichen und weiblichen Bedürfnissen unterschieden wird, da schnell die Gefahr besteht in Stereotypen zu denken und klischeehafte Verhaltensweisen anzunehmen. Die Betonung von Gender könnte dazu führen, dass individuelle Unterschiede und Bedürfnisse innerhalb der Geschlechtergruppen vernachlässigt werden. Es ist daher wichtig, dass zum einen Carsharing-Dienstleister nicht nur Geschlechteraspekte berücksichtigen, sondern auch andere Faktoren wie Alter, Einkommen und kulturelle Hintergründe. Zum anderen muss die Forschung weiter Daten zu geschlechtsspezifischen Unterschieden erheben, um fundierte Maßnahmen zu entwickeln zu können.

6 ANMERKUNG

7 REFERENCES

AMIRNAZMIAFSBAR, EHSAN & DIANA, MARCO: A review of the socio-demographic characteristics affecting the demand for different car-sharing operational schemes, Transportation Research Interdisciplinary Perspectives, Volume 14, 2022.

BERSCH, A.-K., OSSWALD, L.: An alle gedacht?! Frauen, Gender, Mobilität - Wie kommen wir aus der Debatte in die Umsetzung? IVP-Discussion Paper, No. 2021 (3), Technische Universität Berlin, Fachgebiet Integrierte Verkehrsplanung, Berlin, 2021.

BMK INFOTHEK: Mind the Gap: Die Zukunft der Mobilität braucht mehr Frauen!, aufgerufen unter: https://infothek.bmk.gv.at/mind-the-gap-die-zukunft-der-mobilitaet-braucht-mehr-frauen/, Stand: 6.6.2023

BUNDESKANZLERAMT: Frauen und Männer in Österreich. Zahlen, Daten, Fakten, Wien, 2021.

BUNDESVERBAND CARSHARING: Entlastungswirkung verschiedener CarSharing-Varianten. CarSharing fact sheet Nr. 7, 2018.

DRIBE, M. & STANFORS, M.: Does Parenthood Strengthen a Traditional Household Division of Labor? Evidence from Sweden, National Council on Family Relations. Journal of Marriage and Family Volume, 71, 1, 33–45, doi: 10.1111/j.1741-3737.2008.00578.x, 2009.

GUGG, G.: Organisation nicht kommerziellen Carsharings. Diplomarbeit, TU Wien, 2015.

GAUVIN, LAETITIA, TIZZONI, MICHELE, PIAGGESI, SIMONE et al.: Gender gaps in urban mobility Humanities ad social science communications 7, 11, 2020, aufgerufen unter: https://www.nature.com/articles/s41599-020-0500-x

HENNICKE, P., KOSKA, T., RASCH, J., REUTTER O., SEIFRIED, D: Nachhaltige Mobilität für alle: Ein Plädoyer für mehr Verkehrsgerechtigkeit, Wuppertal Institut, 2021.

HINKELDEIN, D., SCHOENDUWE, R., GRAFF, A., HOFFMANN, C.: Who Would Use Integrated Sustainable Mobility Services – And Why? Sustainable Urban Transport, 177-203, 2015.

VON HIPPEL, E.: Lead Users: A Source of Novel Product Concepts. Management Science 32, 7, 791–805. 1986.

HÜLSMANN, F., WIEPKING, J., ZIMMER, W.: share – Wissenschaftliche Begleitforschung zu car2go mit batterieelektrischen und konventionellen Fahrzeugen - Forschung zum free-floating Carsharing, Freiburg, 2018.

KAWGAN-KAGAN, I.: Are Women greener than Men? A preference analysis of women and men from major cities in Germany over sustainable urban mobility. Transportation Research Interdisciplinary Perspectives, Volume 8, https://doi.org/10.1016/j.trip.2020.100236, 2020.

KNAPP, G. & WETTERER, A. (Hrsg.) (2007): Achsen der Differenz. Gesellschaftstheorie und feministische Kritik 2. Westfälisches Dampfboot, Münster.

KNOLL, B. & SZALAI, E.: Gender Mainstreaming und Mobilität in Niederösterreich. Schriftenreihe Niederösterreichisches Landesverkehrskonzept, Heft Nr. 22, 2005.

KONRAD, K.: Mobiler Alltag im Wandel des Geschlechterverhältnisses. In: Gather, Matthias; Kagermeier, Andreas; Kesselring, Sven; Lanzendorf, Martin; Lenz, Barbara; Wilde, Mathias (Hrsg.): Studien zur Mobilitäts- und Verkehrsforschung. Wiesbaden: Springer Fachmedien, 2014.

MCGUCKIN, N. & NAKAMOTO, Y.: Differences in Trip-Chaining by Men and Women. In: Conference Proceedings 35: Research on Women's Issues in Transportation. Report of a Conference, Volume 2; Technical Papers, Transportation Research Board of the National Academies, Washington D.C., 49-56., 2005.

338

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

NOBIS C. & LENZ, B.: Gender Differences in Travel Patterns: Role of Employment Status and Household Structure. In Conference Proceedings 35: Research on Women's Issues in Transportation: Report of a Conference; Volume 2: Technical Papers, Transportation Research Board of the National Academies, Washington, D.C., 114–126, 2005.

ÖBB Rail & Drive: Fahrzeugmodelle Bahnhof Bregenz, verfügbar unter: https://www.railanddrive.at/de/Fahrzeugflotte-standorte/Fahrzeugflotte-bregenz, Stand 19.06.2023.

OECD/ITF (International Transport Forum): Gender and Transport. Discussion Paper No. 2011-11. Abrufbar unter: Gender-and-Transport-Discussion-Paper-2011.pdf (transportgenderobservatory.eu), 2011.

RIEGLER, S., JUSCHTEN, M. HÖSSINGER, R., GERIKE, R., RÖSSGER, L. et al: Carsharing 2025 – Nische oder Mainstream? ifmo – Institut für Mobilitätsforschung, 2016.

RIS, W., PARZINGER, G, GRAUSAM, M, MÜLLER, U, HERDTLE, C.: Potenziale von (E-)Carsharing. In: Carsharing in Deutschland. ATZ/MTZ-Fachbuch. Springer Vieweg, Wiesbaden. https://doi.org/10.1007/978-3-658-15906-1_4. 2018.

SANDERS, E.B.-N. AND STAPPERS, P.J.: Co-creation and the new landscapes of design. CoDesign 4, 1, 5–18. 2008

SCHNEEBAUER, A. & MADER, K.: The gendered nature of intra-household decision making in and across Europe. Department of Economics Working Paper Series, 157. WU Vienna University of Economics and Business, Vienna, 2013.

STADT WIEN: Carsharing Wien – Evaluierung, 2015.

STADT WIEN: Carsharing, verfügbar unter: https://www.wien.gv.at/verkehr/kfz/carsharing/, Stand 19.6.2023.

STIEWE, M. & KRAUSE, J.: Geschlechterverhältnisse und Mobilität– Welchen Beitrag leisten Mobilitätserhebungen?, Proceedings REAL CORP 2012 Tagungsband, 14-16 Mai 2012, Schwechat.

VCÖ: Die Mobilität von Frauen ist vielfältiger, VCÖ-Magazin 2022, Wien.

VCÖ: Frauen fahren im Schnitt mehr mit Öffis und weniger mit Auto. Abgerufen unter: http://www.vcoe.at/news/details/vcoe-frauen-fahren-im-schnitt-mehr-mit-oeffis-undweniger-mit-auto, 2014.

Green Buildings as an Accelerator in Climate Change Mitigation and Air Quality Improvement

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1 ABSTRACT

The world is changing quickly in all spheres, including, but not limited to, technology, cities, finances, society, and the environment. Regarding the latter, the prevailing themes or debated subjects have been the ozone layer, air quality, greenhouse gases, and climate change. As a result, there is now an even greater need to address present and potential climate change concerns. These initiatives are essential if society is to contribute to the development of cities and communities that are efficient, interconnected, and sustainable. The advent and evolution of green buildings throughout the 1990s, which saw the creation of the first-ever sustainability standard and rating system for the built environment, were regarded as turning points because they could be embraced as one of the methods employed to control the deteriorating climate and air quality while enhancing our infrastructure. To aid in the development of the nation's infrastructure, South Africa has its rating system known as the Green Star SA through the Green Building Council of South Africa (GBCSA). In addition to looking at how green buildings have been acting as a catalyst in reducing the challenge of the change in climate in the region, this paper will also look at how the overall commercial green building network in Gauteng can help improve the region's air quality, which tends to be on a "moderate" level according to the World Health Organization (WHO). Reviewing present frameworks and legislation concerning climate change, air quality, and green buildings was the strategy, moving from a global to a local level. The research also examines data from 180 case studies of green buildings in the Gauteng region, which were taken from the GBCSA archives. Observations in 4 buildings for 4 months and a building occupant survey in one of the 4 buildings were used to do additional research on the 180 case studies. According to the research findings, the government in the Gauteng region lacks the motivation to establish and enforce green building policies. This is especially evident given that more than 80% of the region's green buildings are built and owned by the private sector. According to the report, green buildings in Gauteng can accelerate efforts to mitigate climate change and improve air quality by using less energy, incorporating renewable energy sources, enhancing interior air quality, and lowering urban heat islands. Green buildings also have a positive socio-economic impact, creating new jobs and skills, promoting diversity and growing the local economy. The benefits of green building cannot be overlooked. Therefore, the study recommends that the Gauteng government review and develop robust policies to increase investment in green buildings.

Keywords: Climate change, green buildings, air quality improvement, greenhouse gases, Gauteng

2 INTRODUCTION

The primary drivers of climate change and poor air quality are several, including human activities such as burning fossil fuels, transportation activities, agriculture and industrial processes. A greater portion of the fossil fuel burnt is for energy production and according to (Ritchie, Roser and Rosado, 2022) buildings are responsible for more than 40% of global energy used, and as much as one-third of global greenhouse gas emissions. The impacts of climate change are quite vast and can have detrimental effects on both our natural systems and human societies ranging from health problems, economic impacts, rising temperatures etc. According to the IPCC (2020), Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by the interaction of „multiple stresses", occurring at various levels and low adaptive capacity. Hence it is not surprising that the challenges stated are not unique to Gauteng as a region and both climate change and air quality have impacted the region and are most likely to worsen in the future, thus there is a need to mitigate the effects caused to help improve the natural systems and lives of the society in the region. The relationship between buildings, climate change and air quality comes about as these buildings lead to the intensification of climate change and poor air quality and the effects they cause. Suzuki (2019) stated that the current rate is which the population is growing, and the expectation for 2050 is

10 billion people, of which 70% will be occupying space in cities. Subsequently, there will be more construction of buildings to accommodate the needs of these people. This does however pose a threat as stated previously in terms of the rise of emissions of greenhouse gases and energy demand from buildings. The problem is that this growth facilitates the acceleration of climate change and poor air quality hence the need to find ways to accommodate the needs of the current without compromising future generations. Indeed, the issue of climate change and air quality is rather complex, requiring a comprehensive approach that includes mitigation (reducing greenhouse gas emissions) and adaptation (building resilient systems & and infrastructures while adapting to change) (Howard-Grenville et al, 2014). The paper will look into how green buildings in the Gauteng region can act as a partial solution to address and accelerate the much-needed change in mitigating climate change and improving poor air quality. He (2019) suggested that green buildings can help by transitioning to renewable energy, promoting energy & and water efficiency, and adopting sustainable practices. hence it is quite important to understand the developed frameworks and policies developed at local, national and global levels about green building, climate change and air quality.

3 CONCEPTUAL SYNOPSIS

The concept of green buildings and its importance in society can be traced back to the early 1990s when the Building Research Establishment (BRE) developed the world's first sustainability standard and rating system/tool for the built environment known as the Building Research Establishment Environmental Assessment Method (BREEAM) (Doan et al, 2017). The development of green buildings internationally can be attributed to the concept of sustainable development in the period of the 1980s-1990s when international conferences were held to address the growing challenges of the society of climate change and global warming. There have been many conferences held to address climate change and air quality but some of the crucial ones which were also key turning points were:

- The 1987 World Commission on Environment and Development (WCED) known as the Brundtland Commission/Report led to the formal and commonly accepted definition of sustainable development (Brundtland, 1987).

- The United Nations Conference on Environment and Development also known as the Rio Earth Summit, or Rio Summit 1992, where member states of the Un cooperated on issues relating to sustainability, suggesting that this was an issue far greater for individual member states to handle which led to another conference in 1997. (Grubb et al, 2019)

- The Kyoto Protocol is an international treaty which came about as an extension of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) committing member states to reduce greenhouse gas emissions due to impacts on global warming. (United Nations Climate Change, 2019)

- COP 27, the reaffirmation of commitment to limit the global temperature to 1.5 degrees Celsius above pre-industrial levels, in particular with Africa announcing the African Alliance for Sustainable Cities and the Built Environment. (ICLEI, 2022)

Frameworks, international treaties, and policies of this nature and those related which couldn't be covered in this scope have popularized the movement of green buildings and the development of other sustainable and building rating tools globally such as the Leadership in Energy and Environmental Design (LEED) by the United States of America Green building council, the Green Star Australia by the Green building council of Australia (Doan et al, 2017). The latter is the one on which the South African Green Building Council (GBCSA) rating system the Green Star SA is based and changed to accommodate various local conditions. According to Zuo and Zhao (2014), green buildings through their design and construction practices would significantly reduce and eliminate greenhouse gases which are the ultimate cause of climate change and poor air quality through sustainable site planning (efficient design), safeguarding water and water efficiency, energy efficiency and use of renewable energy, the conversation of material and resources, and improved indoor environmental quality. Even though there are international frameworks and policies that exist and act as standards from which countries can work, the development of green building varies from country to country due to many aspects such as the advancement of the country, governance, socio-economic level etc. In South Africa, the Green Building Council of South Africa is the organization responsible for advocacy, training and certification which functions through its membership community comprised of government,

342

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private and educational stakeholders. The GBCSA (2021) reported in their integrated annual report that South Africa had around 740 certified Green Star buildings from the start of the organisation in 2009. Furthermore, the South African government through the Department of Public Works developed the Green Building Framework to help accelerate the movement of green buildings in the country especially with government infrastructure with the intent that these buildings will save water, and energy and lessen the emission of greenhouse gas.

4 LOCAL AND INTERNATIONAL EXPERIENCES OF GREEN BUILDINGS DEVELOPMENT

Through case studies, one can gain an understanding and insight into the realistic perspective of the theoretical work. South Africa (Gauteng) is advancing in their efforts to mitigate climate change and improve air quality through green buildings as stated that already over 700 green buildings have been developed however lessons can be learned from different regions in the world to understand their use of green building in curbing the challenge of climate change and poor air quality. To gain a better perspective and overall scope of the work of green buildings a sample of three case studies was randomly selected from Africa, Europe and Asia which represented developing (Africa, Ghana- Accra), transitional (Europe, Poland-Warsaw) and developed (Asia, Singapore-Singapore) economics respectively. The reason behind choosing the capitals is that most of the green building development advances and implementation of policies and frameworks to mitigate climate change occur in those cities. What was common in all these regions and considered pertinent is the issue of reducing energy consumption (greenhouse gases), meeting the international climate targets of the year 2050, and achieving most of the 2030 sustainable development goals (SDGs). From a local stand-point Gauteng as a region can learn and adopt various lessons from these three regions, the case studies showed that well-organized and competent urban governance is essential through the collaboration of the public and private entities to develop and efficient pipeline and implement green building policies that can help improve climate change and air quality. Another lesson was the need to start developing green buildings on a residential level as over 90% of green buildings in regions are from the commercial sector, hence the buy-in of residents is crucial in understanding the implication of climate change and air quality to the livelihoods, hence the sooner they jump onto the green building wagon these could improve their lives, especially from a health and economic stance.

5 METHODS AND MATERIALS

The research work done in the paper aims to give an understanding of how green buildings in the region of Gauteng can accelerate the mitigation of climate change and the improvement of air quality. The topic of climate change, air quality and green buildings is quite broad and requires thorough investigation, so to help prove the hypothesis of the study if indeed green buildings can reduce greenhouse gases which led to climate change and poor air quality factual and reliable data is crucial which can be obtained through quantitative research as this generates factual, reliable outcomes of the data that can be used to generalize larger quantity of the data (Steckler et al, 1992). Furthermore, the qualitative approach will be taken to gain insights from industry experts which can produce rich, in-depth validity on the basis of experience of how green buildings have an impact on accelerating climate change mitigation and building occupants who experience these green buildings on a frequent use basis. For the quantitative part of the study, the data was collected from 180 green building case studies files in Gauteng from the GBCSA archives and analysed through Python & and Google Data Studio for visualization. From the 180 case studies, 4 buildings were chosen for further actual in-person observations and investigation by the research over a period of 4 months wherein a building occupant survey was conducted through the BUS Occupant methodology in one of the buildings with 55 participants and yielded results of both quantitative & qualitative nature. For the qualitative part of the research 10 industry experts were interviewed through a semi-structured interview via Zoom and Microsft Teams, then analysed through the transcription software Otter which helped identify themes and topics within the conversations. The reason behind the use of semi-structured interviews assisted with open-ended data, explore the participants' thoughts, feelings and beliefs and help delve into their personal ideologies of climate change, air quality and green buildings (DeJonckheere and Vaughn, 2019). This was quite crucial as climate change as a topic has had critics in terms of whether we are really close to reaching the global warming levels of 1.5 degrees Celsius or not.

6 FINDINGS

This section of the paper discusses the findings and results of the hypothesis of green buildings acting as an accelerator in climate change mitigation and air quality improvement. These findings and results outlined here will help give an understanding of the general outlook of green buildings in Gauteng from the 180 case studies sample, furthermore, two aspects of how green buildings can contribute to combating climate change and air quality are energy efficiency & and renewable energy integration and water conversation. The challenges encountered by the green building movement for climate change and air quality improvement will be explored to give a more in-depth understanding of the topic.

6.1 Green buildings in the region of Gauteng, South Africa

The hotspots for green building development in South Africa are the Western Cape, Kwazulu-Natal and Gauteng with the latter being a leader in terms of the number of certified commercial green buildings in the country. The research discovered that a large portion of green buildings developed in Gauteng is concentrated in the City of Johannesburg, particularly in the Northern Subrburb of Sandton City. The reason behind this was the fact that Sandton is the economic hub of the country which houses many international and local corporations as well as the Johannesburg Stock Exchange. From the interviews industry experts indicated that such corporations are seeking the use of green buildings as a way to align with their environment, social and governance strategies. Some industry experts criticised the reasons why developers and investors build green buildings as just a way to just tick box exercises to meet environmental regulations such as carbon tax emissions and keep regulators and the government away. Regardless of what the motive might be at the moment, it becomes less important as these green buildings are contributing to the change in the climate and air quality. From the research, it was recorded that of the 180 case studies more than 80% were developed by the private sector regardless of whether the government is an investor in the GBCSA and even a custodian of the Green Building Framework and Policy. In the next section of the paper, two main topics are covered which relate to water and energy conservation and efficiency techniques and how they were implemented in the 180 case studies while further looking at how they help mitigate climate change and poor air.

6.2 Adoption of Water Conservation and Efficiency Techniques

Conversations with regard to water in green buildings are related to water efficiency in the planned management of water to prevent wastage, overuse and exploitation of this precious resource. It should be understood however that water efficiency and conservation shouldn't be achieved at the expense of building occupants not using water comfortably. Well-designed green buildings are key in achieving water efficiency while still providing comfort to occupants, In one of the 4 buildings observed it was noted that the particular green building could conserve $0.3m^3$ of water usage per annum as compared to a non-green star sa certified building. The Green Star SA awards points of certification out of 10 categories depending on the key features and category that particular green building focused on. The word cloud in (Figure 1), was extracted from the results of the 180 case studies, indicating that water was a key category for green building developers in the Gauteng region. Such just alludes to the fact that great efforts and measures are emphasized in terms of water conservation and efficiency techniques within the majority of the green buildings.
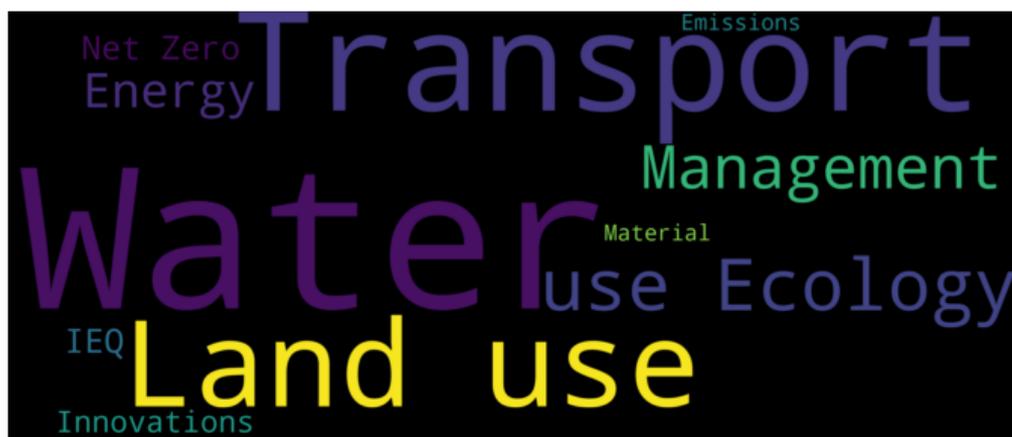
Fig. 1: Green Star SA category ranking on of 180 case studies. (Source: Author, 2021)

344

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It is thus important to understand the measures that are deployed in green buildings for water conservation and efficiency as it is clear that it is an important and crucial category to measure the certification of green buildings. The first way is through water recycling and repurposing measures, the second is through water-efficient plumbing features and the last by irrigation and landscaping measures.

6.2.1 Water recycling and repurposing measures in Gauteng green buildings

The three ways in which green buildings in Gauteng have been adopted can either be any of these three methods, greywater harvesting, rainwater harvesting and blackwater system treatment, but of the three the latter is a rare and unique case which was notably deployed on one building due to being expensive in terms of operations. The rainwater and greywater are harvested from the rain through different channels on the rooftops of buildings and taken to the rainwater tank, while the greywater is harvested from showers, bathroom basins and other sources of this form. Once the greywater has gone through the treatment and filtration process it is usually stored in tanks located in the basements of buildings and supplemented with the harvested rainwater, which then will be used for WCs, urinal flushings and irrigation systems.

6.2.2 Water-efficient plumbing fixtures

Industry experts noted that the reason why the water category could be the leading category would highly be because of this particular feature of green buildings as it is the cheapest of all conservation techniques and strategies, which is low-flow plumbing from installation, operations and maintenance cost.

Fig. 2: Ultra-Low Flow plumbing fixtures (Source: Author, 2021)

All green-certified buildings will generally deploy low-flow fixtures and supplement them with either rainwater or greywater harvesting systems depending on the financial capability of the developer, these efficient water fitting as in Figure 2 reduce the use of potable water. Through the study, the paper found that a building with a rating of 6 Stars of the Green Star SA managed to save 0.52L/day/m2 of water.

6.2.3 Irrigation and Landscaping Measures

Landscape irrigation is another part of the building that consumes large amounts of water, which is why it is very important to reduce the amount of potable water used there. One of the green buildings from the case studies indicated that they could reduce 90% of potable water used for landscape irrigation, and this was achieved in collaboration with processed grey and rainwater to water the plants rather than using potable water.

6.2.4 Water Management Practices, Climate Change and Air Quality

The understanding is that by reducing water demand and promoting conservation, green buildings help address water scarcity issues exacerbated by climate change. It is without a doubt that water conservation and efficiency is a key performance category in the measurability of green buildings due to it being quantifiable in how it can save water usage and then recorded with the building's management systems

which are relevant for the developer and owners from an economic stance as they tend to save on utility bills in a long term run. Therefore the use of water management practices as a feature of green buildings can directly impact the conservation of water resources, enhance resilience to drought and aid sustainable water usage in a changing climate. These techniques can further indirectly help improve air quality and can help minimise water-related pollutants and air pollution from wastewater treatment processes.

6.3 Renewable energy integration, energy efficiency and greenhouse gas emission mitigation

There are various techniques, methods and technologies that have been developed to achieve energy efficiency and reduction of greenhouse gas emissions such as the use of solar energy. Green buildings will tend to incorporate measures such as solar energy to attain their status of being a sustainable building. Investigation into these techniques is crucial in understanding how they help curb climate change and improve air quality, and which in particular have been implemented in green buildings around the Gauteng region.

Notional Bldg	Discovery Sandton	Reduction %
38 059 177.00	18 004 741.00	53

DISCOVERY Energy Target
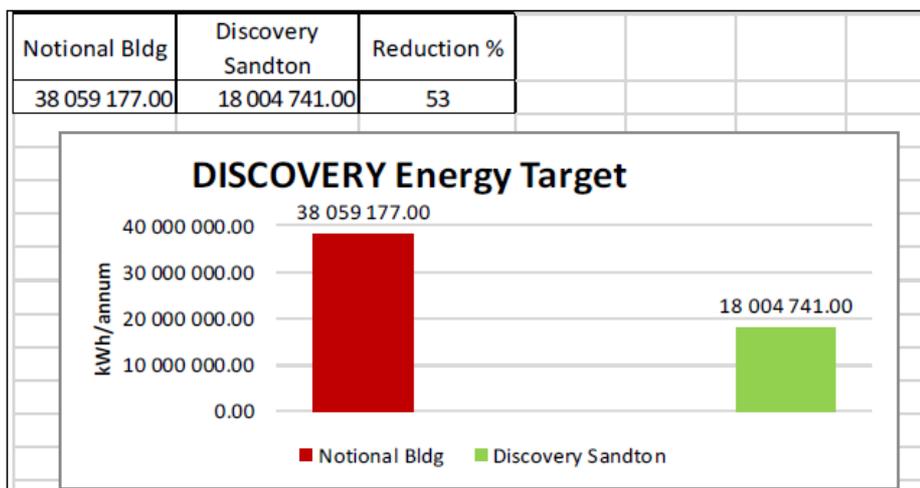
Fig. 3: Projected annual energy consumption (kWh/annum) for Discovery Limited (Source: Discovery Limited, 2017)

(Figure 3) has projected the annual consumption of energy for one of the four green buildings evaluated in the region where the building manager indicated that their energy target was 53% less compared to a SANS 10400 non-certified building (Notional building). It is quite clear that green buildings have the capability of saving and conserving energy which part is what is being investigated through the direct and indirect techniques developed.

6.3.1   Direct energy-saving and greenhouse gas emission reduction techniques

These kinds of techniques and strategies are built-in within green buildings, which includes either technology installed to help conserve energy such as smart lights or through methods adopted in the design and construction of the building. There are quite a few of these measures which include but are not limited to sustainable construction, efficient lighting & and occupancy sensors, HVAC systems & and smart metering, a passive design, solar energy etc. For the purposes of this research paper, only the latter two will be discussed in-depth. Sustainable construction is building through the use of renewable and recyclable materials while minimising water and energy while making sure the waste products is also minimal as the harnessing of the building material such as tree further worsens climate change. Efficient lighting and occupancy sensor requires the cooperation of building occupants through their behaviours.

In (figure 4) a green building that incorporated the passive design approach of saving energy is seen. Passive design is wherein the buildings' architectural features take advantage of local climatic resources to provide an indoor environment that is as comfortable as possible while saving energy that would have been used to provide the indoor environment quality. Through the industry experts, it was noted that the most favoured method in energy conserving and saving strategies was the passive design and more than 60% of the 180 case studies used this method due to the low cost involved in construction and maintenance. Furthermore, the consultant who worked to design the green building in (figure 4) stated that the vertical panels shift with the direction of the sunlight. What these panels help with is daylight harvesting which allows the natural light to be infused into the building thus reducing the need for excessive artificial light and heat from the HVAC.

The building evaluation survey of the 55 occupants of this building does indeed substantiate this notion. The section on occupants' overall temperature comfortability indicates that their working condition was fairly good due to the proper passive design in supplication of the HVAC system.

Fig. 4: High-performance facades (Source: Author, 2021)

Fig. 5: Side view of Photovoltaic solar panels (Source: GLH Architects, 2011)

The building in (figure 5) was the first building to be awarded 6 Stars Green Star SA certification in Africa, which recognizes world leadership standards and the highest rating a building can obtain through the Green Star SA rating system. This building not only achieved this feat but achieved a status for net-positive ecology and net-zero carbon. Essentially this is the certification of projects that go beyond the partial reductions recognized in the current GBCSA tools and have taken the initiative to reach the endpoint of completely neutralizing or positively redressing their impacts (GBCSA, 2017). For this building, the net positive ecology was in recognition of the increasing pilot-level 1: site ecology - brownfield site, while the net zero carbon was a result of the hybrid use of the passive design method discussed previously and the renewable solar energy technology (figure 5). The building has 292 solar photovoltaic panels which deliver 230kWh of energy to the building, the building manager stated that this was more than double what the building required to function at full capacity, and the excess energy produced was fed back into the rest of the buildings of this company's campus.

6.3.2 Indirect energy-saving and greenhouse gas emission reduction techniques

The previous section discussed direct energy conservation methods applied in the construction and functioning of green buildings, the industry experts indicated that green buildings shouldn't be viewed from a segmented view as they are but rather from a holistic approach. Yudelson (2009) cited that green building forms part of an eco-system in the development of sustainable cities and communities hence the understanding of the external factor that in-directly affects green buildings can't be ignored. The reason why these methods are important is that they are particularly linked to the reduction and curbing of greenhouse gases which directly affect climate change and air quality. The location of where a green building is

developed is one of the in-direct strategies as we need to understand if this has an ecological impact on the environment, the other is transportation activities around the green building and how building occupants commute to these green buildings which is the strategy to be discussed. Transport is one of the categories 10 categories used in the Green Star SA rating tool as can be seen in (figure 1) hence the need to discuss it, and due to the fact that a white paper by the South African National Climate Change Response Policy identified that the transport sector is a significant contributor to greenhouses gases, the paper said the transport industry accounted for 70% of energy use and 38% of the region's emissions.

Fig. 6: Bicycle and Electric car charging stations (Source: Author, 2021)

The images in (figure 6) were initiatives from one green building that recognized that there is a need to involve the building occupants in building a sustainable community mitigating climate change and improving air quality by reducing greenhouse gases emitted by the vehicles used by occupants. The building manager indicated that only 10% of the occupants used electric vehicles and would use the facilities hence they provide bicycle stations as well for those occupants who can't afford electric vehicles, while for occupants who didn't have both electric vehicles or are farther away from the building and couldn't use bicycles carpooling was suggested as a way to reduce the vehicles on site.

6.3.3   Energy management practices, climate change and air quality

The use of energy-efficient designs and integration of renewable energy sources in green buildings around Gauteng was highlighted clearly. South Africa is still very reliant on the use of fossil fuels for energy sources but yet they still have challenges in this sector as can be seen through the load-shedding problem the country is facing. The various green buildings showed that the incorporation of efficient energy design such as passive design can help reduce the energy required to power and sustain buildings and harness renewable energy sources like the solar system adopted in one building which was able to produce surplus energy. Then thinking of a greater scale if all buildings were on this scale of green buildings it would definitely have an impact not only in the reduction of greenhouse gas emissions and meeting the goals of the country but also in providing an opportunity to reduce the energy challenges of the country.

6.4 Challenges in the Development of green buildings in Gauteng

The growing pressures of mitigating climate change and improving air quality to make sure that the global warming level doesn't reach 1.5 degrees Celsius have pushed South Africa to be one of the key players in green buildings as they try and adopt these buildings as a means to mitigate these challenges. The certification of over 740 buildings is a clear indication of the commitment to these efforts. As stated previously Gauteng is the top hot spot for green buildings and the largest contributing city in terms of greenhouse gas emissions. In sections 6.2 and 6.3, the paper outlined the benefits of green buildings and how they can mitigate climate change and improve air quality in Gauteng there are however challenges in the development and movement of green buildings that shouldn't be ignored as they can hinder their widespread adoption. The capital costs involved in green building development are quite high compared to building using conventional methods, in other instances, it might be operational costs which can be a problem. In one of the buildings investigated the building manager said that the cost of running the greywater system was

quite high and not viable to the point where it was turned off and not operational as the benefits could only be seen in the long term. Another issue is the lack of awareness from both the public and industry professionals which can be attributed to not being informed or not having the willingness to change from conventional ways of doing things. The industry experts indicated that the practice of implementing green buildings as a rating and tick box exercise was present in many property owners or developers as they just wanted to meet the minimum required standards but didn't have any ambitions to be innovative and implement different ways of building green which meets international standards. Last but not least was the implementation of the objectives within the various frameworks and policies developed in South Africa, it can be noted that such was affected by political challenges and a lack of stakeholder engagement in the development of green buildings

7 CONCLUSIONS AND RECOMMENDATIONS

Through the research, we came to understand that buildings generally consume a substantial amount of water and energy which directly influences water scarcity and the emission of greenhouse gases in the region of Gauteng. These resources in turn directly influence the contribution to climate change levels and poor air quality if not handled appropriately. Hence the hypothesis of the research was to investigate if green buildings had a positive impact by acting as an accelerator in climate change mitigation and air quality improvement within the region of Gauteng, South Africa. After careful investigation of both quantitative and qualitative findings and results, the hypothesis of the paper is correct in that green buildings if implemented at a large scale can act as a catalyst in climate change mitigation and improvement of air quality in Gauteng, South Africa. The recommendation would be an investment from the public sector (government) is quite crucial as the responsibility for the development of infrastructure in the region of Gauteng is primary for them to the society, this can even be explored from a public-private partnership where lessons can be learned from the private sector on how they have managed to achieve building more than 600 green building in just over 13 years in South Africa. Additional elaboration on the advice on methods that could inspire the public sector to invest more in green building development includes but is not limited to, the following. The formation of public-private partnerships would aid in the sharing of resources, expertise, and risk, as well as in finding a balance between sustainability and affordability through careful planning, inventive thinking, and a readiness to adapt and learn.

8 REFERENCES

Brundtland, G.H., Khalid, M., Agnelli, S., Al-Athel, S.A., Chidzero, B.J.N.Y., Fadika, L.M., Hauff, V., Lang, I., Ma, S., Botero, M.M.D. and Singh, N., 1987. Our common future; by World Commission on environment and development.

DeJonckheere, M. and Vaughn, L.M., 2019. Semistructured interviewing in primary care research: a balance of relationship and rigour. Family medicine and community health, 7(2).

Doan, D.T., Ghaffarianhoseini, A., Naismith, N., Zhang, T., Ghaffarianhoseini, A. and Tookey, J., 2017. A critical comparison of green building rating systems. Building and Environment, 123, pp.243-260.

GBCSA. (2019). Net Zero | GBCSA. [online] Available at: https://gbcsa.org.za/certify/green-star-sa/net-zero/.

GBCSA. (2021). Green Building Council South Africa. [online] Available at: https://gbcsa.org.za/.

Grubb, M., Koch, M., Thomson, K., Sullivan, F. and Munson, A., 2019. The'Earth Summit'Agreements: A Guide and Assessment: An Analysis of the Rio'92 UN Conference on Environment and Development (Vol. 9). Routledge.

He, B.J., Zhao, D.X., Zhu, J., Darko, A. and Gou, Z.H., 2018. Promoting and implementing urban sustainability in China: An integration of sustainable initiatives at different urban scales. Habitat International, 82, pp.83-93.

Howard-Grenville, J., Buckle, S.J., Hoskins, B.J. and George, G., 2014. Climate change and management. Academy of Management Journal, 57(3), pp.615-623.

ICLEI, (2022). Highlights of Urban Africa in Action at COP27 | ICLEI Africa. [online] Available at: https://africa.iclei.org/highlights-of-urban-africa-in-action-at-cop27/ [Accessed 29 May. 2023].

IPCC (2020). 9.2.1.5 Sensitivity/vulnerability of settlements and infrastructure - AR4 WGII Chapter 9: Africa. [online] Available at: https://archive.ipcc.ch/publications_and_data/ar4/wg2/en/ch9s9-2-1-5.html#9 2-2 [Accessed 29 May. 2023].

Ritchie, H., Roser, M. and Rosado, P., 2022. Energy. Our world in data.

Steckler A, McLeroy KR, Goodman RM, Bird ST, McGormick L. Toward integrating qualitative and quantitative methods, An introduction. Health Educ Q. 1992;19:1–18.

Suzuki, E., 2019. World's population will continue to grow and will reach nearly 10 billion by 2050. World Bank Blogs.

United Nations Climate Change (2019). What is the Kyoto Protocol? [online] UNFCCC. Available at: https://unfccc.int/kyoto_protocol.

www.gov.za. (n.d.). National Climate Change Response White Paper | South African Government. [online] Available at: https://www.gov.za/documents/national-climate-change-response-white-paper.

Yudelson, J., 2009. Green Building Through Integrated Design (GreenSource Books). McGraw-Hill Education.

Zuo, J. and Zhao, Z.Y., 2014. Green building research–current status and future agenda: A review. Renewable and sustainable energy reviews, 30, pp.271-281.

Harnessing Crowdsourcing Data for Comprehensive Green Window View Analysis

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1 ABSTRACT

The paradigm of sustainable resilient cities underscores the importance of how to withstand and rapidly recover from natural disasters, pandemics, or chronic stresses associated with increasing urbanization, environmental degradation, and climate change through the use of advanced technologies and data analytics. Access to urban green spaces is a key requirement for developing and maintaining a sustainable, resilient, and healthy city, as described in Sustainable Development Goal 11.7 and the Sendai Framework. Due to necessary triple inner urban development processes that creates multifunctional spaces in urban areas, the resulting vertical and horizontal densification often leads to an impairment of visual access to urban green spaces. Green window views, which reveal visual access to green spaces from buildings, provide a significant impact on multidimensional aspects of urban dwellers. Still, few studies present how this form of access, in its quantitative and qualitative complexity, should be operationalized into a tool for urban planning. Given socio-technical advances, crowdsourcing, as an increasingly popular participatory method for collecting and managing data, has the potential to contribute to the realization of inclusive planning by incorporating passive and active participatory processes and open-source standards. Therefore, this study aims to integrate key aspects of crowdsourced-based approach and window view accessibility analysis. By leveraging the power of crowdsourcing, we investigate the potential of Volunteered Window View Imagery (VWVI) for green window view analysis. Incorporating VWVI enables informed decisions by urban planners, ensuring resilient, inclusive, and accessible urban green spaces. This integration of VGI and window view analysis advances sustainable and resilient urban development.

Keywords: sustainable resilient cities, urban green spaces, crowdsourcing, spatial planning, visibility analysis

2 INTRODUCTION

Owing to their multiple ecosystem services to urban populations, planning and ensuring high quality and accessible urban green spaces are crucial for a sustainable and resilient city, as SDG 11.7 requires (Semeraro et al., 2021; United Nations, 2017). In addition to the availability (number, size, and ratio) and accessibility (distance, travel time, and buffer zones), visibility gains a key role in ensuring accessible urban green spaces due to spatial and access consequences of natural disasters like floods or pandemics on the urban space and the urban population (Amerio et al., 2020; Hobeica & Hobeica, 2018; Labib et al., 2021; Yin et al., 2023). Additionally, increasing urbanization and the implementation of necessary triple inner urban development processes, which focus not only on built-up redensification but also on the planning of mobility offers and the increase of urban green spaces quantity and quality, lead to two- and three-dimensional changes of urban space and thus to a changed visual access to urban green spaces (Haaland & Konijnendijk van den Bosch, 2015; Umweltbundesamt, 2022). In order to meet these challenges and to guarantee a sufficiently accessible provision of urban green spaces, it is necessary to measure, evaluate, and investiagte the status quo situation as well as planned scenarios of built-up and urban green spaces. For this purpose, smart approaches, such as the use of digital twins or big data, are increasingly being used to gain the necessary insights (Farkas et al., 2023). In the digital era, leveraging alternative data sources like social sensing, crowdsourcing, and Volunteered Geographic Information (VGI) can enhance data capabilities. Accessing near-real-time geospatial information can lead to better-informed decisions, driving innovation in geospatial technology, improving the quality and applicability of spatial data, overcoming institutional barriers, and strengthening community resilience through enhanced access to geospatial information services (FIG, 2019; UNISDR, 2017; World Bank, 2020).

In this paper, recognizable limitations in the use of these approaches in the quantification of visible access will be addressed by the presentation of an integrated framework that leverages the power of crowdsourcing for visibility analysis of urban green spaces (Lei et al., 2023). The paper first presents the research context of visible urban green spaces and crowdsourcing including their methodologiocal state of the art as well as

challenges and research gaps and links both research areas into an integrated approach for using crowdsourcing to collect and evaluate Volunteered Window View Imagery (VWVI). The paper concludes with an outlook for planning practice and research.

3 RESEARCH CONTEXT

3.1 Visibility of Urban Green Spaces

The visibility of urban green spaces can be understood as the visible connection between the urban dweller and urban vegetated areas (adapted from Wang et al. (2017)). Depending on the location of the observer, the observation level can be on the street (street view) or in the building (window view) (Bolte et al., 2019). Streets are primarily publicly accessible and can therefore be used by the general public, whereas in the case of buildings a distinction needs to be made between publicly accessible and usable (such as schools, and hospitals) or privately accessible and used (e.g. residential buildings or workplaces). In both access cases, the visibility of urban green spaces matters. The exemplary studies in Fig. 1 serve to illustrate the complex research field of visibility analysis of urban green spaces.
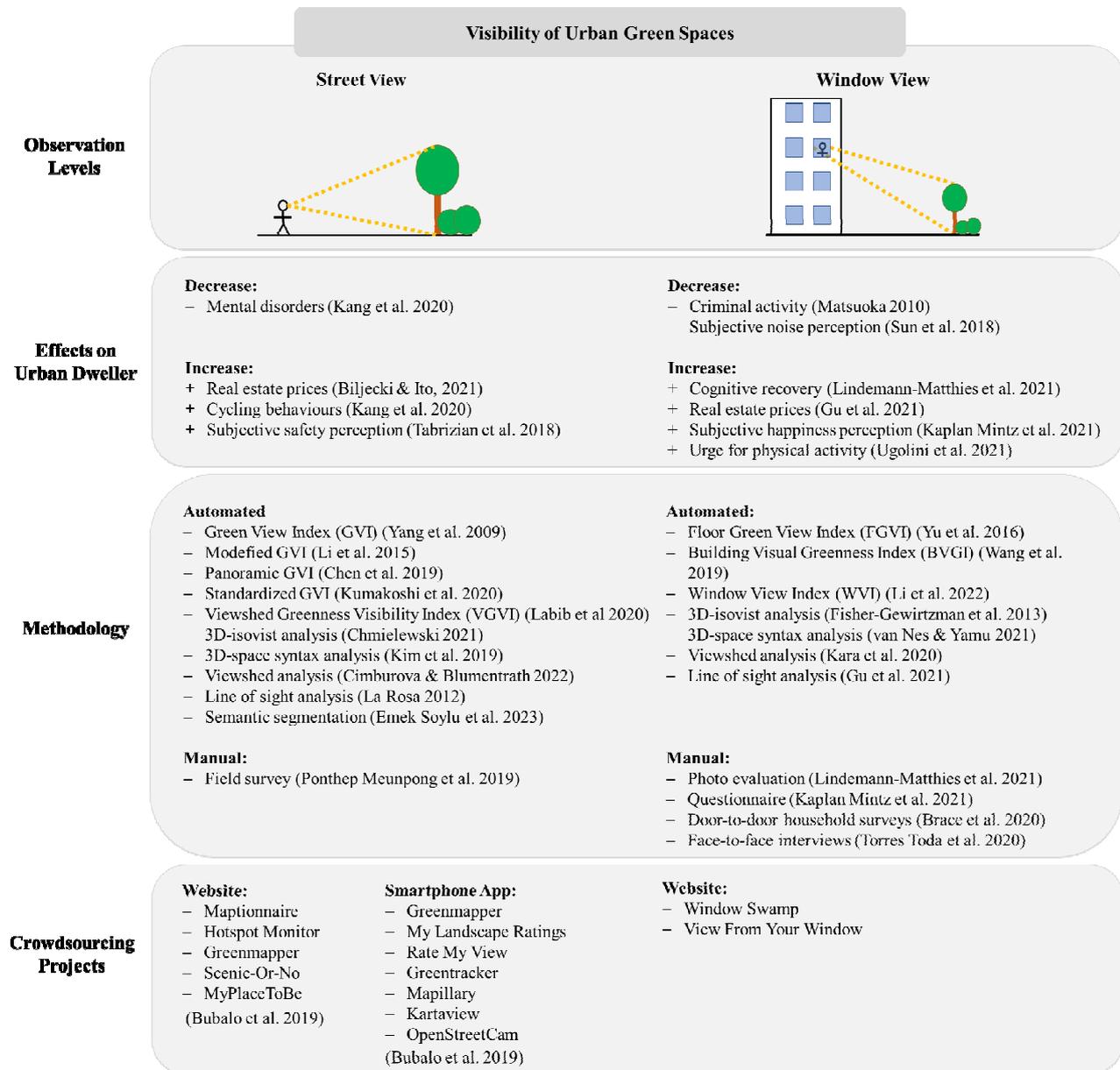
Fig. 1: Visibility of urban green spaces. Source: Own illustration.

3.1.1 Multidimensional Effects on Urban Dweller

Independent of the level of observation, the view of urban green spaces has significant positive effects on urban dwellers. Effect areas concerning the psyche or cognitive recovery as well as the subjective noise, and safety perception, for example are positively influenced (Kang et al., 2020; Kaplan Mintz et al., 2021; Lindemann-Matthies et al., 2021; Sun et al., 2018; Tabrizian et al., 2018). The view of green spaces leads to an increase in physical activity or in real estate values and to a decrease in criminal activity (Biljecki & Ito, 2021; Gu et al., 2021; Kang et al., 2020; Matsuoka, 2010; Ugolini et al., 2021). The consequently illustrated relevance for the integration of visibility analysis into planning practice includes street planning as well as building planning.

3.1.2 Methodology to Measure Quantity and Quality of Visible Urban Green Spaces

A variety of automated or manual methods can be applied by now in order to measure the quantity and quality of visible urban green spaces (Brace et al., 2020; Chen et al., 2019; Chmielewski, 2021; Cimburova & Blumentrath, 2022; Emek Soylu et al., 2023; Fisher-Gewirtzman et al., 2013; Gu et al., 2021; Kaplan Mintz et al., 2021; Kara et al., 2020; KIM et al., 2019; Kumakoshi et al., 2020; La Rosa, 2012; Labib et al., 2020; M. Li et al., 2022; X. Li et al., 2015; Lindemann-Matthies et al., 2021; Ponthep Meunpong et al., 2019; Torres Toda et al., 2020; van Nes & Yamu, 2021; Wang et al., 2019; Yang et al., 2009; Yu et al., 2016). The majority of automated indices to quantify urban green spaces on the street level rely on semantic segmentation of Street View Imagery (SVI), in which Google Street View® plays a key role as data provider (Biljecki & Ito, 2021; Chen et al., 2019; Emek Soylu et al., 2023; Kumakoshi et al., 2020; X. Li et al., 2015; Yang et al., 2009). For window view quantification, the majority of automated approaches are based on three-dimensional environment modeling and use viewshed analyses or line of sight analyses(Gu et al., 2021; Kara et al., 2020; Wang et al., 2019; Yu et al., 2016). Concerning manual quantification approaches to investigate window views, there is a noticeable focus on surveying the inhabitants or users of buildings. Especially these manual approaches are also used for the assessment of window views (Brace et al., 2020; Kaplan Mintz et al., 2021; Lindemann-Matthies et al., 2021; Torres Toda et al., 2020).

3.2 Crowdsourcing and Voluneteered Geographic Information (VGI)

The rapid progress in geospatial technologies, fueled by emerging data sources such as Digital Twins, Web 2.0, mobile communications, volunteer crowdsourcing, digital volunteering, georeferencing, and geotagging, has led to profound changes in urban studies. These advancements have prompted urban initiatives to reevaluate their core principles and approaches. By harnessing the power of these technological capabilities, urban initiatives can proactively reshape planning and practices. However, this requires embracing the potential of these technologies to adapt and effectively respond to evolving challenges, thereby optimizing the overall resilience and sustainability of urban areas for a livable city (Goodchild, 2007; Haworth & Bruce, 2015; Porto de Albuquerque et al., 2021).

Over a decade ago, VGI was defined by Goodchild (2007) as the utilization of tools to voluntarily create, compile, and distribute geographic data contributed by individuals. Since then, the landscape of VGI activities has expanded, encompassing a wide range of contributions such as online crowdsourced mapping and location-related posts on social media. This, coupled with the advent of digital transformation, has transformed the acquisition and provision of geospatial data, significantly impacting established authoritative systems and fostering new avenues of public engagement through voluntary contributions (Fernandes et al., 2020; Foody et al., 2017). Noteworthy attributes of VGI include its ability to capture the temporal dynamics of spatial information, enabling multidirectional communication, enhancing situational awareness, and harnessing collective intelligence, potentially surpassing the capabilities of traditional geospatial datasets (Haworth et al., 2018; Kankanamge et al., 2019).

Hence, incorporating VGI into sustainable green space initiatives offers numerous advantages. It not only helps bridge the data gap in geospatial information related to green spaces by involving volunteers in the collaborative creation, curation, and dissemination of free, up-to-date, and near-real-time geospatial data (Givoni, 2016; Solís et al., 2021), but also fosters self-organization within the digital volunteer network. This empowers remote citizens and volunteers to actively contribute their technical expertise, local knowledge, and on-site insights to enhance sustainable green space initiatives (Capineri et al., 2016; Johnson & Sieber, 2013). Furthermore, leveraging these collaborative data ecosystems can promote the accessibility of

geospatial information and associated techno-social tools for all individuals, while also facilitating the development of innovative customized tools that contribute to assess visibility and accessibility of green spaces (Arsanjani et al., 2015).

3.2.1 Existing Cowdsourcing Projects for Quantifying and Assessing Visible Urban Green Spaces

The integration of the mentioned potentials and strengths of crowdsoucing and VGI is mainly considered in the street view analysis (see Fig. 1, p.2). A plurality of projects focus on the collection of Volunteered Street View Imagery (VSVI), view locations, and view ratings and are operated through websites or smartphone apps (Bubalo et al., 2019; Hou & Biljecki, 2022; Mahabir et al., 2020; Qiu et al., 2023). The existing number of different projects initiates the quality check of data and information in terms of subjectivity and objectivity, as well as the comparison of applications, complementing the investigation of individual visibility effects at the street level with VSVI (Hou & Biljecki, 2022; Mahabir et al., 2020; Qiu et al., 2023). Considering crowdsourcing for window views, VWVI is collected via websites or on request in a blog forum and presented with further information about the location and time of VWVI. The artistic focus of both projects, with no discernible claim to research utility, is unifying.

4 UTILIZAZING CROWDSOURCING IN WINDOW VIEW ANALYSIS

4.1 Information Bundling from Volunteered Window View Imagery (VWVI)

Despite the wide range of multidimensional effect areas of visible urban green spaces, the low level of integration of crowdsourcing to quantify and evaluate window views so far highlights the need to design an appropriate crowdsourcing application to benefit from a broad and comparable VWGI basis for research and planning pracise. By collecting VWVI, detailed information that was previously collected separately by automated or manual methodologies in window view analysis can be bundled together while maintaining consistent and transparent data resolution and quality. The information concerns the a) observer, b) location, c) environment, and d) window view (see Fig. 2.). They are explained in more detail below and are based on the insights of the studies mentioned in Fig. 1., p. 2:
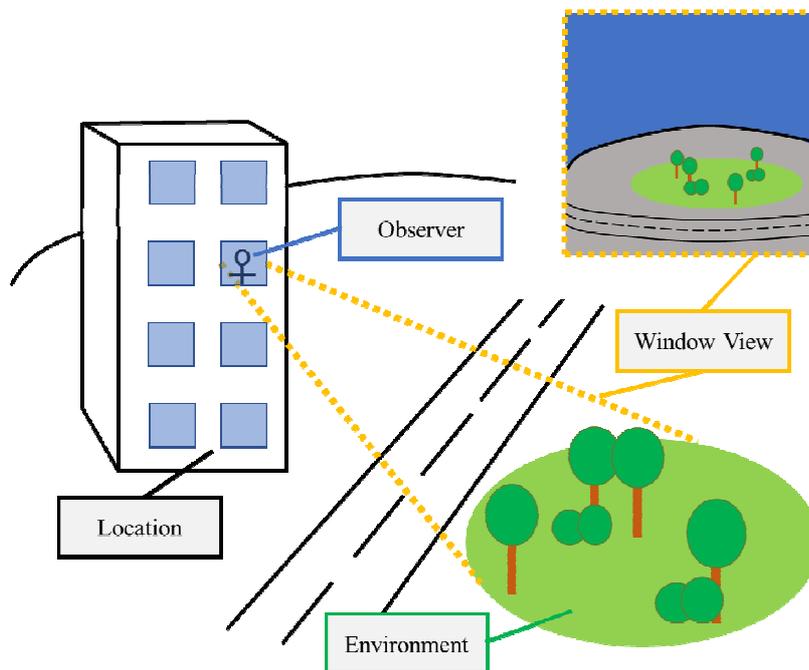
Fig. 2: Information bundling from VWVI. Source: Own illustration.

4.1.1 Observer

The observer can be characterized in terms of age, gender, occupation and/or reason for staying in the building (Brace et al., 2020; Gu et al., 2021; Kaplan Mintz et al., 2021; Lindemann-Matthies et al., 2021; Matsuoka, 2010; Sun et al., 2018; Torres Toda et al., 2020; Ugolini et al., 2021).

354

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4.1.2 Location

The location can be described spatially and functionally: This includes the geographical localization and information concerning the building, such as the floor number where the observer is standing, as well as the observer's position in the room and their distance to the window. The primary function of the building should not be mistaken for the occupation or the observers's reason for staying, since different functions can be performed in the same building (e.g. hospital: work of the nurse and recovery of the patient) (Brace et al., 2020; Fisher-Gewirtzman et al., 2013; Gu et al., 2021, 2021; Kaplan Mintz et al., 2021; Kara et al., 2020; M. Li et al., 2022; Lindemann-Matthies et al., 2021; Matsuoka, 2010; Sun et al., 2018; Torres Toda et al., 2020; Ugolini et al., 2021; van Nes & Yamu, 2021; Wang et al., 2019; Yu et al., 2016).

4.1.3 Environment

The environment is described by the characteristics of the topography as well as the type, phenological characteristics, shape, and height of the urban green area and the distance of the area to the location (Brace et al., 2020; Fisher-Gewirtzman et al., 2013; Gu et al., 2021, 2021; Kaplan Mintz et al., 2021; Kara et al., 2020; M. Li et al., 2022; Lindemann-Matthies et al., 2021; Matsuoka, 2010; Sun et al., 2018; Torres Toda et al., 2020; Ugolini et al., 2021; van Nes & Yamu, 2021; Wang et al., 2019; Yu et al., 2016).

4.1.4 Window View

The window view is first described technically. This includes the window size, the observer's personal field of view (FOV), the window's direction and the time. Information on the quantity and quality of the window view describes the amount and type of visible targets in the view. Reduced visibility due to smog or weather conditions may also fall under this category. In addition to vegetated areas, other elements such as, sky or built-up as well as sealed structures could also be mentioned. Furthermore, the observer's personal assessment of the window view's content as well as their multidimensional effects on him need to be adressed (Brace et al., 2020; Fisher-Gewirtzman et al., 2013; Gu et al., 2021, 2021; Kaplan Mintz et al., 2021; Kara et al., 2020; M. Li et al., 2022; Lindemann-Matthies et al., 2021; Matsuoka, 2010; Sun et al., 2018; Torres Toda et al., 2020; Ugolini et al., 2021; van Nes & Yamu, 2021; Wang et al., 2019; Yu et al., 2016).

4.2 Key Aspects of Utilizing Crowdsourcing and VGI

Adapted from Moghadas et al. (2022) core crowdsourcing and VGI aspects related to visibility analysis of urban green spaces were identified as below (see Fig. 3 for an overview):
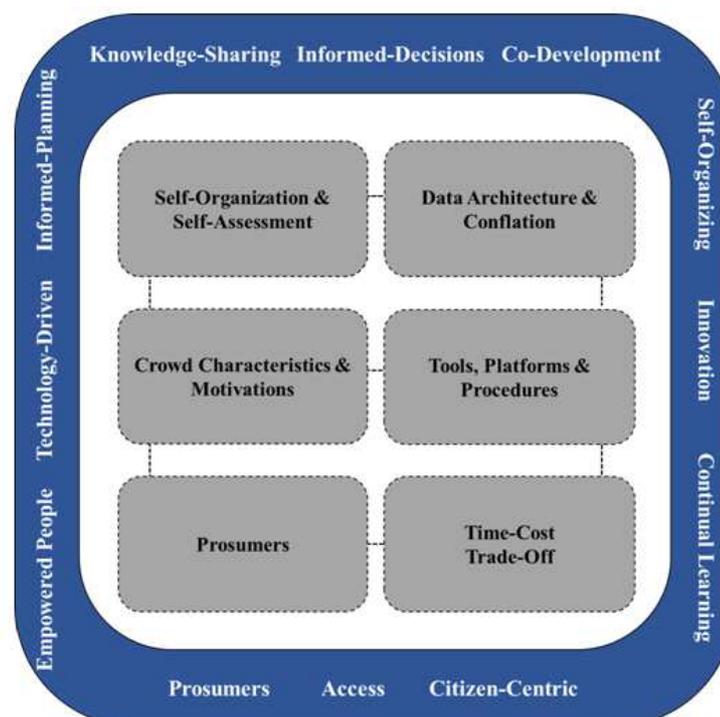
Fig. 3: Key aspects of utilizing crowdsourcning and VGI for assessment of urban green spcae visibility. Source: Own illustration.

4.2.1 Self-Organization and Self-Assessment

The potential for self-organization and self-assessment becomes evident within VGI-based communities through the active engagement of citizens, community-led organizations, and digital technologies that promote e-participation (Malek et al., 2021). Self-organization, which involves internal reorganization and increased self-awareness, enables innovative problem-solving based on collective intelligence (Palen et al., 2020). Community platforms like OSM, Mapathons, and Missing Maps serve as channels through which local communities and remote volunteers collaborate in collecting, validating, analyzing, and sharing information, thereby fostering a people-centric approach to humanitarian efforts (Givoni, 2016).

4.2.2 Crowd Characteristics and Motivations

Within the realm of visibility of green spaces, VGI platforms can engage participants with diverse levels of expertise, experience, and responsibilities (Coleman et al., 2010). Motivations for contributing to crowdsourcing and VGI initiatives also vary, ranging from positive and altruistic motivations like social recognition, personal reputation, professional interest, community connection, and skill development (Elwood et al., 2012), to potential detrimental contributions such as the spread of misinformation or mass deletions (Coleman et al., 2010). Understanding the characteristics of the crowd and formulating effective motivational strategies play a crucial role in shaping the outcomes of VGI initiatives focused on assessing the visibility of green spaces (Senaratne et al., 2017). Since the nature of a crowd can be relative, it is essential to identify contribution patterns, types, and roles within the initiative's goals and roadmap at an early stage (Yan et al., 2020).

4.2.3 Prosumers

Prosumers, individuals who actively engage as both producers and consumers (Rifkin, 2015), have emerged as key contributors in assessing the visibility of green spaces. Enabled by VGI platforms and associated processes, citizens and remote volunteers can participate as prosumers, generating geospatial content that specifically addresses the assessment of green space visibility based on their own needs and community requirements. By bringing together prosumers, collaborative production and utilization of geospatial data for assessing green space visibility becomes possible. This empowers real-time access to information and minimizes duplication of effort, optimizing the use of resources (Yan et al., 2020) in the pursuit of assessing and enhancing visibility and accessibility of green spaces.

4.2.4 Data Architecture and Conflation

Data architecture plays a vital role in governing the standardized processes of data collection, analysis, and utilization within organizations (Steiniger et al., 2016). To effectively analyze the visibility of green spaces using VGI, it is essential for researchers to adopt a systematic approach that guides contributors in creating, curating, and analyzing relevant data. Establishing practical guidelines for data architecture, considering the potential absence of standardized metadata in VGI, is crucial to ensure a comprehensive understanding of green space visibility. VGI, as a socially constructed epistemology, encompasses distinct labor, reference, and governance relationships that should be treated independently (Sieber & Haklay, 2015). It serves as a valuable complement to authoritative datasets in analyzing the visibility of green spaces, addressing challenges such as cost, outdated information, and restrictive licenses (Grinberger et al., 2019). By incorporating VGI into a formalized data collection and collaboration process, initiatives can meet specific requirements, including real-time updates, additional attribute information, community engagement, and cost-effectiveness (FIG, 2019). Embracing hybrid epistemologies and data conflation processes, integrating VGI into the analysis of green space visibility, offers significant opportunities for data-driven decision-making (Yan et al., 2020). This shift enables the effective utilization of VGI alongside authoritative data, empowering stakeholders with valuable insights to assess and enhance the visibility of green spaces in a meaningful and impactful way.

4.2.5 Tools, Platforms, and Procedures

Location-based and GPS-based services, such as maps, social media apps, and tracking tools, offer valuable support in assessing the visibility of green spaces (Mooney & Minghini, 2017). By collecting user data and providing actionable information through map interfaces, these services aid in evaluating and the visibility of green spaces. Volunteer-driven methods, including OSM, WikiMapia, and Geo-Wiki, along with smartphone

356

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

apps enable the collection and sharing of geospatial data (Haworth & Bruce, 2015; Moreri et al., 2018). These tools empower citizens to contribute to the assessment of green space visibility, improving the availability and accuracy of information. Urban dashboards or urban digital twin platforms can serve as centralized platforms to aggregate various data sources, such as social sensing, facilitating real-time visibility assessment and promoting transparency and efficiency (Moghadas et al., 2023). To ensure effective assessment of green space visibility, practices like organizing community mapping events (Mapathons) and employing planning checklists, workflows, and data catalogs are crucial (Givoni, 2016). These practices enable the contextualization of visibility assessment initiatives based on specific goals, local values, and community needs.

4.2.6   Time-Cost Trade-Offs

In the realm of assessing green space visibility, the power of modern communication technologies allows individuals known as prosumers to share their location-based knowledge, goods, and services at reduced costs (Rifkin, 2015). VGI plays a pivotal role in this context, enabling the rapid and cost-effective sharing of diverse geographic information (Haworth & Bruce, 2015) related to green spaces. By engaging digital and on-site volunteers, internet-based platforms facilitate the real-time collection and dissemination of large volumes of geospatial data, contributing to better assessment of green space visibility (Moreri et al., 2018). These advancements, including crowdsourcing, digital volunteering, and mobile communications, empower dynamic monitoring and multidirectional communication, driving advancements in green space visibility assessments beyond traditional and costly methods (Pan et al., 2016).

5   OUTLOOK AND CONCLUSION

To cope with sudden shocks and chronic stresses that change the visual access to required urban green spaces, advanced technologies and data analytics must be used to ensure sustainable and resilient urban planning. The increasing popularity and importance of crowdsourcing as a participatory method for data collection and management is indispensable for the realization of inclusive urban planning. The introduced approach, which integrates crowdsourcing into window view analysis, effectively addresses these issues and presents the current state of the art. It not only identifies the research gaps in visibility analysis and crowdsourcing but also emphasizes the multifaceted potentials for an integrated planning application. Future research will focus on exploring concrete technical implementation possibilities to facilitate a comprehensive collection of Volunteered Window View Imagery (VWVI) to derive planning recommendations for planning buildings of private and public purposes and to strengthen both research and practical planning purposes. By utilizing crowdsourced data, consequently, planners gain insights into the visibility of green spaces from various vantage points, enabling them to make informed decisions about land use and development. Moreover, this approach aligns with the goal of designing accessible and livable spaces, promoting inclusive planning that considers the needs of diverse communities. The insights derived from crowdsourced data facilitate the creation of urban environments that positively impact residents' well-being. Moreover, the integration of crowdsourcing in urban planning strategies, such as the Urban Green Space Network, allows for smart growth and development. Planners can strategically connect green spaces, considering their visibility and accessibility, thus optimizing land usage and fostering sustainable urban expansion. In this way, crowdsourced window view data not only enriches urban planning processes but also contributes substantially to the evaluation of land suitability and its potential for enhancing the overall urban experience.

6   REFERENCES

Amerio, A., Brambilla, A., Morganti, A., Aguglia, A., Bianchi, D., Santi, F., Costantini, L., Odone, A., Costanza, A., Signorelli, C., Serafini, G., Amore, M., & Capolongo, S. (2020). COVID-19 Lockdown: Housing Built Environment's Effects on Mental Health. International Journal of Environmental Research and Public Health, 17(16), 5973–5982. https://doi.org/10.3390/ijerph17165973

Arsanjani, J. J., Zipf, A., Mooney, P., & Helbich, M. (2015). OpenStreetMap in GIScience Experiences, Research, and Applications. http://www.springer.com/gb/book/9783319142791

Biljecki, F., & Ito, K. (2021). Street view imagery in urban analytics and GIS: A review. Landscape and Urban Planning, 215, 104217:1-104217:20. https://doi.org/10.1016/j.landurbplan.2021.104217

Bolte, A.-M., Kötter, T., & Schuppe, S. (2019). Can you see green or blue? On the necessity of visibility analysis of urban open spaces using Remote Sensing techniques and Geographic Information Systems. 2019 Joint Urban Remote Sensing Event (JURSE), 1–4. https://doi.org/10.1109/JURSE.2019.8808936

Brace, O., Garrido-Cumbrera, M., Foley, R., Correa-Fernandez, J., Suarez-Caceres, G., & Lafortezza, R. (2020). Is a View of Green Spaces from Home Associated with a Lower Risk of Anxiety and Depression? INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH, 17(19). https://doi.org/10.3390/ijerph17197014

Bubalo, M., van Zanten, B. T., & Verburg, P. H. (2019). Crowdsourcing geo-information on landscape perceptions and preferences: A review. Landscape and Urban Planning, 184(April 2019), 101–111. https://doi.org/10.1016/j.landurbplan.2019.01.001

Capineri, C., Haklay, M., Huang, H., Antoniou, V., Kettunen, J., Ostermann, F., & Purves, R. (2016). European Handbook of Crowdsourced Geographic Information. Ubiquity Press. http://dx.doi. org/10.5334/bax

Chen, X., Meng, Q., Hu, D., Zhang, L., & Yang, J. (2019). Evaluating Greenery around Streets Using Baidu Panoramic Street View Images and the Panoramic Green View Index. Forests, 10(12), 1109. https://doi.org/10.3390/f10121109

Chmielewski, S. (2021). Towards Managing Visual Pollution: A 3D Isovist and Voxel Approach to Advertisement Billboard Visual Impact Assessment. ISPRS International Journal of Geo-Information, 10(10), 1–19. https://doi.org/10.3390/ijgi10100656

Cimburova, Z., & Blumentrath, S. (2022). Viewshed-based modelling of visual exposure to urban greenery – An efficient GIS tool for practical planning applications. Landscape and Urban Planning, 222(June 2022), 1–11. https://doi.org/10.1016/j.landurbplan.2022.104395

Coleman, D. J., Sabone, B., & Nkhwanana, N. J. (2010). Volunteering geographic information to authoritative databases: Linking contributor motivations to program characteristics. Geomatica, 64(1), 383–396. https://doi.org/10.5623/geomat-2010-0004

Elwood, S., Goodchild, M. F., & Sui, D. Z. (2012). Researching Volunteered Geographic Information: Spatial Data, Geographic Research, and New Social Practice. Annals of the Association of American Geographers, 102(3), 571–590. https://doi.org/10.1080/00045608.2011.595657

Emek Soylu, B., Guzel, M. S., Bostanci, G. E., Ekinci, F., Asuroglu, T., & Acici, K. (2023). Deep-Learning-Based Approaches for Semantic Segmentation of Natural Scene Images: A Review. Electronics, 12(12), 1–49.

Farkas, J. Z., Hoyk, E., de Morais, M. B., & Csomós, G. (2023). A systematic review of urban green space research over the last 30 years: A bibliometric analysis. Heliyon, 9(2), 1–14. https://doi.org/10.1016/j.heliyon.2023.e13406

Fernandes, V. O., Elias, E. N., & Zipf, A. (2020). INTEGRATION OF AUTHORITATIVE AND VOLUNTEERED GEOGRAPHIC INFORMATION FOR UPDATING URBAN MAPPING: CHALLENGES AND POTENTIALS. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLIII-B4-2020, 261–268. https://doi.org/10.5194/isprs-archives-XLIII-B4-2020-261-2020

FIG (Ed.). (2019). New Trends in Geospatial Information: The Land Surveyors Role in the Era of Crowdsourcing and VGI: Current State and Practices Within the Land Surveying, Mapping and Geo-Science Communities.

Fisher-Gewirtzman, D., Shashkov, A., & Doytsher, Y. (2013). Voxel based volumetric visibility analysis of urban environments. Survey Review, 45(333), 451–461. https://doi.org/10.1179/1752270613Y.0000000059

Foody, G., See, L., Fritz, S., Mooney, P., Olteanu-Raimond, A. M., Fonte, C. C., & Antoniou, V. (2017). Mapping and the Citizen Sensor. In Mapping and the Citizen Sensor (pp. 1–12).

Givoni, M. (2016). Between micro mappers and missing maps: Digital humanitarianism and the politics of material participation in disaster response. Environment and Planning D: Society and Space, 34(6), 1025–1043. https://doi.org/10.1177/0263775816652899

Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. GeoJournal, 69(November), 211–221. https://doi.org/10.1007/s10708-007-9111-y

Grinberger, A. Y., Schott, M., Raifer, M., Troilo, R., & Zipf, A. (2019). The Institutional Contexts of Volunteered Geographic Information Production: A Quantitative Exploration of OpenStreetMap Data. Proceedings of the "Geographical and Cultural Aspects of Geo-Information: Issues and Solutions," 4–9.

Gu, J., Wang, X., & Liu, G. (2021). Rediscovering the amenity value of urban landscapes in the mountainous areas with high-rise buildings from the perspective of 3D vertical urban systems. Urban Forestry & Urban Greening, 60, 127018:1-. https://doi.org/10.1016/j.ufug.2021.127018

Haaland, C., & Konijnendijk van den Bosch, C. (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. Urban Forestry & Urban Greening, 14(4), 760–771. https://doi.org/10.1016/j.ufug.2015.07.009

Haworth, B., & Bruce, E. (2015). A Review of Volunteered Geographic Information for Disaster Management. Geography Compass, 9(5), 237–250. https://doi.org/10.1111/gec3.12213

Haworth, Bb., Bruce, E., Whittaker, J., & Read, R. R. (2018). The Good, the Bad, and the Uncertain: Contributions of Volunteered Geographic Information to Community Disaster Resilience. Frontiers in Earth Science, 6, 1–15. https://doi.org/10.3389/feart.2018.00183

Hobeica, L., & Hobeica, A. (2018). Flood-prone urban parks: Linking flood adaptation and risk awareness. Territorium, 25(2), 143–160. https://doi.org/10.14195/1647-7723_25-2_12

Hou, Y., & Biljecki, F. (2022). A comprehensive framework for evaluating the quality of street view imagery. International Journal of Applied Earth Observation and Geoinformation, 115(December 2022), 1–15. https://doi.org/10.1016/j.jag.2022.103094

Johnson, P. A., & Sieber, R. E. (2013). Situating the Adoption of VGI by Government. In Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice (pp. 65–81).

Kang, Y., Zhang, F., Gao, S., Lin, H., & Liu, Y. (2020). A review of urban physical environment sensing using street view imagery in public health studies. Annals of GIS, 26(3), 261–275. https://doi.org/10.1080/19475683.2020.1791954

Kankanamge, N., Yigitcanlar, T., Goonetilleke, A., & Kamruzzaman, M. (2019). Can volunteer crowdsourcing reduce disaster risk? A systematic review of the literature. International Journal of Disaster Risk Reduction, 35(February), 101097. https://doi.org/10.1016/j.ijdrr.2019.101097

Kaplan Mintz, K., Ayalon, O., Nathan, O., & Eshet, T. (2021). See or Be? Contact with nature and well-being during COVID-19 lockdown. Journal of Environmental Psychology, 78, 101714:1-101714:13. https://doi.org/10.1016/j.jenvp.2021.101714

358

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
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Kara, A., van Oosterom, P., Çağdaş, V., Işıkdağ, Ü., & Lemmen, C. (2020). 3 Dimensional data research for property valuation in the context of the LADM Valuation Information Model. Land Use Policy, 98, 104179:1-104179:1. https://doi.org/10.1016/j.landusepol.2019.104179

KIM, G., KIM, A., & KIM, Y. (2019). A new 3D space syntax metric based on 3D isovist capture in urban space using remote sensing technology. Computers, Environment and Urban Systems, 74(March 2019), 74–87. https://doi.org/10.1016/j.compenvurbsys.2018.11.009

Kumakoshi, Y., Chan, S. Y., Koizumi, H., Li, X., & Yoshimura, Y. (2020). Standardized Green View Index and Quantification of Different Metrics of Urban Green Vegetation. Sustainability, 12(18), 7434. https://doi.org/10.3390/su12187434

La Rosa, D. (2012). The observed landscape: Map of visible landscape values in the province of Enna (Italy). Journal of Maps, 7(1), 291–303. https://doi.org/10.4113/jom.2011.1183

Labib, S. M., Huck, J. J., & Lindley, S. (2020). Modelling and mapping eye-level greenness visibility exposure using multi-source data at high spatial resolutions. Science of The Total Environment, 755(1), 1–14. https://doi.org/10.1016/j.scitotenv.2020.143050

Labib, S. M., Lindley, S., & Huck, J. J. (2021). Estimating multiple greenspace exposure types and their associations with neighbourhood premature mortality: A socioecological study. Science of The Total Environment, 789(147919), 1–14. https://doi.org/10.1016/j.scitotenv.2021.147919

Lei, B., Janssen, P., Stoter, J., & Biljecki, F. (2023). Challenges of urban digital twins: A systematic review and a Delphi expert survey. Automation in Construction, 147(March 2023), 1–15. https://doi.org/10.1016/j.autcon.2022.104716

Li, M., Xue, F., Wu, Y., & Yeh, A. G. O. (2022). A room with a view: Automatic assessment of window views for high-rise high-density areas using City Information Models and deep transfer learning. Landscape and Urban Planning, 226(October 2022), 104505. https://doi.org/10.1016/j.landurbplan.2022.10450

Li, X., Zhang, C., Li, W., Ricard, R., Meng, Q., & Zhang, W. (2015). Assessing street-level urban greenery using Google Street View and a modified green view index. Urban Forestry & Urban Greening, 14(3), 675–685. https://doi.org/10.1016/j.ufug.2015.06.006

Lindemann-Matthies, P., Benkowitz, D., & Hellinger, F. (2021). Associations between the naturalness of window and interior classroom views, subjective well-being of primary school children and their performance in an attention and concentration test. Landscape and Urban Planning, 214, 104146:1-. https://doi.org/10.1016/j.landurbplan.2021.104146

Mahabir, R., Schuchard, R., Crooks, A., Croitoru, A., & Stefanidis, A. (2020). Crowdsourcing Street View Imagery: A Comparison of Mapillary and OpenStreetCam. ISPRS International Journal of Geo-Information, 9(6), 1–22. https://doi.org/10.3390/ijgi9060341

Malek, J. A., Lim, S. B., & Yigitcanlar, T. (2021). Social Inclusion Indicators for Building Citizen-Centric Smart Cities: A Systematic Literature Review. Sustainability, 13(1), 376. https://doi.org/10.3390/su13010376

Matsuoka, R. H. (2010). Student performance and high school landscapes: Examining the links. Landscape and Urban Planning, 97(4), 273–282. https://doi.org/10.1016/j.landurbplan.2010.06.011

Moghadas, M., Fekete, A., Rajabifard, A., & Kötter, T. (2023). The wisdom of crowds for improved disaster resilience: A near-real-time analysis of crowdsourced social media data on the 2021 flood in Germany. GeoJournal, 1–27. https://doi.org/10.1007/s10708-023-10858-x

Moghadas, M., Rajabifard, A., Fekete, A., & Kötter, T. (2022). A Framework for Scaling Urban Transformative Resilience through Utilizing Volunteered Geographic Information. ISPRS International Journal of Geo-Information, 22(114). https://doi.org/10.3390/ijgi11020114

Mooney, P., & Minghini, M. (2017). A Review of OpenStreetMap Data. In Mapping and the citizen sensor (pp. 37–59). biquity Press.

Moreri, K., Fairbairn, D., & James, P. (2018). Issues in developing a fit for purpose system for incorporating VGI in land administration in Botswana. Land Use Policy, 77(November 2017), 402–411. https://doi.org/10.1016/j.landusepol.2018.05.063

Palen, L., Anderson, J., Bica, M., Castillos, C., Crowley, J., Díaz, P., Finn, M., Grace, R., Hughes, A., & Imran, M. (2020). Crisis Informatics: Human-Centered Research on Tech & Crises: A Guided Bibliography Developed by Crisis Informatics Researchers.

Pan, Z., Yu, H., Miao, C., & Leung, C. (2016). Efficient collaborative crowdsourcing. Thirtieth AAAI Conference on Artificial Intelligence, 4248–4249.

Ponthep Meunpong, P., Buathong, S., & Kaewgrajang, T. (2019). Google Street View virtual survey and in-person field surveys: An exploratory comparison of urban tree risk assessment. Arboricultural Journal, 41(4), 226–236. https://doi.org/10.1080/03071375.2019.1643187

Porto de Albuquerque, J., Anderson, L., Calvillo, N., Coaffee, J., Cunha, M. A., Degrossi, L. C., Dolif, G., Horita, F., Klonner, C., Lima-Silva, F., Marchezini, V., Martins, M. H. da M., Pajarito-Grajales, D., Pitidis, V., Rudorff, C., Tkacz, N., Traijber, R., & Zipf, A. (2021). The role of data in transformations to sustainability: A critical research agenda. Current Opinion in Environmental Sustainability, 49(June), 153–163. https://doi.org/10.1016/j.cosust.2021.06.009

Qiu, W., Li, W., Liu, X., Zhang, Z., Li, X., & Huang, X. (2023). Subjective and objective measures of streetscape perceptions: Relationships with property value in Shanghai. Cities, 132(January 2023), 1–29. https://doi.org/10.1016/j.cities.2022.104037

Rifkin, J. (2015). he Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism. Griffin.

Semeraro, T., Scarano, A., Buccolieri, R., Santinoano, A., & Aarrevaara, E. (2021). Planning of Urban Green Spaces: An Ecological Perspective on Human Benefits. Land, 105(10), 1–25. https://doi.org/10.3390/land10020105

Senaratne, H., Mobasheri, A., Ali, A. L., Capineri, C., & Haklay, M. (Muki). (2017). A review of volunteered geographic information quality assessment methods. International Journal of Geographical Information Science, 31(1), 139–167. https://doi.org/10.1080/13658816.2016.1189556

Sieber, R., & Haklay, . (2015). The epistemology(s) of volunteered geographic information: A critique. Geo: Geography and Environment, 2(2), 122–136. https://doi.org/10.1002/geo2.10

Solís, P., Anderson, J., & Rajagopalan, S. (2021). Open geospatial tools for humanitarian data creation, analysis, and learning through the global lens of YouthMappers. Journal of Geographical Systems, 23(0123456789), 599–625. https://doi.org/10.1007/s10109-020-00339-x

Steiniger, S., Poorazizi, M. E., & Hunter, A. J. S. (2016). Planning with citizens: Implementation of an e-planning platform and analysis of research needs. Urban Planning, 1(2), 49–64. https://doi.org/10.17645/up.v1i2.607

Sun, K., Echevarria Sanchez, G. M., De Coensel, B., Van Renterghem, T., Talsma, D., & Botteldooren, D. (2018). Personal Audiovisual Aptitude Influences the Interaction Between Landscape and Soundscape Appraisal. Frontiers in Psychology, 9, 780:1-780:15. https://doi.org/10.3389/fpsyg.2018.00780

Tabrizian, P., Baran, P. K., Smith, W. R., & Meentemeyer, R. K. (2018). Exploring perceived restoration potential of urban green enclosure through immersive virtual environments. Journal of Environmental Psychology, 55(February 2018), 99–109. https://doi.org/10.1016/j.jenvp.2018.01.001

Torres Toda, M., Miri, M., Alonso, L., Gómez-Roig, M. D., Foraster, M., & Dadvand, P. (2020). Exposure to greenspace and birth weight in a middle-income country. Environmental Research, 189, 109866. https://doi.org/10.1016/j.envres.2020.109866

Ugolini, F., Massetti, L., Pearlmutter, D., & Sanesi, G. (2021). Usage of urban green space and related feelings of deprivation during the COVID-19 lockdown: Lessons learned from an Italian case study. Land Use Policy, 105, 105437:1-105437:11. https://doi.org/10.1016/j.landusepol.2021.105437

Umweltbundesamt (Ed.). (2022). Dreifache Innenentwicklung—Definition, Aufgaben und Chancen für eine umweltorientierte Stadtentwicklung (Triple inner urban development—Definition, tasks, and opportunities for environmentally oriented urban development). https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/221208_uba_hg_dreifacheinnenentwicklung.pdf

UNISDR (Ed.). (2017). Sendai Framework Data Readiness Review 2017, Disaster-related Data for Sustainable Development. In Journal of Personality and Social Psychology (1st ed., Vol. 1, pp. 1188–1197). United Nations Office for Disaster Risk Reduction.

United Nations. (2017). Resolution adopted by the General Assembly on 6 July 2017 Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development.

van Nes, A., & Yamu, C. (2021). Introduction to Space Syntax in Urban Studies (1st ed.). Springer.

Wang, W., Lin, Z., Zhang, L., Yu, T., Ciren, P., & Zhu, Y. (2019). Building visual green index: A measure of visual green spaces for urban building. Urban Forestry & Urban Greening, 40, 335–343. https://doi.org/10.1016/j.ufug.2018.04.004

Wang, W., Tang, B., Fan, X., Mao, H., Yang, H., & Zhu, M. (2017). Efficient visibility analysis for massive observers. Procedia Computer Science, 111, 120–128. https://doi.org/10.1016/j.procs.2017.06.018

World Bank (Ed.). (2020). Solid Ground, Increasing Community Resilience through Improved Land Administration and Geospatial Information Systems. http://hdl.handle.net/10986/33706

Yan, Y., Feng, C. C., Huang, W., Fan, H., Wang, Y. C., & Zipf, A. (2020). Volunteered geographic information research in the first decade: A narrative review of selected journal articles in GIScience. International Journal of Geographical Information Science, 34(9), 1765–1791. https://doi.org/10.1080/13658816.2020.1730848

Yang, J., Zhao, L., Mcbride, J., & Gong, P. (2009). Can you see green? Assessing the visibility of urban forests in cities. Landscape and Urban Planning, 91(2), 97–104. https://doi.org/10.1016/j.landurbplan.2008.12.004

Yin, C., Peng, N., Li, Y., Shi, Y., Yang, S., & Jia, P. (2023). A review on street view observations in support of the sustainable development goals. International Journal of Applied Earth Observation and Geoinformation, 117(March 2023), 1–11.

Yu, S., Yu, B., Song, W., Wu, B., Zhou, J., Huang, Y., Wu, J., Zhao, F., & Mao, W. (2016). View-based greenery: A three-dimensional assessment of city buildings' green visibility using Floor Green View Index. Landscape and Urban Planning, 152, 13–26. https://doi.org/10.1016/j.landurbplan.2016.04.004

360

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Impact of Educational Building Design on Users' Psychological and Physical Well-Being – Case Study High School in Egypt

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1 ABSTRACT

The design of educational buildings can significantly impact the well-being of their users, both psychologically and physically. Hence, psychological and physical factors are key concepts in evaluating educational buildings' performance as they affect the occupants' well-being, comfort, productivity, and satisfaction. These factors are interrelated and influence each other in complex ways. Therefore, it is essential to design and maintain educational buildings that balance both psychological and physical factors to create optimal learning environments for students and teachers.

This paper aims to execute an analytical study of the relationship between the design of educational buildings and users' physical and psychological well-being. It focuses on the case of schools designed by the General Authority for Educational Buildings in Egypt, which are often characterized by typicality and lack of diversity. It examines the quality of educational institution design, which includes aspects such as Functional, behavioral, and aesthetic. It also highlights the importance of creating educational environments that are conducive to learning, health, and comfort for students and teachers.

Educational building design is a multidisciplinary and complex topic that requires a holistic and user-centered approach to optimize the users' well-being and performance. The methodology adopted for this study includes an analytical study of the relationship between architectural design and users' physical and psychological well-being. Certain methods for data collection will be adopted for this purpose: observations, surveys, and questionnaires.

Through this study, a conceptual framework model is developed that can guide the design and evaluation of educational buildings in Egypt. The model is based on a literature review of significant criteria and considerations that affect the quality and performance of educational environments. The criteria and considerations include aspects such as spatial organization, functional efficiency, environmental comfort, social interaction, and aesthetics. The model is then applied to a sample of high schools in Egypt to test its validity and usefulness. A questionnaire survey is also conducted to collect data on the user experience and satisfaction of students and teachers in these schools. The results of the study are expected to provide insights and recommendations for improving the design and assessment of educational buildings in Egypt.

Keywords: educational building design, users' well-being, design analysis and evaluation, psychology, standards of school design

2 INTRODUCTION

"One of the essential roles of architecture is to provide built environments that sustain the occupants' psychological well-being. This role is made even more important because, in modern society, more than 70% of a person's lifespan is spent indoors." (Kim, 1998).

Although every building's design is equally vital, the buildings that adolescents deal with are more important than others, because the effect of emptiness on the adolescent's psyche is deeper than if the person is an adult. Therefore, schools are among the most important built environments, the school building has a human and social role that is no less important than its functional role.

In fact, psychological and physical needs during school age are associated with educational success, the development of a healthy lifestyle, and reduced risk of adverse socioeconomic outcomes, psychiatric disorders, self-harm, and suicide in later life (Kidger et al., 2012). Over the last decade, evidence has been accumulating on the relationship between environments and users' health within a "user-centered" perspective (Gifford, 2007). This approach aims at planning and designing spaces that align with the needs, preferences, and behavioral responses of current and potential users, as well as with the instrumental goal for

which those spaces have been created. For this purpose, the interaction between the setting features and functions and the users' characteristics and activities should be taken accurately into account.

In sum, school building design is supposed to play a central role in the creation of environments that improve educational attainment. Promoting a higher level of design humanization in a school environment means taking into account its spatial-physical configuration, in order to increase the outcome in terms of both learning and well-being, especially when considering the high proportion of time that both staff and students spend at school each week.

Consistent with the user-centered design approach, the construct of "design humanization" has been developed, particularly for school environments (Fornara et al., 2006) (Nagasawa, 2000) referring to those spatial-physical features that influence users' responses. Although the educational process is established for the sake of the human being, it often begins without paying attention to basic human considerations. It is logical for the designer to place physiological goals such as health, comfort, and security next to psychological ones such as belonging and privacy along with technological, legal, and economic determinants, as it was found that school spaces affect the student in three directions:
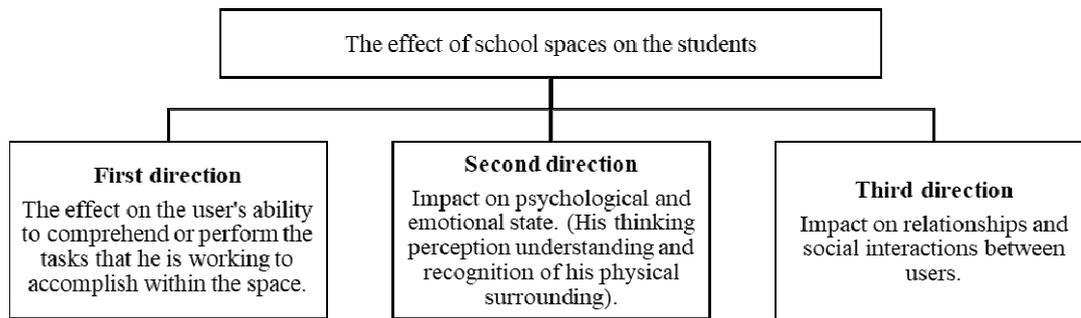
Figure 1: The effect of school spaces on the students (Source: Moharram, 2005).

As a result of these effects, human behavior is determined, which the architect must be aware of in order to avoid negative behavior and its design stimulates the positive behavior of the student towards the surrounding space (Moharram, 2005).

By presenting the psychological and physical requirements of the students during school time, as well as the design principles that are meant to fulfill their needs, and in order to monitor the possibility of applying this on the ground, a field study had to be conducted on a case study of a selected school.

Design principles provided a solution to the challenges produced by traditional school architecture while also allowing for the development of many schools in some global situations. In this paper, An example from an Egyptian high school is presented and analyzed in this paper. How pupils adjust to it and design requirements for schools that care about users' psychological and physical well-being are established. The example shows how the school environment affects the pupils' mood, motivation, and performance. The paper argues that schools should consider human factors in their design and provide a comfortable and stimulating learning space for the pupils.

3   MATERIALS AND METHODS

The methodology of this research is based on a descriptive and qualitative approach. An initial survey to investigate the relationship between the architectural design of educational buildings and the psychological and physical well-being of users was conducted. It focuses on three main factors (function, behavioral, and aesthetic). Function refers to how well the building meets the needs and expectations of users. While behavior refers to how the building affects the users' actions and interactions. Aesthetics refers to how the building appeals to the users' senses and emotions. Certain methods for data collection will be adopted for this purpose, observations, surveys, and questionnaires. The observations allow to capture characteristics of either space itself or its users; surveys allow essentially assist the analysis of the physical characteristics of space; the questionnaires identify and evaluate in a fast and structured way, the needs and satisfaction of users.

362

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The paper uses an analytical study method that examines a case study of a school in Egypt and identifies the key factors that contributed to its performance. The paper also discusses the implications and recommendations of the findings for the design of schools in Egypt.

The analytical method begins with providing descriptions of the samples. It covers the location of the school building, its components, the size of the project, its area, and the number of students in it through its engineering drawings, which were obtained from the Public Authority for Educational Buildings. The performance of the structures' interior spaces is then examined from a functional, behavioral, and aesthetic perspective. In addition to outlining the flaws and their causes, the results also document the benefits and drawbacks of the designs of those schools using the evaluation scale.

3.1 Selected case study

An architectural study of Abdel-Moneim Amer High School is conducted, a public high school located in Kafr El-Sheikh Governorate, Egypt as shown in Table 1. The study examines the school's physical components, such as its buildings, facilities, spaces, and layout, and evaluates their suitability for enhancing students' psychological and physical well-being. The study also identifies the strengths and weaknesses of the school's design, which guides in proposing criteria for improving existing schools or designing new schools in similar contexts. The criteria will be based on three main categories as follows:

- Functional aspects: building form, scale, accessibility, and circulation).
- Behavior aspects: social interaction, common spaces, and social spaces).
- Aesthetic elements: coloring and linking to nature

The main method employed to achieve the study's objective was filling out the evaluation tables with numerical ratings from 1 to 10 for different patterns, which aided in comparing and analyzing the patterns based on various criteria and dimensions. The evaluation analysis sought to document the evaluation of each section as well as the degree of achievement in each, in addition to the benefits and drawbacks of the buildings. Three sections make up the evaluation tables:

- Measuring the functional aspects of a building's performance, such as its shape, design, and circulation, is the focus of the first section.
- The behavioral components of building performance, which deal with psychological variables including privacy, productivity, and social interactions, are measured in the second section.
- The final section measures the aesthetic aspects of a building's performance, including color and Linking to nature (Physical variable).

To do this, we analyzed the building codes of nine countries that have different standards and regulations for this type of construction. We extracted the main elements of the evaluation from each code and assigned them a weight based on their frequency and relevance. This allowed us to compare and rank the elements according to their significance in the design process.

To find out and determine the weight of each element of the evaluation, the building codes for educational buildings were analyzed for nine different countries that have different standards and regulations. The main elements of the evaluation from each code were extracted and were assigned a weight based on their frequency and relevance. This allowed us to compare and rank the elements according to their significance in the design process as shown in Table 2.

For instance, the functional aspect is calculated as: their weight in the evaluation = X / 108, where 108 represents the total number of elements of the functional aspects, which is the product of multiplying 12 elements by the number of 9 different countries. Whereas, the behavioral aspect: their weight in the evaluation = X / 45, where 45 expresses the total number of elements of the behavioral aspects, which is the product of multiplying 5 elements by 9 different countries. While the elements that can be measurably expressed in the aesthetic aspect are two elements, therefore the aesthetic aspect: their weight in the evaluation = X / 18, which is the product of multiplying 2 elements by the number of 9 different countries.

As a result, components are rated from 1 to 10 after being evaluated in accordance with the chosen system evaluation. According to element weight. Each aspect was calculated independently (with a 100% internal computation that made up 33.33% of the overall result).

The functional, behavioral, and aesthetic aspects are fixed. Sub-aspects and indicators can be changed depending on the study's emphasis, the region it is conducted in, and the data that are accessible, which offers future studies more flexibility to add or delete indicators.

3.2 Analysis of the architectural design of the school (data analysis)

Abdel-Moneim Amer High School is located in the city of Al-Riyad - Kafr El-Sheikh Governorate, in Delta Egypt, and is affiliated to the Kafr El-Sheikh Educational Administration, on a Street with a width of 8 m, and it is one direction for vehicular traffic, and the school is located in the middle of a residential area (The General Authority for Educational Buildings, 2011). The school consists of one building consisting of 5 floors, and it contains one open courtyard. The following table shows the descriptive analysis of the school.

Item	Descriptive analysis
School name	Abdel-Moneim Amer High School
Major activity	High school
Designed by	Educational Buildings Authority
Project size	2219 m²
Main component	(12 ordinary classrooms, 2 laboratories, courtyard, Library, Multipurpose hall, football yard, and administration area)
Number of floors	5-Story school building
Number of students	430

Table 1: Descriptive analysis of Abdel-Moneim Amer High School (Source: Author).
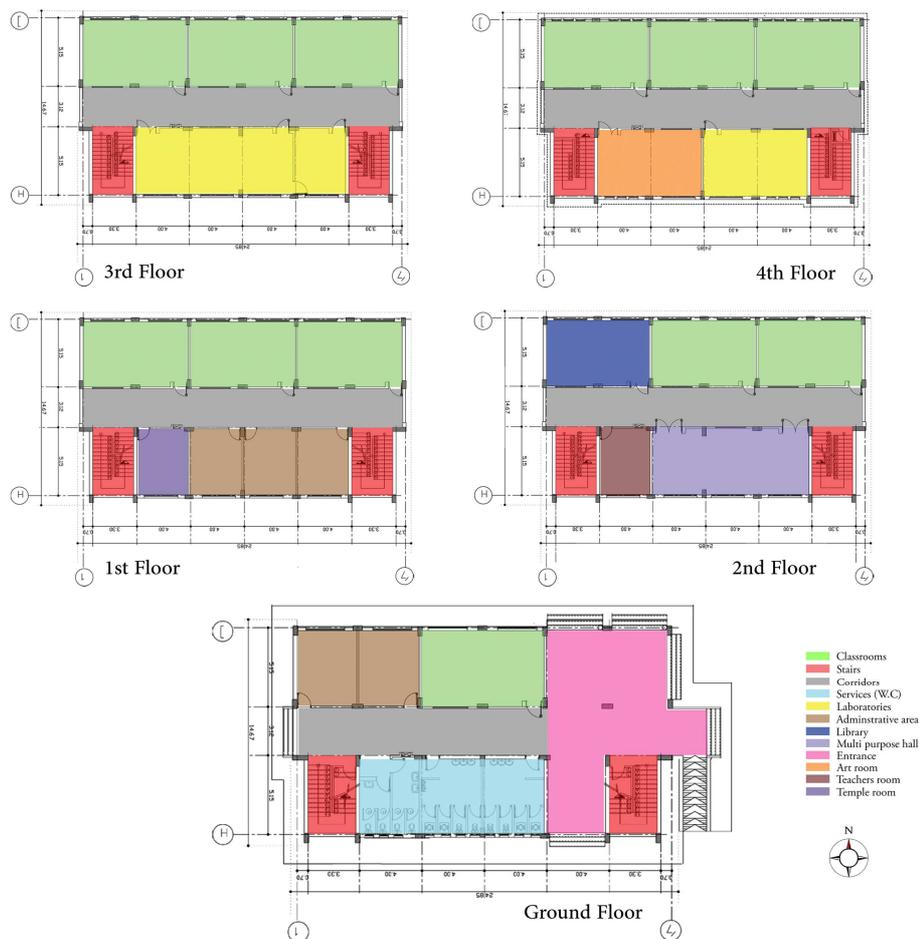
Figure 2: Plans of Abdel-Moneim Amer High School (Source: The General Authority for Educational Buildings, 2011, modified by author).

364

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3.2.1 Evaluation analysis

By observing the characteristics of the building and its components and analyzing it as illustrated in Figure 3, the evaluation analysis is displayed. As depicted in Figure 3, it clarifies the main criteria that influence school users from three different aspects.

Functional Aspects	Code of India	Code of USA	Code of UK	Code of Finland	Code of Japan	Code of Qatar	Code of Lebanon	Code of Saudi Arabia	Code of Egypt	Weight (108)
Spaces design and scale										
Size of classroom	1.2 m²/St.	2.1 m²/St.	2 m²/St.	1.5 m²/St.	1.5 m²/St.	1.5-2 m²/St.	1.5-2 m²/St.	1.6 m²/St.	1 m²/St.	9
No. of students in the classroom	40	30	30	24	30	-	-	25	36	7
Ratio of classroom	1:1.5	2:3/ 3:4	2:3/ 3:4	2:3/ 3:4	2:3/ 3:4	-	-	-	-	5
Exist storage area	1 locker/ St.	1 locker/ St.	3 m²/ class	1 locker/ St.	3 m²/ class					5
Accessibility and circulation										
No. of stairs and elevators	Min. 2	Min. 2	Min. 2	Min. 2	Min. 2	-	Min. 2	-	Min. 2	7
No. of school entrances	1	1	1	1	1	1	1	1	1	9
No. of school exits	1	1	1	1	1	-	-	1	More than 1	7
Comfortable corridors with enough spaces	1.5 m	1.2 m	1.2 -1.8 m	1.5 – 2 m	1.5 –2 m	2.5m	1.5m	-	2.4m	8
Building percentage of the land area, and student's area of the yard	1 m²/St.	3 m²/St.	0.3 m²/St.	0.6 m²/St.	0.6 m²/St.	-	-	400 m²	200 m²	7
School form										
Site area to be achieved	-	(400-1200) St.	(1400-1700) m²	-	-	3500 m²	-	180 St. or more	1250 m²	5
General orientation of the classrooms	North/ Northeast		North/ Northeast	North/ Northeast	North/ Northeast				North/ Northeast	5
Maximum height of the school	-	-	-	-	-	-	-	-	5 floors	1

Behavioral Aspects	Code of India	Code of USA	Code of UK	Code of Finland	Code of Japan	Code of Qatar	Code of Lebanon	Code of Saudi Arabia	Code of Egypt	Weight (45)
Social need										
Desirable average density in classrooms	40 St./ Class	30 St./ Class	30 St./ Class	24 St./ Class	30 St./ Class	-	-	25 St./ Class	36 St./ Class	7
Providing spaces to increase social activities (cafeteria)	-	1.1 m²/St.	0.9 m²/St.	-	-	-	-	-	-	2
Personal psychological needs										
Providing spaces to increase communication (laboratory)	65 m²	130 m²	2 m²/ St.	2 m²/St.	2 m²/St.	-	-	2.1 m²/St.	38 m²	7
Providing spaces to increase communication (library)	(50-150) m²	(900-1000) m²	9 m²/St.	1.5 m²/St.	1.5 m²/St.	-	-	2.8 m²/St.	-	6
Providing spaces to increase communication (sports area)	1500 m²	300 m²	(250-500) m²	6400-3220 m²	6400-3220 m²	-	-	Min. 300 m²	-	6

Aesthetic Aspects	Code of India	Code of USA	Code of UK	Code of Finland	Code of Japan	Code of Qatar	Code of Lebanon	Code of Saudi Arabia	Code of Egypt	Weight (18)
Links to nature (Physical Environment)										
View indoor and outdoor spaces (garden – seating area – fountains …etc.)	1 m²/St.	Track 400m	0.3 m²/St.	-	-	-	-	-	-	3
Outdoor classroom	-	Area of class/2	-	-	-	-	-	Area of class/2	-	2

Table 2: Evaluation weight (Source: Author). Note: These listed values were obtained through educational building codes for each country mentioned.
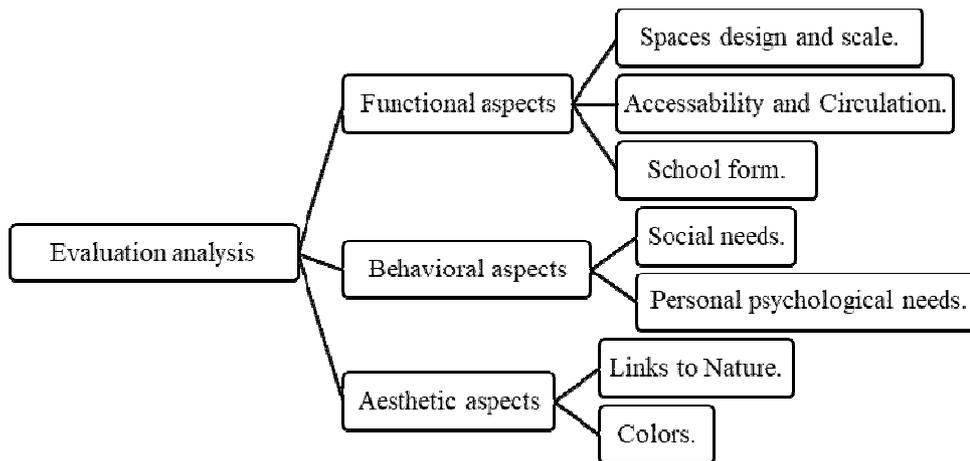
Figure 3: Evaluation analysis criteria (Source: Author).

4 RESULTS OF EVALUATION ANALYSIS

To assess how well the school performed in relation to the case study's objectives, procedures, and data collection and analysis methods, the tables below are used to track and describe the school's elements and evaluate their outcomes. The functional, behavioral, and aesthetic aspects of Abdel Moneim Amer High School's performance are evaluated in Tables 3, 4, and 5, respectively, and each evaluation element is shown with its result.

School Name Abdel-Moneim Amer High School						
Evaluation (EV.) %					78%	
			Factor's weight	Total grade	750	585
Functional Aspects	**Spaces design and scale**				EV.	EV. by weight
	Classroom size: The minimum internal dimensions of the classroom = 6 * 8.15 in the case of a rectangular plan, and 7.25 * 7.25 in the case of a square plan, and the net area is 50m². The minimum area for each student in the classroom is 1.5-2m²/Student.		9X	1-------10 Not Achieved - Achieved	5	45
	The number of students in the classroom or group: 25 students and no more than 30 students.		7X		0	0
	Classroom scale: 2:3 / 3:4 widths to length.		5X		10	50
	The storage area in classrooms: Minimum storage area per student (1 Locker/St.)		5X		0	0
	Accessibility and circulation				EV.	EV. by weight
	Directly exits from classrooms to the outside, courtyards, or gardens. There must be at least 1 emergency exit.		7X	1-------10 Not Achieved - Achieved	10	70
	The number of elevators and stairs in the school, with an emergency ladder. (2 stairs/school = 5 floor), (1 elevators/school >5 floors)		9X		10	90
	The school entrances should be clear and easily accessible; there should be at least 2 entrances to the school.		7X		10	70
	Clear and comfortable corridors: Minimum width of one-way corridor = 2m. Minimum width of two-way corridor = 3m.		8X		10	80
	Courtyard or garden. The building percentage of the school is (25-30%) of the land area, and the yard area must be at least 200 m², with a minimum of 10m for its smallest sides. The student's area of the yard must be at least (0.6-1) m².		7X		10	70
	School form				EV.	EV. by weight
	The site area for the high school should not be less than 3,500m².		5X	1-------10 Not Achieved - Achieved	10	50
	The general orientation of the classrooms is to the north, but they can deviate 25 degrees to the east or west from the north.		5X		10	50
	The maximum height (ground + 4 floors).		1X		10	10

Table 3: Result of functional aspect evaluation analysis (Source: Author).

The results show that Abdel Moneim Amer high school achieved 78% of the functional criteria, but only 33.9% of the behavioral criteria and none of the aesthetic criteria, as illustrated in Tables 3, 4, and 5 respectively. These low percentages indicate serious deficiencies in the design of the school, especially in the behavioral and aesthetic aspects, which affect the users' efficiency and educational attainment negatively.

Therefore, this paper highlights the importance of addressing these deficiencies and improving the design quality of educational buildings.

School Name Abdel-Moneim Amer High School						
Evaluation (EV.) %					33.9%	
		Factor's weight	Total grade	280	95	
Behavioral Aspects	**Social need**	(Density)			EV.	E.V. by weight
	Desirable average density in classrooms would be about 30 Students / Classroom	7X	1-------10 Not Achieved - Achieved	0	0	
	Social need (Common spaces and active learning & social spaces)					
	Providing spaces to increase social activities among students, such as (Cafeteria, green areas, etc.). Cafeteria: (1 m²/student)	2X		0	0	
	Personal psychological needs			EV.	E.V. by weight	
	Providing spaces to increase communication: Laboratory: (1.5-2 m²/student).	7X	1-------10 Not Achieved - Achieved	5	35	
	Providing spaces to increase communication: Library: (1.5-2) m²/student.	6X		5	30	
	Providing spaces to increase communication: Sports area: 30% of the outdoor school area	6X		5	30	

Table 4: Result of behavioural aspect evaluation analysis (Source: Author).

School Name Abdel-Moneim Amer High School						
Evaluation (EV.) %				0%		
Aesthetic Aspects		Factor's weight	Total grade	50	0	
	Links to nature (Physical Environment)			EV.	EV. by weight	
	Views of indoor and outdoor spaces (garden, fountains, sitting areas, etc.), (0.5-1) m²/Student.	3X	1-------10 Non-Existing - Existing	0	0	
	Outdoor Classroom: the school provides outdoor classrooms that allow students to study overlooking a natural view, (area of classroom/2).	2X		0	0	

Table 5: Result of aesthetic aspect evaluation analysis (Source: Author).

Questions (n = 40)	Yes		No		Maybe	
	No.	%	No.	%	No.	%
Q1: Is the number of students in the class more than 25 students?	33	82.1	1	2.5	6	15.4
Q2: Do you feel that the classroom space is insufficient for the number of students?	17	41	13	33.3	10	25.6
Q3: Does the classroom have storage units for each student's personal belongings?	5	12.8	32	79.5	3	7.7
Q4: Does the school design contain at least two stairs?	37	92.3	2	5.2	1	2.5
Q5: Can you walk with your classmate next to each other in the corridors between classes?	38	94.9	1	2.55	1	2.55
Q6: Is there at least one emergency exit in the school?	26	64.1	10	25.6	4	10.3
Q7: Is the number of entrances to the school not less than two entrances?	36	89.7	4	10.3	0	0
Q8: Can schoolyard accommodate all the students during break, or when doing morning activities?	28	69.2	2	5.2	10	25.6
Q9: Do you feel thermal comfort in the classroom if the windows are open?	9	23.1	21	51.3	10	25.6
Q10: Is there a cafeteria (restaurant) where you can sit with your friends during a break?	2	5.1	37	92.3	1	2.6
Q11: Is the school has laboratories, not less than two laboratories (computer lab, science lab)?	36	89.7	1	2.6	3	7.7
Q12: Is there a school library through which you can search and study?	27	69.2	6	12.8	7	17.9
Q13: Are there sports fields (football, basketball, etc.) equipped and usable?	14	35.9	21	51.3	5	12.8
Q14: Does the school contain aesthetic elements (trees, fountains, seating areas, pergolas, etc.)?	16	38.5	12	30.8	12	30.8
Q15: Is there an outside study space (Outdoor classroom)?	11	28.2	25	61.5	4	10.3
Q16: Do you like the colors of the paints at school?	10	25.6	22	53.8	8	20.5

Table 6: Questionnaire results (Source: Author).

After analyzing and reviewing the results of the psychological and physical elements of the users in its three aspects (functional, behavioral, and aesthetic), for Abdel Moneim Amer High School, results of the questionnaire for high school students are presented in Table 6, as the number of students in the school reaches 430 students distributed over 12 classes, which makes the study sample for this level consists of (35-40) students.

From the questions and answers presented in the questionnaire, Figure 4 summarizes the response rate for each question separately. Through the percentages shown, we conclude that the functional aspect of the school achieves the highest rate of user satisfaction, despite the presence of deficiencies in some of the functional elements of the school. Then the percentage of users' satisfaction decreases for the behavioral

aspect of the school, but it is almost non-existent in terms of the aesthetic aspect, as it lacks many elements and thus does not capture the satisfaction of users.
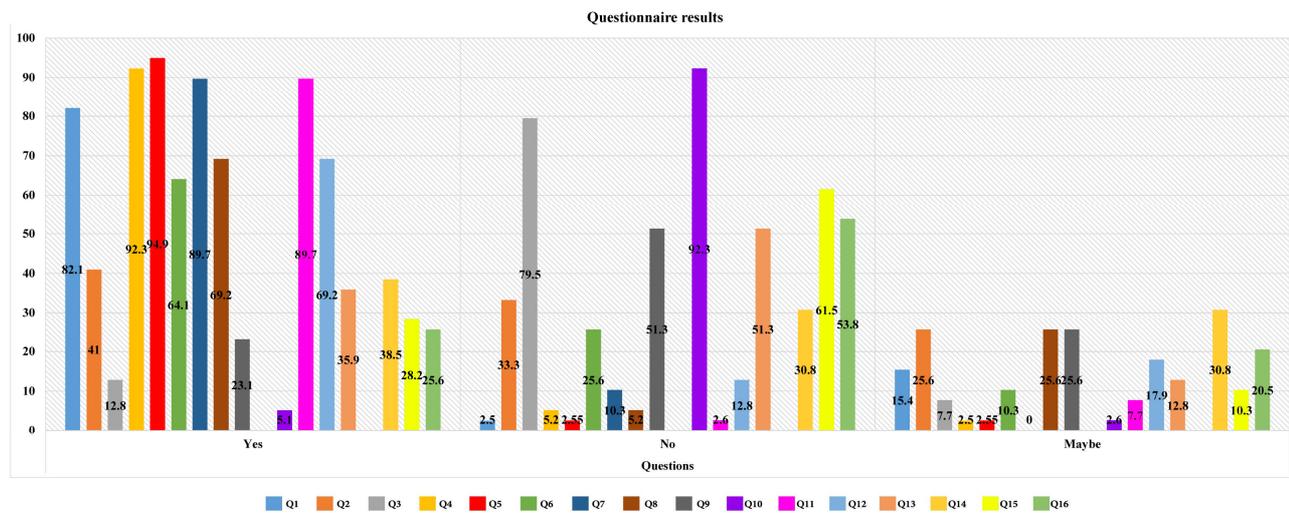
Figure 4: Percentages of questionnaire results (Source: Author).

5 CONCLUSION

This study is considered a step forward in improving school design by keeping in mind the psychological and physical well-being of students, which affects their performance. The discussion follows the application of architectural design principles of psychological and physical well-being to the selected samples, which are divided into three sections. The discussed outcomes were the result of an evaluation sheet developed based on (C. Kenneth Tanner's, 2008) studies, which used an evaluation sheet filled out by designers to evaluate the performance of schools based on architectural psychology studies.

To understand the design tools that should be used to apply the architectural design principles of psychological and physical well-being on users, a case study proves that the design elements aspects of the architectural design of physical and psychological well-being are categorized into three aspects; Function, Behavioral, and Aesthetic aspects. Those aspects clarify the essential elements that help to achieve the best space performance.

Accordingly, the impact of applying these aspects in architectural spaces design by discussing each element's psychological and physical effect on users is a strong impact of architectural space design elements on users. These proofs lead to a link between the design of educational buildings and the psychological and physical well-being of users.

6 REFERENCES

BAN, S. B. Recommendations for Basic Requirements of School Buildings. 1978.
Department for Education. Area guidelines for mainstream schools. School building design and maintenance, Issue 6, p.p 39-40. 2014.
Division, B. School design guidelines. School Planning and Building Division, Issue 1. 2020.
Fornara, F., Bonaiuto, M., & Bonnes, M. Perceived hospital environment quality indicators: A study of orthopaedic units. Journal of Environmental Psychology, Vol. 26, Issue 4, p.p. 321-334. 2006.
Gifford, R. Environmental psychology: Principles and practice. Optimal books Colville, WA, 2007.
Hall, L. Public School Standards Design. APS Facilities Design and Construction, Vol. 6, Issue 10, p.p. 16-25. 2021.
Kidger, J., Araya, R., Donovan, J., et al. The effect of the school environment on the emotional health of adolescents: a systematic review. Pediatrics, Vol. 129, Issue 5, p.p. 925-949. 2012.
Kim, J. Sustainable Architecture Module. National Pollution Prevention Center for Higher Education. Michigan: The University of Michigan, .1998.
Ministry of Education. Manual of the Minimum Design Criteria for Private Schools and Approval Procedures. Tatweer Buildings Company, 2019.
Moharram, L. A. Studying the psychological impact of the environment on humans and its importance to the architectural designer and urban planner. 2005.
Nagasawa, Y. The geography of hospitals. In Theoretical perspectives in environment-behavior research. Springer, pp. 217–227. 2000.

Tanner, C. K. Explaining relationships among student outcomes and the school's physical environment. Journal of advanced academics, Vol. 19, Issue 3, p.p. 444-471. 2008.

The General Authority for Educational Buildings. Standards and requirements for the validity of school sites and buildings public primary and high schools (in existing cities and villages), General Administration of Research and Studies, Kafr El-Sheikh, 2011.

Tomohiro, H. Introduction to the Building Standard Law - Building Regulation in Japan. p.p. 237. 2013.

Virginia Department of Education. Guidelines for School Facilities in Virginia's Public Schools. Issue 6, p.p. 1-83. 2010.

Wieczorek, C.C. Comparative Analysis of Educational Systems of American and Japanese Schools: Views and Visions. Educational Horizons, Vol. 86, Issue 2, p.p. 99-111. 2008.

Impact of Urban Attributes on Human Happiness and Health in Alexandria as an Egyptian City

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1 ABSTRACT

Creating livable, safe, healthy, and sustainable urban spaces requires the prioritisation of interactive urban environments (UE) and social connections in city design. Previous studies have examined the relationship between sustainability, health, and happiness, focusing primarily on macro-level factors like air pollution, temperature, wind speed, ambient noise levels, economics, and life satisfaction. Consequently, this research aims to address the following question: How can urban planners establish cities that promote happiness, health, and overall quality of life? This paper specifically explores these aspects in the context of Alexandria, Egypt, with a focus on mental health outcomes and the notions of an "all-inclusive city." Furthermore, the study examines the key elements of inclusive notions for creating happier spaces, as in the case study area (Pharos promenade (PP)), based on Alexandria's historical importance. Methodologically, this paper employs a systematic review approach, incorporating both quantitative and qualitative indicators to establish measurement tools and design principles for happier cities. Ultimately, the study concludes by presenting design principles relevant to creating a sustainable and healthy city that prioritises the health and happiness of its residents within the scope of Alexandria.

Keywords: Happier city, urban environment, mental health, all-inclusive city, measurements for the happier city

2 INTRODUCTION

Fig. 1: Model of the pathways linking the built environment to subjective happiness. Source: Researchers.

The growing interest in understanding and measuring happiness in society has led to a focus on the relationship between happiness and social, environmental, and health factors. The built environment of a city is crucial for creating liveable, secure, healthy, and sustainable cities, as illustrated in Figure 1 (Gehl, 2010). Factors such as urban sprawl (Rong, 2018), megacities, anxiety and depression disorders, and insufficient resources contribute to dissatisfaction with city life. A healthy environment affects human activities and characteristics, including individual happiness, intelligence, and talent. So, the present study highlights the potential of urban design to harness the attributes of the urban environment to promote mental health and happiness while simultaneously mitigating or minimising factors that pose a risk to these outcomes. Two sets of city planner concepts are developed and displayed, analysing how happiness is linked to city design and highlighting the city's enablers of happiness (Najmeh Bitaab, 2018). This discusses the most important notions of an "all-inclusive city", with a particular emphasis on Alexandria City for its historical importance. These concepts are investigated and analysed through three key pillars: influential factors, modifiers, and pathways (McCAY, 2021). The study area on (Pharos Promenade (PP)), Alexandria, Egypt, aims to support psychological and emotional happiness through strong and human-centred design. The paper also investigates how improvement strategies for urban environments impact people's happiness and how happiness is measured. It also presents a framework for designing happier cities and guidelines that will be flexible enough to design happier cities in the future while establishing a model unique to the city's identity.

3 METHODOLOGY AND SCOPE

A literature review focuses on designing happier cities, particularly historical ones like Alexandria, Egypt. Through correlating various studies and examining their relevance by considering important factors such as environmental, potential, physical and mental health, and social connection aspects. following qualitative study (inductive and deductive approaches) are used to identify happiness-affecting factors and the link between urban design and happiness. Participatory Design Research (PDR) is used to analyse and evaluate design and environmental elements contributing to happiness. Alexandria, Egypt, is the scope of this study. As shown in Figure 2, since Mohammed Ali's reign (1805), the city has since extended east and west and has 2,679 km² (Pierre-Arnaud Barthel, 2020). Its recent unorganised expansion has generated urban restrictions and vulnerabilities. So, the study applies inclusive city notions. In addition, as shown in Figure 8 and Table 1, happiness in Alexandria might be affected by light, nature, access, surprise, sociality, and identity. Based on that, the happier city design framework and guidelines are designed to promote happiness, sustainability, and positive health for urban planners, architects, and decision-makers.
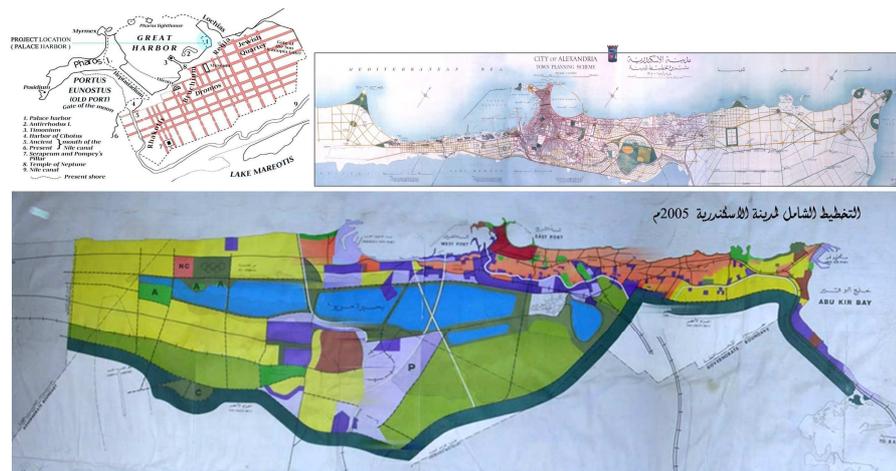
Fig. 2: Expansion of Alexandria during different periods of time. Source: Trethewey.

4 HAPPINESS ACROSS THE WORLD

Nations vary widely, as in Figure 3; Finland, Norway, Denmark, and Netherlands, top 2022 stats (all with averages above 7). The Central African Republic, South Sudan, Tanzania, and Rwanda had the lowest national ratings (below 3.5), and Egypt in 2020 (below 4.5). Particularly, the Subjective Well-Being worldwide ranking for Egyptian cities is No. 158 for Alexandria with a rating of 4.660 and No. 177 for Cairo with a rating of 4.088. (John F. Helliwell, 2022)
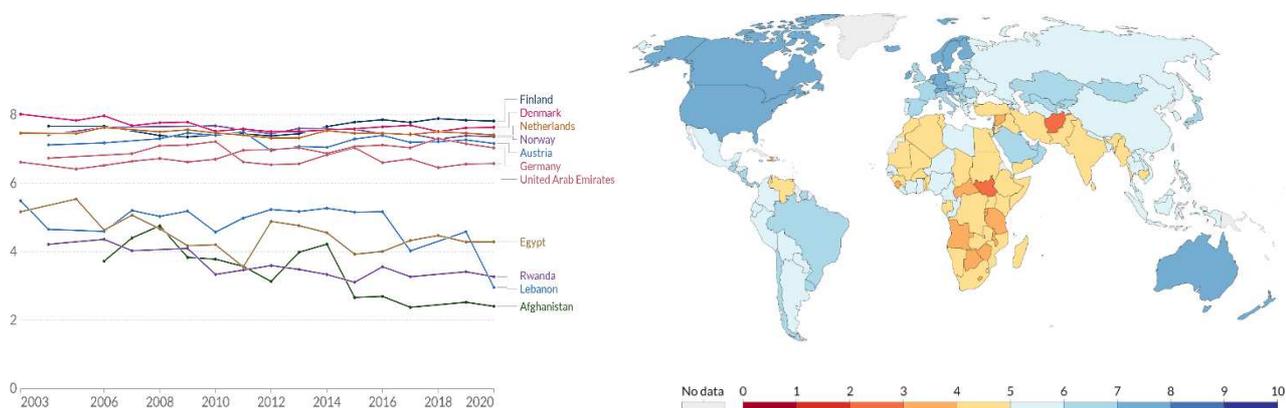
Fig. 3: Self-reported life satisfaction,2003 to 2020. Source: World Happiness Report 2022. (Roser, 2020)

5 URBAN ENVIRONMENT AND HEALTH

Urban environments significantly impact mental health and happiness globally. Figure 4 shows the urban health implications at the city/neighbourhood, street, and building scales, with mental illness costs amounting to over 4% of GDP, as estimated by the OECD (2014). This includes increased risks of physical illness, education challenges, unemployment, and homelessness. Designing urban environments that promote

physical activity, green space, recreational facilities, and affordable healthy foods can be crucial for enhancing health and happiness.

Fig. 4: Exposures and health effects at three scales (city/neighbourhood/street/building). Source: Researchers.
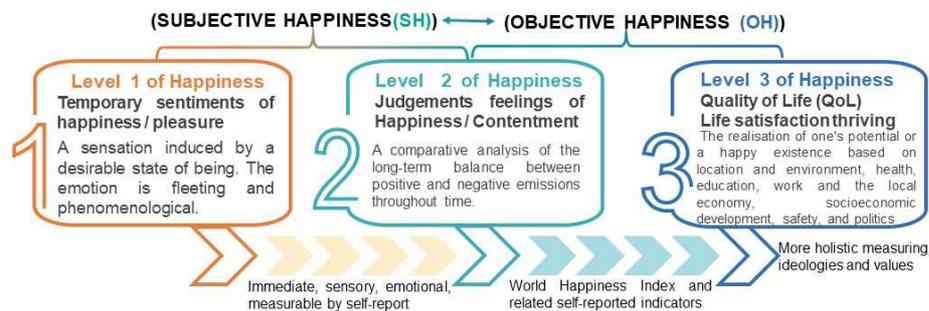
Fig. 5: Using Nettle's graphic from "Happiness: the science behind your smile" to define happiness. Source: Researchers.

5.1 Psychology of happiness

Multidisciplinary researchers split happiness into three phases, as shown in Figure 5: Level 1 of immediate happiness differs from Level 2 of satisfaction or contentment, but both are related. Contentment and joy are essential for a successful existence to reach Level 3, depending on one's potential or purpose in life.

5.1.1 Level 1 of happiness

Emotional happiness involves joy or pleasure. The pleasant sentiments are not permanent. These sentiments are detectable by equipment that recognises brain activity and questionnaires. These evaluations use pleasure centre activation and reduced stress and frustration as indications of happiness.

5.1.2 Level 2 of happiness

Subjective happiness and life satisfaction are studied. Level 1 and level 2 of happiness are related because someone with a high level of life satisfaction has likely experienced many joyous and restorative feelings. This is reflected in the World Happiness Index and related self-reported indicators. Subjective happiness (SH) includes emotional (level 1) and cognitive happiness (level 2) measurements.

5.1.3 Level 3 of happiness (Objective happiness (OH))

For a more complete perspective on happiness, researchers use indices that encompass numerous factors that impact "Objective Happiness" (level 3). which recognises the significance of location and environment, design of the urban environment, health, education, work, the local economy, socioeconomic development, safety, and politics in determining individual happiness. Subjective happiness (Levels 1 and 2) affects objective happiness (Level 3).

5.2 Influence of urban design on mental health and happiness

The Centre for Urban Design and Mental Health (UD/MH) aims to promote community mental health.

through happier and wiser urban design. They recognise the need for social capital and mental-health-friendly architecture to create a happier and healthier city (MH, 2018). The GAPS Framework, as shown in

Figure 6, highlights the link between social connections, security, and environmental aspects of happiness. Copenhagen, Denmark, has successfully developed a socially linked society to create a happy city. Traffic planners created a double-wide bike lane to encourage cycling and strengthen citizen connections.

6 DESIGN PRINCIPLES OF HAPPIER CITIES WITH POSITIVE HEALTH

Design and policy initiatives can enhance health and happiness in urban areas, e.g., Alexandria, as shown in Figure 7. The first theme (a) focuses on the physical and social fabric of the city, such as streets, piazzas, buildings, cycling routes, and parks that may be seen and touched. On the other hand, the second theme (b) highlights the conceptual aspects, such as city culture, community relationships, and services, which are symbolic and relational despite being concrete.

Fig. 6: MIND the GAPS Framework. Source: www.urbandesignmentalhealth.com
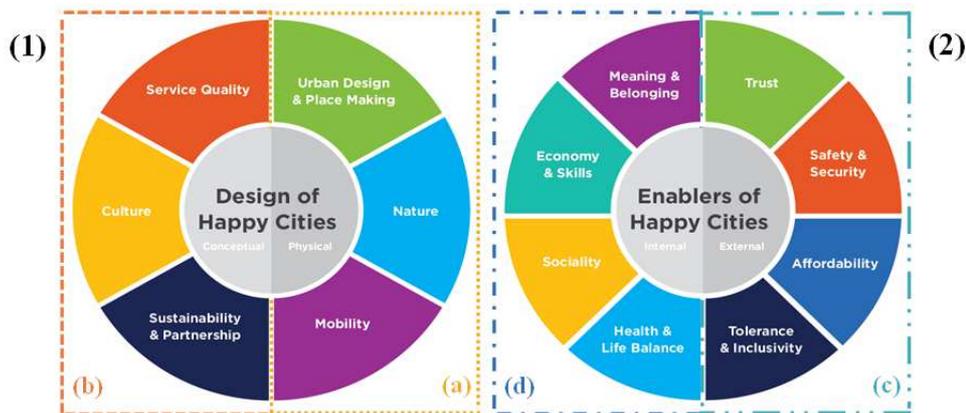
Fig. 7: This shows two sets of categories as a practical tool for city makers. Source: Aisha Bin Bishr, 2019
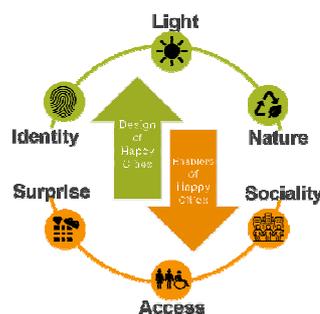
Fig. 8: Approach to happy and healthy cities. Source: Researchers.

7 APPROACH TO HAPPY AND HEALTHY CITIES

This research highlights that better-designed streets and public spaces are more important than a quicker path. In Alexandria, it is better to cancel highway projects and invest the money in cycle paths, gardens, and open spaces. Planners should also alter the car-centric design of the city, reducing hospital admissions by a third and reducing air pollution. So, nature, light, surprise, identity, access, and sociality positively affect people's happiness in Alexandria, so urban planners and policymakers should follow the suggestions for a happy city as in Table 1.

Environmental aspects	PRINCIPLES	DESCRIPTION
NATURE	Clean Cities of Blue and Green	Green parks and shoreland areas are crucial for creating a happier city with a clean atmosphere.
	Public Spaces	City prioritizes parks, natural landscapes, seashore, plazas, and accessible roads.
	Healthy And Security	Prioritize health and safety, focusing on air quality, freedom of fear, zero crime targets, mental and physical health, and natural light cycle.
LIGHT	Sustainability & Efficiency	Sustainable cities that use less energy and materials and incorporate green technologies
SOCIALITY & INTEGRATION	Community Spirit	A strong community-based home with friends, family, and neighbors is essential for outdoor activities and socializing.
	Integrated Neighborhoods	Living, working, and receiving essential services in one's area with mixed zoning.
SURPRISE	Humans Priority	Cities surprise with unexpected features, while machines detract from metropolis, blending into the backdrop when needed.
	Surprise Elements	happy and unexpected surprises, inclusive beauty to lessen class conflict
ACCESS	Walkable & Accessible	Cities with walkable, efficient transportation prioritize pedestrian and cycling, with excellent public transit and housing proximity.
	Compactness	Compact designs minimise distances. Wide roadways and parking lots have a lower passenger capacity than light rail.
	Regionalism	Cities and regions are integrated. Without regional connections, transportation is useless.
IDENTITY	Cultural & Civic Pride	Clean, distinct areas preserve identity and culture, engaging but not overwhelming the senses.
	Quality Of Life (QoL)	Urban design enhances self-reported quality of living, attracting economic activity and investment, enhancing overall well-being.

Table 1: Approach to happy and healthy Egyptian cities based yon 6 environmental aspects. Source: Researchers.

8 CASE STUDY: (DEVELOPMENT OF THE PHAROS PROMENADE (PP))

In 2001, the Ministry of Tourism and the Governorate of Alexandria developed a master plan for the PP and QC with the objective of establishing an integrated urban space with historical significance within six months (Asmaa Abdelrahman, 2018). Figure 9 depicts a pedestrian spine PP that respects human scale and provides visitors with a sense of place. Table 2 compares the physical and behavioural qualities of Pharos promenade before and after development. Currently, once a prominent tourist attraction, the Pharos Promenade has lost regional prominence due to poor design, a lack of entertainment amenities, and poor maintenance. As shown in Table 3, it also lacked comfort and safety for pedestrians and vehicles.

Fig. 9: Site plan for the development of Pharos Promenade in 2001. Source: https://www.binaomran.com/tnews_details.php?n=2

Before Development	After Development 2001
Two primary paths experienced pedestrian and vehicle interference, affecting comfort and safety; the former location deteriorated due to a lack of maintenance.	PP has three levels: two for pedestrians and one for vehicles, using an open-continuous staircase to preserve shoreline views and QC. The third trail is extended with a 42-m tongue.
In this region, limited landscaping and lighting units resulted in a lack of activities and engagement.	Landscape elements like planting, lighting, urban furniture, pavement materials, and public art create a unique experience in the study area, influencing people's interactions with PP.

Table 2: Comparison of development after and before. Source: Asmaa Abdelrahman, 2018, Ragheb, 2014.

	Problems Identification	Resources and Approaches
Cultur	1. The large-scale development of the urban waterfront is considered the start of a modern urban development aimed at encouraging investment. But it's difficult to revitalise historical waterfronts by generating a new design identity while retaining its overall character.	The heritage areas improvement strategy is based on three major pillars:
	2. No civilised entrance reflected the area's history. 3. Restoring the study area's design identity. This necessitates understanding the need of having a thorough waterfront plan in order to prevent future design blunders. 4. The absence of architectural identity of surrounding buildings as well as the usage of distracting materials and components. 5. Uses and activities in the area did not suit the region's culture.	**The first strategy** is to protect existing historic sites. For this strategy to work, all the built-up blocks' facades must be changed to match the local history and bring the design's spatial character together. **The second strategy** is to restore and redesign the surrounding buildings using the same architectural components and materials as the QC. **The third strategy** is to make existing buildings and open spaces more efficient and come up with creative designs to create more jobs and places for people to visit and bring more tourists to the area.
Social And Urban Environment	6. Insecurity from overlapping bikes, vehicles, and pedestrians' lanes.	Providing a safe passage from outside of the PP for bikes, vehicles, and pedestrians.
	7. Parking for vehicles and buses is limited.	Parking spots for all kinds of vehicles are a must, and the promenade should be designed in a way that reduce driving speed.
	8. The absence of recreational venues and green spaces 9. The inadequacy of landscape furniture, poor pavement materials, and public art. All of these elements do not contribute to a happy environment. 10. Few lights in the research area are insufficient. 11. Misuse and uncleanliness of the waterfront. 12. There are no well-designed selling units for street vendors. 13. Absence of a tourist and informative support facility. 14. Insufficient public services and locations for recreational and cultural activities (diving centres, yacht berths, restaurants, etc.) and constrained usage of private clubs.	Redesigning the place based on **sustainability**, **health**, and **happiness** principles

Table 3: Problem identification and analysis of available tools and approaches. Source: Researchers.

376

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9   RESULTS

9.1 Measurements and Policies for the Happier City

Experts are identifying factors that promote happiness and health in urban areas, with a focus on Egypt As depicted in Figure 10. Happy City, established in 2010, aims to combat the notion that economic development is the primary measure of human happiness. The organization creates measuring tools to recognize, analyze, and enhance happiness in people and places. Important instruments, such as the "Collection of Happiness Measure" in the World Database of Happiness (WDH), are analyzed in this section (Veenhoven, Ruut, 2017).
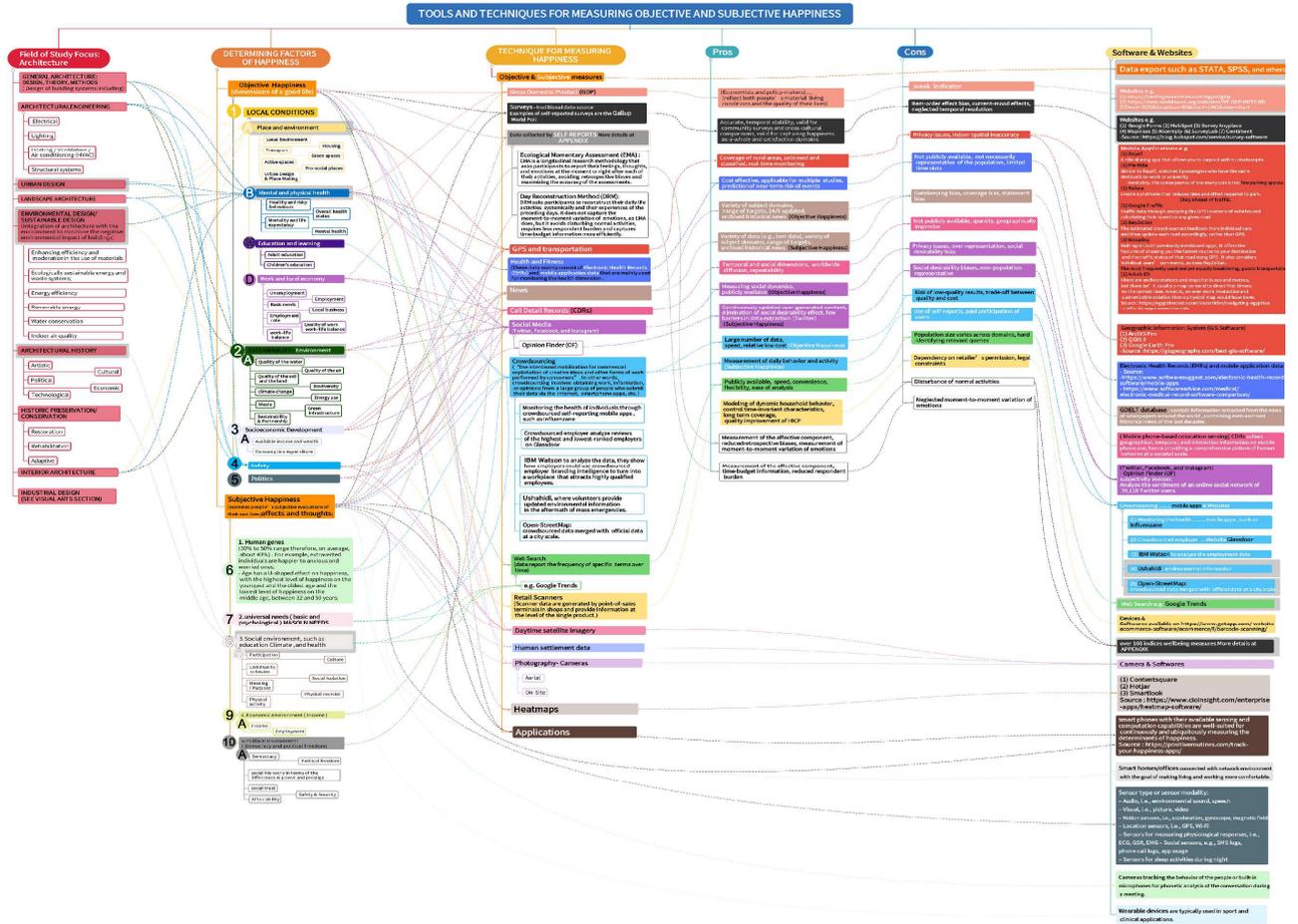
Fig. 10: Tools and techniques for measuring objective and subjective happiness are needed to assess happiness levels in the city. Source: Researchers.

9.2 Framework for a Healthy and Happier City

This study sets out a new framework for "happier urbanism" based on the "all-inclusive city" idea that examines how city and neighbourhood design may create happiness, focusing on mental health outcomes as:
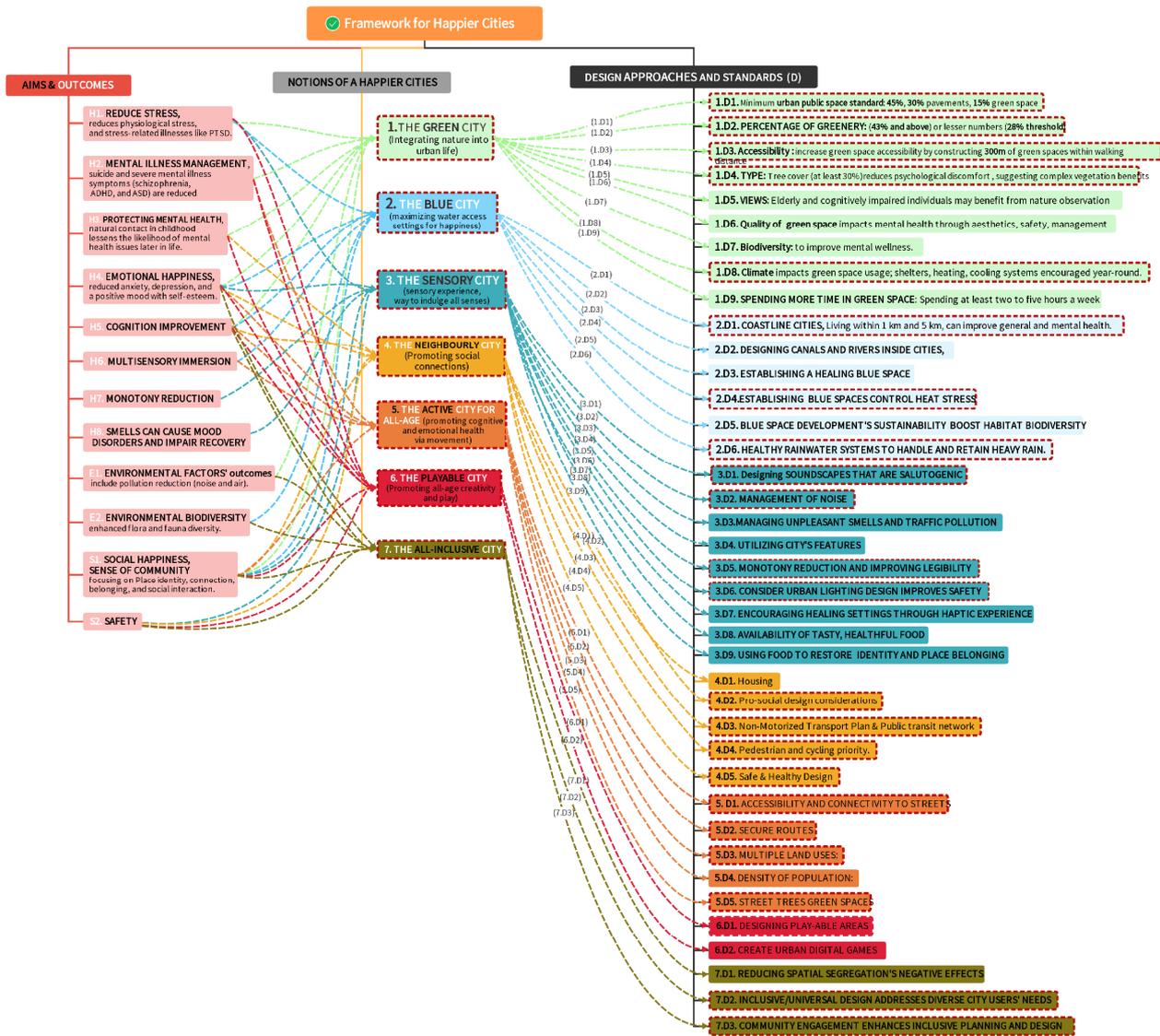
Fig. 11: Framework for a healthy and happier city. Source: Researchers.

10 CONCLUSION

Few studies explore happier cities' design principles for architecture and urban design. To promote health and happiness, architects and planners should use the GAPS Framework to create Green spaces, Active spaces, Pro-social places, and Safe places based on sustainability principles.

To design or plan a happier city, there are three distinct factors that may be applicable:

(1) Urban Design for Health and sustainability

- Cities are hubs of creativity and innovation, but they also contribute to climate change and planetary health problems. Global sustainability involves more than treating urban woes; that requires rethinking urban systems.

- Citizen happiness is tied to city planning and design. So, architects and urban planners should create active designs with walking and cycling access, social contact, and a direct link between humans and the environment by putting activities in green areas in diverse neighbourhoods with health and sustainability in mind. Good urban design and reliable public transit allow individuals to conveniently travel and be active.

- Nature, light, accessibility, and identity are also keys to urban attractiveness. So, green landscapes, water, and natural light are restorative; a complicated spatial plan adds interest and encourages exploration; and visual markers aid direction and offer relaxation.

378

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

(2) Participation at work

The work-life balance contributes to national happiness. Example: flex time, working from home, and a year of maternity leave for both parents. This helps citizens enjoy life and be happy at work while maintaining strong family relationships.

(3) Reduce impediments

- Health care and education are provided. People can access these services effortlessly. Less stress increases their happiness.

- Although happiness cannot be quantified, the quantitative environmental elements influencing human happiness, such as fluctuating temperatures, wind speed, water and air pollution, and other factors, may be measured and compared. As a result, public places are created in accordance with agreed-upon sustainable environmental criteria.

- Based on the facilities, resources, and data that are available, the designer must figure out the best ways and tools to measure happiness.

- In Egypt, particularly in the city of Alexandria, there is a noticeable lack of open-access data and data repositories, which is regarded as a barrier to any improvement.

- The Thriving Places Index (TPI) is a modern compass. It helps decision-makers from all sectors evaluate and prioritise policies based on people's well-being and community sustainability. Businesses of any size can utilise the TPI and Happiness Pulse together. So that may be useful in Egyptian projects by analysing happiness elements and how individuals are doing.

11 REFERENCES

Alter, Lloyd. "How Should We Measure the Happiness of Cities?". October 2018.

Asmaa Abdelrahman, Khalid Al-Hagla, and Dina Saadallah. "The role of landscaping elements in enhancing passive and active engagement in urban promenade: The case of Pharos Promenade, Alexandria, Egypt" Alexandria Engineering Journal (Faculty of Engineering, Alexandria University. Production and hosting by Elsevier B.V) 57 (November 2018): 3227–3236.

Bhutan. "Defining a New Economic Paradigm: The Report of the High-Level Meeting on Wellbeing and Happiness" New York: United Nations headquarters, 2012.

Chinmoy Sarkar, Chris Webster, John Gallacher. "Neighbourhood walkability and incidence of hypertension: Findings from the study of 429,334 UK Biobank participants" International Journal of Hygiene and Environmental Health 221, no. 3 (2018): 458-468.

Foley, Ronan. "Healing Waters: Therapeutic Landscapes in Historic and Contemporary Ireland" Routledge, 2010.

Forburkerrådet. "DECEIVED BY DESIGN: How tech companies use dark patterns to discourage us from exercising our rights to privacy" 2018.

Gehl, Jan. "Cities for people". Washington- Covelo -London: ISLAND PRESS, 2010.

Gesler, W M. "Therapeutic Landscapes: Theory and a Case Study of Epidauros, Greece" Environment and Planning D: Society and Space 11, no. 2 (2016).

Gianoglio, Martina. "Dubai's route to world's happiest city" Living Map. 2017.

Jenny J. Roe, Catharine Ward Thompson, Peter A. Aspinall, Mark J. Brewer, Elizabeth I. Duff, David Miller, Richard Mitchell, and Angela Clow. "Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban Communities". Int J Environ Res Public Health 10, no. 9 (2013): 4086–4103.

Joanne K.Garrett, Mathew P.White, Junjie Huang, Simpson Ng, Zero Hui, Colette Leung, Lap Ah Tse, Franklin Fungm Lewis R. Elliott, Michael H. Depledge, Martin C.S.Wong. "Urban blue space and health and wellbeing in Hong Kong: Results from a survey of older adults". Health & Place 55 (2019B).

Joanne K.Garrett, Theodore J.Clitherow, Mathew P.White, Benedict W.Wheeler, Lora E.Fleming. "Coastal proximity and mental health among urban adults in England: The moderating effect of household income". Health & Place 59 (2019A).

John DHetherington, Shmuel Burmil, Terry CDaniel. "Human values and perceptions of water in arid landscapes". Landscape and Urban Planning 44, no. 2–3 (1999): 99-109.

John F. Helliwell, Richard Layard, Jeffrey D. Sachs, Jan-Emmanuel De Neve, Lara B. Aknin, and Shun Wang. "World Happiness Report 2022". New York: Sustainable Development Solutions Network, 2022.

Jolanda Maas, Sonja M E van Dillen, Robert A Verheij, Peter P Groenewegen. "Social contacts as a possible mechanism behind the relation between green space and health". Health & Place 15, no. 2 (2009): 586-595.

Marc G Berman, Ethan Kross, Katherine M Krpan, Mary K Askren, Aleah Burson, Patricia J Deldin, Stephen Kaplan, Lindsey Sherdell, Ian H Gotlib, John Jonides. "Interacting with nature improves cognition and affect for individuals with depression". Journal of Affective Disorders 140, no. 3 (2012): 300-305.

Marco Helbich, Derek de Beurs, Mei-Po Kwan, Rory C O'Connor, Peter P Groenewegen. "Natural environments and suicide mortality in the Netherlands: a cross-sectional, ecological study". The Lancet Planetary Health 2, no. 3 (2018): e134-e139.

Mathew P. White, Ian Alcock, James Grellier, Benedict W Wheeler, Terry Hartig, Sara L Warber, Angie Bone, Michael Depledge, Lora E Fleming. "Spending at least 120 minutes a week in nature is associated with good health and wellbeing". Scientific Reports, 2019.

McCay, Jenny Roe, Layla : "Restorative Cities: Urban Design for Mental Health and Wellbeing". London: Bloomsbury visual arts, 2021.

Najmeh Bitaab, Farahbod Heydari, and Nadia Khadivi Golestani: "Investigating strategies for creating healthy cities with sustainable development approach". European Journal of Research (Social Science and Humanities), 2018: 34-44.

P. J. Irga, M. D. Burchett, F. R. Torpy. "Does urban forestry have a quantitative effect on ambient air quality in an urban environment? ". Atmospheric Environment 120 (2015): 173-181.

Ragheb, Riham A. "Alexandria's Eastern Entrance: Analysis of Qaitbay Waterfront Development". International conference on Architecture and Urban Design At:Barcelona. Barcelona: World Academy of Science, Engineering and Technology International Journal of Architectural and Environmental Engineering, 2014.

Rong, Iris Lim Wan. "Architecture of Urban Happiness : Creating A New Positive Typology". Singapore University of Technology and Design (SUTD), 2018.

Solomon M Hsiang, Marshall Burke, and Edward Miguel. "Quantifying the influence of climate on human conflict" Science, 2013.

Thomas Astell-Burt, Xiaoqi Feng. "Association of Urban Green Space With Mental Health and General Health Among Adults in Australia" Original Investigation Public Health 2, no. 7 (2019).

Trethewey, Ken. "Ancient Lighthouses - Part 5: The Pharos". UK: Gravesend Cottage, Torpoint, Cornwall , n.d.

Veenhoven, Ruut. "Measures of happiness: Which to choose?" In Metrics of Subjective Well-Being: Limits and Improvements. Springer, Dordrecht, 2017.

Wil Gesler. "Lourdes: healing in a place of pilgrimage" Health & Place 2, no. 2 (1996): 95-105.

380

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Implementierung von Waldinseln im Bereich der gründerzeitlichen Innenhöfe von Graz

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1 ABSTRACT

Viele Städte in Europa sind seit jeher von Platzproblemen betroffen. Die Etablierung von Grünflächen innerhalb urbaner Gebiete stellt eine komplexe Herausforderung dar, die oftmals einschneidende Veränderungen in dicht besiedelten Arealen erfordert. In diesem Kontext erweist sich die Stadt Graz als bemerkenswerte Ausnahme, da sie über eine beträchtliche Anzahl unbebauter Innenhöfe im Stadtzentrum verfügt. Nichtsdestotrotz ist Graz, wie viele andere städtische Zentren, den Auswirkungen extremer Wetterereignisse ausgesetzt. Insbesondere während der Sommermonate treten Extremhitze, intensiver Starkregen und ähnliche meteorologische Phänomene auf, die erhebliche Herausforderungen darstellen. Eine Möglichkeit diesen entgegen zu wirken stellen Waldinseln in den Innenhöfen der gründerzeitlichen Bebauung von Graz dar.

Keywords: Grünraum, Klimawandel, Wärmeinsel, Innenhof, Gründerzeit

2 GRÜNDERZEITLICHE INNENHÖFE VON GRAZ

Gründerzeitliche Innenhöfe stellen in einigen Bezirken von Graz eine große Grünraumressource dar. Sie befinden sich gut versteckt im Inneren der historistisch geprägten Baublöcke. Diese teils brachliegenden, teils bespielten Grünflächen sind vor allem in den Bezirken St. Leonhard, Geidorf und Jakomini zu finden – jedoch kommen sie auch in den Bezirken Innere Stadt, Lend und Gries vor. Aufgrund ihrer Begrenzung durch die umliegenden Baublöcke sind sie für Passanten meist uneinsehbar.

3 FORSCHUNG UND METHODE

Dieser Beitrag basiert auf den Forschungsergebnissen der Dissertation der Autorin, die derzeit in Form einer Monografie verfasst wird. Die Forschungsfrage hierzu lautet: „Wie können gründerzeitliche Innenhöfe in Graz in der Geschichte verortet werden, wie werden sie heute genutzt und welche Potenziale für die Zukunft stellen sie dar?"

Wie auch die Forschungsfrage schon andeutet, gliedert sich die Dissertation in drei Teile: Die Vergangenheit der gründerzeitlichen Innenhöfe, die Gegenwart und die Zukunft dieser. Diese Veröffentlichung beschäftigt sich vor allem mit dem dritten Teil der Zukunft und wie das Potenzial der Innenhöfe bestmöglichst genutzt werden kann. Hierbei werden die Ergebnisse der Forschung, die den zweiten Teil der Dissertation (Gegenwart) bildet, miteinfließen.

Um eine bessere Vergleichbarkeit zu gewährleisten und das Thema besser abgrenzen zu können, fokussiert sich diese Dissertation vor allem auf den Aspekt „Wohnen". Von den anfangs 246 in Betracht gezogenen Innenhöfen erfüllten 131 folgende von der Autorin festgelegten Kriterien:

Der Innenhof befindet sich in einem der Grazer Bezirke, der zu großen Teilen gründerzeitliche Bebauung aufweist.

Der Innenhof ist zum Großteil von gründerzeitlicher Bebauung umschlossen.

Abbildung 1: Mapping ausgewählter Innenhöfe.

Der Innenhof wird vor allem der Funktion „Wohnen" zugeschrieben oder ist zum Großteil von Wohnungen umgeben.

Der Innenhof ist ganz oder teilweise geschlossen.

Da keine Daten über alle den Kriterien entsprechenden Innenhöfen vorhanden waren, mussten diese mit unterschiedlichen Methoden selbst erhoben werden. Mittels den „Messtools", welche online über „GoogleMyMaps[1]" bereitgestellt werden, wurden Daten über Blockgröße, Innenhofgröße und Bebauung des Innenhofs generiert. In Zuge von Begehungen wurde eine Fotodokumentation mit über 4.000 Fotografien von Innenhöfen erstellt. Hierfür wurden alle infrage kommenden Innenhöfe von mindestens drei unterschiedlichen Blockseiten mehrmals fotografiert. Die Fotos wurden dann verortet und mittels Festlegung von rund 70 Merkmalen wie (Abgrenzung, Erschließung, Bodenbelag, Nutzung für Fahrzeuge...) analysiert. Im Zuge der Dissertation wurden mithilfe eines Katalogs der ausgewählten Innenhöfe die Entstehung dieser und der jetzige Zustand sowie deren Nutzung festgehalten. Die Daten der Evaluierung des Naturschutzbundes Steiermark aus dem Jahr 2004[2] wurden miteingearbeitet, um Veränderungen hinsichtlich der Innenhofbebauung sichtbar zu machen. Weiters war eine genaue Verortung (Kennzeichnung, Straßenbegrenzungen, Satellitenbild, grafische Darstellung im Bezirk) für die Wiederauffindbarkeit für spätere Arbeiten von großer Wichtigkeit. Grundlegende Informationen wie Block- und Innenhofgröße wurden in Zahlen dargestellt. Die wichtigsten Daten über Besitzverhältnisse, Mikroklima sowie Nutzung aus der Fotodokumentation[3] wurden grafisch auf Katalogblättern abgebildet. Die Nutzung durch die Bewohnerinnen und Bewohner wurde auf Basis der vorliegenden Daten geschätzt. Da die Begehung der Innenhöfe nicht immer zu 100 Prozent möglich war, wurde dies auf jedem Katalogblatt sichtbar gemacht. Um eine grobe Vorstellung der Flächenaufteilung zu bekommen wurde die Karte des Katasterauszuges des jeweiligen Innenhofes im Katalogblatt aufgenommen.

Um mehr über die Nutzung der Innenhöfe durch Bewohnerinnen und Bewohner zu erfahren, wurde über das Tool „Google Forms[4]" eine Umfrage erstellt, welche im Zeitraum Mai 2017 bis Juli 2018 durchgeführt und in Folge dessen statistisch ausgewertet wurde. Als Gesamtheit der Umfrageteilnehmer wurden alle Grazerinnen und Grazer, welche in einem Mehrparteienhaus mit Innenhof wohnen, ausgewählt. Die Umfrage wurde über Facebook in verschiedenen Gruppen, welche eine möglichst breite Erhebung gewährleisten, verbreitet. Da jedoch bestimmte Altersgruppen auf Facebook schwächer vertreten sind, wurde ein Aufruf zur Teilnahme an der Umfrage an „Schwarze Bretter" direkt in den Eingangsbereichen der Gebäude, welche für die Umfrage relevant waren, gehängt. Weiters wurden Personen, die zufällig während der Fotodokumentation getroffen wurden, gebeten an der Umfrage teilzunehmen. An ältere Personen, welche nicht an der Umfrage mittels Internet teilnehmen konnten/wollten, wurde die Umfrage in Papierform ausgegeben und nach dem Ausfüllen in die online Umfrage eingetragen. Die Stichprobe dieser Umfrage liegt bei 263 Personen.[5] Die Umfrage wurde grafisch in Abbildung 3 aufgearbeitet, um ein Meinungsbild der Teilnehmerinnen und Teilnehmer in den für dieses Paper relevanten Aspekten besser darzustellen.

Der Wohnungsmarkt wurde analysiert indem von Mitte Jänner 2017 bis Mitte Jänner 2018 insgesamt 2278 Wohnungsanzeigen auf ihre Angaben zu Innenhöfen bei historistischen Grazer Häusern evaluiert wurden.[6]

4 FUNKTION DER GRÜNDERZEITLICHEN INNENHÖFE VON GRAZ

Aus Archivunterlagen und der auch heute noch sichtbaren Parzellierung (Abbildung 2) wird klar, dass die Größe und Form der Grundstücke je nach Gegebenheiten gewählt wurden. Grundlagen hierfür sind Straßenverläufe, Bäche sowie die Lage der bereits bestehenden Gebäude. Weiters ist zu bemerken, dass der Innenhof bei Eckgebäuden meist deutlich kleiner ausfällt als bei mittig stehenden Gebäuden. Häufig wurde entlang der Hausgrenze, die an das benachbarte Haus angrenzt, eine Linie gezogen um den Innenhof zu

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[1] Online abrufbar: https://www.google.com/maps/d/ (abgerufen im Zeitraum 2017)
[2] Informationen und Unterlagen direkt vom Naturschutzbund Steiermark, Herdergasse 3, 8010 Graz, Durchführung der Studie 2004
[3] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017
[4] Online abrufbar: https://www.google.com/intl/de_at/forms/about/ (abgerufen im Zeitraum 2017/2018)
[5] Bewohnerinnen und Bewohnerbefragung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai 2017 bis Juli 2018
[6] Wohnungsmarktanalyse, durchgeführt von Petra Kubin, Durchführungszeitraum Mitte Jänner 2017 bis Mitte Jänner 2018

begrenzen. Die Begrenzung, die mittig des Hofes verläuft, wurde von Baublock zu Baublock und von Innenhof zu Innenhof unterschiedlich gezogen. Dies führt dazu, dass man nicht von einheitlichen Innenhofgrößen innerhalb eines Blocks ausgehen kann.

Abbildung 2: Parzellierung heute (Eigene Grafik nach Digitaler Atlas Steiermark[7])

Diese ungleichen Innenhofgrößen machen es schwierig eine einheitliche Funktion festzustellen. Vor allem gilt dies für die Innenhofbereiche im Zentrum des jeweiligen Gründerzeitblocks. Die Freibereiche, welche direkt an die Hausseite anschließen, werden auch Haushufen genannt. Sie hatten früher großteils einheitliche Funktionen. So dienten diese, zumeist mit Beton versiegelten Bereiche, den hauswirtschaftlichen Tätigkeiten. Sie waren in unmittelbarer Nähe zur Waschküche und den Hausbesorgerinnen- und Hausbesorgerwohnungen. Als Ausstattung sind die heute oft noch bestehenden Teppichklopfstangen und Wäscheleinen signifikant. Die Haushufen wurden meist mit einem Gartenzaun begrenzt, sodass man nur durch eine Gartentür in den weiteren Innenhof gelangte. Der vom Wohnhaus weiter entfernte Bereich des Innenhofes besticht heute mit seinen Grünflächen und Altbaumbeständen auf denen immer wieder auch alte Obstbäume zu finden sind. Diese Bereiche könnten durch ihre geschützte Lage auch früher schon der Eigenversorgung gedient haben.[8] Schriftlich konnten jedoch hierzu keine Anhaltspunkte gefunden werden.

4.1 Nutzung der Innenhöfe heute

Die Nutzung der Innenhöfe variiert. Durch die Befragung[9] wird deutlich, dass über ein Drittel der Bewohnerinnen und Bewohner besonders die Ruhe im Innenhof schätzen (Abbildung 3: Nutzung). Hier ist der Innenhof eine besonders wertvolle Ressource, da er durch die Häuserblöcke von der Straße abgeschirmt ist. Diese Ruhe kann man dank des Innenhofes jedoch nicht nur im Innenhof selbst sondern auch über innenhofseitige Fenster oder Balkone genießen. Ist der Innenhof zusätzlich noch begrünt und frei von Motorgeräuschen kommt ein besonders hoher Entspannungswert zu tragen. Im Gegensatz zum Wunsch nach einem ruhigen Innenhof steht das Bedürfnis vieler Bewohnerinnen und Bewohner den Innenhof in Gesellschaft zu erleben. Hier wird besonders oft das Spielen von oder mit Kindern oder geselliges Zusammensitzen genannt (Abbildung 3: Nutzung). Bei der Befragung konnte festgestellt werden, dass Bewohnerinnen und Bewohner, die eine Wohnung mit Innenhof in Graz besitzen, diesen oft nutzen, wenn sie Kinder haben (Abbildung 3: Nutzung nach Häufigkeit mit und ohne Kinder). Grünbereiche in sehr kurzer Distanz der Wohnung sind besonders attraktiv, da keine zusätzlichen Gegenstände mitgenommen werden müssen, und man schnell wieder in der eigenen Wohnung ist. Durch die Umfrage konnte ermittelt werden, dass der Personenkreis 51+ den Innenhof besonders stark nutzt (Abbildung 3: Nutzung nach Häufigkeit und Alter). Dies könnte mit der freigewordenen Zeit im Ruhestand, mit den kurzen Wegen im fortgeschrittenen Alter und mit der Nutzung mit Enkelkindern im Zusammenhang stehen. Da prozentuell nur ein kleiner Anteil der Innenhöfe Kinderspielgeräte besitzt dürften diese nur von sekundärer Bedeutung sein. Untersuchungen zeigen, dass Bewohnerinnen und Bewohner, die sich mit ihrem Wohnumfeld identifizieren, soziale Strukturen stärken. Die aktive Nutzung der Innenhöfe kann zu einer verstärkten Identifizierung mit diesem führen und somit die gesellschaftliche Teilhabe fördern und Verwahrlosung und Stigmatisierung

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[7] Digitaler Atlas Steiermark, https://www.landesentwicklung.steiermark.at (eingesehen 06.10.2022)
[8] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017
[9] Bewohnerinnen und Bewohnerbefragung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai 2017 bis Juli 2018

entgegenwirken.[10] Sitzmöglichkeiten sind in einigen Innenhöfen vorhanden. Hier können temporäre und langfristige Möglichkeiten, welche auch während der Wintermonate im Garten bleiben, unterschieden werden. Temporäre Sessel und kleinere Tische mit Klappmöglichkeiten werden oft von einzelnen Bewohnerinnen und Bewohnern in den Garten gebracht und wieder abgebaut nach der Benützung. Auch Grillmöglichkeiten sind in einigen Innenhöfen zu finden. Bei den Kinderspielmöglichkeiten sind vor allem Sandkästen und Schaukeln, die an den vorhandenen Teppichklopfstangen angebracht sind, vorherrschend. Laut eigener Umfrage wird der Innenhof von rund 40 Prozent der Befragten für das Abstellen von Fahrrädern genutzt (Abbildung 3: Nutzung). Von dieser Abstellmöglichkeit nehmen vor allem Bewohnerinnen und Bewohner in Ausbildung besonders starken Gebrauch. Die Nutzung als Autoabstellplatz wird hingegen nur bei 9,5 Prozent der Befragten angegeben (Abbildung 3: Nutzung). Durch die Auswertung der Begehungen der Innenhöfe wurde klar, dass Vermieterinnen und Vermieter Innenhöfe oft als Abstellmöglichkeit für Abfalltonnen nutzen. 28 Prozent der Bewohnerinnen und Bewohner geben an, den Innenhof überhaupt nicht zu nutzen (Abbildung 3: Nutzung nach Häufigkeit). Hier sind jedoch die unmittelbaren Nutzungen durch das Öffnen der Fenster und der Ausblick ins Grüne nicht zu unterschätzen. In vielen Wohnungsanzeigen werden genau diese Aspekte zur Bewerbung der Wohnung genutzt. [11,12,13]
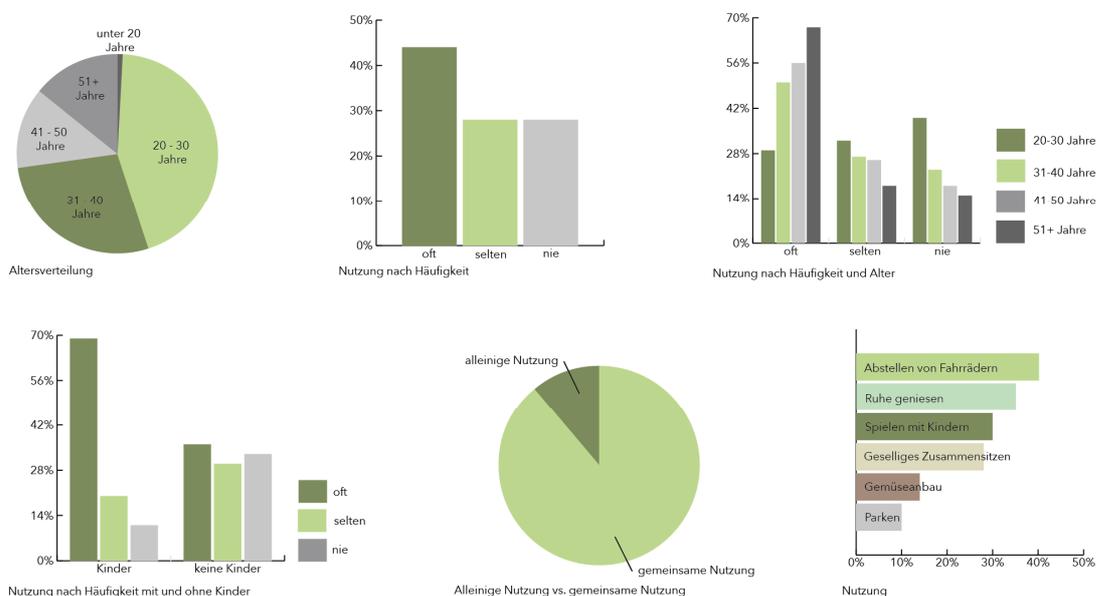
Abbildung 3: Auswertungen aus der Bewohnerinnen und Bewohnerumfrage[14]

4.2 Private, semiprivate und öffentliche Nutzung der Grazer Innenhöfe

Grazer Innenhöfe können zum Großteil von ganzen Hausgemeinschaften genutzt werden. In der Umfrage geben 89 Prozent an, dass ihnen der Innenhof zur gemeinsamen Nutzung mit anderen Hausbewohnerinnen und Hausbewohnern zur Verfügung steht (Abbildung 3: Alleinige Nutzung vs. gemeinsame Nutzung). Nur in wenigen Höfen finden sich Hinweise, die davon ausgehen lassen, dass der Innenhof für andere Hausbewohnerinnen und Hausbewohner gesperrt ist. Direkte Ausgänge über Erdgeschoßwohnungen sind die Ausnahme. Der Zugang zum Innenhof erfolgt großteils über einen Ausgang, welcher vom Stiegenhaus aus für alle Bewohnerinnen und Bewohner gleich begangen werden kann. Öffentliche Nutzung und Begehbarkeit ist fast immer unerwünscht. Schilder auf Innenhoftüren weisen häufig klar darauf hin, dass darauf zu achten ist, dass die Türen verschlossen zu halten sind.

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[10] Vielfalt von Stadtgrün, in: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, Referat Öffentlichkeitsarbeit, (Hg.):Grün in der Stadt – Für eine lebenswerte Zukunft, Grünbuch Stadtgrün, Rostock 2015, 8–67, hier 24–25.

[11] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017

[12] Bewohnerinnen und Bewohnerbefragung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai 2017 bis Juli 2018

[13] Wohnungsmarktanalyse, durchgeführt von Petra Kubin, Durchführungszeitraum Mitte Jänner 2017 bis Mitte Jänner 2018

[14] Bewohnerinnen und Bewohnerbefragung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai 2017 bis Juli 2018

In den einzelnen gründerzeitlichen Blocks in Graz gibt es eine unterschiedliche Anzahl von Innenhöfen. Meist sind die Innenhöfe klar einem Haus zugeordnet. Öffnungen zu anderen Innenhofbereichen sind nur in wenigen Fällen vorhanden. Viel mehr ist zu bemerken, dass die Abgrenzung gewünscht ist und durch Sichtschutz, Hecken und Bäume auch innerhalb des Blocks eine Intimität und Uneinsichtigkeit geschaffen wird. Abgrenzungen sind in allen Grazer Innenhöfe zu finden.

Die Vorstellung eines großen Innenhofs, der in Graz oft bis und über einen Hektar groß sein könnte, ist für viele Planerinnen und Planer eine schöne Vorstellung. Großräumige Grünflächen, die alle Möglichkeiten des Verweilens bieten und Kinder großer Wohnblöcke ohne störenden Verkehr miteinander spielen lassen könnten, wären theoretisch anzustreben. Hierfür gibt es in anderen Städten bereits Vorbilder. In Graz jedoch scheint diese Vorstellung aufgrund der Besitzverhältnisse (meist gehört jeder Wohnungsbesitzerin und jedem Wohnungsbesitzer ein ideeller Anteil der Innenhoffläche) und aufgrund der gewünschten Intimität nicht das Ziel zu sein. [15]

5 GEOGRAFISCHE UND KLIMATISCHE GEGEBENHEITEN IM ZUSAMMENHANG MIT GRÜNDERZEITLICHEN INNENHÖFEN

Die Stadtklimakarte von Graz entstand im Zuge der Stadtklimaanalyse. Diese wurde von der Stadt Graz in Auftrag gegeben und vom Institut für Geographie und Raumforschung an der Karl-Franzens-Universität Graz durchgeführt. Die gründerzeitlichen Gebiete der Stadt Graz befinden sich innerhalb der sehr stark bis stark von Überhitzung betroffenen Gebiete. Verantwortlich dafür sind die windarme Tallage von Graz sowie die stark eingeschränkte Durchlüftung aufgrund von dichter Bebauung. Infolgedessen bilden sich hier Wärmeinseln aus. Obwohl sich die Wohnungen der gründerzeitlichen Baublöcke innerhalb der am meisten von Hitze betroffenen Gebieten befinden, weisen diese, wenn sie begrünte Innenhöfe besitzen, laut Stadtklimaanalyse ein bioklimatisch behagliches Wohnklima auf.[16]

Der Begrünungsgrad der gründerzeitlichen Innenhöfe in Graz ist meist recht hoch. Viele der Innenhöfe weisen einen hohen Grad an Wiese und vereinzelten Bäumen auf. Die Nutzung des Innenhofes ist laut Bewohnerinnen und Bewohnerbefragung mit 44 Prozent die den Innenhof "oft" nutzen und 28 Prozent die diesen "selten" nutzen recht hoch. Weitere 28 Prozent geben an, den Innenhof nie zu nutzen. Somit verbleiben 72 Prozent der Befragten die den Innenhof nutzen (Abbildung 3: Nutzung nach Häufigkeit). Als häufigste Nutzung wird das Abstellen von Fahrrädern angegeben (Abbildung 3: Nutzung). Dies lässt sich auch sehr gut über die Begehung und die darauffolgenden Auswertung bestätigen. Fast in jedem Innenhof sind Fahrräder zu finden. Was sich aber durch die Begehung auch gezeigt hat, ist, dass meist ein kleiner Bereich des Innenhofes genutzt wird. So sind Sitzgelegenheiten meist im Bereich zu finden der nicht weiter als zehn Meter von der Blockrandbebauung entfernt ist. Die inneren Bereiche der Innenhöfe sind weitgehend unbenutzt.[17,18]

Abbildung 4,5,6: Eigene Fotografien von gründerzeitlichen Innenhöfen in Graz

So stellt sich unweigerlich die Frage, wie der Innenhof genutzt werden sollte? Wie oben schon eingehend erläutert, ist vor allem die Intimität der Innenhofbereiche eine wichtige Funktion, die diese in Graz erfüllen sollen. Mit Zäunen und Hecken wird innerhalb der Wohnblöcke eine Privatheit geschaffen. Das Verweilen im Innenhof und das Spielen mit Kindern sind weitere wichtige Punkte. Spielgeräte für Kinder findet man

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[15] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017

[16] Lazar/Sulzer, S 169, 224-225.

[17] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017

[18] Bewohnerinnen und Bewohnerbefragung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai 2017 bis Juli 2018

jedoch auch eher wenige. Hier ist der genutzte Bereich auch meist auf den Bereich beschränkt, der 10 Meter von der Hauskante entfernt ist. [19,20]

Grundsätzlich ist die Nutzung der Innenhöfe als Grünfläche ein sehr positives Beispiel für eine Nutzung von Flächen im innerstädtischen Bereich. Wie die Grafik „Ökosystemleistungen von Vegetationsstrukturen" von Grzimek aus dem Buch „Die Grüne Stadt" (Abbildung 7) veranschaulicht, ist das Potenzial an Ökosystemleistungen noch nicht ausgeschöpft. Vergleicht man eine Rasenfläche mit einem Laubwald, wäre der Nutzen für das Ökosystem deutlich höher einzustufen. Die Biomasse des Grünraums würde bei einem Laubwald um das 12-Fache und bei „Intensivem Grün" um das 16-Fache höher sein als bei einer Rasenfläche. Ähnlich sieht es bei der Temperaturminderung, der Schadstoffbindung sowie der Lärmminderung aus. Hieraus ergibt sich die Frage: Welche Möglichkeiten für eine Etablierung eines Waldes gibt es in den gründerzeitlichen Innenhöfen beziehungsweise welche Vorteile würden diese bieten?

		Biomasse Sommer	Biomasse Winter	Biomasse insgesamt	Temperaturminderung	Luftschadstoffbindung	Lärmminderung	Optische Kulissenwirkung
RASEN	häufig geschnitten immergrün hoher Pflegeaufwand	1	1	1	1	1	0	0
ZIER-PFLANZEN	Boden intensiv bearbeitet, keine geschlossene Fläche, im Winter offen	2	0	1	2	2	1	1
PARK	getrennter Wuchs in Bodendecke-, Busch und Baumzone, hoher Pflegeaufwand	13	3	8	12	10	8	6
LAUBWALD	je nach Dichte Strauch- und Bodendeckerschicht	18	6	12	16	14	14	14
INTENSIVES GRÜN	Intensiver Wuchs in drei Schichten, Biomasse Sommer	20	12	16	18	20	20	20

Abbildung 7: Ökosystemleistungen von Vegetationsstrukturen (gekürzt)[21]

5.1 Begriffsdefinitionen für urbane Flächen mit Baumbestand

Es gibt viele Arten und Bezeichnungen von urbanen Flächen mit Baumbestand. Unter „Urban Forest" versteht man urbane Baumbestände, die unabhängig von ihren Eigentümern als „Ressource" und insgesamt als Anbieter von Ökoleistungen agieren und von denen Stadtbewohner profitieren. Dies schließt alle urbanen Gehölzbestände und Wälder ebenso ein, wie alle Bäume im öffentlichen und privaten Besitz. Als „Urbane Wälder" hingegen bezeichnet man überwiegend Waldrelikte, die durch natürliche Sukzession und durch Pflanzung in Städten entstanden sind. Sie verfügen über ein eigenes Waldklima in dem spezielle Lebensraumbedingungen entstehen. Laut Leser 2008 und Dietrich 2013 müssen sie mindestens 0,5 Hektar groß sein. Burkhardt hingegen gib die Mindestgröße mit 0,3 Hektar an jedoch müssen sie einen Mindestdurchmesser von 50 Metern aufweisen. Sie können im öffentlichen oder auch privaten Eigentum sein und müssen in der Regel öffentlich zugänglich sein. Nach Kowarik sind Stadtwälder entweder angepflanzte oder ursprünglich natürlich entwickelte standortgerechte Gehölzkombinationen. [22]

Aus einem Projekt der Universität Potsdam, dem Bezirksverband Berlin –Süden der Kleingärten e.V., dem Freilandlabor Britz e.V und dem Umwelt- und Gartenamt der Stadt Kassel, das im April 2021 gestartet wurde, ist der Name „Urbane Waldgärten" hervorgegangen. Ein urbaner Waldgarten besteht vorwiegend aus essbaren Pflanzen wie Obst- und Nussbäumen, Beerensträucher sowie Gemüsen und Kräutern, die langfristig miteinander angebaut und geerntet werden können. Es soll die Bodenfruchtbarkeit aufbauen und erhalten und so ein klimaangepasstes Anbausystem mit hoher Artenvielfalt gewährleisten. [23]

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[19] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017

[20] Bewohnerinnen und Bewohnerbefragung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai 2017 bis Juli 2018

[21] Breuste S 119., (verändert unter Verwendung von Grzimek 1965; zitiert in Greiner und Gelbrich 1975, Abb. 18, S. 26/27., 20-teilige Skala zwischen 0 = keine Leistung und 20 = sehr hohe Leistung)

[22] Breuste, S 145.

[23] Urbane Waldgärten

386

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Eine besondere Art des „Urban Forest" stellt der „Tiny Forest" dar. Das Tiny Forest Konzept basiert auf der Restaurierungsarbeit für Brachflächen des japanischen Försters Akira Miyawaki aus den 1970er-Jahren.[24] Ein „Tiny Forest" kann schon ab einer Größe von 0,01 bis 0,04 Hektar Fläche entstehen. Das besondere am Konzept ist, dass auf kleinstem Raum eine Maximierung der Vegetationsstruktur und der Artenvielfalt geschaffen wird. Hierfür werden die Bodenverhältnisse durch gezieltes Zuführen von natürlichen Materialien verbessert. Durch eine extrem dichte Bepflanzung von verschiedenen heimischen Gehölzen wird das Wachstum so stark angeregt, dass schon in kurzer Zeit ein dichter Wald entsteht. So können vor allem auch Brachflächen in grüne Inseln verwandelt werden. Wichtig ist die Einbindung von Anwohnern in die Planung, Umsetzung und Pflege der Wälder, um sicherzustellen, dass auch alle Wünsche und Bedürfnisse für die Gestaltung und Funktionen der städtischen Grünfläche berücksichtigt werden. Der Wissenschaftsingenieur Shubhendu Scharma hat die Methode in seinem Öko – Unternehmen umgesetzt und weiter in die Öffentlichkeit gestellt. So kann man das Konzept der Umsetzung eines „Tiny Forest" über YouTube Videos in einem DIY-Kurs erlernen.[25] [26]

6 ANWENDUNG EINES „URBAN FOREST" KONZEPTES AUF DEN GRÜNDERZEITLICHEN INNENHOF VON GRAZ

Die Innenhöfe der 131 gründerzeitlichen Baublöcke, welche im Zuge der oben genannten Dissertation bearbeitet wurden, stellen eine Gesamtfläche von etwa 80 Hektar dar. Einzelne Innenhöfe sind unterschiedlich groß, der kleinste Innenhof hat eine Größe von 0,073 Hektar und der größte ist 2,2 Hektar groß. Im Durchschnitt liegt die Größe der erfassten gründerzeitlichen Innenhöfe 0,6 Hektar. Durch die unterschiedlichen Gegebenheiten ist es natürlich schwierig ein gemeinsames Konzept für eine Innenhofbewaldung zu erstellen. Die Mindestgröße eines „Urbanen Waldes" von 0,5 Hektar wird nicht von allen Innenhöfen erreicht. Die Mindestfläche für einen „Tiny Forest" von 0,01 bis 0,04 Hektar jedoch ist bei jedem der bearbeiteten Innenhöfe gegeben.
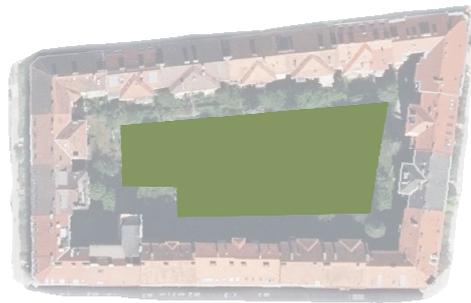
Abbildung 8: Gründerzeitlicher Innenhof in Graz mit möglicher intensiv begrünter Fläche[27]

Hier kann jedoch nicht die gesamte Fläche, die den Innenhof definiert, mit Bäumen bepflanzt werden, da ein gewisser Abstand zu den Gebäuden bestehen bleiben muss. So könnte der Ansatz zwischen intensiv mit Bäumen begrünter Fläche und Gebäude in Anlehnung an die im steiermärkischen Baugesetz vorgeschriebenen Mindestabstände von Häusern liegen.[28,29] Bei den meist drei geschossigen Gründerzeitbebauungen sowie den 10 bis 20 Meter hohen Bäumen würde sich daraus ein ungefährer Abstand von 10 Metern ergeben. Dies ist auch in dem Bereich, der laut Begehung am intensivsten von den Bewohnerinnen und Bewohnern genutzt wird. Hier ergeben sich je nach Größe des Innenhofes unterschiedliche Flächen, welche bepflanzt werden könnten. Im vorliegenden Beispiel handelt es sich um einen Innenhof mit 0,66 Hektar Fläche, welcher mit 10 Metern Abstand zu den Gebäuden eine Fläche von

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[24] Lewis, S.

[25] Afforest

[26] Egerer, Suda, S 1.

[27] GIS Steiermark, Karte nachbearbeitet

[28] (1) Gebäude sind entweder unmittelbar aneinander zu bauen oder müssen voneinander einen ausreichenden Abstand haben. Werden zwei Gebäude nicht unmittelbar aneinadergebaut, muß ihr Abstand mindestens so viele Meter betrgen, wie die Summe der beidseitigen Geschoßzahl, vermehr um 4, ergibt (Gebäudeabstand)

[29] RIS

0,3 Hektar erreicht. Innerhalb dieser 0,3 Hektar Fläche (Abbildung 8, grüne Fläche) könnte eine intensive Bepflanzung stattfinden.[30]

Da die Innenhofbereiche der Grazer gründerzeitlichen Innenhöfe meist sehr viele Besitzerinnen und Besitzer haben, und jeder Wohnungseignerin bzw. jedem Wohnungseigner gehört meistens ein Anteil des Haushofes, ist es von großer Bedeutung, die Wichtigkeit von intensiver Bepflanzung mit Bäumen für die Besitzerinnen und Besitzer sichtbar zu machen. Hierfür kann das dreistufige Verfahren, das von der TEEB DE 2016 entwickelt wurde, herangezogen werden, um ökonomische Perspektiven auf die Stadtnatur zu schaffen. Als erster Schritt wird die Identifizierung und Anerkennung genannt. Besitzerinnen und Besitzern die ihren Innenhof als Möglichkeit der Verbesserung des Stadtklimas akzeptieren und auch als dieses wertschätzen werden bei einem Projekt zur Umsetzung eines intensiv bewachsenen Waldes in ihrer unmittelbaren Wohnungsumgebung und in ihrem Besitzt eher zustimmen bzw. daran mitarbeiten als Bewohnerinnen und Bewohner die nicht im Projekt involviert sind. Dies stimmt auch mit den Grundsätzen des „Tiny Forest" überein, die auch die Einbindung der Anwohnerinnen und Anwohner als sehr wichtig ansehen. Als zweiter Punkt wird das Erfassen und das Bewerten von Stadtnatur hervorgehoben. Hier soll der Wert der neu geschaffenen Stadtnatur herausgestellt werden. Hierfür eignet sich die Grafik der Ökosystemleistungen (siehe Abbildung 7). „Urbane Ökosystemleistungen bezeichnen Leistungen, die von Stadtnatur erbracht und von Menschen genutzt werden. Sie basieren auf ökologischen Funktionen, von denen Menschen aktiv oder passiv einen direkten Nutzen für ihr Wohlbefinden haben."[31] Positive Aspekte wie Temperaturminderung, Luftschadstoffminderung, Lärmminderung und auch die optische Wirkung als Kulisse können als solch ein Wert definiert werden. Der dritte Punkt ist die Berücksichtigung von Werten in Entscheidungen. Demnach müssen Ökosystemleistungen als Wert betrachtet werden. Maßnahmen für die Entstehung einer Stadtnatur stehen somit in direktem Zusammenhang mit einem höheren Kapital und können so als Instrumente zur Generierung dieses Kapitals herangezogen werden. Hier wird ein wirtschaftlicher Zugang geschaffen, um durch Mehrwerte zu überzeugen.[32]

6.1 „Tiny Forest"

Der Vorteil des „Tiny Forest" liegt vor allem im schnellen Wachstum der Pflanzen und in der hohen Biodiversität, die dadurch erreicht werden kann. Die mehrschichtige Art der Begrünung gewährleistet einen sehr dichten, aber auch unbegehbaren Wald. Es können zwar Wege durch den Wald geschaffen werden, jedoch ist diese Durchwegung mit den vorherrschenden Besitzverhältnissen innerhalb der Baublöcke nur schwer zu realisieren. Ein weiterer Faktor, der berücksichtigt werden muss, ist der Aufwand, der für die Durchführung eines „Tiny Forest" entsteht. Bodenschichten müssen angereichert und somit umgegraben werden. Bestehende Zäune können oft nicht bestehen bleiben da, diese eine Anlegung erschweren würden. Die Privatheit, die von den meisten Grazer Bewohnerinnen und Bewohner so geschätzt wird, würde für bis zu drei Jahre gestört sein. Weiters ist eine Pflege der bepflanzten Fläche in den ersten Jahren notwendig. Hierfür müssten Freiwillige, die vor Ort sind, gefunden werden. Das Projekt, das durch die Entwicklung eines „Tiny Forest" entsteht, würde aber auch die Stärkung des sozialen Gefüges innerhalb der Blockgemeinschaft anstoßen. Alle können mitarbeiten und sind Teil eines Projektes das einen Mehrwert für ihre Wohnungsumgebung schafft.[33]

6.2 Waldinsel

„Urban Forest" hingegen ist nicht genau definiert und kann durch jeden zusätzlichen Baumbestand erreicht werden. Hierfür wurde in diesem Paper die Bezeichnung Waldinsel gewählt. Hiermit sind stark bepflanzte Bereiche innerhalb der Blockrandbebauung gemeint. Die Innenhofgemeinschaft, die sich aus allen Akteuren, die Teile des Innenhofes besitzen oder bewohnen, zusammensetzt, kann beschließen, ihren Teil des Innenhofblocks intensiv und mehrschichtig mit heimischen Gehölzern zu begrünen. Um daraus ein Projekt entstehen zu lassen, welches viele Innenhofbesitzer motiviert, sich anzuschließen, müsste ein Leitfaden mit Best-Pracis-Beispielen erstellt werden. Hierfür gibt es schon einige Anregungen, wie zum Beispiel das oben

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[30] Daten von Begehung und Fotoauswertung, durchgeführt von Petra Kubin, Durchführungszeitraum Mai bis Juli 2017
[31] Breuste S 101.
[32] Kowwarik/Bartz/Brenck/Hansjürgens S 16-23.
[33] Afforestt

erwähnte Projekt „Urbane Waldgärten".[34] Welche Baumarten sich besonders eignen, kann über verschiedene Informationsbroschüren ermittelt werden, die von der Bayrischen Landesanstalt für Wein und Gartenbau erarbeitet wurden und über deren Homepage öffentlich zugänglich sind. Im Zuge des Forschungsprojektes Stadtgrün 2021+ wurden klimafite Stadtbaumarten zusammengestellt und aufgelistet.[35] Diese strategisch durchdachte, intensive, mehrschichtige Begrünung durch heimische Gehölze und Laubbäume könnte im kleinen Maßstab, also in einzelnen Innenhofbereiche oder auch auf einen ganzen Block angewendet werden. So müssten die von den Grazer Bewohnerinnen und Bewohnern geschätzten Abgrenzungen zum gesamten Block nicht entfernt werden. Der Boden müsste meistens nicht aufgebessert werden, da eine nicht so dichte Bepflanzung wie beim „Tiny Forest" angestrebt wird. Wenn ausreichend große Flächen zur Verfügung stehen, könnten Waldinseln ebenfalls begehbar sein, ähnlich wie Wälder. Eine Waldinsel im Innenhof des Wohnhauses könnte auch Kindern als natürlicher Spielplatz dienen.

7 CONCLUSION

Um den städtischen Wärmeinseleffekt zu verringern, ist intensive Begrünung mit mehrschichtiger Bepflanzung von heimischem Gehölz und Laubbäumen in diesen Gebieten von besonderer Bedeutung. Solche Waldinseln könnten innerhalb der Grazer Blockrandbebauung entstehen. Sie hätten nicht nur einen wichtigen Effekt auf die Temperaturregulierung in den heißen Sommermonaten, sondern könnten auch anderen Problemen im städtischen Bereich entgegenwirken. Angesichts der zunehmenden Wetterextreme aufgrund der Klimaerwärmung ist die lokale Wasserversickerung von besonderer Bedeutung. Bei Starkregen ist es oft unmöglich für das städtische Kanalsystem, die Wassermassen aufzunehmen. Waldinseln könnten einen erheblichen Anteil des Wassers vor Ort aufnehmen. Eine weitere wichtige Funktion besteht darin, zur Luftreinigung beizutragen und den CO_2-Ausgleich zu unterstützen. Graz könnte weiters von einer Reduzierung der Feinstaubbelastung profitieren Die Lärmbelastung im Innenhof sollte ebenfalls nicht unterschätzt werden. Im Vergleich zu einer Wiese kann intensive Begrünung eine um das 20-fache reduzierte Lärmbelastung gewährleisten.[36]

Die gemeinsame Entscheidungsfindung und Nutzung einer Waldinsel kann einen neuen sozialen Wert schaffen. Gemeinsame Tierbeobachtungen, Spielen im Wald und Entspannen in bewaldeten Bereichen tragen zum physischen und psychischen Wohlbefinden bei.[37] Für ältere Bewohnerinnen und Bewohner wäre eine im Innenhof gelegene Waldinsel aufgrund der kurzen Erreichbarkeit und der angenehmeren Temperaturen besonders wertvoll.[38] All diese Aspekte können herangezogen werden, um die ökologischen Leistungen von vegetativen Strukturen zu bewerten und auch wirtschaftlich darzustellen, um die Bedeutung solcher Maßnahmen verständlich zu machen.[39]

8 REFERENCES

AFFORESTT: https://www.afforestt.com/methodology

BREUSTE, Jürgen: Die Grüne Stadt. Stadtnatur als Ideal, Leistungträger und Konzept für Stadtgestaltung. Berlin, 2019.

BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ, BAU UND REAKTORSICHERHEIT: Grün in der Stadt – Für eine lebenswerte Zukunft. Grünbuch Stadtgrün. Rostock, 2015

DIGITALER ATLAS STERERMARK: https://gis.stmk.gv.at/wgportal/atlasmobile/map/Basiskarten/Basiskarte

EGERER, Monika/ SUDA, Michael: Desining „Tiny Forest" as a lesson for transdisciplinary urban ecology learing, https://doi.org/10.1007/s11252-023-01371-7, 2023

ESCOBEDO, Francisco/ NOWAK, David: Spatial hetrogeneity and air pollution removal by an urban forest. Elsevier, 2008

FOLDAL, Cecilie, Birgitte/ HOLLOSI, Brigitta/ KODYM, Andrea/ ÖLLERER, Barbara: Die Grüne Stadt aus forstlicher Sicht. Eine Studie im Auftrag der Österreichischen Akademie der Wissenschaften, Arbeitsgruppe 'Klima und Luftreinhaltung', Wien. Ausgeführt durch das Bundesforschungszentrum für Wald (BFW) und der Zentralanstalt für Geodynamik und Meteorologie (ZAMG). 2022

KOWARIK Ingo/ BARTZ, Robert/ BRENCK, Miriam/ HANSJÜRGENS, Bernd: Ökosystemstellungen in der Stadt. Gesundheit Schützen und Lebensqualität erhöhen. Makranstädt, 2017

LEWIS, Hannah: Mini-Forest Revolution: Using the Miyawaki Method to Rapidly Rewild the World. Vermont, 2022.

LWG BAYERN: https://www.lwg.bayern.de/landespflege/urbanes_gruen/085113/index.php

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[34] Urbane Waldgärten

[35] LWG Bayern

[36] Breuste S 119.

[37] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, Referat Öffentlichkeitsarbeit, S 8 – 67.

[38] Afforestt

[39] Breuste S 119.

MOEBUS, Susanne/ GRUEHN, Dietwald/ POPPEN, Jonas/ SUTCLIFFE, Robynne, HASELHOFF, Timon, LAWRENCE, Bryce: Akustische Qualität und Stadtgesundheit – Mehr als nur Lärm und Stille. Bundesgesundheitsblatt 2020-63:997-1003, https://doi.org/10.1007/s00103-020-03184-x, 2020
RASTANDEH, Amin/ JARCHOW, Meghann: Creating Resilient Landscapes in a Era of Clima Change. Abingdon, 2023
RECHTSINFORMATIONSSYSTEM DES BUNDES: Steiermärkisches Baugesetz abgerufen über das Rechtsinformationssystem des Bundes (RIS), https://ris.bka.gv.at
LAZAR, Reinhold/ SULZER, Wolfgang: Stadtklimaanalyse 1986,1996,2004 & 2001, Stadt Graz Stadtplanung Stadtvermessung
TEEB (2011) TEEB manual for cities: ecosystem services in urban management. http://www.naturkapitalteeb.de/aktuelles.html. Zugegriffen: 26. Aug. 2014
URBANE WALDGAERTEN: https://www.urbane-waldgaerten.de
WUCHERT, Margitta: Landschaftlichkeit als Architekturidee. Berlin, 2022

390

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Increase Occupancy Rate in Passenger Cars – Potentials of Awareness Raising for Carpooling

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1 ABSTRACT

Transport is responsible for 30% of Austria's CO_2 emissions. Of these, 17.13% are caused by passenger cars. Car traffic (kilometres driven) has increased significantly in recent years, while at the same time, the occupancy rate is continuously decreasing and is currently only 1.15 persons per car in Austria. Due to the traffic load and the associated negative environmental impacts, there is a great need to increase the occupancy rate in passenger cars. The shared mobility concept of carpooling offers starting points to counteract this trend. In this context, carpooling in particular shows great potential for reducing the volume of traffic. Carpooling reduces emissions and lowers the risk of accidents, and an improvement of occupancy rate of cars can reduce traffic by up to 10%. However, the "critical mass" of carpooling platforms is often not reached and there is a lack of adequate advertising and communication measures. Traditional advertising channels such as print rarely reach the entire target group in the shared mobility sector and digital advertising channels miss internet-averse target groups who hardly use social media.

This article is therefore dedicated to the evaluation of an advertising campaign that aims to increase awareness and acceptance of the accelerated use and market penetration of carpooling offers. By means of a digital display placed at the side of the road, attention was drawn to the degree of occupancy by means of various statements - with the aim of triggering a rethink in the direction of carpooling. Based on a preliminary survey, the perception and acceptance were surveyed using feedback from passers-by and app users. The main finding is that many car drivers noticed the display and rated it as positive. Ultimately, however, only a small number of people could be motivated to use carpooling or to give other people a ride. The main barriers to use carpooling are the lack of schedule flexibility, reliability of passengers and loss of time.

Keywords: signage, ridesharing, carpooling, awareness, Occupancy rate

2 BACKGROUND AND STATE-OF-THE-ART

The occupancy rate in Austrian vehicles is 1.15% (VCÖ 2017). In other words, most people drive predominantly alone, leading to resource consumption, increased traffic, environmental pollution, and an inefficient use of transport systems. At the same time, this low utilization represents a great potential (Mühlethaler et al 2011). Ridesharing and carpooling, as part of shared mobility, are promising concepts that can counteract the low utilization of passenger cars and the associated consequences. Both terms are often used synonymously, but important distinctions exist (see 2.1.). What they have in common is that by pooling routes, several people can share one vehicle. This is often based on mobile solutions that facilitate booking and payment for the drivers. Both concepts still have an awareness and image problem, for which there are various approaches to raising awareness.

2.1 Carpooling and ridesharing as sustainable transport modes

Carpooling and ridesharing are promising tools when it comes to sustainable mobility. Carpooling involves a group of individuals sharing a single vehicle to travel together, usually for a regular commute or a specific trip. Typically, the passengers and the driver know each other, are part of the same organization or community, or are matched through a digital platform (Shaheen 2018). Ridesharing involves connecting individuals seeking transportation with drivers through a digital platform or mobile application. The drivers provide transportation services in their own vehicles for a fee, and passengers are typically strangers to the driver. Uber is often mentioned as a Ridesharing service from the American perspective (Wallsten 2018). This primarily serves as an on-demand transportation service, allowing individuals to request rides as needed. In this article, ridesharing is referred to as a shared trip transportation option rather than an on-demand transportation service. In contrast to carpooling, ridesharing represents a transportation option for

spontaneous trips (Furuhata et. al. 2013). Especially in rural communities, carpooling and ridesharing offer great potentials and until now, it has been considered as a supplement to public transport, which is still insufficiently established. However, there are "many influencing factors to consider - local and temporal distributions of demand, specific trip requirements, and attitudes of potential participants toward car pooling" (Mühlethaler et al 2011).

2.2 Mobile Solutions

Ridesharing and carpooling depend predominantly on mobile solutions which organize the communication and connection between the users (someone offering a ride and someone requesting a ride). Today, numerous online platforms exist in Austria for the organized networking of unknown persons (e.g. BlaBlaCar, Mitfahrgelegenheit.at, mitfahrzentrale.at). It is striking that the ride offers on these intermediary platforms are primarily limited to longer distances (usually several hundred kilometres). Pave Commute for example, offers a white-label solution for employers to connect employees, using commuting time wisely and reducing CO_2 emissions. Pave Commute focuses on B2B use and is mainly used by employees of medium-sized and large companies (Pave Commute 2023).

2.3 Signage as a nudging mechanism?

There are different possible ways to motivate commuters toward a more sustainable behaviour. "Nudging" is one way to change behaviour and refers to influencing the behaviour of an individual without monetary incentives (Thaler & Sunstein 2008). In road traffic for example, nudging is well known in the form of visual speed feedback. A study showed that displays that communicated verbal feedback such as "thank you" or "slow down" were more effective than those with a pure speed display (Schulze & Gehlert 2010). In terms of occupancy levels, there are defined carpooling lanes in the US, which are reserved for the exclusive use of vehicles with a driver with one or more passengers (Javid at al 2018). In the field of mobility sharing, there are only very few empirical studies in the context of nudging and these tend to be applied in the "offline" world (Dörrzapf at al. 2019, Namazu et al., 2018).

In this project, nudging is thus understood as "soft" measures that influence people in their decision-making and behaviour, whereby it is crucial that freedom of choice is always enabled. Nudging in this case is linked with digital signage and positive reinforcement. This project is the first to apply this principle to the occupancy rate of cars. The combination of individual feedback from the roadside in combination with the promotion of alternative mobility solutions has not yet been scientifically evaluated in such a form. If it is effective enough, it can create a completely new communication channel for environmentally friendly mobility, which will bring new momentum to the transport transition.

3 METHODOLOGY

3.1 Goals and settings

The project aimed to foster ridesharing and carpooling through the app Pave Commute as an innovative, user-friendly solution. Furthermore, the awareness and acceptance of commuters for ridesharing and carpooling should be increased in the test area by implementing an "awareness campaign". The other component is the hardware: a digital display, which provides feedback on the occupancy rate of a passing car to the commuter themself.

3.1.1 Software

As part of this project, the app was opened up and made available to all citizens of Amstetten for free use. In the course of the technical onboarding the Amstetten ride-sharing platform was created in the app, which was accessible in just a few steps and gave app users the certainty that local carpools with people from the region were in the foreground. Data collection and processing of user requests during the awareness campaign were also prepared.

3.1.2 Hardware

In this research project, the prototype of an innovative street installation was used to carry out the awareness campaign. The survey of the respective occupancy rate of passing cars was carried out on site by a team using a manually operated input device (Windows tablet with specially programmed interface), as is still

392

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used in many places for occupancy rate surveys. This input device in combination with two specially assembled feedback displays resulted in the prototype of Carpacity. With the help of a streetscape installation, "praise" and "thanks" were presented to the drivers. However, gentle feedback should also encourage solo commuters to reconsider other means of transport (see Figure 1).
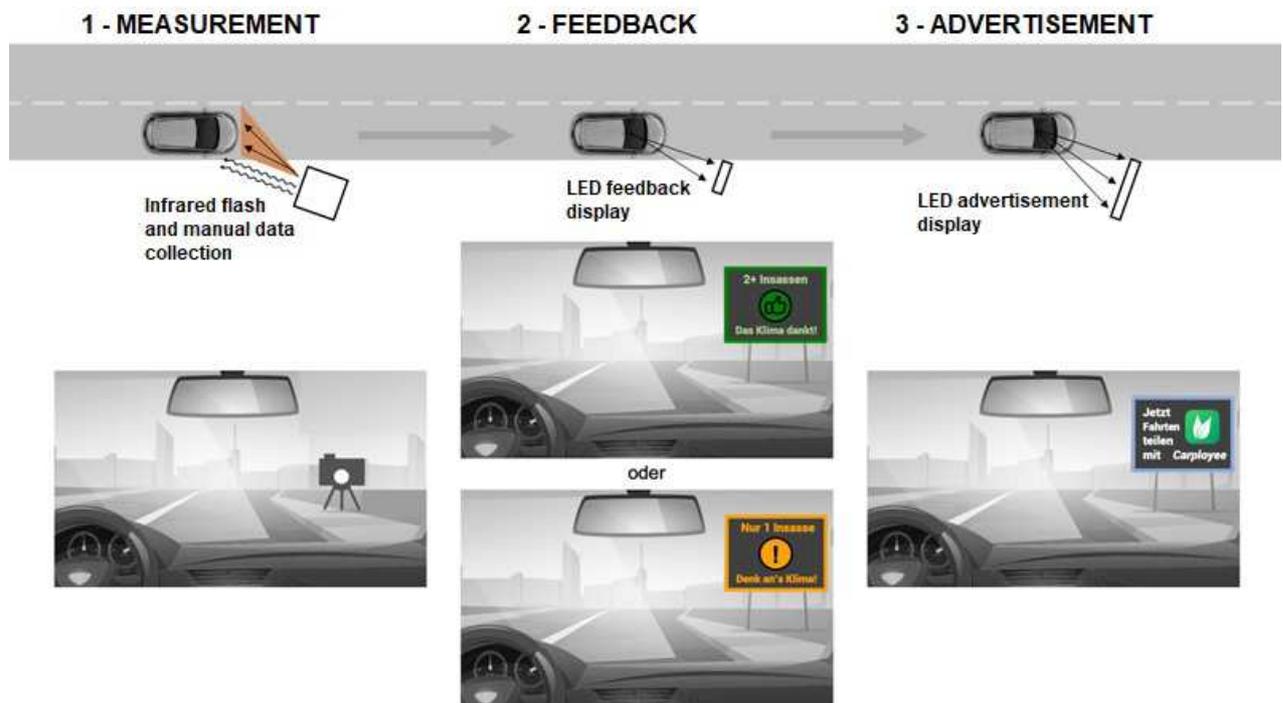
Fig. 1: Streetscape installation as digital signage (source project "Happy smileys for full cars")

3.2 Methods

3.2.1 Preliminary Questionnaire

	Group 1	Group 2	German average
Age			
0-20	2,4%	4%	18,8%
21-40	56%	55,9%	24,5%
41-60	35,2%	32,7%	27,3%
61-80	6,4%	7,1%	22,2%
81+	0%	0,3%	7,2%
Gender			
Male	60,8%	67,2%	49,3
Female	38,9%	32,8%	50,7
Other	0,3%	0%	n/a
Highest level of education			
Apprenticeship	14,9%	14%	46,6%
Middle school	8,8%	14,4%	23,5%
Matriculation/Secondary education	27,4%	26,8%	33,5%
Higher education	**46,9%**	**42,1%**	18,5%

Table 1: Comparison of the two sample groups to the German average. Source: Statistisches Bundesamt, 2019; 2022

Data collection throughout the project took place through four main channels. During the project, a preliminary online survey to generally assess perceptions and attitudes of individual occupancy level feedback LED displays were incorporated into the design of the experiment. The questionnaire collected socio-demographic characteristics, patterns of mobility behaviour, but most importantly participants were asked to imagine themselves experiencing the awareness campaign. This was "simulated" by a picture story. In the simulation, group one (N=296) was driving by a feedback display that slightly criticised their low rate of car occupancy before passing by the PAVE Commute ridesharing advertisement. Group two (N=299) did not pass by a feedback display at all before passing the advertisement. Subsequently, participants were asked

about their perception of the campaign, their attitudes towards carpooling in general and their openness to using the PAVE app.

A total of 595 Participants were recruited using the Clickworker platform. As 91,7% of the respondents currently reside in Germany, participant representativeness will be compared to the German average. Despite slight differences in middle school respondents, a certain degree of comparability is achieved between the two groups (see Table 1). Compared to the German average, the sample significantly overrepresents younger and highly educated men. The findings therefore represent a specific sub-group and cannot be generalised to the broader German population.

3.2.2 Awareness campaign

The main experiment revolved around the 6-week awareness campaign consisting of a station where oncoming traffic was manually analysed with regards to the rate of occupancy by trained staff, during peak hours in the morning (primarily from 6:00 to 9:00) and the afternoon (primarily from 14:30 to 17:00). All entries were made using a tablet, which stored the data in real time and forwarded it to the feedback displays 30 meters further down the street, thereby allowing for personalised feedback to be created.

Two LED displays were installed 150 meters apart on the busy B1 street entering Amstetten from the east (see Figure 2). The first display either provided positive feedback to vehicles occupied by two or more people or nudged vehicles with only one passenger with slightly negative feedback. All passing vehicles would see an advertisement for PAVE Commute, an app to organise carpooling and ridesharing on the second display.

Fig. 2: Location of the pilot project on the B1-Reichstraße at the eastern entrance of Amstetten and view of the green strip where the feedback displays would later be implemented (source project "Happy smileys for full cars")

The exact slogans of the feedback and advertising displays as well as other measures to further carpooling practices were discussed at a workshop and information event with local stakeholders. It was decided that displays with a local reference, for example "Amstetten says thank you" and emphasis on the cost-saving potential of carpooling were preferred.

Fig. 3: Two positive feedback signs, two negative feedback signs and two advertisements used during the awareness campaign (source project "Happy smileys for full cars")

Parallel to the implementation of the pilot project, an online survey recording the perception and impact of the installation was conducted with participants in Amstetten. A total of 77 responses were collected, 26 of which had passed the installation. Participants were recruited by means of social media, billboards, e-mails and personal contact. Due to the relatively small sample size, the main focus of the questionnaire lies in its

394

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qualitative elements, where participants were able to write detailed accounts of their experience and perception regarding the installation.

3.2.3 Traffic counts

As part of the awareness campaign, the vehicles that passed the displays were also counted and classified by means of a visual inspection of the trained staff. This was done using a simplified classification tool allowing categorisation into the following: buses, larger and smaller trucks, vans, cars, cars with trailers, motorcycles, bicycles and non-classified vehicles. Likewise, the rate of occupancy for each vehicle was recorded. Each data entry also included a timestamp with the day of the week, date and time when the entry was made.

3.2.4 Smartphone app user data

Being able to utilise the project partner's data from the PAVE Commute app, further analysis could be conducted on the user-data in Amstetten. Most importantly, this included data such as the number of app downloads in the region, the number of completed onboardings, new carpooling groups created, tracked commutes. Utilising user data was a key parameter allowing to evaluate the success of the awareness campaign.

3.3 Data Analysis

A mixed-method approach was employed throughout the data analysis process. Statistical analysis of the two groups was used to analyse and compare findings in the preliminary questionnaire. Likewise, with the data regarding the number of vehicles, vehicle classification, rate of occupancy. The written replies within the awareness campaign survey highlighting participants' perception and impact of the feedback displays were assessed using qualitative content analysis.

To illustrate the potential for work-related carpooling beyond the app, 35 home and workplace locations collected in the awareness campaign questionnaire were utilised using georeferencing to create a network analysis of potential commuting routes in Amstetten. The commuting routes reflect the fastest connection between home and workplace and may therefore not reflect actual routes.

4 FINDINGS

4.1 The role of individual feedback displays in shaping car-occupancy levels
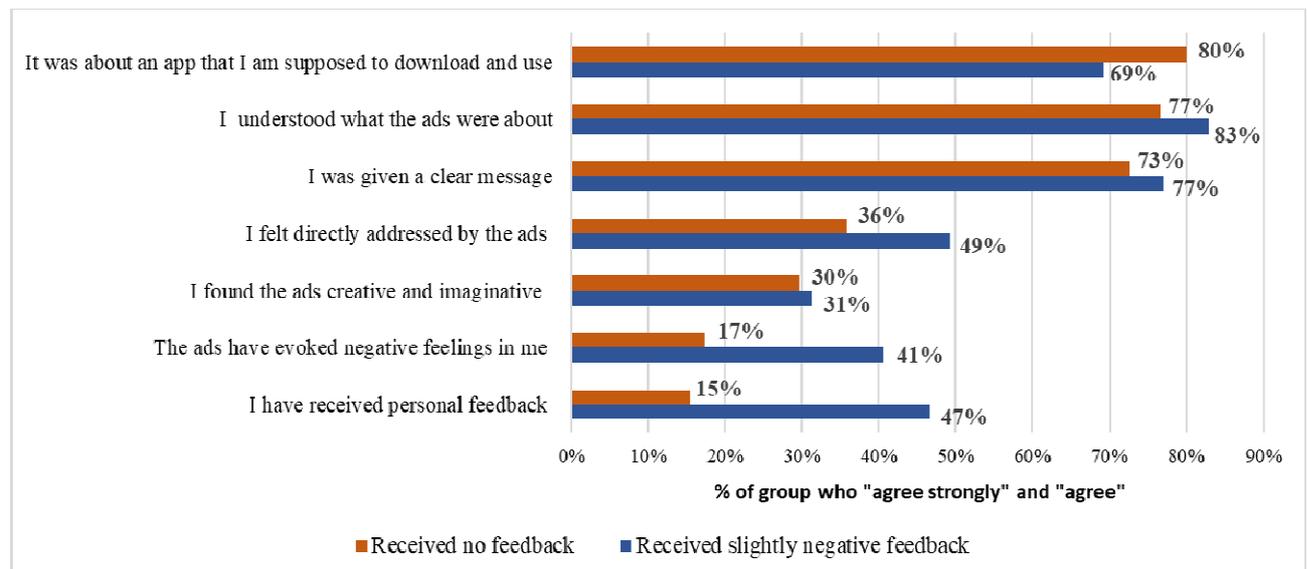
Fig. 4: Experience of simulated feedback and advertisement displays (N=595)

As part of the preliminary questionnaire, 595 participants from outside of Amstetten underwent an image guided simulation of passing the LED feedback displays. Group 1 (N=296) received slightly negative feedback before passing the advertisement whilst group 2 (N=299) did not receive any feedback at all before passing the advertisement. Comparing different perceptions of the simulated experience (see Figure 4), both groups emphasised that they had understood the feedback and advertisement displays and characterised them

as providing a clear message about downloading and using a carpooling app. Many more participants who received feedback felt addressed more directly (49%) than those who just saw the advert (36%) and felt more personally addressed. At the same time, those who received slightly negative feedback were more often experiencing negative feelings (41%) compared to those who did not (17%). It can therefore be said that feedback displays provide an opportunity to directly and personally address drivers whilst also carrying the risk of evoking negative emotions.

In addition, the survey aims to illuminate the potential of the simulated nudging experience on attitudes of carpooling and openness to utilise the advertised smartphone application. Regarding attitudes of carpooling (see Figure 5), participants who have received slightly negative feedback within their simulation showed more negative attitudes towards carpooling. Accordingly, whilst they were equally open to riding in other people's cars, they were less open to taking other people with them (20%) compared to those who have not received feedback (25%). Likewise, those who did not receive feedback agreed more strongly on the importance of not driving by themselves for environmental reasons (85%) than those who received slightly negative feedback (72%).
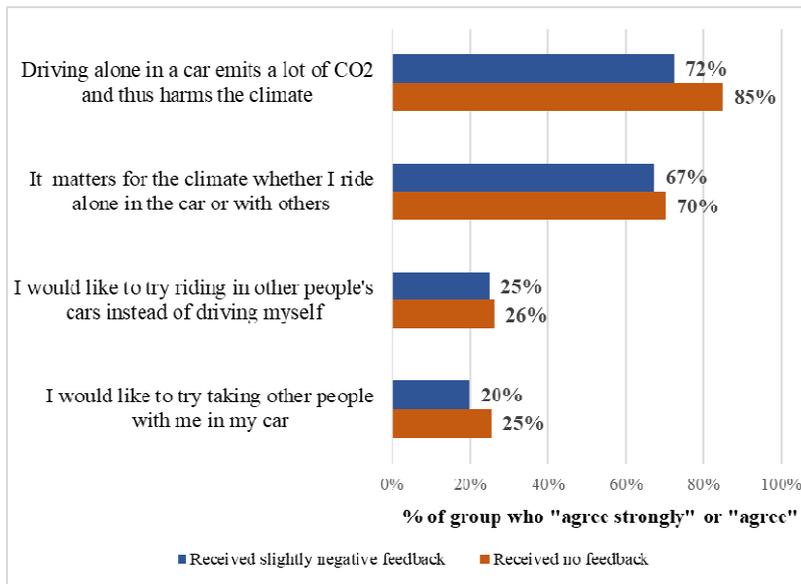
Fig. 5: Attitudes towards carpooling (N=595)

Similarly, with the openness to using the carpooling app, participants who have received slightly negative feedback in the simulation were generally less open to use the PAVE Commute app to organise carpooling both as a driver (see Figure 6) and as a passenger. Accordingly, only 19% of participants who had received feedback could imagine themselves commuting with the PAVE app several times a day, daily or several times a week as a driver compared to 27% of those who had not received feedback.
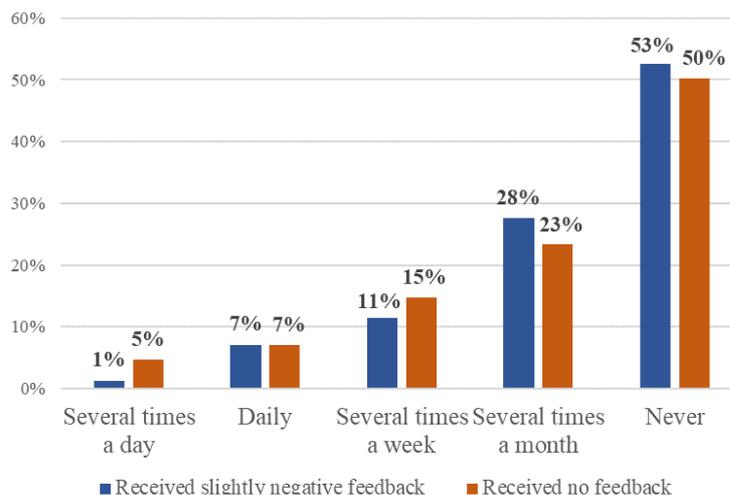
Fig. 6: Openness to using the PAVE Commute app to share car trips as a driver (N=595)

Likewise, only 20% of participants who had received feedback could imagine using the PAVE app to commute as a passenger several times a day, daily or several times a week compared to 24% of those who did not receive any feedback. Generally, willingness to commute as a passenger was higher than to be a driver. Whereas an average of 48,5% across both groups were open to driving others, an average of 52% could imagine themselves as carpooling passengers. This echoes data from the US, where the rate of people who wanted to be a passenger was generally higher, primarily for people who did not own a car themselves (Park et al., 2018). This pattern continues when it comes to expressed motivations of testing the carpooling app. Overall, only 18% of participants who had received feedback on their car occupancy expressed feeling strongly motivated or motivated compared to 29% of those who had not seen feedback.

4.2 Factors shaping vehicle occupancy rates in Amstetten

Throughout the process of the awareness campaign, the number and type of passing vehicle and the number of occupants within the vehicle were counted by trained personnel. The timeframe of data collection included workdays (Mondays to Fridays) from the 4.10.2022 to the 20.10.2022. In general, findings from the project indicate an average annual daily rate of traffic of 15.000 vehicles. This contrasts with earlier automated counts on Amstetten's B1 in 2019, which have arrived at an annual average daily rate of 13.000 vehicles (NOE, 2020). As emphasised in Figure 7, traffic peaks of up to 850 vehicles per hour occurred between 6:40 and 7:00 am. Isolated peaks may be explained in reference to shift changes in the surrounding industrial area

Throughout the recorded timeframe, the vast majority of recorded trips were made with cars occupied by only one occupant. Other modes of transportation such as bicycles, buses or motorcycles play a negligible role in the traffic volume. Considering the split of vehicle types recorded throughout the experimentation phase, cars made up 84% of the traffic. Amongst the cars recorded, 77,5% were occupied by a single person. Likewise, amongst the local participants from Amstetten who participated in the main questionnaire (N=77), 93,5% reported work as their primary reason to commute. This and the large share of single-occupancy rides reflects the continuing potential for carpooling as a means to reduce individual transport, especially for work trips.

Whereas car trips with only one occupant were especially dominant throughout the morning hours, a clear increase in the number of car trips with two or more occupants can be observed in the afternoon, when cars were occupied by an average of 1,3 to 1,35 people. Especially in light of the high volume of morning traffic, car occupancy rates in these hours remained between 1,15 and 1,2 individuals per vehicle. Findings from Amstetten are thereby generally slightly below the Austrian average of 1,3 for all trips and especially for the rate of 1,7 for recreational traffic (Österreich Unterwegs, 2013/14).
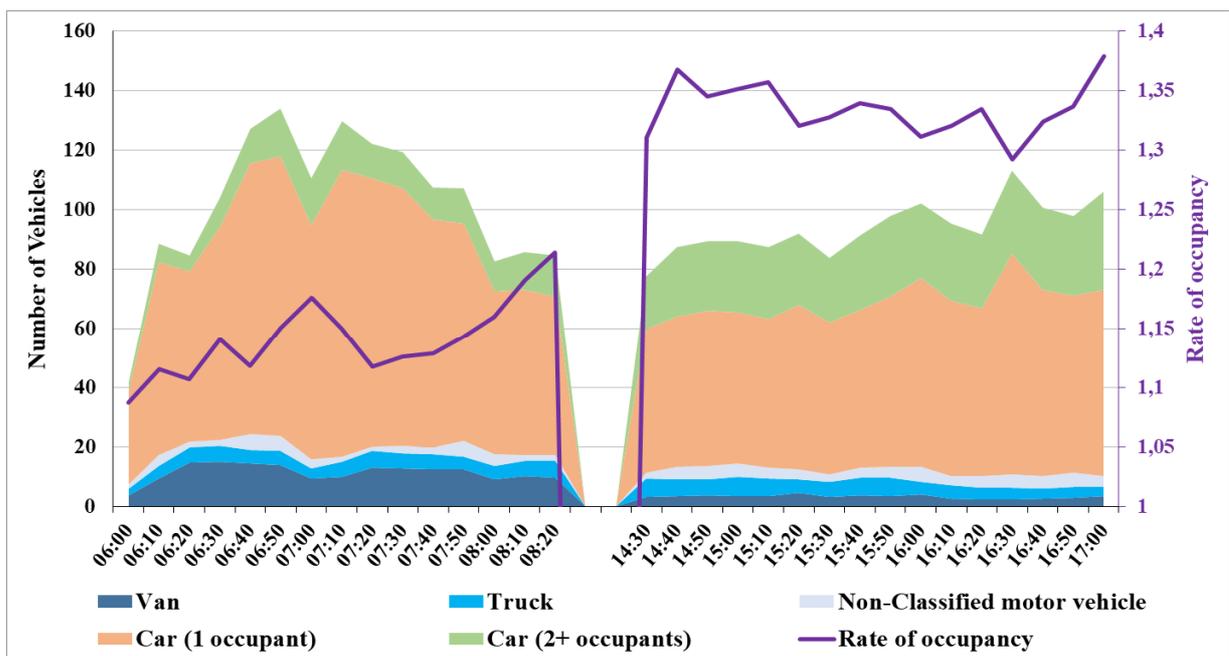
Fig. 7: Average daily rate of traffic as per type of vehicle and rate of occupancy 4.10.2022 - 20.10.2022

The highest traffic flow of 120 cars per 10 minutes between 6:40 and 7:30 only shows a rate of occupancy of 1,1 to 1,17 people per car. This could be explained by the high volume of single-person workplace traffic in the morning in contrast to more recreational traffic in the late afternoon and evening. To illuminate other factors shaping the rate of occupancy, weekdays have been considered. In this context, the rate of occupancy has been examined during traffic peak hours. Only minor variations in vehicle occupancy from 1,12 on Tuesdays to 1,15 on Mondays can be observed at the first peak of the day from 07:00 to 08:00 in the morning. In contrast, occupancy rates during the second peak from 15:00 to 16:00 remain at stable levels between 1,32 and 1,34 from Monday to Thursday but rise significantly to 1,39 on Friday afternoons, thereby echoing existing findings highlighting the correlation between occupancy rates and recreational traffic on weekends (Rapp et al. 2001).

4.3 The impact and perception of Amstetten's nudging awareness campaign

Amongst the survey respondents in and near Amstetten (N=77), a general inquiry of carpooling perceptions has been conducted. Accordingly, most respondents had a positive (18,2%) or rather positive (26%) rather than negative (7,8%) or rather negative (16,9%) perception of carpooling. The largest group, however, has expressed neutral views (31,2%) towards carpooling. Elaborating on their response through an open question, participants have especially highlighted the financial and ecological benefits of carpooling. On the other hand, lack of flexibility, dependency on others as well as discomfort of travelling with strangers were amongst the key disadvantages that have been named. Potential drivers have highlighted the barrier of being responsible for their passengers. Potential passengers on the other hand occasionally referred to the lack of knowledge of the driver's driving style as a negative factor. Some participants have thus referred to carpooling as "saving money, stress free" but also negatively in terms of the "lack of punctuality of passengers" or "feeling not comfortable carpooling with strangers". Whereas the findings further illustrate the potential of carpooling as a means of contributing to more sustainable patterns of mobility, there is an ongoing need for social or technological innovation to overcome some of its inherent limitations.

Building on the rather positive perception of carpooling, the experiment has explored the potential of LED displays to improve car occupancy levels by nudging single occupant cars with slightly negative feedback whilst providing positive feedback to cars occupied by two or more people coupled with creating awareness for a carpooling app. Quantitative analysis of responses to the nudging signs is limited in terms of the low number of participants who have filled in the main survey and also passed the signs (N=26). Of those who have passed and read the nudging display, open text replies in the questionnaire have provided mixed feedback. Overall, 48% of the qualitative responses were positive, 26% negative and 26% neutral. This was partly based on the display being perceived as unnecessary and overly intrusive. Accordingly, participants emphasised how they "had a guilty conscience because I was driving alone, but at the same time were a bit annoyed, because I can't take anyone with me". Others have highlighted, that the displays were "prompting but not encroaching" has provided a thought-provoking impulse, since they "always go to work alone".

Feedback towards the advertisement display were much more negatively amongst the participants in Amstetten who had passed it (N=26). In total, 63% of the qualitative responses were negative, 31% positive and 6% neutral. Consequently, whilst some referred to the advertisement as evoking positive connotations of "carpooling is good", the majority experienced it as "one of many useless distractions on the road" or another advertisement for "just one more app on the phone".

Following the instalment of the field experiment in Amstetten, the app activity in the region was closely monitored. During the time of the experiment, a total of 66 new users have downloaded the app and registered for the Amstetten commuting platform. Of those, 48 have completed the onboarding process of getting familiarised with how PAVE functions leading to a total of 9 new commuting groups being established. Despite registration numbers in Amstetten growing much more significantly during the experiment in comparison to the time after the experiment, the goal of 250 downloads had not been reached. A total of 29 carpooling rides have been registered during the experimentation phase, connecting individuals with similar times and routes of travel.

Illustrating local potential of work-related carpooling in Amstetten, 35 home and workplace locations were utilised using georeferencing. Maps were created reflecting potential commuting routes in Amstetten (see Figure 8). As the routes reflect the fastest connection and route choice is generally subject to various factors

398

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such as personal habits or potential stops along the way, it is important to highlight that actual routes may differ.
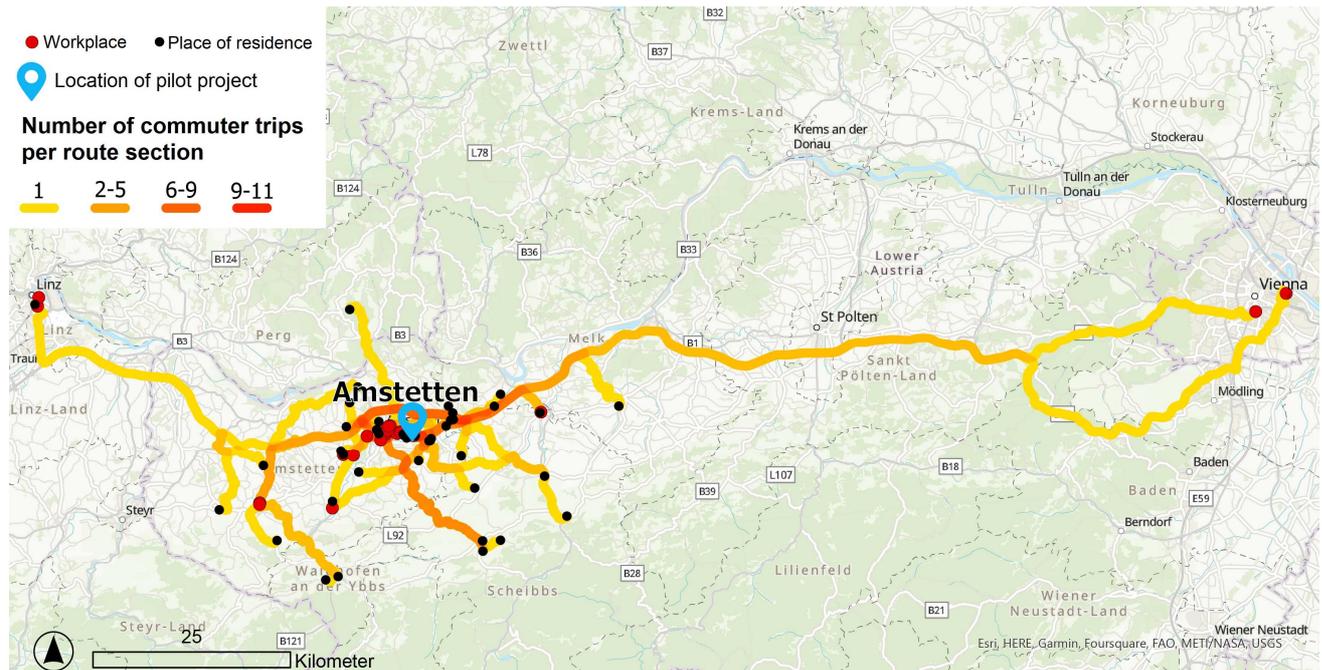
Fig. 8: Network analysis of potential commuting trips in Amstetten from 4:00 – 9:00 o'clock

As can be seen in the figure, there is a limited accumulation of commuting routes and thus a lower potential for shared car trips. Whereas workplaces are strongly concentrated in the city of Amstetten, the places of residence are dispersed across the region. This may be due to the low levels of elevation in the region, resulting in few clusters of roads. Carpooling may therefore hold more potential in mountainous areas where traffic is limited to fewer and more concentrated roads.

In addition to the spatial dimension of potential routes, the time of departure and arrival also plays a critical role. Potential routes were analysed in 60-minute increments. Whilst the highest potential for carpooling was identified between 5:00 and 7:00 in the morning, the differing temporal needs of commuters generally further limits the chances for carpooling.

5 CRITICAL REFLECTION

The following section involves the critical reflection of the methodology and other implications of the study like the challenge of the critical mass.

5.1 Methodological limitations in the preliminary questionnaire

Whereas it seems that the feedback displays might have negatively impacted the participants' perceptions and attitudes of carpooling and their openness to utilise carpooling apps, the differences between the two groups is not significant. It therefore remains questionable whether these differences result from the simulation or if they just reflect differences amongst the two sample groups. Other statistical methods like t-test or ANOVA could be considered. The findings do, however, highlight low levels of awareness and sense of relevance of increasing car occupancy levels as an important sustainability measure. Additionally, it has to be considered that the simulation on a display does not reflect real world conditions and social desirability might have played a role in the preliminary questionnaire.

5.2 The critical mass problem

The network analysis of potential carpooling illustrates the need for platforms to navigate both spatial and temporal differences in their matchmaking. This reflects the fundamental dependence of app providers on high numbers of users as a prerequisite for offering carpooling options. Especially in rural and less dense areas this aspect becomes even more of a challenge. Whereas the use of awareness campaigns using feedback displays and nudging can certainly contribute to establish this critical mass of users on carpooling

platforms, other measures such as the integration of multiple communication channels on different types of media or the inclusion of carpooling options in existing MaaS apps (Wright at al. 2020).

In addition, it can be assumed that longer detours and longer travel times tend to lead to a higher rejection rate. Which factors influence this refusal requires further research (König & Grippenkoven 2020).

6 CONCLUSION AND OUTLOOK

In the project a striking campaign was used to raise awareness for sustainable mobility in road traffic. It can be summarized that participants who received slightly negative feedback felt more directly addressed and experienced more negative feelings compared to those who did not receive feedback. Additionally, participants who received feedback showed more negative attitudes towards carpooling and were less open to utilizing carpooling apps compared to those who did not receive feedback. The majority of recorded trips in Amstetten were made with cars occupied by only one person, indicating the potential for carpooling to reduce individual transport. Car occupancy rates in Amstetten were generally below the Austrian average, with an increase in the number of car trips with two or more occupants observed in the afternoon. Participants in and near Amstetten had mixed perceptions of carpooling, with positive views emphasizing the financial and ecological benefits, and negative views highlighting the lack of flexibility and discomfort of traveling with strangers. The experiment with LED displays for nudging car occupancy levels received mixed feedback, with some participants perceiving it as unnecessary and intrusive, while others found it thought-provoking. Overall, the findings suggest that feedback displays and nudging interventions have the potential to shape car-occupancy levels and attitudes towards carpooling, but their effectiveness and acceptability can vary among individuals.

The findings from the research project can be used to increase awareness and acceptance of shared mobility services such as carpooling and ridesharing, and thus reduce the number of private cars on public roads. In addition to the promotion of carpooling, as was done in this project, a number of other mobility offers and modes such as on-demand transport (call buses, shared taxis, on-demand mobility, etc.) could be the focus of a further awareness campaign in road transport. In the course of follow-up projects, omni-channel communication campaigns should be taken as a basis to further increase the effectiveness of awareness campaign. All available channels can be used (posters, flyers, social media, etc.) to achieve a strong and repeated involvement of all stakeholders.

7 ACKNOWLEDGEMENT

8 REFERENCES

JAVID, R.J., NEJAT, A., HAYBOE, K.: Quantifying the environmental impacts of increasing high occupancy vehicle lanes in the United States, Transportation Research Part D: Transport and Environment, Volume 56, 2017, Pages 155-174, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2017.07.031.
KÖNIG, A. & GRIPPENKOVEN, J.: Travellers' willingness to share rides in autonomous mobility on demand systems depending on travel distance and detour, Travel Behaviour and Society, Volume 21, 2020, Pages 188-202, https://doi.org/10.1016/j.tbs.2020.06.010.
MÜHLETHALER, F., AXHAUSEN, K., CIARI, F., GERTSCH-JOSSI, U., TSCHANNEN-SÜESS, M.: Potenzial von Fahrgemeinschaften, Forschungsauftrag ASTRA 2008/017 auf Antrag des Bundesamtes für Strassen, Zürich, 2011
NAMAZU, M., ZHAO, J., AND DOWLATABADI, H.: Nudging for responsible carsharing: using behavioral economics to change transportation behavior. Transportation 45, 1, 105–119. 2018.
NOE: Ergebnisse der Straßenverkehrszählung im Straßennetz, Dauerzählstellen (JDTV) Niederösterreich, available under: https://www.noe.gv.at/noe/OGD_Detailseite.html?id=25be09e4-ed4d-4c26-bcab-8ce0dc97385b , 06.07.2023.
ÖSTERREICH UNTERWEGS: Ergebnisbericht zur österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014", Wien, 2016.
PARK, Y., CHEN, N., & AKAR, G.: Who is Interested in Carpooling and Why: The Importance of Individual Characteristics, Role Preferences and Carpool Markets. Transportation Research Record, 2672(8), 708–718. https://doi.org/10.1177/0361198118756883, 2018.
PAVE COMMUTE, Website, available under: https://pavecommute.app/de/
RAPP, P., LOEWENGUTH, S. FIEDLER, C.: Besetzungsgrad von Personenwagen: Analyse der Bestimmungsgrössen und Beurteilung von Massnahmen zu dessen Erhöhung, Forschungsauftrag 42/97 auf Antrag der Vereinigung Schweizerischer Verkehrsingenieure (SVI), 2001.

SCHULZE, C. & GEHLERT, T.: Evaluation dynamischer Geschwindigkeitsrückmeldung, Unfallforschung der Versicherer (Hrsg.), Berlin, 2010.

SHAHEEN, S., COHEN, A., & BAYEN, A. (2018). The Benefits of Carpooling. UC Berkeley: Transportation Sustainability Research Center. http://dx.doi.org/10.7922/G2DZ06GF Retrieved from https://escholarship.org/uc/item/7jx6z631

STATISTISCHES BUNDESAMT: Bevölkerung nach Altersgruppen & Bevölkerungsstand 2022, available under: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Tabellen/bevoelkerung-altersgruppen-deutschland.html and https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/_inhalt.html, 06.07.2023.

STATISTISCHES BUNDESAMT: Bildungsstand - Bevölkerung im Alter von 15 Jahren und mehr nach allgemeinen und beruflichen Bildungsabschlüssen nach Jahren, https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bildung-Forschung-Kultur/Bildungsstand/Tabellen/bildungsabschluss.html , 06.07.2023.

THALER, R.H. AND SUNSTEIN, C.R.: Nudging- Wie man kluge Entscheidungen anstößt. 2008.

VCÖ: Autoverkehr in Österreich hat sich binnen 30 Jahren verdoppelt, available under: https://vcoe.at/presse/presseaussendungen/detail/20181206-autoverkehr-oesterreich-30-jahre, 2017.

WALLSTEN, S.: The Competitive Effects of the Sharing Economy: How is Uber Changing Taxis?.Technology Policy Institute, NY, 2015.

WRIGHT, S., NELSON, J. D. COTTRILL, C. D.: MaaS for the suburban market: Incorporating carpooling in the mix, Transportation Research Part A: Policy and Practice, Volume 131, 2020, Pages 206-218, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2019.09.034, 2020.

Inside Babyboomer – Gesundheits- und Wohnstandortverhalten deutscher Babyboomer und deren planerische Herausforderungen für die Gesundheitsversorgung in ländlich-suburbanen Räumen

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1 ABSTRACT

Rund ein Viertel der deutschen Bevölkerung wurde in den geburtenstarken Jahren zwischen 1955 und 1969 geboren und ist damit Teil der sogenannten Babyboomer-Generation.[1] Mit zunehmender Alterung ergibt sich für diese ein höherer Bedarf an medizinischer Versorgung – als künftig größte Patientengruppe haben die Babyboomer daher eine hohe Relevanz bei der Sicherung der medizinischen Versorgung. Entsprechend dem gesetzlichen Auftrag zur Sicherstellung einer jederzeit verfügbaren, wohnortnahen ambulanten Versorgung, ist ein bedarfsgerechtes Versorgungsangebot erforderlich.[2] Als Erreichbarkeitsstandard werden etwa 15 Minuten für die hausärztliche Versorgung und in der Regel 30 Minuten für die allgemeine fachärztliche Versorgung angesetzt.[3] Ebenso wenig wie zu dem Gesundheitsverhalten und Mobilitätsverhaltender Babyboomer besteht allerdings auch kaum Datenmaterial über deren Wohnstandortverhalten nach ihrer anstehenden Verrentung.

Aus Sicht der Nachfrage und künftig im wesentlichen aus Sicht der Babyboomer ergeben sich eine Reihe an planungsrelevanten Fragestellungen. Welche Rolle etwa spielen die hausärztliche, allgemein fachärztliche und zahnärztliche Versorgung im ambulanten Bereich sowie die stationäre Versorgung für das künftige Wohnstandortverhalten der Babyboomer-Generation? Welche Bedarfe und welche Nachfrage sind aktuell und in Zukunft gegeben? Wie kann die Qualität und Zugänglichkeit der medizinischen Versorgung im ländlich-suburbanen Raum durch Einbeziehung telemedizinischer Dienste verbessert werden? Welche Akzeptanz finden digitale, mobile sowie hybride Angebotsformen der medizinischen Versorgung bei der Babyboomer-Generation? Auch aus Sicht des Angebots (Kommunen, Ärzteschaft etc.) ergeben sich Fragen. Welche Relevanz hat die medizinische Versorgungsinfrastruktur für die kommunale Entwicklung? Welche Weichenstellungen und Entscheidungen der Ärztinnen und Ärzte sind für kommunale Entscheidungsträgerinnen und Entscheidungsträger relevant? Welche Möglichkeiten bestehen, auf die Standortwahl von medizinischen Versorgungsangeboten (MVZ, kommunale und private Kliniken) Einfluss zu nehmen? Welche Rückschlüsse lassen die Determinanten der Wohnstandortwahl der Babyboomer-Generation auf die Konzepte und Modelle der Siedlungsentwicklung (Wohnen) der Raumplanung (Fokus Raumordnung) zu?

Zur Untersuchung einiger dieser Fragestellungen wurde im Teilprojekt „Gesundheit" des von der Carl-Zeiss-Stiftung im Rahmen des Programms „Durchbrüche" mit 4,3 Millionen Euro geförderten Forschungsprojektes „Ageing Smart – Räume intelligent gestalten"[4] eine teilstandardisierte Befragung zur Gesundheitsversorgung in zwei ländlichen und zwei suburbanen Kommunen in Rheinland-Pfalz, Baden-Württemberg und Thüringendurchgeführt. Mit den gewonnenen Erkenntnissen über Nachfrageverhalten und Bedarfe bei der Gesundheitsversorgung, das (überörtliche) Wohnstandortverhalten, das Mobilitätsverhalten sowie Akzeptanz und Relevanz digitaler und mobiler medizinischer Angebotsformen, sollen sowohl für politische Entscheidungsträgerinnen und Entscheidungsträger als auch für Träger der Gesundheitsversorgung Handlungsbedarfe aufgezeigt und Handlungsoptionen zur Sicherung der Gesundheitsversorgung und Mobilität formuliert werden.

Perspektivisch dienen diese der Einspeisung in das angestrebte DSS (Decision-Support-System) des Gesamtprojektes „Ageing Smart" zur politischen Entscheidungsunterstützung in den Modellkommunen. Die Ergebnisse der Befragung sowie die daraus abgeleiteten Schlussfolgerungen zur Sicherung der Gesundheitsversorgung und Mobilität auf kommunaler Ebene werden in diesem Beitrag thematisiert.

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[1] vgl. STEFAN, Benjamin/LOEPPKE, Yannick/SPELLERBERG, Annette (2022): S.1f.

[2] vgl. KASSENÄRZTLICHE BUNDESVEREINIGUNG KdöR (2023): Bedarfsplanung.

[3] vgl. SUNDMACHER, Leonie/BRECHTEL, Thomas et al. (2018): S.7f.

[4] RPTU Kaiserslautern-Landau: „Ageing Smart – Räume intelligent gestalten" unter https://www.ageing-smart.de/

Keywords: Entscheidungsunterstützung, Gesundheitsversorgung, Babyboomer, Daseinsvorsorge, Befragung

2 EINLEITUNG

2.1 Forschungsansatz im Carl-Zeiss-Projekt „Ageing Smart – Räume intelligent gestalten"

Das von der Carl-Zeiss-Stiftung und der RPTU Kaiserslautern-Landau über einen Zeitraum von fünf Jahren geförderte Forschungsprojekt „Ageing Smart – Räume intelligent gestalten" adressiert die geburtenstarken Jahrgänge 1955 bis 1969 (nachfolgend „Babyboomer") und führt in einem integrierten Ansatz erstmals raumplanerische und versorgungsseitige Ansätze, Bedarfe der Babyboomer sowie Handlungserfordernisse und -optionen von Kommunen zusammen. Das interdisziplinäre, im universitären Potentialbereich „Region und Stadt" der RPTU angesiedelte, Forschungsvorhaben gliedert sich in zehn Teilprojekte der Disziplinen Raumplanung, Stadtsoziologie, Klimatologie, Informatik sowie Mathematik und wird federführend am Fachgebiet Stadtsoziologie unter Prof. Dr. Annette Spellerberg koordiniert.[5]

Als ein Aspekt der Daseinsvorsorge widmet sich das Teilprojekt „Gesundheitsversorgung", das am Lehrstuhl Regionalentwicklung und Raumordnung koordiniert wird, der hausärztlichen sowie der allgemein fach- und zahnärztlichen Versorgung in vier ländlich-suburbanen Kommunen – den beiden Verbandsgemeinden Kusel-Altenglan und Nieder-Olm, dem Geisaer Land und der Gemeinde Remshalden. Ein Fokus liegt einerseits auf der klassisch standortgebundenen und digital-mobilen Gesundheitsversorgung (Angebot und Nachfrage), andererseits auf den verkehrlichen Infrastrukturen zur Gewährleistung von individueller Mobilität und Erreichbarkeit der medizinischen Einrichtungen. Konkret gilt es, die Bedürfnisse der alternden Menschen, die Raumentwicklung und die Versorgungsmöglichkeiten vor Ort in Einklang zu bringen.[6] Ein Baustein zur Generierung neuer Daten ist dabei die teilstandardisierte Befragung zu der Gesundheitsversorgung in diesen Kommunen unter Babyboomern. Sowohl mit Blick auf den Alterungsprozess als auch auf unterschiedliche Lebenslagen, -formen und -stile handelt es sich bei den Babyboomern um eine überaus heterogene Gruppe, über die jedoch vergleichsweise wenig bekannt ist.[7] [8]

2.2 Zielsetzung

Ziel dieser Umfrage war es daher, Daten zur aktuellen Wohnsituation, dem künftigen Wohnstandortverhalten beim Eintreten in den Ruhestand und zum spezifischen Gesundheitsverhalten der Babyboomer sowie deren Anforderungen an Erreichbarkeit und Ausgestaltung der medizinischen Versorgung zu erheben. Die Analyse der Präferenzen und Bedarfe dient der Beantwortung relevanter Fragestellungen und der Ableitung von Handlungsbedarfen und -optionen bei der Gesundheitsversorgung in ländlich-suburbanen Kommunen. Diese dienen im späteren Verlauf des Projektes zur Einspeisung in das im Gesamtprojekt „Ageing Smart – Räume intelligent gestalten" projektierte Decision-Support-System, insbesondere mit Blick auf eine steigende Nachfrage bei gleichzeitig geringerem verfügbaren Angebot. Dieser Beitrag thematisiert Auszüge aus den Ergebnissen und Herausforderungen bei der (inter)kommunalen Sicherung der Gesundheitsversorgung.

3 METHODIK

Der standardisierte Fragebogen war in vier inhaltliche Themenblöcke mit insgesamt 43 Fragen gegliedert, teils mit ein bis mehreren Antwortkategorien, teils auch mit offener Antwortmöglichkeit:

(1) Fragen zur Gesundheit (Gesundheitszustand und Einschränkungen, Regelmäßigkeit und Anlass bei der Nutzung von Angeboten der Gesundheitsversorgung, Akzeptanz digitaler und mobiler Angebotsformen),

(2) Fragen zur aktuellen Wohnsituation (Wohnstandort, Wohnfläche und -form, Wohnstandortfaktoren, Bedeutung von Gesundheits- und Verkehrsangeboten, Ausstattung der örtlichen Gesundheitsversorgung, verfügbare/genutzte Verkehrsmittel),

(3) Fragen zur künftigen Wohnsituation(Überlegungen zum Leben und Wohnen im Alter, Wohnstandort, Wohnfläche und -form (antizipiert), Wohnstandortverhalten, künftige Bedeutung von Gesundheits- und Verkehrsangeboten) sowie

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[5] RPTU Kaiserslautern-Landau: „Ageing Smart – Räume intelligent gestalten" unter https://www.ageing-smart.de/

[6] vgl. STIEWING, Marvin/WEBER, Tobias/MANGELS, Kirsten et al. (2022): S.132f.

[7] vgl. STEFAN, Benjamin/LOEPPKE, Yannick/SPELLERBERG, Annette (2022): S. 3.

[8] vgl. KÖRBER-STIFTUNG (2022): S.6f.

404

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(4) Fragen zur Person (Geschlecht, Alter, Haushaltsgröße, familiäre Situation und soziale Einbindung, Bildung, Erwerbstätigkeit und Einkommen).

Die Befragung wurde von Oktober bis Dezember 2022 in digitaler Form über einen Zeitraum von je etwa vier Wochen in den zwei ländlichen (VG Kusel-Altenglan, Geisaer Land) und zwei suburbanen (VG Nieder-Olm, Remshalden) Modellkommunen des Forschungsprojektes durchgeführt. Die auf Basis der jeweiligen Melderegister ermittelten Babyboomer in den Kommunen wurden über eine Postkarte mit Kurztext, Link und QR-Code zur Befragung eingeladen. In den beiden Verbandsgemeinden wurde eine Stichprobe von 50% aller Personen in der einschlägigen Altersgruppe aus dem Melderegisterermittelt, in Remshalden und dem Geisaer Land erfolgte die Umfrage als Vollerhebung unter allen vor Ort ansässigen Babyboomern. Insgesamt wurden in den ländlichen Kommunen 4.737 und in den suburbanen Kommunen 7.204 Babyboomer zur freiwilligen Teilnahme an der Umfrage eingeladen. Durch die anonyme Beteiligung an der Umfrage per Link bzw. QR-Code war eine Zuordnung der Teilnehmenden zu den Adressen der postalisch eingeladenen Babyboomer nicht möglich.

Die um die nicht zustellbaren Postkarten bereinigte Rücklaufquote in den ländlichen Kommunen betrug rund6% (Stichprobenumfang n=281), in den suburbanen 7,1%(Stichprobenumfang n=506).Insgesamt haben 787 und damit 6,7% der angeschriebenen Personen an der Befragung teilgenommen. Dies entspricht in den ländlichen Kommunen 3,6% und in den suburbanen Kommunen 4,5% aller dortigen Babyboomer. Im Mittel benötigten die Befragten ca. 20 Minuten zur Beantwortung der Fragen. Da vereinzelt Fragenunbeantwortet blieben oder ungültig beantwortet wurden, wird bei der folgenden Darstellung der Ergebnisse jeweils der Stichprobenumfang je Frage (n) angegeben. Die Auswertung der Ergebnisse erfolgte überwiegend deskriptivdurch Häufigkeitsanalysen. Die teils recht umfangreichen Angaben bei der Beantwortung offener Fragen wurden im Sinne einer übersichtlicheren Darstellung kategorisiert. Die Ergebnisse der Umfragewerden im Folgenden dargestellt, gegliedert nach suburbanem und ländlichem Raum. Sofern Werte ohne weitere Erklärung in Klammern angegeben sind, bezieht sich der vordere Wert auf die ländlichen, der hintere Wert auf die suburbanen Kommunen (z.B. 3%/8%).

4 ÜBERBLICK ÜBER DIE ERGEBNISSE

4.1 Demografie

Tab. 1 zeigt das soziodemografische Profil der Befragten im Vergleich zwischen ländlichen und suburbanen Kommunen. Die Befragten sind im Mittel59,8 (ländlich) Jahre bzw. 59,5(suburban) alt. Der Großteilist den Jahrgängen 1960 bis 1964 (38%/37%) zuzuordnen, gefolgt von den Jahrgängen 1965 bis 1969 (32%/36%) und 1955 bis 1959 (30%/27%). Frauen haben sich geringfügig häufiger als Männer beteiligt.

Die meisten Befragten leben sowohl im ländlichen als auch im suburbanen Raum in Zwei-Personen-Haushalten. Während im ländlichen Raum die zweit- und dritthäufigste Nennung der Mehrpersonenhaushalt und der Zwei-Personen-Haushalt mit Kind(ern) ist, wird im suburbanen Raum als zweit- und dritthäufigste Form der Zwei-Personen-Haushalt mit Kind(ern) und der Ein-Personen-Haushalt genannt.

Über 80% der Befragten haben ein Kind bzw. Kinder, die wiederum überwiegend bereits ausgezogen sind (74% im ländlichen Raum, 65 % im suburbanen Raum). 25% (ländlicher Raum) bzw. 20% (suburbaner Raum) der Kinder leben im elterlichen Wohnort, die Entfernung der Befragten zum Wohnort ihres Kindes bzw. ihrer Kinder beträgt im Mittel 40km/60km. Knapp die Hälfte der Befragten aus dem ländlichen Raum hat bereits Enkelkinder (48%), im suburbanen Raum sind dies 32% der Befragten.

Mit Blick auf das Bildungsniveau zeigt sich eine höhere schulische Bildung bei den suburbanen Befragten, ebenso eine höhere berufliche Bildung. Gut die Hälfte der noch erwerbstätigen Befragten ist als (Fach-)Arbeiter oder im Angestelltenverhältnis (52% ländlich bzw.58% suburban) tätig, gleiches gilt auch für die überwiegende berufliche Stellung der Befragten im Ruhestand.

Das monatlich verfügbare Netto-Haushaltseinkommen liegt unter den Befragten aus dem ländlichen Raum im Mittel bei 2.500 bis 3.000 Euro, bei denjenigen aus dem suburbanen Raum bei 3.500 bis 4.000 Euro.

Jeder vierte bis fünfte Befragte (27%, n=281ländlicher Raum/20%, n=506 suburbaner Raum) ist bereits im Ruhestand, in den ländlichen Kommunen ist der Anteil der Befragten im Ruhestand größer. Ein Großteil (73%, n=281/80%, n=506) steht dagegen noch im Erwerbsleben. Letztere gehen nach eigener Aussage in durchschnittlich 7,5/7,0 Jahren in den Ruhestand (n=187/n=370).

Soziodemografisches Profil der Befragten im Überblick*   Angaben in %

		Angaben in %
Geschlecht (n=274 / n=503)	männlich	46,7 / 48,1
	weiblich	52,2 / 51,5
	divers	1,1 / 0,4
Haushaltsform (n=281 / n=506)	Ein-Personen-Haushalt	13,2 / 13,8
	Paar ohne Kind / Kinder	51,2 / 47,4
	Paar mit Kind / Kindern	16,4 / 27,1
	Mehrpersonenhaushalt (Familienangehörige)	20,3 / 9,5
	Mehrpersonenhaushalt (Freunde / Bekannte)	0,7 / 1,2
Anzahl der Kinder (n=275 / n=402)	keine	14,5 / 19,5
	1	23,2 / 20,1
	2	46,1 / 57,2
	3	10,4 / 17,7
	mehr als 3	4,0 / 4,7
Bildungsniveau (n=281 / n=504)	Volks-/Hauptschulabschluss / POS 8./9. Klasse	23,8 / 8,1
	Realschulabschluss / POS 10. Klasse	42,6 / 28,4
	Abitur / Fachhochschulreife (Gymnasium / Erweiterte Oberschule)	32,9 / 60,7
	kein Schulabschluss	- / -
Ausbildungsniveau (n=281 / n=506)	betriebliche o. schulische Ausbildung	63,0 / 45,3
	Fachschule, Meister-, Technikerschule, Berufs- o. Fachakademie	18,5 / 18,6
	(Fach-)Hochschulabschluss	20,6 / 43,3
	kein beruflicher Ausbildungsabschluss	2,8 / 1,6
Erwerbstätigkeit (n=281 / n=506)	noch im Erwerbsleben stehend	73,0 / 79,8
	bereits im Ruhestand	26,7 / 20,2

ländlich ▬
suburban ▬

	MW [min.; max.]
monatlich verfügbares Netto-Haushaltseinkommen (in Tsd. Euro) (n=262 / n=459)	2,5 bis 3 / 3,5 bis 4
verbleibende Jahre bis zum Ruhestand (n=187 / n=370)	7,5 / 7,0 [0; 27]
Alter (in Jahren) (n=275 / n=383)	59,8 / 59,5 [53; 67]
am Wohnort lebend seit (in Jahren) (n=184 / n=415)	25,3 / 22,6 [0; 62]
Befragungsdauer (in Minuten)	23 [5; 70] / 22 [8; 67]

* n variiert aufgrund fehlender Daten; MW Mittelwert

Tab. 1: Soziodemografisches Profil der Befragten anhand ausgewählter Variablen; Werte auf jeweilige Antwort bezogen (ländlich/suburban). Quelle. eigene Darstellung.

4.2 Gesundheitszustand und Nachfrageverhalten der Patientengruppe Babyboomer

Gemessen an der durchschnittlichen Lebenserwartung als Querschnittsindikator für den Gesundheitszustand sind die Babyboomer gesünder als deren Vorgänger-Generationen.[9] Als Folge des demografischen Wandels steigt jedoch die Anzahl älterer Menschen, was mittelfristig zu einer Erhöhung der Krankheitslast und einem steigenden Bedarf an medizinischer Versorgung führt.

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[9] vgl. KÖRBER-STIFTUNG (2022): S.8.

Zur Beurteilung des Gesundheitszustands und der Multimorbidität innerhalb der Generation der Babyboomer wurden die Teilnehmenden nach dem subjektiven Gesundheitszustand und objektiven Kriterien (Tab. 2) wie körperlichen Einschränkungen, Krankheiten mit regelmäßigem Behandlungsbedarf, chronischen Erkrankungen und Risikofaktoren befragt. Die Frage „Wie bewerten Sie Ihren derzeitigen Gesundheitszustand?" (n=279/n=506) (1= sehr gut, 5 = sehr schlecht) wurde ländlich zu54% und suburban zu 71% mit sehr gut bis gut beantwortet. Der Teil, der den Gesundheitszustand mittel (36%/22%) und schlecht bis sehr schlecht (10%/7%) bewertet, ist unter den Befragten aus dem ländlichen Raum höher. Auffällig ist hier die relativ positive Einschätzung des allgemeinen Gesundheitszustands bei gleichzeitiger Angabe wegen einer bzw. mehreren Krankheiten in ständiger Behandlung zu sein (vgl. Tab. 2). Bei der Einnahme von Medikamenten nehmen 68%/50% diese ein bis zwei Mal täglich, 12%/7% auch öfter ein(n= 279/n=504).

Einschränkungen (n=275 / n=503) (stark oder mäßig; leicht)	Hören/Sehen,	23,8; 53,4 / 15,5; 51,1
	Herz-Kreislaufsystem	12,7; 37,0 / 5,4; 22,7
	Mobilität	11,3; 34,9 / 9,0; 23,4
	Gedächtnis	4,4; 29,8 / 3,6; 19,8
Krankheiten in ständiger Behandlung und / oder Kontrolle (n=275 / n=506)	Ja, eine	33,5 / 35,4
	Ja, mehrere	37,1 / 18,6
chronische Erkrankungen / Risikofaktoren (n=281 / n=506); Mehrfachnennung möglich	Bluthochdruck	46,6 / 31,4
	Gelenkerkrankung / Rheuma	24,6 / 18,6
	Herzkreislauferkrankungen	17,4 / 6,3
	chronische Bronchitis / Asthma	11,7 / 6,1
	Diabetes mellitus	8,5 / 6,3
	Durchblutungsstörungen / Schlaganfall	3,2 / 2,6
	Übergewicht	24,2 / 22,1
ländlich ▬ suburban ▬	Alkohol: gelegentlich; regelmäßig	34,2; 7,1 / 34,6; 10,3
	Raucher; Exraucher [in Jahren]	11,4; 15,7 [19,4] / 8,9; 13,2 [17,3]

Tab. 2: Einschränkungen, Krankheitslast und Risikofaktoren; Prozentwerte auf jeweilige Antwort bezogen (ländlich/suburban), Mehrfachnennungen möglich. Quelle: eigene Darstellung.

Hinsichtlich ihres Bedarfs bei der Gesundheitsversorgung wurden die Befragten nach der Inanspruchnahme, (Regelmäßigkeit und Anlass) verschiedener Ärzte und den hier akzeptierten Erreichbarkeiten (Tab. 3) bei unterschiedlichen Verkehrsträgern befragt. Hausärzte wurden in den letzten 12 Monaten zu 36%/35% zwei bis drei und zu 30%/24% vier bis sechs Mal in Anspruch genommen (n=273/n=494). Allgemeine Fachärzte (n variiert)wurden dagegen meist nur ein Mal oder gar nicht, Orthopäden und Frauenärzte hierbei am ehesten konsultiert. Zahnärzte (n=273/(n=493) wurden meist (48%/48%)zwei bis drei Mal aufgesucht. Gemeindeschwesteroder Pflegedienst wurden dagegen kaum (1%) genutzt.

	Hausarzt	Facharzt	Zahnarzt	Apotheke
zu Fuß	15 (n=111)/15 (n=344)	15(n=60)/15 (n=189)	15 (n=80)/15 (n=264)	15 (n=99)/10 (n=381)
Fahrrad	10(n=57)/ 10 (n=191)	15(n=37)/15 (n=150)	10(n=45)/15 (n=163)	10 (n=46)/10 (n=178)
E-Bike, Pedelec	15(n=56)/15 (n=173)	15(n=40)/20 (n=142)	15(n=43)/15 (n=148)	15(n=50)/10 (n=158)
Auto	15(n=246/15 (n=368)	30(n=251)/30 (n=436)	15(n=237)/20 (n=380)	15 (n=238)/10 (n=294)
Bus, Bahn	20(n=48/20 (n=149)	30(n=45)/30 (n=186)	30(n=47)/30 (n=152)	15(n=44)/15 (n=124)

Tab. 3: Tolerierte Distanz bei der Nutzung medizinischer Angebote:„Wie lange sind Sie bereit, zur nächsten Arztpraxis/Apotheke zurückzulegen? (einfache Strecke in Minuten)"; Median-Werte in Minuten(ländlich/suburban), Mehrfachnennungen möglich. Quelle: eigene Darstellung.

Als vorwiegende Gründe für Arztbesuche (n=277/n=503) werden mit 66%/73% die Inanspruchnahme ärztlicher Leistungen angeführt, zu 24%/15%die Ausstellung oder Abholung von Rezepten und zu 11%/13%

meist Vorsorge oder Impfungen. 81%/76% der Befragten sind gesetzlich krankenversichert, 11%/18% haben eine Zusatzversicherung und 17%/24% sind privat versichert (n=281/(n=506).

Weiterhin wurde nach der Akzeptanz digitaler und mobiler Angebotsformen als Alternative zur klassischen Gesundheitsversorgungvor Ort gefragt, Tab. 4 zeigt die entsprechenden Zustimmungswerte. Suburban liegt diese bei beiden Formen und besonders beider digitalen Beratung und Behandlung höher als im ländlichen Raum. Für jeweils ein Drittel der ländlichen Befragten sind digitale oder mobile Angebote weder für eine Behandlung noch Beratung eine Option. 18% lehnen beides ab, für 19% ist beides hingegen eine Option. Suburban ist die Akzeptanz größer, hier lehnt ein Drittel eine mobile und nur jeder Fünfte eine digitale Beratung oder Behandlung ab. 12% lehnen beides ab, für 25% ist beides eine Option Die größte Akzeptanz unter allen Befragten erfährt die mobile Beratung und Behandlung, gefolgt von der digitalen Beratung.

	digital Beratung und Behandlung	mobil Beratung und Behandlung	digital nur Beratung	mobil nur Beratung	digital weder Beratung noch Behandlung	mobil weder Beratung noch Behandlung
ländlich	23,3	53,8	43,4	14,7	33,3	32,1
suburban	31,4	59,2	45,8	12,1	22,7	28,7

Tab. 4: Akzeptanz digitaler und mobiler Angebotsformen: „Können Sie sich vorstellen, sich a. von einem Arzt bzw. einer Ärztin in einem Onlineformat (z.B. Videosprechstunde)(n=279/n=505)/b. in einer mobilen Arztpraxis (z.B. Medibus) (n=278/n=505): beraten/behandeln zu lassen?“; Prozentangaben auf jeweilige Antwort bezogen. Quelle: eigene Darstellung.

Hinsichtlich der psychischen Gesundheit spielen u.a ein unterstützendes Umfeld und die soziale Einbindung eine Rolle. 84%/82% der Befragten bewerten ihre nahen verwandtschaftlichen Beziehungen sowie80%/81% ihre nahen freundschaftlichen Beziehungen (n=276/(n=501) als sehr gut bis gut. 81% /77% haben üblicherweise zudem täglich bis wöchentlichen Kontakt zu einem Teil der Familie (n=276/(n=500).

4.3 Wohnsituation und Wohnwünsche antizipiert für den Eintritt in den Ruhestand

Insgesamt wurden Menschen aus 47Gemeinden erreicht. 34%/18% leben seit Geburt in der Kommune, ein Viertelist in den letzten 25/23 Jahren zugezogen (n=280/n=506).Die Mehrheit lebt im Ein-/Zweifamilien-haus, überwiegend im Eigentum (92%/82%) und nur zu einem geringen Teil (7%/18%) zur Miete (n=278/n=504). Keiner der Befragten wohnt bisher in einer Senioren-Wohngemeinschaft, einem -heim oder einer -residenz.50%/44% der Befragten stehen durchschnittlich über 100m² Wohnfläche, weiteren 27%/23% stehen 75 bis unter 100m²pro Person zur Verfügung (n=275/n=500). 43%/58% der Befragten bewerten ihre Wohnsituation damit mit sehr gut, weitere 45%/36% mit gut(n=278/(n=506).

Beim künftigen Wohnstandortverhalten ist relevant, ob die Babyboomer einen Wohnstandortwechsel sicher planen, perspektivisch planen oder sich diesen vorstellen können (n=281/n=506). 50%/64% der Befragten können sich diesen unter bestimmten Bedingungen vorstellen. Bei den Gründen für einen Umzug liegt das Eintreten körperlicher Einschränkungen im Alter (41%/50%) vorne, gefolgt von Änderungen des Familienstandes (Scheidung, Verwitwung etc.) (21%/36%) und dem Renteneintritt (10%/21%). Während 6%/5% ihre Wohnsituation bereits entsprechend altersgerecht verändert haben und 4%/5% schon konkret nach einer neuen Wohnung bzw. einem neuen Haus suchen, können sich 45%/31% einen Umzug dagegen nicht vorstellen.

Nach möglichen Veränderungen an der Wohnsituation gefragt möchten bis zu 67%/56% das derzeit eigene Haus bzw. die eigene Wohnung grundsätzlich (n=281/n=506) beibehalten, gegebenenfalls mit einem altersgerechten Umbau oder bedarfsgerechter Betreuung. Wohnen bei den (Enkel-)Kindern ist mit deren Unterstützung/Pflege für 20%/14% eine Option, mit professioneller Unterstützung/Pflege sogar für 50%/47%.

Bei den Befragten, die einen Umzug in Erwägung ziehen, möchten 27%/40% in derselben Gemeinde, 32%/28% im Landkreis und 21%/18% in der Region bleiben (n=281/n=329). Die Befragten, die bereits konkrete Überlegungen für einen Umzug anstellen (n=139/n=329), werden zu 14%/10% in ihrer Wohnung bzw. im Haus wohnen bleiben. Bei der künftigen Wohnfläche pro Person möchte sich die Mehrheit der Befragten verkleinern, zu 47%/38% auf 50 bis unter 75m², zu 28% auf 25 bis unter 50m² (n=127/n=314).

Insbesondere bei den Befragten, die einen Umzug nicht in Erwägung ziehen, stellt sich die Frage nach der Zufriedenheit mit der Gesundheitsversorgung, Mobilität und Infrastruktur im Umfeld ihres Wohnstandortes

(n variiert). Dabei lassen sich zwischen den Raumtypen Unterschiede erkennen. Weniger als die Hälfte der ländlichen Befragten ist mit der hausärztlichen (45%) und allgemein fachärztlichen (38%)Versorgung zufrieden, ebenso wenig mit der Anbindung mit öffentlichen Verkehrsmitteln und deren Haltepunkten (26%) Die zahnmedizinische Versorgung (72%), die stationäre Versorgung (57%) und die Ausstattung mit Apotheken (84%) sowie die Anbindung mit dem Pkw (93%) wird mehrheitlich mit sehr gut oder gut bewertet. Die Befragten in den suburbanen Kommunen sind mit der hausärztlichen (67%) und zahnärztlichen (69%) Versorgung und insbesondere mit der Pkw-Anbindung (97%), der Ausstattung mit Apotheken (94%) sowie der Anbindung mit öffentlichen Verkehrsmitteln und deren Haltepunkten (60%) zufrieden. Weniger zufrieden sind diese hingegen mit der stationären (42%) und der allgemein fachärztlichen Versorgung (33%). In allen vier Kommunen sind digitale und mobile medizinische Angebote überwiegend unbekannt. Die digitale Infrastruktur bewerten 50%/77% mit sehr gut oder gut.

Tab. 5 stellt die Bedeutung der Gesundheitsversorgung, der Anbindung und Infrastruktur sowie der Nähe zu Kindern und Familie als Standortwahlfaktor bei der Entscheidung für den aktuellen Wohnstandort der Priorität bei der künftigen Wohnstandortwahl gegenüber. Erkennbar wird ein erheblicher Bedeutungsgewinn in allen zur Auswahl gestellten Bereichen – ambulante und stationäre Gesundheitsversorgung, soziale Angebote für ältere Menschen, technische Infrastruktur sowie Nähe zu Kindern und Familie.

Standortfaktoren bei der Wahl des Wohnstandortes (Vergangenheit; antizipiert)
(n=281; 139/n=506; 329)

		ländlich	suburban
gute Gesundheitsversorgung	allgemeinmedizinische Versorgung	33,5; 87,1	35,6; 89,1
	allgemeine fachmedizinische Versorgung	17,4; 71,9	11,1; 64,1
	zahnmedizinische Versorgung	22,8;73,4	17,2; 71,7
	stationäre Versorgung (Krankenhäuser)	19,9; 57,6	5,1; 40,7
	Apotheken	28,8; 74,8	31,0; 79,9
	Beratungsstellen für Ältere	1,1; 18,7	1,4; 19,5
	soziale Begegnungsstätten für Ältere	1,8; 47,5	2,2; 47,4
	stationäre Einrichtungen (Alten-/Pflegeheime)	5,0; 22,3	3,2; 19,5
	ambulantes Betreuungs- und Pflegeangebot	3,2; 41,0	3,8; 52,6
gute Anbindung/Infrastruktur	Verkehrsanbindung mit dem Pkw	42,3; 57,6	59,1; 65,7
	Verkehrsanbindung mit öffentlichen Verkehrsmitteln (Bus, Bahn), Haltepunkte des ÖPNV	17,1; 82,7	53,2; 89,1
	digitale Infrastruktur (Internet/DSL, mobiles Internet, Mobilfunk)	12,1; 68,3	23,3; 80,5
Nähe zu Kindern und Familie		33,1; 51,8	24,9; 51,7

Tab. 5: Wohnstandortwahl: „Welche Gründe waren Ihnen bei der Entscheidung für den aktuellen Wohnstandort wichtig?/Welche Faktoren sind Ihnen bei der Wahl des künftigen Wohnorts wichtig?"; Prozentwerteauf jeweilige Antwort bezogen (ländlich/suburban), Mehrfachnennungen möglich. Quelle: eigene Darstellung.

5 DISKUSSION UND FAZIT

5.1 Stärken und Limitationen der Umfrage

Eine der Stärken der Umfrage besteht in der Verschneidung der Themen Gesundheit, Wohnen und Mobilität bei der Untersuchung der Babyboomer sowie der damit einhergehenden Verbesserung der aktuell schlechten Datenlage zu dieser Generation. Durch die Befragung in mehreren Kommunen des Forschungsprojektes konnten zudem Teilnehmende aus ländlich wie auch aus suburban geprägten Räumen erreicht und bei der Auswertung der Ergebnisse entsprechend differenziert werden. Schwächen bestehen dagegen in der geringen Rücklaufquote von sechs bis sieben Prozent und einer damit nicht hinreichenden Belastbarkeit der zuvor dargestellten Ergebnisse. Diese sind daher nicht repräsentativ und methodisch lediglich als Hypothesen bzw. Schlaglichter zu verstehen. Gründe für den geringen Rücklauf werden zum einen im Zeitpunkt der Feldphase gesehen, um welchen bereits weitere Umfragen (Zensus 2022, Bürgerbeteiligung, Grundsteuererklärung im

Rahmen der Grundsteuerreform) in den Kommunen im Umlauf waren. Zum anderen wird die ausschließlich digitale Möglichkeit zur Teilnahme negativ beurteilt. Diese Einschätzung wird von den Ergebnissen einer weiteren Befragung im Forschungsprojekt „Ageing Smart" durch das Fachgebiet Stadtsoziologie gestützt. Diese konnte frei wählbar als Papierfragebogen oder online ausgefüllt werden. Nur ein kleiner Teil der Babyboomer (27%) nutzen hierbei die online-Variante, in den suburbanen Kommunen 32%, in den ländlichen 18%.[10] Ein Bias auf Grund einer stärkeren Teilnahme inhaltlich betroffener und so besonders motivierter Personen sowie digital affineren Personen kann zudem nicht ausgeschlossen werden.

5.2 Entwicklungen im Gesundheitswesen als Herausforderung für die Raumentwicklung

Als Folge des demografischen Wandels und einer unzureichenden Nettozuwanderung prognostiziert das Statistische Bundesamt eine Zunahme des Anteils der Menschen im Alter von 65 und mehr Jahren auf etwa 31% im Jahr 2060[11], wobei die Babyboomer bereits ab 2030 das Schwergewicht im Rentenalter bilden.[12]

Diese Entwicklung lässt sich auch bei der Ärzteschaft beobachten. Zwar ist die Zahl der berufstätigen Ärzte im Jahr 2022 geringfügig gestiegen,9% der Ärzte sind jedoch 65 Jahre oder älter und stehen dem Arbeitsmarkt auf absehbare Zeit nicht mehr voll zur Verfügung.[13] Drastischer stellt sich die Lage in der ländlichen geprägten Modellkommune Verbandsgemeinde (VG) Kusel-Altenglan dar. Im Jahr 2022 waren dort 74% der Hausärzte, 61% der Fachärzte und 54% der Psychotherapeuten über 54 Jahre alt, 37,8% der Hausärzte gar 65 Jahre und älter und somit im Durchschnitt 59,7 Jahre alt. Bei einem aktuellen Median-Abgangsalter von je 65, 59 und 63 Jahren bedeutet dies einen prognostizierten Nachbesetzungsbedarf von 50% der Hausärzte, 59% der Fachärzte und 30% der Psychotherapeuten bis 2027.[14] Die Gruppe der Ärzte im Alter von 50 bis 65 Jahren zeichnet sich dabei durch hohe Wochenarbeitsstunden aus, wird erfahrungsgemäß jedoch nach Erreichen des 65. Lebensjahres überwiegend in den Ruhestand eintreten oder nur noch in Teilzeit tätig sein.[15]

Zudem lässt sich eine doppelte Fehlverteilung innerhalb der ambulanten Gesundheitsversorgung feststellen.[16] Einerseits nimmt die Zahl der Hausärzte ab und die der Fachspezialisten stark zu, verbunden mit einem Trend zur Tätigkeit in einem Angestelltenverhältnis. Die Motivation zur Niederlassung in einer eigenen Praxis sinkt hingegen seit Jahren, ebenso der Teilnahmeumfang an der vertragsärztlichen Versorgung. Dieses in Vollzeitäquivalenten angegebene Verhältnis zwischen gearbeiteten Stunden und üblicher Arbeitszeit einer Vollzeittätigkeit lag 2009 bei durchschnittlich 0,98 und 2022 je nach KV-Region zwischen 0,8 und 0,9.[17] [18]

Die Zahl der niedergelassenen Ärzte als Rückgrat einer bedarfsgerechten flächenhaften Versorgung sank daher im Jahr 2022 zuletzt um 3,8%.[19]

Andererseits bestehen erhebliche regionale Allokationsprobleme, da Ärzte oftmals dort praktizieren, wo die Versorgung bereits gesichert ist – beginnend bei Stadtteilen mit vielen Privatpatienten und einem hohem sozioökonomischem Status bis hin zu ländlich-peripheren Gemeinden mit einer gefährdeten medizinischen Grundversorgung.[20] Nach Befragungen aus den Jahren 2014 und 2018 geben fast 50% der nachrückenden Ärztegeneration gar eine Aversion gegen das Arbeiten auf dem Land an.[21] Zusätzlich zur demografiebedingt steigenden Nachfrage an Nachfolgern haben daher besonders Ärzte im ländlichen Raum Schwierigkeiten bei der Nachbesetzung offener Sitze und Stellen.[22] Trotz angestrebter Gleichwertigkeit der Lebensverhältnisse

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[10] vgl. Befragung der Stadtsoziologie RPTU Kaiserslautern-Landau „Wohnen, Alltagsgestaltung und Lebensqualität von Babyboomern am Wohnort 2022", Auswertung Benjamin Stefan.

[11] vgl. STATISTISCHES BUNDESAMT (2023): 14. koordinierte Bevölkerungsvorausberechnung für Deutschland.

[12] vgl. KÖRBER-STIFTUNG (2022): S.5

[13] vgl. BUNDESÄRZTEKAMMER (2023): Ergebnisse der Ärztestatistik zum 31.12.2022.

[14] vgl. KASSENÄRZTLICHE VEREINIGUNG RHEINLAND-PFALZ (2023): Digitale Statistiken.

[15] vgl. BUNDESÄRZTEKAMMER (2023): Ergebnisse der Ärztestatistik zum 31.12.2022.

[16] vgl. GERLACH, Ferdinand et al. (2014): S.349ff und S. 377ff.

[17] vgl. ZWIERLEIN, Ruben/PORTENHÄUSER, Frank/FLÄGEL, Kristina/STEINHÄUSER, Jost (2020): S.2.

[18] vgl. KASSENÄRZTLICHE BUNDESVEREINIGUNG KdöR (2023): Gesundheitsdaten.

[19] vgl. BUNDESÄRZTEKAMMER (2023): Ergebnisse der Ärztestatistik zum 31.12.2022.

[20] vgl. GERLACH, Ferdinand et al. (2014): S.349ff und S. 377ff.

[21] vgl. JACOB, Rüdiger/KOPP, Johannes/SCHULTZ, Sina (2015):S.61f.

[22] vgl. ZWIERLEIN, Ruben/PORTENHÄUSER, Frank/FLÄGEL, Kristina/STEINHÄUSER, Jost (2020): S. 2.

hinsichtlich der medizinischen Versorgung wird deutlich, dass mit Blick auf bestehende Disparitäten[23] und die skizzierten Entwicklungen Herausforderungen bei der Sicherung der Gesundheitsversorgung bestehen.

5.3 Einordnung und Schlussfolgerungen

Die Ergebnisse passen in das Bild, welches frühere Untersuchungen von der Generation zeichnen. Über die Hälfte der Babyboomer hat eine abgeschlossene Berufsausbildung, ein Drittel ein Studium hinter sich. Drei Viertel stehen im Erwerbsleben, der Rest ist bereits im Ruhestand oder nicht erwerbstätig. Das monatlich verfügbare Netto-Haushaltseinkommen lag 2017 bei 3.817 Euro und damit über dem Bundesdurchschnitt. Etwa 73% leben in einer Partnerschaft, wobei eventuell vorhandene Kinder meist schon ausgezogen sind. Der Anteil Alleinlebender liegt mit 21% dagegen höher als unter den Befragten.[24]

Die Befragung verdeutlicht bestehende Defizite der Gesundheitsversorgung in ländlich-suburbanen Räumen. Gemessen am subjektiven Gesundheitszustand und objektiven Kriterien zur Gesundheit sind die suburban Befragten gesünder, materiell besser aufgestellt und eher privatkrankenversichert. Verbunden damit ist die Nachfrage bei der Gesundheitsversorgungunter den Befragten im ländlichen Raumhöher. Gleichzeitig fällt die dortige Bewertung insbesondere des hausärztlichen und allgemein fachärztlichen Angebots sowie der Verkehrsanbindung mit öffentlichen Verkehrsmitteln mehrheitlich schlecht bis sehr schlecht und damit auch insgesamt schlechter aus als in den suburbanen Kommunen.

Mit Blick auf die akzeptierten Erreichbarkeiten ergibt sich teils eine Diskrepanz zwischen den Präferenzen der Befragten und den angebotsseitigen Standards bei der Bereitstellung der medizinischen Versorgung. Wie die Umfrage zeigt, können mobile und digitale Dienste aus Sicht der Babyboomer zumindest teilweise eine alternative Möglichkeit der Beratung bzw. Behandlung bieten und zur Sicherung der Versorgung, Entlastung der Ärzte und Verbesserung der Qualität im ländlich-suburbanen Raum beitragen. Grundsätzlich ist für zwei Drittel der Befragten eine digitale und/oder mobile Form der Beratung bzw. Behandlung eine Alternative zur klassischen Gesundheitsversorgung vor Ort. Unterstützt wird dies durch die digitale Kompetenz (n=699/n=1.185) und Offenheit gegenüber neuen Technologien (n=699/n=1.187). 38%/62% schätzen sich hier als (eher) kompetent ein, Smartphones sind für eine Mehrheit (85%/96%) der Befragten Standard.[25]

Mit Blick auf die Wohnsituation lebt die Mehrheit zu Hause im vertrauten Umfeld, deutlich mehr als die Hälfte bis fast zwei Drittel leben im Eigentum. Die meisten sind zufrieden mit ihrer Wohnsituation, über die Hälfte bewertet diese mit sehr gut, 40,5% mit gut und nur 2% mit schlecht oder sehr schlecht. Zufriedenheit mit der Wohnsituation gilt ebenso wie eine gute Gesundheit und ausreichende Mittel zur Unterstützung im Bedarfsfall als Grund die aktuelle Wohnsituation beizubehalten. Motivierend kann hingegen ein Angebot an Wohnformen sein, die an die sich wandelnden Bedürfnisse im Alter anpassbar sind.[26]

Auch eine Mehrheit der Befragten kann sich einen Umzug zumindest bei gleichbleibender Gesundheit nicht vorstellen, wodurch die Sicherung der Gesundheitsversorgung im Wohnumfeld in den Fokus rückt. Für die Mehrheit spielte die medizinische Versorgung bei der letzten Wohnstandortwahl keine Bedeutung. Bezogen auf einen künftigen Umzug hingegen ist diese mehrheitlich von Bedeutung, ebenso soziale Angebote für Ältere und eine gute Anbindung insbesondere an öffentliche Verkehrsmittel und digitale Infrastrukturen. Die Gesundheitsversorgung gewinnt damit zunehmend an Bedeutung für die kommunale Entwicklung.

6   AUSBLICK

Langfristiges Ziel des Forschungsvorhabens ist die Entwicklung eines daten-, IT- und KI-basierten Systems zur Entscheidungsunterstützung (Decision Support System = DSS), welches von öffentlichen Akteuren in ihrem Planungs- und Entscheidungsprozess herangezogen werden kann. Infrastrukturen, Angebote und Dienstleistungen sollen so nachfragegerecht, tragfähig und zukunftsorientiert entwickelt werden können, um die Lebensqualität der Babyboomer und perspektivisch der Gesamtbevölkerung zu sichern und zu fördern.[27]

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[23] vgl. BMI (2020): Deutschlandatlas – Karten zu gleichwertigen Lebensverhältnissen. S.76ff.

[24] vgl. KÖRBER-STIFTUNG (2022): S.7, S.50.

[25] vgl. Befragung der Stadtsoziologie RPTU Kaiserslautern-Landau „Wohnen, Alltagsgestaltung und Lebensqualität von Babyboomern am Wohnort 2022", Auswertung Benjamin Stefan.

[26] vgl. KÖRBER-STIFTUNG (2022): S.9f.

[27] vgl. STIEWING, Marvin/WEBER, Tobias/MANGELS, Kirsten et al. (2022): S.132f.

Relevanz gewinnt neben der kommunalen Ausstattung mit medizinischen Einrichtungen die Erreichbarkeit der Standorte, weshalb die Erarbeitung eines intermodalen Erreichbarkeitsmodells als Querschnittsansatz aus Raumplanung und Mathematik einen vielversprechenden Forschungsansatz darstellt. Dieses bietet als ein Baustein des DSS ein Analysetool für Akteure der räumlich planenden Verwaltung (z.B. Stadt-, Verkehrs- und Sozialplanung), um verschiedene Entwicklungsvarianten bei unterschiedlichen Entscheidungsoptionen nachvollziehbar und verständlich für politische Entscheidungsträgerinnen, Entscheidungsträger und Akteure der medizinischen Versorgungsforschung und Bedarfsplanung (z.B. Kassenärztliche Vereinigungen) aufzubereiten. Dadurch wird eine sachgerechte und datengestützte Entscheidungsfindung unterstützt.[28]

Die im Zuge der Umfrage erhobenen Daten können hier u.a. Toleranzen und Präferenzen zur Erreichbarkeit der – künftig von den Babyboomern geprägten – Nachfrageseite einbringen und die weiteren Parameter bei der mathematischen Modellierung ergänzen. Neben frei verfügbaren Daten werden diese u.a. aus Experteninterviews und der Literaturrecherche abgeleitet, etwa hinsichtlich der Standorte medizinischer Einrichtungen unter Berücksichtigung unterschiedlicher Strukturmerkmale, verkehrsplanerischer Parameter oder angebotsseitigen Schwellenwerten und Standards zur Erreichbarkeit.[29] Die Analyse der Erreichbarkeit für den Status Quo und im zeitlichen Verlauf kann dadurch Handlungsbedarfe (lokal unterversorgte Bereiche etc.) bei der Sicherung der Gesundheitsversorgung aufzeigen und zur Bildung von Szenarien genutzt werden.

Ausgehend von den Ergebnissen der Umfrage und der weiteren Arbeit im Forschungsprojekt zeigen sich zudem Handlungsbedarfe bei der kommunalen Bereitstellung der Gesundheitsversorgung und Mobilität. Entsprechende Strategien und unterschiedliche Handlungsoptionen für Kommunen und Träger medizinischer Angebote (Einflussnahme auf Standorte neuer Praxen, altersgerechte Wohnangebote etc.) sollen im weiteren Verlauf des Projekts eruiert werden. Mit Blick auf die geringe Umzugsbereitschaft der Befragten gilt dies auch für Strategien für altersgerechtes Wohnen im ländlich-suburbanen Raum. In Zusammenarbeit mit den Modellkommunen im Projekt erfolgt zudem im Rahmen von Workshops die Definition spezifischer „Use Cases" im Bereich Gesundheit, die in die Konzeption des DSS einfließen.

Perspektivisch soll außerdem das antizipierte Wohnstandort-, Mobilitäts-und Versorgungsverhalten bei der Nutzung von Gesundheitsdienstleistungen den raumordnerischen Konzepten und Modellender Siedlungs-und Verkehrsentwicklung sowie zur Versorgung mit Gesundheitsdienstleistungen gegenübergestellt werden. Die Modelle der Raumordnung (z.B. Zentrale-Orte-Konzept) sollen so auf den Prüfstand gestellt werden um gegebenenfalls auch Handlungsbedarfe der Raumordnung identifizieren zu können.

7   ANMERKUNGEN

(1) In diesem Beitragverwenden wir an einigen Stellen das generische Maskulinum als geschlechtsneutrale Schreibweise. Selbstverständlich wenden wir uns damit ausdrücklich auch an alle Menschen, die sich nicht dem binären Geschlechtssystem zugehörig fühlen, haben uns aus Gründen der Lesbarkeit und Formatierung aber gegen eine gegenderte Schreibweise entschieden.

(2) Eine ausführliche Darstellung der Ergebnisse zu allen Fragen wird im Laufe des Forschungsvorhabens über www.ageing-smart.de zugänglich gemacht.

(3) Wir danken Benjamin Stefan für die Bereitstellung und Auswertung der Befragungsergebnisse des Fachgebiets Stadtsoziologie der RPTU.

8   LITERATURVERZEICHNIS

BUNDESÄRZTEKAMMER (2023): Ergebnisse der Ärztestatistik zum 31.12.2022, abgerufen am 03.06.2023 unter:
          https://www.bundesaerztekammer.de/baek/ueber-uns/aerztestatistik/2022
GERLACH, Ferdinand et al. (2014): Sachverständigenrat zur Begutachtung der Entwicklung im Gesundheitswesen. Gutachten 2014.
          Bedarfsgerechte Versorgung – Perspektiven für ländliche Regionen und ausgewählte Leistungsbereiche. Bonn/Berlin.
JACOB, Rüdiger/KOPP, Johannes/SCHULTZ, Sina (2015): Berufsmonitoring Medizinstudenten 2014. Ergebnisse einer
          bundesweiten Befragung. In: Kassenärztliche Bundesvereinigung (Hrsg.). Berlin.
KASSENÄRZTLICHE BUNDESVEREINIGUNG KdöR (2023) Bedarfsplanung, abgerufen am 03.06.2023 unter:
          https://www.kbv.de/html/bedarfsplanung.php
KASSENÄRZTLICHE BUNDESVEREINIGUNG KdöR (2023) Gesundheitsdaten, abgerufen am 03.06.2023 unter:
          https://gesundheitsdaten.kbv.de/cms/html/16402.php

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[28] ebd. S. 136ff.
[29] ebd. S. 137.

KASSENÄRZTLICHE VEREINIGUNG RHEINLAND-PFALZ (2023): Digitale Statistiken, abgerufen am 03.06.2023 unter: https://www.kv-rlp.de/institution/statistiken-und-berichte/digitale-statistiken/altersstruktur/

KÖRBER-STIFTUNG (2022): Ageing in Place. Wohnen in der altersgerechten Stadt. Kommunale Strategien für die Babyboomer-Generation. Hamburg.

STATISTISCHES BUNDESAMT (2023):14. koordinierte Bevölkerungsvorausberechnung für Deutschland, abgerufen am 03.06.2023 unter: https://service.destatis.de/bevoelkerungspyramide/#!y=2060&a=20,65&g

STEFAN, Benjamin/LOEPPKE, Yannick/SPELLERBERG, Annette: Babyboomer in Deutschland – demografische, soziale und räumliche Differenzierungen. Analysen auf Basis des sozio-ökonomischen Panels 2019. Kaiserslautern, 2022.

STIEWING, Marvin/WEBER, Tobias/MANGELS, Kirsten/RUZIKA, Stefan/FRÖHLICH, Nicolas/HAUSBRANDT, Nils (2022): "Black Box Babyboomer" – Was kommt auf Kommunen zu? Decision Support System mit Hilfe mathematischer Erreichbarkeitsmodellierung medizinischer Versorgungsstandorte. In: Schrenk, Manfred; et al. (Hrsg.): REAL CORP 2022 „Mobility, knowledge and innovation hubs in urban and regional development", Proceedings/Tagungsband 14-16 November 2022. Wien. S. 131-141. ISBN 978-3-9504945-1-8.

SUNDMACHER, Leonie/BRECHTEL, Thomas et al. (2018): Gutachten zur Weiterentwicklung der Bedarfsplanung i.S.d. §§ 99 ff. SGB V zur Sicherung der vertragsärztlichen Versorgung. München, Leipzig, Bonn, Greifswald und Köln.

WEBER, Tobias /MANGELS, Kirsten /GROTHEER, Swantje (2022): Gesundheitsförderung in der Regionalentwicklung zur Schaffung gesunder Lebensverhältnisse In: Schrenk, Manfred; et al. (Hrsg.): REAL CORP 2022 „Mobility, knowledge and innovation hubs in urban and regional development", Proceedings/Tagungsband 14-16 November 2022. S.395-406. ISBN 978-3-9504945-1-8.

ZWIERLEIN, Ruben/PORTENHÄUSER, Frank/FLÄGEL, Kristina/STEINHÄUSER, Jost (2020): Determinanten der Niederlassung als Allgemeinmediziner – eine qualitative Studie. Stuttgart/New York.

Integrating Multi-Scalar Attributes in Assessing Urban Sustainability for the Built Environment in Heritage Sites: The SHAI Model

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1 ABSTRACT

Sustainable development approaches are a widely used term, which has been increasingly essential in the Middle East, in general and, in Egypt in specific, for the purpose of planning and urban policies formulation specifically in heritage sites. The research was inspired by the significance of assets of historical areas which motivated the researchers to study and define their values, and find appropriate processes and mechanisms to measure, and evaluate their qualities.

A proposed model, for re-structuring planning processes and assessing information in regards of relative materials on sustainable, urban indicators is discoursed in order to develop a distinctive representation that integrates approaches of urban sustainability in the built environment, in terms of socio-culture and socio-economic aspects, environmental, and spatial dimensions, furthermore, various factors such as time, activities, space, interests, and quality of life.

This paper aims to reduce the complexity of multi-attribute criteria of sustainability, by adopting analytical representation for selected case study, based on a integral model to assess urban sustainability in the built environment for Heritage Sites. This approach investigates indicators of urban qualities relying on the integration of a BEQUEST framework implementing effective qualitative scales (quantifiable cities) and concludes with recommendations to develop an integrative, multi-scalar assessment method.

The paper present details for the proposed framework; Sustainable Historical Area Index (SHAI); model as an integrated tool used to evaluate the capacity of the multi-scaler attributes to assess the urban sustainability in the built environment for Heritage Sites. Results should provide assessment methods to be used in developing the model and provides sustainable evaluations for enhancing urban aspects.

Finally, the paper applies its findings on a case study assessment of the urban setting in El Fustat, Cairo, Egypt. The application comes to show the validity of the conceptual application of the proposed multi-scalar attributes of the Sustainable Historical Area Index upon evaluating values and principles within an existing Heritage Sites towards more sustainable built environment. This paper investigates the optimal corresponding values to be applied in evaluating the sustainability of urban development based on the analytical techniques of the empirical study.

Keywords: fustat old Cairo, assessment models, heritage sites, urban planning, sustainable design

2 INTRODUCTION

Over the past few decades, historical and heritage sites have gained a great priority, reflecting the new urban agenda goals. From this perspective, employing urban sustainability assessment frameworks for the built environment in historical and heritage sites, as key mechanisms for assessing the sustainability variables have become crucial instruments to follow sustainable urban development (UWH, 2015). Particularly during the last decade, sustainability assessment through indicators and indexing models has gained recognition. These assessment approaches based on reliable variables are highly considered as logical approaches in determining urban sustainability measurable values (Singh R. et al, 2009).

Although various urban sustainability assessment methodologies, models, and tools have been developed so far(Kalman H. , 2014), only a few have focused on the historical and heritage sites with a multi-scalar integral approach that takes into account all of the urban sustainability domains; environmental, economic, and social, ecological, and urban.

The importance of the Sustainable Historical Area Index (SHAI) Model as a variable-based urban sustainability assessment model is the quantifiability of the urban sustainability variable and parameters. In addition itaims to reduce the complexity of multi-attribute criteria of sustainability by simplifying, quantifying, and analysing complex and complicated information (A.Nayer, & Fattah, D. A., 2015).

3 HISTORICAL AND HERITAGE SITES

The interpetation of the term "heritage" is quite broad and encompasses various aspects. Part of the heritage are the historic buildings that not only refer to an inheritance from the past, but also carry a definite connotation of value or importance or frame: architectural, aesthetic, economic, and even political and symbolic values. (Nasreldin, R. 2019).

3.1 Defining Heritage sites

The term heritage has different meanings in different contexts. The World Heritage Convention classifies heritage into two categories: Cultural heritage: a monument, group of buildings or site of historical, aesthetic, archaeological, scientific, ethnological or anthropological value. Natural heritage: includes outstandingphysical, biological, and geographical features, different kind of plants or animals species and areas with significant scientific or aesthetic value; those could be best for conservation (UNESCO, 2002).

The Budapest Declaration on World Heritage Convention (UNESCO, 2002) made reference to"ensure an appropriate and equitable balance between conservation, sustainability and development, so that World Heritage properties can be protected through appropriate activities contributing to the social and economic development and the quality of life of our communities". Historical and Heritage are invaluable resources for cities and regions; they contribute to economic development, social cohesion, and citizens" sense of place.

In addition, to these arguments there might be other perspectives to approach historical and heritage values.Adding the word "sites" to the term "heritage" will reveal multiple dimensions of identity and emotional symbol of characteristics continuity in the sense that it has a physical existence (Embaby. M. ,2014).

Historical and Heritage sites, whatever their size and scale, are an essential resource to build identity and a sense of belonging and can serve social cohesion, pride and integration. As a diverse resource, it ranges from tangible valuesof buildings, landscapes, etc. to intangible values, such as traditions, language, knowledge, etc. An important characteristic of the built heritage is its presence in time and space(UWH, 2015). Great attention has been devoted to Historical and Heritage sites considered as request to save local identity(Singh R. et al, 2009). The idea of sustaining Historical and Heritage sites from the urban perspective can help to visualise the diversity of urban form and to explore the cultural, political and historical character of the urban areas, for more suatainable approaches (Singh R. et al, 2009).

3.2 Urban Sustainability for Historical and Heritage sites

The World Commission on Environment and Development (WCED) in 1987 proposed a definition of sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The definition considered the balance across three interconnected domains: economic, environmental, and social dimensions(Guzmán PC, ,2017).

Urban sustainability for historical and heritage sites tackles the conservation of the urban context and heritage from deterioration.From this approach, heritage, which has long been absent from the platform of urban sustainability is nowadays recognised to have great potential in contributing to social, economic, and environmental development. Urban sustainability for historical and heritage sites can significantly maintain social capital and generate economic resources and can strengthen the sense of living place and sense of belonging. The new urban agenda also acknowledges historical and heritage sites as a crucial component of urban sustainable development (10,11), particularly in the sub-goal 11.4 that aims to "strengthen efforts to protect and safeguard the world's cultural and natural heritage" (Fletcher, R., 2007).

4 ASSESSMENT TOOLS: MULTI-SCALAR ATTRIBUTE

In recent years, various tools and methodologies have been developed, both at a strategic and operative level, for Assessing Urban Sustainability For the Built Environment in Heritage Sites (Murtiyoso, A., 2018). The research is adopting the multi-scalar approach as a tool for assessment. The multi-scalar approach works on the concept of variable and parameters that enables the exploration of the urban sustainability dynamics of interrelated key processes in the Historical and Heritage Sites.

4.1 Quantitative assessment method

The Multi- scalar attribute represents a family of methods that describes and models integral evaluations with respect to different interests, subsystems of the cases, or disciplinary perspectives. This method is a mean to analysing situations and creating an evaluation process. As a case evaluation method,the multi- scalar attribute tackles both the conceptual/qualitative and numerical/quantitative approaches. The objective of the multi- scalar attribute is to attain a conjoint measure of the urban sustainability variables in correspondence to the urban sustainability main domain (Guilherme C. et al., 2013).

4.2 Sustainable Historical Area Index (SHAI)

The literature highlights the shortcomings of the current evaluation models and the urgent need for more efficient assessment methods and tools as sustainable urban development demands rise rapidly (Vincenzo B., et al., 2002). Accordingly, the current study demonstratesthe multi- scalar attribute as an assessment tool. It discussses a proposed model for re-structuring planning processes and assessing information regarding sustainable, urban variables. The purpose is to develop a distinctive representation that integrates approaches of urban sustainability into the built environment, in terms of socio-cultural and socio-economic aspects, environmental, and spatial dimensions. Furthermore, it incorporates various factors such as time, activities, space, interests, and quality of life. This index is based on the bequest framework(Mark D. et al., 2014) and the quantifiable city theories (Rose, C., 1995), in addition to local community psychological aspects, and taking into consideration the decision making process among key actors representing governmental institutions, local communities and NGOs (A.Nayer, & Fattah, D. A., 2015). The model aims to provide a more effective sustainability assessment by taking all of the major aspects affecting sustainability into account.

5   RESEARCH METHODOLOGY: SHAI MODEL FOR ASSESSMENT

The paper is presenting a structured methodology to provide a coherent assessment of heritage beneficial implementation of sustainable development approaches. Based on the literature review and the qualitative and quantitative content analysis, with the integrated community involvement, the methodology is running accordingly:

Step 1: Building up the model: Integration between different approaches, based on the literature review, backgrounds and definitions.

Step 2: Discussion: Case study analysis (on site documentation for existing conditions, including investigations through observations and semi-structured interviews with multiple stakeholders (local-residents and visitors – NGOs – Local government and institutions)

Step 3: Model implementation and variable assessment (measurable verification), case study as an application.

Step 4: Demonstration of proposed solutions as part of more extended development strategic plan, findings, conclusions, and recommendations.
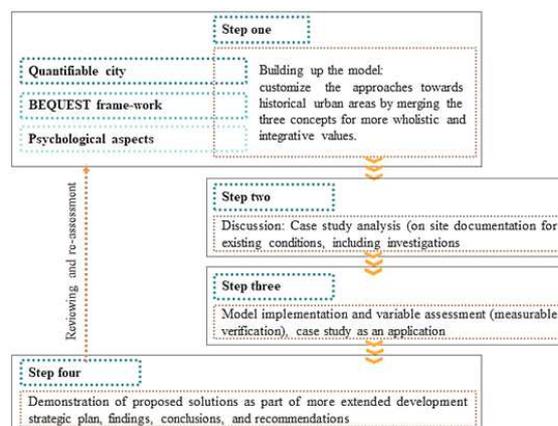
Figure 1: Structured Methodology, by Authors.

STEP 1: BUILDING UP THE MODEL: The integration of multiple approaches, each representing certain concept. The model introduces wholistic vision that accommodates various layers of informations, and tackles deep interpretation for the historical and heritage sites.
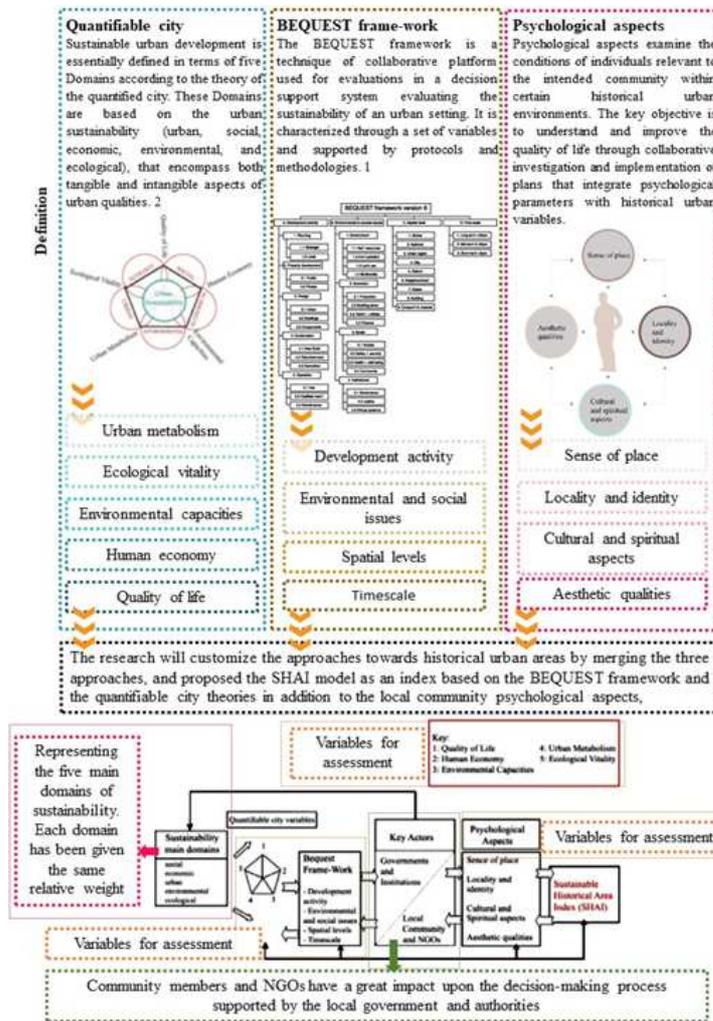
Figure 2: Sustainable historical areas index (SHAI) Diagram, by Authors.

Theories and approaches	Variables	Discussion
Quantifiable city	Quality of life	Giving a value and standards to the living environment.
	Urban metabolism	Reflects the deep relation between the urban physical features of street width, building heights, and theirrelationship with the environment, in terms of shades and shadow, air circulation, and landscaping.
	Ecological vitality	Analysing the impact of the environment and studying the interactions withinthe local community
	Environmental capacities	It is a process that involves, shifting societal attitudes, to pursue environmental development, strengthening individuals" capabilities.
	Human economy	The ability of the local community to be a part of the financial process of the sustainable urban development in the historical areas
BEQUEST frame-work	Development activity	Projects and strategies, in the approach to conservation and preservation, property development public and private interests.
	Environmental and social issues	It explains how the local community is capable of preserving its surrounding environment and re-using the resources of the local materials.
	Spatial levels	Various spatial levels ranging from the scale of the whole urban setting down to that of the individual historical building and its construction systems and material components.
	Timescale	Represents the normal scale used in economic and strategic planning, as time-scale phases of evaluation and re-assessment.
Psychological aspects	Sense of place	It is a place made up of a web of various buildings and streets, from different periods along history, which creates various cultural and urban strata.
	Locality and identity	The feeling of belonging to a certain urban context, as part of the self-conception and self-perception to local community within its urban settings.
	Cultural and spiritual aspects	Aspects represent the psychological values of the local communities related to their urban setting, and culture.
	Aesthetic qualities	The theory of beauty, providing luxury for human demands, feeling comfortable, safe and secure.

Table 1: Sustainable historical areas index (SHAI), by Authors.

The sustainability historical areas index (SHAI) Model is developed as an advanced variable-based urban sustainability indexing model.It is presented through thirteen variables, which will be evaluated based on statistical methodology according to their relative weights, depending on case study approach, applying data gathering based on observation,and semi-structured interview for the actual physical context for the designated site (A.Nayer, & Fattah, D. A., 2015). The idea of the direct weighting means that the evaluator is asked to simply specify the weights numerically. This is, of course, possible for only a small number of attributes. The weight can be specified in percentage (with all weights summing to 100%) (Vincenzo B., et al. , 2002).Appropriate values are expected to be assigned, each variable (X1,X2… Xn) gives a value to each domain of the (SHAI) = YN, (social, urban… etc.,) Scale as: Inconvenient: 0-5%, Moderate: 6-10%, Good: 11-15%, Convenient: 16-20%.

The five domains originally driven from the "Quantifiable city" approach are representing a pentagon with equal values, translated within the SHAI Model as 20% value for each domain. In addition, for more accurate calculations, and more reliable numerical values, the formula had to have one variable to be measured (the thirteen variables) while the other conditions on a constant state. Accordingly the five domains kept an equal relative weight to facilitate assessing the variables, and validate the idea of applying the model upon various historical sites (which might not by necessary have a domain with a privilege upon the others), dealing with all the domains on an equal distance approach.

Sustainability Historical Areas Index Variables / Urban Sustainability main Domain	Sustainability historical areas index variables													
	Human economy	Urban metabolism	Ecological vitalities	Quality of life	Environmental capacities	Development activities	Environmental and social issues	Spatial levels	Timescale	Sense of place	Locality and identity	Cultural and spiritual aspects	Aesthetic qualities	Total
Social20%														
Economic20%														
Ecology20%														
Environmental20%														
Urban20%														
Total100%														

Table 2: Assessment methodology sustainability historical areas index (SHAI), by Authors.

The paper methodology indicates the application on the SHAI Model by analysing a case study of a historical setting. The evaluation process followed the hierarchy of the site introduction, the documentation of the existing conditions, the observation and finally the application of the assessment tool.

6 STEP 2: DISCUSSION: CASE STUDY ANALYSIS ASSESSING URBAN SUSTAINABILITY IN HERITAGE SITES; FUSTAT, CAIRO EGYPT

6.1 Defining the Context of Fustat

Fustat's historical significance is rooted in the days of the Arab conquest in 21 AH/641 AD during the Byzantine era. Caliph „Umar ibn al-Khattab" gave his orders to establish a new capital for Egypt. Fustat was founded by "Amr Ibn al-Aas" becoming Egypt's first Islamic capital. The new capital, with its unique location in proximity to the Nile and the Fortress of Babylon, had quite distinguished values. Later, it became part of the Fatimid capital. References mention that the area was named Fustat, derived from the Arabic word for "tent", named after the camp set up by the army of "Amr ibn al-As" because its initial inhabitants lived in the army"s tents before they built the original Amr Ibn Al-Aas Mosque in the same location as the new one (which is also known as al-"Atiq" the Old Mosque). Fustat remained the capital of Egypt for around 500 years, on and off, until 1168(Feilden, B., 2007).

Today, Fustat is a part of the Old Cairo District, one of the historically significant spots in Cairo, famous for its important archaeological sites, such as the Mosque of „Amr ibn al-As", the seven old churches, the excavated ruins of the old city, the Nilometer, al-Manesterley palace, and Mohammad Ali Palace in al-Manyalm (Karim K., 2016). Fustat is considered one of the unique cultural heritage sites in the world, where

the integrated area of Fustat along with the area of Islamic Cairo and Khedivian Cairo is a world heritage site, in figure 3, (Wladyslaw B., 2016). Great dedication was attributed to site preservation and development, and projects have been implemented, tackling various aspects and domains (Aghakhan, 2001). The development project suggested a framework of integrated development policies, based on having the greatest variety of archaeological sites on a global scale. It aims to integrate historical and modern areas in order to ensure continuity and vitality while balancing the economic development of the site with environmental and aesthetic heritage as well as tourism potential (Feilden, B., 2007).
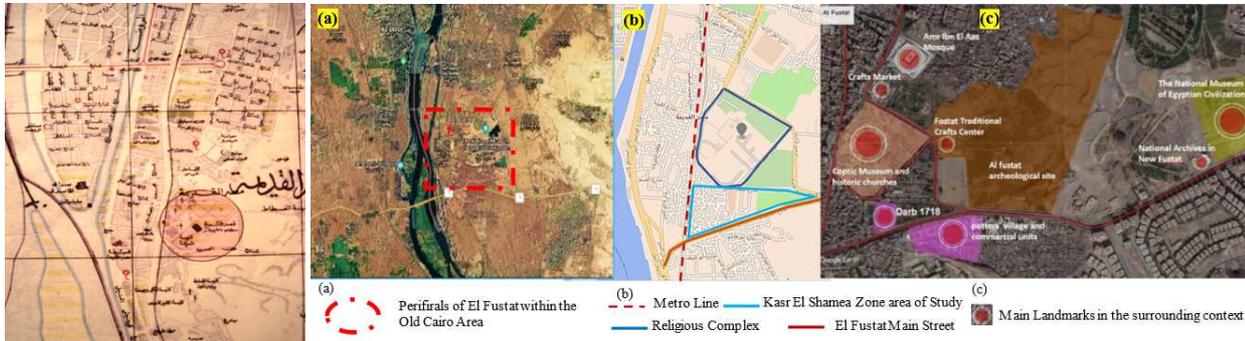
Figure 3: Fustat contextual map, Wladyslaw B. 2016. Figure 4: Case study Localisation: Old Cairo zone highlighting the study area of "Kasr El Shamea" in the core of "El Fustat" ,by Authors.

The selected localisation represents the three main aspects of architectural heritage, comprising the following integrated properties which promote the importance of urban sustainablility:

Firstly the integration of monuments: this refers to all the buildings and structures of conspicuous historical, archaeological, artistic, scientifc, social, or technical interest, including their fixtures and fitting presented in the existance of the "Religious Complex"as indicated in Figure 4.

Secondly the surrounding context containsa group of heritage buildings in addition to residential neighbourhouds at various densities which require interventions to assure the sustainable developmentof the area showcasing its historical, archaeological, artistic, scientifc, social, and technical interest.

Thirdly, the selected site of Kasr Elshamea incorporates combined contributions ofhumankind and nature.Some activities based on local products such as leather workshops and stone carving are supporting the tourism and visitors interest in the area. Their settingsare distinctive within the topography and, together with the inherited historical background rooted in cultural settings of the inhabitantsthey are built upon.

6.2 Landmarks in the surrounding context

Several Projects have adopted the idea of restoring the existing historical buildings in Fustat, in particular the Religious Complex in "Babylon Fort" (Figure 5).
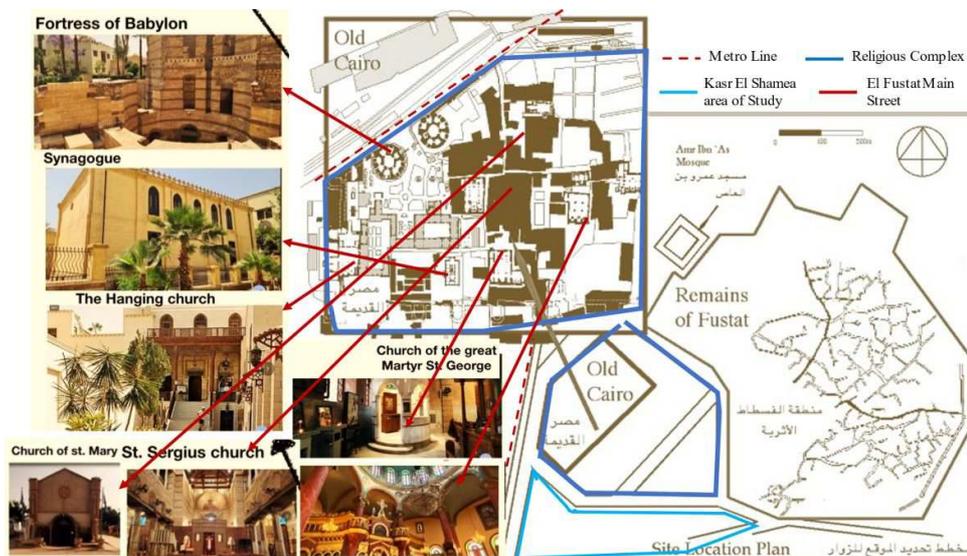
Figure 5: The Main Landmarks in the surrounding Context of "Kasr El Shamea", by Authors.

6.3 Defining the studying site

Figure 6 shows existing values to be assessed by the research team in the urban context of Kasr El Shamea regarding architectural features. Explain the architecture in terms of heritage building, and discuss their relevance in terms of heritage values related to the built environment add ref. to the cond. And regulations for future additions and renovations. This highlights the importance of elaborating urban management processes to support sustainable development of future city expansions and public spaces (Matero F., 2000). Urban heritage streets have some common characteristics that define their style and history. They can create a more liveable community by providing a setting for activities which are attractive for all people, including walkability to enhance the pedestrian experience (H. Elshimy& R. Ragheb, 2017).
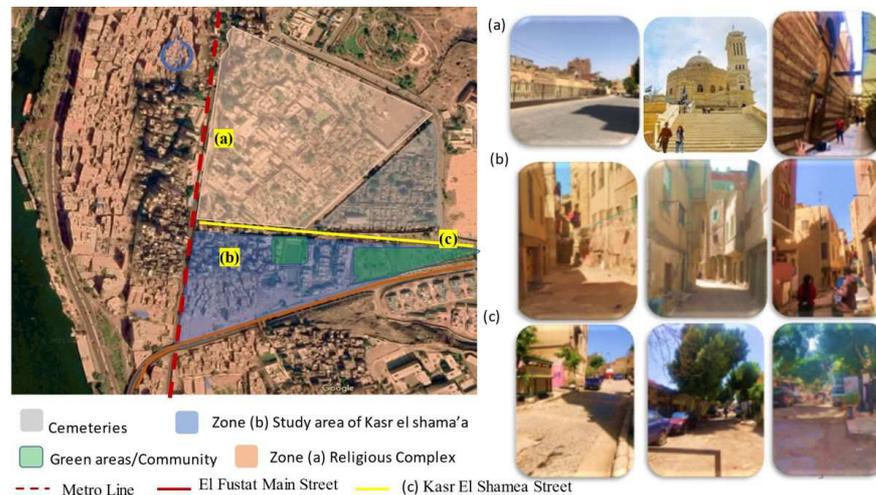
Figure 6: Existing values to be assessed in the urban context in terms of architectural features, by Authors.

6.4 Discussion: Assessing Urban Sustainability Domains

Assessing urban sustainability domains plays a key role in defining sustainable measures of development in heritage-related sites (De la Torre M, 2002). Studies are provided continuously by local authorities and researchers with a set of demonstrations as their main target, that supports the recognition and expression of the values latent in the work asbeing of special importance in the conservation of architectural heritage (20). Analysing the urban context and the settings of activities of the inhabitants activity brings more value to the decision-making on treatment and intervention in such settings (Sama Badawi, A.Nayer, 2017).Nevertheless, the selected site shows a wide concentration of heritage buildings, sites, structures, and landscapes, as well as the consistency in visual elements throughout the district, including scale or built form, all give the impression of a distinct time period, and define the uniqueness of an area (A. Nayer, Samaa Badawi, 2016).

This section discusses the detailed aspects influencing the conservation policies in the Fustat area in an integrative approach while being inspired and aspiring local community anddecision makers like the case of Jameel Community in 2022, highlighting the role of participatory approches in sustainable urban development initiatives.

6.4.1 Demographic and Social Domain

A thorough investigation is done to define the social demographics of inhabitants of the study zone,to emphasis on the local residence capacities and potentials, (H.Rashed, 2013). The results in Figure 6 shows that the majority of inhabitants are elderly persons and families of 4 to 6 persons residing in the units allocated to the south of the Kasr El Shamea Street. Educational facilities do not exist on site. Nevertheless it comprises a medical complex and community centre including sport court.

The majority of the residents are middle sized families of 4 to 6 persons and children are mostly attending schooling in the younger age while trying to find small jobs to support their parents. Most of the residents tend to learn the local crafts related to leather making or pottery enherited from elderly generations. It is recognised that number of females is up to 65% of the total population and they do participate in sustaining the local cgftsmenship by selling the products to small shops or for lower daily wages.
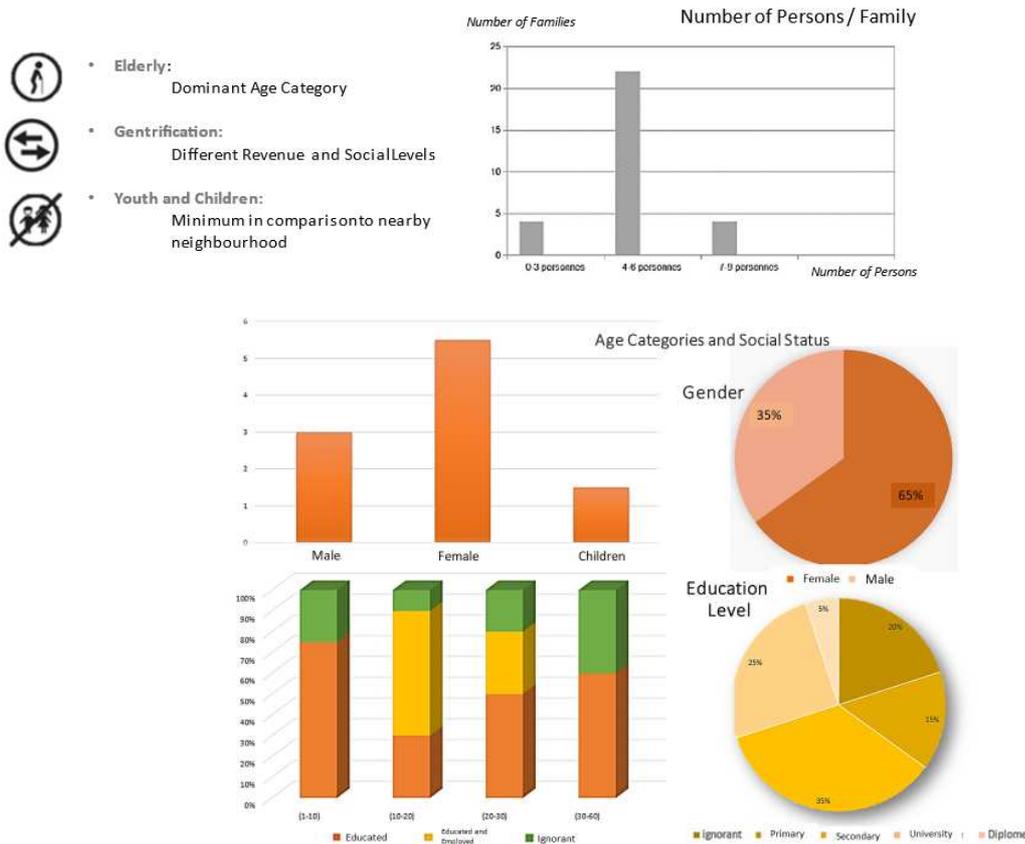
Figure 7: Demographic pattern for Kasr El Shamea residents, by Authors.

6.4.2 Economic Domain

The most relevant economic activities are supporting the tourism potential of the nearby existing heritage sites (Figure 7). The existence of local small shops for leather works and gifts are located on the ground level of the residential units, inhabited mostly by low-income families. Some local food stalls and cafes are more frequently active in the evenings and during weekends. The commercial activities on site have the purpose of preserving the historical and cultural built environment (Shaheen, P. 2010).

Figure 7: Exiting activities supporting the sustainable development in the area, by Authors.

6.4.3 Ecological Domain

Ecological values are driven by the role of the environment and the interactions among the local community. Fustat has a unique ecological footprint, and direct access to the Nile banks, in addition to the Ein-ElSira lake. There has been a large change in the surface water masses of the area where some have dried out while others have extended. since Ain al-Sira lies on lower land, sewage water runs down to the lake, creating both ecological and environmental damages (UNESCO, 2012).On the other hand, the natural topographical settings in the nearby area are due to archeological sites going back to the Greco Romain eras. The existence of natural stones also encouraged the settings of local human activities for artifacts and touristic products, as well as locally built units for workshops or residential units in an informal setting.

422

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6.4.4 Environmental Domain

The natural environment supports and sustains human life in many different ways. It plays a critical role in delivering social, cultural, economic, and environmental outcomes for the local community. The Site is currently in the heart of the potential for developing Old Cairo, It provides opportunities to diversify and strengthen the economy in sectors like tourism and local art-crafts, yet the environmental conditions impose adaptation to the environmental settings of the capital with related densities and infrastructure demands, (URHC, 2012). As mentioned, The site suffers deeply from sewage complicationsand need for more support regarding waste management and garbage collection, in addition to lacking vegetation and air quality.

6.4.5 Urban Domain

The site has faced layers of development and showcases the typical sprawl impact on the existing urban fabric (Figure 8) showing densities and quality of the urban fabricof three different zones.

Figure 8: Existing densities and varity of urban fabric, by Authors. Figure 9: Demolished units on Fustat main street, by Authors.

The site has a unique organic urban fabric with layers of accumulated history and spirtual values. Due it its significance many project redevelopments have been proposed for the area (UNESCO, 2015). Of the most recent ones, thedevelopment project for informal areas in the heart of Cairo has resulted in the demolition of a number of residential buildings with deteriorated status (Figure 9 a) resulting in vacant land (Figure 9 b) where further solutions for sustainable development are proposed by the research project, in alignment with policies as well as considering local potentials resulting from the assessment of related values on the site.

Considerations for the displaced inhabitants forming less than 10% for actual residents of the site are alocated to new housing settelments at Al-Asmarat , the process is focusing on the upgrading of the economic conditions of existing site by ensuring the available infrastructure and the actual potentials of craftsmanship in the study area. Further studies by Saleh E., 2022, highlights the advantages and drawbacks of the upgrading project comprehensively of informal settlements in Cairo region.

Considerations for decision making regarding further develepment plans discusses the impact on the local art and craft activities which gain income from integrating the community and enhancing touristic values of the site.

6.5 Step 3: Model implementation and variable assessment

Sustainable Historical Area Index (shai):Model Assessment

Based on the documentation of the existing conditions, and the studies of the sustainability domains, the SHAI model proposes to analyse, measure, and assess the implemented sustainable development for the Fustat area. The model represents five domains: social, economic, ecology, environmental and urban, in addition to thirteen variables defining the sustainability historical area index. Each domain has a weight of 20% with a total of five domains of 100% total. Each cell represents a value of the variable in reference to the domain with a weight out of 20, with a final row with a total percentage of each variable, in addition to the vertical column indicating the percentage of each domain.

The assessment methodology of the Sustainability Historical Areas Index for the Fustat site presented in Table 3 indicates a set of measurable values and weights for each domain and variable. The values were attributed by the evaluators (Fattah, D. A., 2017), representing multiple categories. The community as the local residences, in addition to the historical sites" visitors, whether national or foreigners. As for the NGOs, number of non-governmental institutions offered support through cooperative representative from the local residences accommodated guided tour around the site, and facilitated group meetings with the families, women, and children. Those NGOs, one supported by Amr Ibn Alas Mosque, the other represented the Christian community, and finally the workmanship representing the craftsmen and the local art. Regarding

the local authorities, they acted as enabler, they supported the idea of community involvement and provided validation documents to allow the researcher to collect data, applying observation, taking photos, and produce visual maps.

Sustainability Historical Areas Index Variables / Urban Sustainability main Domains	Human economy	Urban metabolism	Ecological vitalities	Quality of life	Environmental capacities	Development activities	Environmental and social issues	Spatial levels	Timescale	Sense of place	Locality and identity	Cultural and spiritual aspects	Aesthetic qualities	Total	Percentage
V1,V2,V3……..Vn	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13		
Social 20%	13	17	15	15	13	18	13	18	16	17	19	19	17	210	**80%**
Economic 20%	12	14	13	13	13	17	13	15	16	17	17	17	17	194	75%
Ecology 20%	16	17	13	14	14	18	14	15	15	18	18	18	17	207	79%
Environmental 20%	14	14	13	13	11	18	14	16	16	18	18	18	18	201	77%
Urban 20%	16	14	12	13	12	19	14	18	18	18	18	20	18	210	**80%**
Total 100%	71%	76%	66%	**68%**	**63%**	**90%**	68%	82%	81%	88%	**90%**	**92%**	87%	Total percentages	

Table 3: Assessment methodology sustainability historical areas index (SHAI), by Authors.

The numerical values were extracted and translated by the researcher from huge amount of date collected through the semi-structed interview, and focus groups. The idea of the numerical assessment was to validate the qualitative data into quantitative values. From the table above, the relatively high values of three variables are noted (V6: Development activities – V11: Locality and identity – and V12: Cultural and spiritual aspects) scoring approximately 90 - 92%, affecting the values of both the social and urban domain, scoring an accumulative figure of approximately 80% from the thirteen variables. The emphasis of V6 (Development activities) represents all the previous projects, and the current ones, targeting sustainable developments. The values of V11, and V12 (Locality and identity, Cultural and spiritual aspects) are expressing the high sense of locality and place attachment of the local community, and the significant cultural and spiritual values within the Fustat sites. The readings are representing the sensitivity of the current status, with high values of the variables related to the development and local identity, while, on the other hand, the Environmental capacities (V5), and Quality of life (V4) show very low values. The results indicate that, despite the historical and heritage values of the Fustat site, and its significant character with all the proposed and implemented sustainable development projects, still suffers from lacking services, facilities, and environmental and ecological treatments. Measures are indicating a poor quality of life, which urges a more holistic vision that would tackleall the variables in a parallel pattern.

Step 4: Demonstration of proposed solutions

The SHAI model is offering the interrelation of the integrated variables in a graphical visualization as per the framework shown in figure 10. The arrows represent the flow of information and how the model works, how the variables are connected and affecting each other as an endless loop of enhancements and developments. Annotated on the model the values of the variables with a highlight on the highest (green) and lowest (red) values. Noted that both Environmental capacities and environmental and social issues scoring the lowest values 63% and 68% respectively. These numbers indicate the poor environmental quality, and its direct harmful impact on the historical site. It acquires an instant urban solution. Although, development projects are introduced, but the aim of the SHAI model is to highlight, focus and define the deficiencies.

The implemented projects had focused on the urban development, in terns of building restoration and street networks, however, lacking the environmental approach with disregards to its importance and damageable effect. On the other hand, the SHAI model flourishes the variables with the highest scores as: locality and identity, and cultural and spiritual aspects, 90% and 92% respectively.
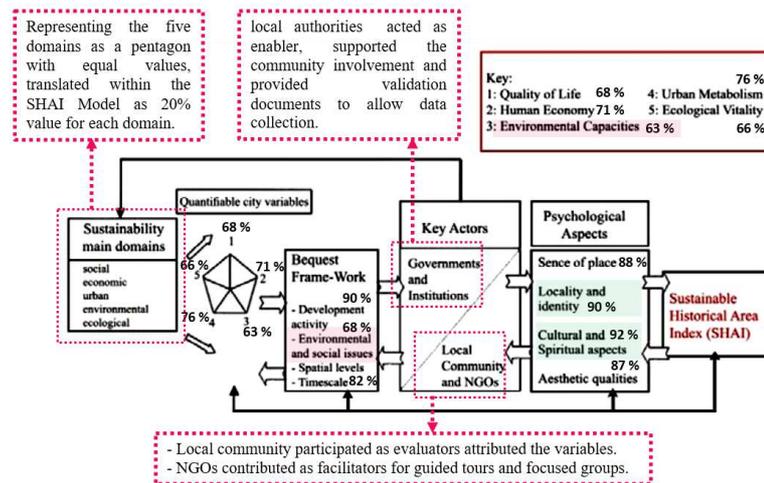
Figure 10: Framework demonstration of proposed solutions integration, by Authors.

The site is quite rich with sense of locality, that creates a strong identity and community solidity. These vibes were shown throughout the focus groups. The idea of having a strong identity and community connections, facilitating the residences participation and involvement. This promotes a stable platform of a motivated community to support the development projects and act together to enhance their local urban setting.

7 CONCLUSION

The paper applies its findings to show the validity of the conceptual application of the proposed multi-scalar attributes of the Sustainable Historical Area Index upon evaluating values and principles within existing Heritage Sites towards a more sustainable built environment.

The paper presented details of the proposed framework; the Sustainable Historical Area Index (SHAI); model as an integrated tool used to evaluate the capacity of the multi-scalar attributes to assess the urban sustainability of the built environment for heritage sites. The model has been applied to a case study based on a research project for assessing the urban sustainability of the Fustat site, focusing on Kasr El Shamea Street. Assessment results indicates promising results in the social and urban domains (as mentioned in the discussion) scoring relatively high values on the SHAI Model. The numerical values provide reliable readings, conveying valid figures with a clear vision of the site's existing conditions. Investigations, surveys and the analysis of gathered data demonstrate that detected points need specific remedies that should be mended in terms of spatial solutions and community involvement. Parallel investigations of people's responses, as well as physical surveys provide a complete image of howpublic involvement would work best to enhance the visitors' experience. Despite all the dedicated efforts and proposed projects, the site is still lacking essential needs, with major deficiencies of environmental issues such as waste management, freshwater supply, ecology of water level and sewage leaking into the lake water, and finally the economy, with poor communities and low-incomes.

Further suggestions are made towards resolving major points to urban enhancements. They include: encouraging safe pedestrian accessibility while preserving the built environment in the historical area of Kasr El Shamea; encouraging public services and enhancing the quality of spatial features and establishing connecting points with the adjacent heritage sites by including commercial purposes and while preserving the historical and cultural built environment.

Accordingly it can be concluded that there is a need for a regulatory model assessing the values of sustainable developemnet factors existing in the heritage sites to support the presence and conservation of development of today's societies taking in consideration the the architectural heritage. The research emphasises on the main purpose of attracting visitors, both local residents and tourists, sustaining the unique sources of income and improving the quality of life of the district's surrounding neighbourhoods while integrating existing community in the process of assessment and potential developement.

8   LIMITATIONS

Limitations of the study is due to the continuous alterations performed on the extentions of infrastructure development plans in the periferals of El Fustat zone. Instead, reflection on site potentials should consider more sustainable and effective developments for both residents' and visitors' interests in the zone of Kasr El Shamea.

9   SUGGESTIONS FOR FURTHER STUDIES

The main goal of the "SHAI Model" research project is to assess sustainable values for sites under study by means of weighted analysis to provide quantifiable measures towards setting priorities for planimplementation. Thus, other potential areas of study can be suggested to apply the model while adjusting the value settings according to related analytical investigations with the aimto simulate a heuristic responsive set of recommendations and guidelines for future sites under study.

10   REFERENCES

A.Nayer& Fattah, D. A.: Methodology towards defining multi-scalar attributes of sustainability indicators in historical urban areas: assessment tool development. In WIT Transactions on the Built Environment. WIT Press, 2015.

A.Nayer, Samaa Badawi: Heritage Preservation within public open spaces: the case of Qabel Street (Old Jeddah) Spacious Experience, Sustainable Vital Technologies in Engineering & Informatics BUE ACE1 , Cairo, Global Science and Technology , 2016.

Aga Khan Trust for Culture, Mugamma' al-Adyan Project, Cairo, Egypt, 2001. Accessed in August 2023: https://www.archnet.org/sites/5113 : Archnet> Site >Mugamma' al-Adyan Project

Avrami E, Mason R, de la Torre M. Report on research. Values and heritage conservation: research report, p. 3–11, Los Angeles: The Getty Conservation Institute; 2000.

Recommendation concerning the Protection, at National Level, of the Cultural and Natural Heritage, UNESCO, 2002. https://www.unesco.org/en/legal-affairs/recommendation-concerning-protection-national-level-cultural-and-natural-heritage (Last retrieved April 2023)

De la Torre M, editor. Assessing the values of cultural heritage. Getty conservation institute; 2002. https://www.getty.edu/conservation/publi cations_resources/pdf_publications/pdf/assessing.pdf.

Embaby, M.: Sustainable Urban Rehabilitation of Historic Markets: "Comparative Analysis". International Journal of Engineering Research & Technology (IJERT). Architecture Department, Faculty of Engineering, Fayoum University, Egypt. vol 03, Issue 04. ISSN: 2278-0181, 2014.

Fattah, D. A. Nasreldin, R. Aboubakr, Motivating participation in regenerating sustainable urban neighbourhood open spaces. Sustainable Design of the Built Environment SDBE, London, UK D, 2017.

Feilden, B., Conservation of Historic Building, Architectural, Butterworth Architecture, Oxford, Routledge, 2007. https://doi. org/10.4324/9780080502915.

Fletcher, R.; Johnson, I.; Bruce, E.; Khun-Neay, K. Living with heritage: Site monitoring and heritage values in Greater Angkor and the Angkor World Heritage Site, Cambodia. World Archaeol. Vol.39, 3(WCED,1987).5–405, 2007

GOPP, General Organisation of Physical Planning, Greater CairoUrban Development Strategy, Future vision and strategic directions, p:175-188, 2012.

Guilherme C. et al. Defining best practices in Sustainable Urban Regeneration Projects, Building Sustainability Assessment Tools, Portugal SB13 – Contribution of Sustainable Building to Meet EU 20-20-20 Targets, 2013.

Guzmán PC, Pereira Roders AR, Colenbrander BJF: Measuring links between cultural heritage management and sustainable urban development: An overview of global monitoring tools. Cities, 60, 192–201, 2017.

H. Elshimy& R. Ragheb: "Sustainable Urban Street Design: Evaluation of El-Moaz Street in Cairo, Egypt", Elsevier Procedia Environmental Sciences Journal, volume 37, 2017.

H. Rashed, Sustainable Urban Development in Historic Cairo, Ph.D. Thesis, p: 87-95, 2013.

Jameel Community, Egypt Impact Lab launches to strengthen evidence-based policy and development outcomes, Cairo 2022. Last accessed august 2023: Egypt Impact Lab launches to strengthen evidence-based policy and development outcomes (communityjameel.org)

Kalman, H.: Heritage Planning Principles and Process. New York: Rout-ledge, 2014.

Kesseiba K., Re-considering Al-Fustat: Urban Development in Old Cairo in Reaction to Mega Projects Re-considering Al-Fustat: Urban Development in Old Cairo in Reaction to Mega Projects, SBE16 conference, Cairo 2016.

Mark D. et al. Sustainable Cities and Sustainable urban development: Use of the environmental assessment methods, Journal of Sustainable Cities and Society, vol. 10, pp. 39–48, Elsevier, 2014. www.elsevier.com/locate

Matero F. Ethics and policy in conservation. Conservation: The Getty Conservation Institute Newsletter. 2000;15(1). pp. 05. https://www.bcin. ca/bcin/detail.app?id=414624.

Murtiyoso, A.; Grussenmeyer, P.; Suwardhi, D.; Awalludin, R. Multi-Scale and Multi-Sensor 3D Documentation of Heritage Complexes in Urban Areas. ISPRS Int. J. Geo-Inf. Vol. 7, 483, 2018.

Nasreldin, R. Aboubakr, D. Fattah, D. A. (2019). Spatio-temporal dynamics of socio-economic public life in historical contexts. tools for studying life between historical buildings. ARCHCAIRO 8, Architecture department,Faculty of Engineering, Cairo University, Cairo, Egypt.

Nocca F.: The role of cultural heritage in sustainable development: Multidimensional indicators as Decision-Making tool. Sustainability, 9 (10), 2017.

Rose, C.: Fustat context, Cairo, Egypt, 1995. https://www.laits.utexas.edu/cairo/history/fustat/fustat.html. (Last retrieved May 2023).

Saleh E. et al., Community Development Within Slums" Illumination: A Post Occupancy Evaluation Study of Al-Asmarat Project Inhabitants, Journal of Al-Azhar University Engineering Sector Vol. 17, No. 63, P: 684 – 697, April 2022.

Sama Badawi, A.Nayer; Jeddah city as a contemporary gateway: new vision for city smart growth management, Procedia Environmental Sciences, vol.37; Elsevier, P. 330-34, Jan. 2017.

Shaheen, P.: Babylon of Egypt: The archaeology of old Cairo and the origins of the city. Cairo: American University in Cairo Press, 2010.

UNESCO World Heritage Centre: The Budapest Declaration on World Heritage, 2002. https://whc.unesco.org/en/documents/1334 (Last retrieved May 2023)

UNESCO World Heritage Centre. (2015). Operational Guidelines for the Implementation of the World Heritage Convention

Singh, R.K.; Murty, H.R.; Gupta, S.K.; Dikshit, A.K. An overview of sustainability assessment methodologies. Ecol. Indicat. Vol. 9, 189-212 2009.

UNESCO: Urban Regeneration project for Historic Cairo, First Report of Activities, June 2012. http://whc.unesco.org/uploads/activities/documents/activity663-3.pdf

UNESCO:World Heritage and Sustainable Development, 2015. https://whc.unesco.org/en/sustainabledevelopment/

UN General Assembly: Our World: The 2030 Agenda for Sustainable Development, 2015.

Vincenzo B., et al. A vision and methodology for integrated sustainable urban development: BEQUEST, Building Research and Information, 2002. http://dx.doi.org/10.1080/096132102753436468 (Last retrieved April 2023).

Wladyslaw B., AL-FUST AT Its Foundation and Early Urban Development, The American University in Cairo Press, ISBN 978 1 61797 741 1, 2016.

WCED: World commission on environment and development, 1987. https://idl-bncidrc.dspacedirect.org/bitstream/handle/10625/152/WCED_v17_doc149.pdf (Last retrieved April 2023).

Integrative Design Solutions for Connecting Street Trees to the Urban Water Cycle

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1 ABSTRACT

Climate change adaptation and the need to improve micro-climates in cities bring urban forestry into focus. Street trees are important nature-based solutions (NBS) with multiple functions. But only large, well-developed trees that are at least a few decades old can provide the necessary range of ecosystem services and perform the tasks required. There are two essential criteria for trees to grow old: (1) the qualities of the site, in particular the adequate supply of water, air, and nutrients to the root zone, and (2) the choice of tree species. This links tree planting in the urban environment to the improvement of the urban water cycle, which is a goal of NBS in its own right.

In this paper, we explore how tree planting and the urban water cycle can be combined by means of integrated design solutions in different types of open spaces in cities. Based on a qualitative analysis of built design projects using NBS in Austria and scholarly literature, we explore the requirements for and the range and combinations of different design solutions for NBS.

In the design of urban rainwater management based on the "sponge city" principle, NBS can be used for the "collection of water", "retention of water", "purification of water", and "discharge of water to the atmosphere or water bodies". Three different design approaches for water management are possible: "concealment" (diverting rainwater rapidly from the surface to underground systems), "integration" (leaving the water visible, but unobtrusive, and integrating it into the overall design of the site), and „showcasing" (transforming stormwater measures into water-based amenities).

The analysis of 24 projects showed that implementing NBS by using the sponge city principle for trees has become an important element in stormwater management cascades and has been applied in a range of different types of urban open spaces. The sponge city principle for trees is primarily a NBS with low design impact: strategies of "concealment" and "integration" predominate. "Showcasing" has only occurred in conjunction with sunken planters for purification. Incorporating NBS into the overall design of an open space has untapped potential.

The projects under analysis also show that while the water conditions for trees are being improved, the choice of species is also changing. The focus now is on species that are able to cope with hotter and drier conditions. Native species are being replaced with trees from appropriate climatic regions.

The conclusion is that finding synergies between landscape design and engineering provides a rich source of innovation for new urban open spaces. The overall design goal is to achieve an integrative solution serving technical, ecological, social, and economic needs. Designing nature-based solutions means taking a site-specific, integrative approach and connecting with a citywide network of green infrastructure.

keywords: street tree, urban water cycle, urban design, sponge city, nature-based solutions

2 INTRODUCTION

2.1 NBS connecting stormwater management and street trees

Stormwater management in urban planning and site planning is increasingly becoming an issue (Kruse 2014). On the one hand, quantitative changes in the water cycle caused by surface sealing – in conjunction with a climate change-related increase in heavy rainfall events –have brought existing sewer systems to the limits of their capacity. On the other, urban heat islands created by enlarged structures and surfaces, increased waste heat, and reduced evaporative cooling in connection with the climate change–induced aggravation of heat periods are becoming a public health problem. This problem can be counteracted through shading by vegetation and adiabatic cooling caused by increased evaporation (Schmidt 2010). This requires many strong, healthy, and well-irrigated trees providing evapotranspiration in built-up areas.

Summarizing the two EU Commission strategies (EC Energy, Climate Change, Environment n.d.& European Research Executive Agency n.d.), green infrastructure is the strategically planned network of

green structures, while nature-based solutions are the concrete measures to address specific challenges that can be integrated into a strategic network. NBS can thus be seen as modules of green infrastructure. Many of them address water management or at least have an influence on the water balance (Fig. 1).
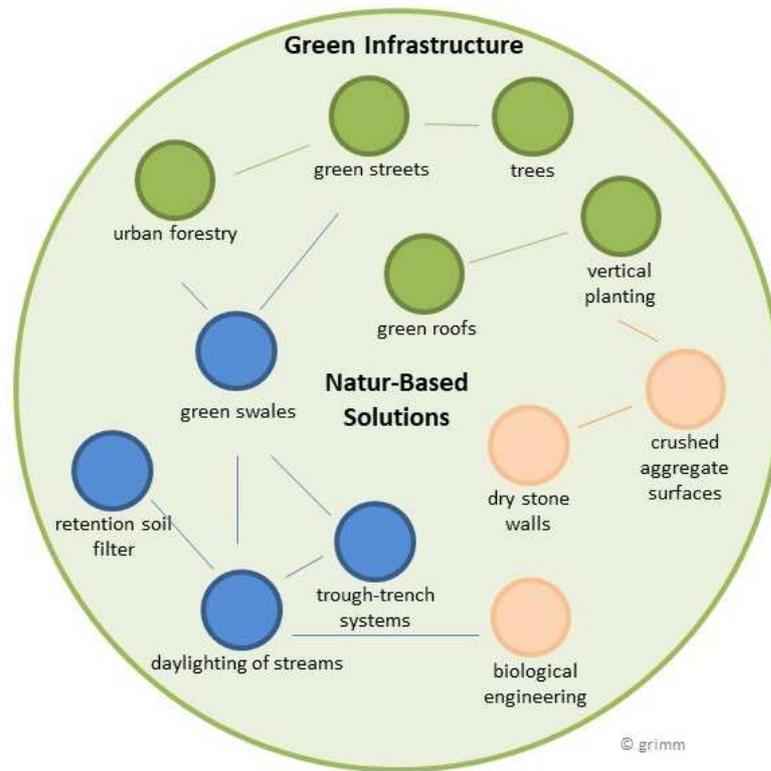
Fig. 1: Nature-Based Solutions –Modules of Green Infrastructure (source: Karl Grimm)

Seen from a climate and water-management perspective, increasing the evaporation of stormwater has the highest priority, ahead of infiltration for groundwater recharge. Stormwater management in combination with urban greening measures can also support biodiversity, offer an experience of nature, and enhance recreational value in urban areas. Accordingly, stormwater management implemented on roofs and facades and in open space is increasingly interlinked with landscape architecture. The transformation of urban drainage systems includes opportunities to enhance the quality of open space in existing urban structures as well as in new urban developments in terms of a network of green infrastructure (Grimm 2018). The living elements of open-space design – trees, planting, permeable surfaces – are themselves NBS. To effectively deploy the multiple functions and services of NBS, a precise development and integration of NBS into high-quality designs is a major task for the future. This implies a paradigm shift in planning for infrastructure and in designing open space, moving towards integrative solutions that are also customized for specific sites.

2.2 Research question and aim of the paper

The focus of this paper is on NBS in the context of trees and water. We investigated which NBS have been implemented in public space in Austria and how water was integrated in the design of the open space.

It is the aim of the research to identify the status of NBS realizations in Austrian projects and to build a knowledge base on tree planting and the urban water cycle. It was important to identify the scope and trends of implementation.

3 MATERIAL AND METHODS

A literature analysis covered the topics urban rainwater management and design, the sponge city principle for trees, and the tree species suitable for urban environments, so-called climate-fit trees. The literature review set out to identify criteria for the analysis of the built projects taking into account the various functions of the realized NBS in connection with a design approach for rainwater.

Based on lists from AK Schwammstadt (the sponge city working group), we conducted a survey in May and June 2023 and identified 60 sponge city projects in Austria focusing on tree planting and the urban water cycle, which varied in terms of their stage of completion, size, and complexity. All the projects are either in a public space or publicly accessible. The list does not claim to be complete. We excluded projects that are still in preparation or planning or in which construction is not yet complete. We also excluded built projects where no information was available that could be analysed. We included projects focusing on rainwater management to cover a broader scope of NBS. This resulted in a list of 24 projects (Tab. 1) for further analyses. We conducted a qualitative analysis of the 24 cases aiming at complementary rather than comparable information (Yin 2010) to get an overview of the range and state of implementation.

Name / Location	Type of open space	Planning and Design	Consultancy	Year of realization
8020, Graz, Eggenberger Allee	street	Freiland ZT	Stefan Schmidt, Erwin Murer	2018
2103, Langenzersdorf	street	3:0 Landschaftsarchitekten	Stefan Schmidt, Erwin Murer	2019
1220, Wien, Quartier am Seebogen	street	3:0 Landschaftsarch., Stoik ZT	Stefan Schmidt, Erwin Murer	from 2020
3730, Eggenburg, Pulkauer Straße	street	NÖ Straßenbauabteilung 1, Hollabrunn	Karl Grimm, Erwin Murer	2021
2011, Sierndorf, Wiener Straße	street	Karl Grimm Landschaftsarchitekten	Erwin Murer	2021
3340, Waidhofen/Ybbs, Freisinger Berg	street	Karl Grimm Landschaftsarchitekten	Erwin Murer	2021
4020, Linz, Kroatengasse	street	3:0 Landschaftsarchitektur		2021
6020, Innsbruck, Ing.-Etzelstraße	street	Stadtgartenverwaltung Innsbruck,	Stefan Schmidt, Erwin Murer, Grimm	2021
1160, Wien, Thaliastraße	street	D\D Landschaftsplanung	City of Vienna, MA 42	2022
8010, Graz, Leonhardgürtel	street	3:0 Landschaftsarchitektur	Stefan Schmidt, Erwin Murer	2022
8742, Obdach	parking area	lichtblauwagner architekten	Karl Grimm Landschaftsarchitekten	2021
3580, Horn	parking area	Held & Franke	Karl Grimm Landschaftsarchitekten	2023
6020, Innsbruck Wallnöferplatz	urban plaza	LAAC		2010
8020, Graz, Lendhotel	urban plaza	Studio Boden / LAM	Freiland ZT	2018
4880, Attnang-Puchheim	urban plaza	Arch. Peter Gilhofer	studioblaugrün	2020
1180, Wien, Johann-N.-Vogl-Platz	urban plaza	Karl Grimm Landschaftsarchitekten	Erwin Murer (substrate)	2020
2821, Lanzenkirchen	urban plaza	3:0 Landschaftsarchitektur	Stefan Schmidt, Erwin Murer	2020
1020, Wien Praterstern	urban plaza	D\D Landschaftsplanung	Stefan Schmidt, Erwin Murer	2022
1190, Wien Leopold-Ungar-Platz	urban plaza	FCP Fritsch, Chiari & Partner ZT GmbH	Karl Grimm Landschaftsarchitekten	2022
1100, Wien Neues Landgut	urban plaza	Arge SimZim Grimm	Karl Grimm Landschaftsarchitekten	2023
1220, Wien, Süssenbrunnerstraße	residential UGS	Jakob Fina Landschaftsarchitekt	Karl Grimm Landschaftsarchitekten	2013
1100, Wien, Biotope City	residential UGS	Knollconsult		2019
1220, Wien Leben am Langen Felde	residential UGS	Arge SimZim Grimm	Karl Grimm Landschaftsarchitekten	2019 -2022
6020, Innsbruck, Campus Technikerstraße	campus	Karl Grimm Landschaftsarchitekten		2018

Tab. 1: List of analysed projects

4 BACKGROUND

4.1 Urban rainwater management

Traditional urban drainage was developed in the 19th century (Brombach et al. 2011) and is based on end-of-pipe solutions (Geiger&Dreiseitl 1995). Water is primarily regarded as a problem and is rapidly removed into the sewers, into surface waters, or into the groundwater via dry wells. Green infrastructure seeks integrative solutions, and water is recognized as a resource. It aims to rehabilitate natural water cycles, harvest rainwater, protect against urban flooding caused by stormwater and cloudbursts, and reduce pollution. Furthermore, rainwater can also be regarded as an amenity (Grimm 2018). It is necessary to distinguish between these goals, as there is some conflict between them, and they require different solutions. As a result, water-sustainable urban design cannot be separated from open-space design.

4.1.1 Functions of NBS on site-level

When implementing NBS as design elements in an urban open-space context, the functioning of green infrastructure in more natural landscapes may serve as a model. The principles of hydrological systems are well researched. Surface runoff is determined by topology, geology, and land cover. The extent of tree canopies plays an important role. In the design of urban rainwater management based on the sponge city principle, NBS are used for various functions in different stages of the water cycle:

- Reduction of runoff
- Collection of runoff
- Retention of water
- Purification of water
- Discharge of the water to the atmosphere or water bodies (surface water or groundwater).

The systematic arrangement of these elements is referred to as a "management train" (Roehr&Fassmann-Beck 2015).

4.1.2 Design strategies for rainwater

Water features are a traditional topic in landscape architecture, but the creation of multifunctional systems based on green infrastructure principles requires a new taken design approaches, incorporating the various functions and benefits of NBS.

Following an analysis of literature and case studies in Europe and North America, three major design strategies for designing rainwater-based NBS were identified (Grimm 2017):

"Concealment" means that rainwater is removed from view as rapidly and unobtrusively as possible and diverted to underground systems, e.g. in downpipes and gutters.

"Integration" describes designs in which the water flow is open, but the system and its components are not highlighted. It is an unobtrusive integration of the infrastructure in the overall design of the site and everyday use of the open space. The elements involved can include green roofs, green swales, or sunken planters.

"Showcasing" means that the design not only addresses stormwater management but transforms these measures into stormwater-based amenities. Designs create site-specific features and interactions. The term "artful rainwater design" was coined by Stuart Echols and Eliza Pennypacker (2015) to describe this approach. A major consideration when designing for rainwater is that open space is used less when it rains, so showcasing rainwater should also make a feature of the system in dry weather. A planting design approach is called a "rain garden", when swales or sunken planters are designed as herbaceous or mixed borders. The planting design can be naturalistic or explicitly horticultural. It is a popular design approach in the USA that originated as a concept for making infiltration in front or back yards popular, but the term is now applied to any infiltration measure using specific planting.

On-site, a combination of "integration" and "concealment" is usually applied, and "showcasing" is the exception. The overall goal is to achieve an integrative solution serving social, technical, ecological, and economic needs by combining these three design approaches with functions of NBS.

432

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4.2 From urban greenery to green infrastructure

4.2.1   Sponge city principle for trees

The use of structural soils (Bassuk et al. 2015) as root space for trees that are mostly under impermeable surfaces in combination with the infiltration of rainwater is referred to in Austria as a "sponge city principle for trees" (Grimm et al. 2022). This method has been developed and successfully applied in Sweden for about 15years. The pioneer was the city of Stockholm (Embrén et al., 2009). A defined grading of the mineral components of the soil ensures the long-term preservation of pores for the supply of soil air and soil water to the tree roots (Zeiser et al. 2023). A basic structure of uniformly sized crushed stones makes the substrate suitable for carrying traffic loads, so it can be used under public traffic areas. The Swedish recommendations have been further developed for application in Austria. The first results were published in 2021 (Grimm et al. 2021;Zeiser et al. 2021). Comparable systems have also been developed in Germany (Richter et al. 2021). However, the German solutions rely more on an impermeable trough in the subsoil for water storage and less on plant-available water retention in the substrate through field capacity. There are also current developments in Germany to realize the two infrastructural functions of the „improvement of the root space of trees" and "infiltration of rainwater", only in separate constructions (GALK 2023; Helmreich 2022).

In 2022 the Austrian Standards Institute published a revised national standard L 1112 "Requirements for the Irrigation of Vegetation Areas" (ÖNORM L 11122022), which includes a definition that reads "3.3 Sponge city principle for trees – Construction method of root spaces for trees that simultaneously functions as a base layer for vegetation, a water storage and distribution medium, and a subterranean infiltration system, and that can be installed under paved surfaces so that large-volume root space is made available."

The system is described as a storage medium for irrigation water as follows: "When the sponge city principle is applied to trees, the use of available surface water forms the basis of the water supply, with the substrate in the subsoil being the storage medium. A distribution system shall be provided under impermeable surfaces for the introduction of water and air. For surface water that cannot be absorbed directly by the storage medium, infiltration or drainage must be provided."

Our analysis of the projects is based on the description in standard L 1112.
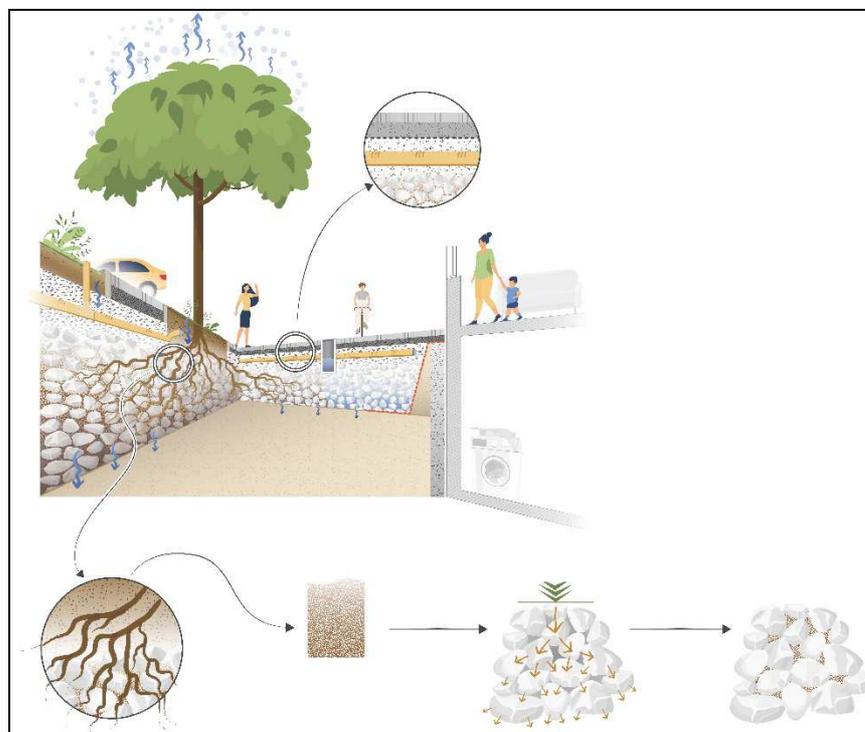
Fig. 2:Sponge city principle for trees (source: Grimm, Murer, Schmidt 2021)

The method is disseminated in Austria through landscape architects and engineers to municipalities and in the larger cities to garden administrations, city planning, and environmental departments. Non-profit

organizations such as Climate Alliance and Soil & Land Alliance play an important role in informing smaller municipalities.

The number of design projects using the technique was estimated at 16 in 2021 (Grimm et al 2021). Currently there are about 60 projects that are completed, under construction, or planned.

4.2.2 Tree species

Moisture availability and temperature potentially have a significant effect on the growth, development, and fitness of plants in the urban public landscape (Alizadeh&Hitchmough 2020). Plants make species-specific demands on their environment. If these are not met, they will deteriorate, be more susceptible to diseases and pests, and ultimately die. Choosing the right plant for the site becomes more important the longer the life span, the greater the investment in the plant, and the more significant the functions assigned to it. Full ecosystem services are provided by large, well-developed trees that are at least a few decades old. A tree planted today will reach its full potential in about 50 years – if it reaches that age. It is a fact that in urban streetscapes our native trees struggle to cope with extreme radiation climates, drought, pollutant inputs, and mechanical damage (Moser et al. 2017). Few native tree species survive in these locations. In accordance with climate change scenarios, the choice of tree species and varieties is changing.

For several years, experts have been addressing the question of which tree species do well in urban environments. In 1976, the German Conference of Garden Officials (GALK) decided to support municipalities and planning offices in the selection of trees for streets and squares with a list based on experience and observation. This "GALK Street Tree List" has been available as an online tool since 2012 and has become a sound source of information (GALK-Straßenbaumliste n.d.). The varieties and their ratings are regularly discussed and published in professional journals. Since 2009, the Bavarian State Institute for Viticulture and Horticulture (LWG) in Veitshöchheim has investigated 30 tree species at three Bavarian sites in the "Stadtgrün 2021" project (Schönfeld 2022). In 2022, a "climate tree grove" was planted out for research purposes at the "Höhere Bundeslehr- und Forschungsanstalt für Gartenbau" in Schönbrunn, Vienna (Grimm et al. 2022). The aim is to identify so-called future trees. These are tree species and varieties that can not only cope with the current adverse conditions in urban areas but are also expected to be able to endure future conditions exacerbated by climate change.

New varieties of trees and species that have been rarely used in the past are in demand. The search is focused on deciduous tree species from climatic regions that are warmer and drier than we are currently experiencing but also have cold winters (Schönfeld 2022; Bund deutscher Baumschulen n.d.). In forestry, this approach relies on what are called "climate analogues" (Mette et al. 2021).Such comparable regions, characterized by a continental climate, can be found in South-eastern Europe and Anatolia, East Asia, and North America, for example. Another way is to breed new varieties. For example, Resista® elms are largely immune to Dutch elm disease and well suited as street trees in Central Europe.

The adaptation and diversification of tree species, together with the creation of suitable site conditions through larger root spaces with improved air and water supply, are the key to future-proof urban forests. Therefore, in addition to studying the design approaches, we also looked at whether the selection of tree species in projects applying the sponge city principle for trees was based on traditional urban trees or whether new tree species and varieties were used that are considered fit for the future.

5 RESULTS AND DISCUSSION

In the 24 projects selected for further investigation, three groups of projects were identified by using the criteria function of NBS, design approach and tree irrigation:

Group A: 7 projects – the sponge city tree principle is applied, but there is no integration in an overall design.

Group B: 4 projects – there is a focus on designing rainwater management without sponge city trees.

Group C: 13 projects – the sponge city tree principle is integrated in an overall design of the open space.

5.1 Group A: 7 projects – the sponge city tree principle is applied but there is no integration in an overall design.

The projects are realized in three different types of open space:

434

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4 streets

2 parking areas

1 urban plaza

The projects were constructed between 2018 and 2023. In all seven cases, the sponge city trees are a single infrastructure element. The effective part, the structural soil, lies underground and is invisible. The focus is on road infrastructure without any further creative claims. All seven projects investigated address the same NBS functions, which are the collection, retention, and discharge of rainwater. The same design approach – "concealment" – is applied in all the projects. The source of irrigation for trees is always rainwater collected on the surface. In group A, the "purification" function is mostly not applied. This keeps the design simple. The omission of purification is possible because only stormwater from areas without motorized traffic is collected, which is permissible for underground infiltration. Often trees were added into ongoing projects. The trees were either implemented separate from the open space design or there was no design at all: for example, when it involved the replacement of single trees, or new rows of trees were planted in a streetscape in the course of road reconstruction.

5.2 Group B: 4 projects – there is a focus on designing rainwater management without sponge city trees.

2 residential open spaces

1 urban plaza

1 university campus
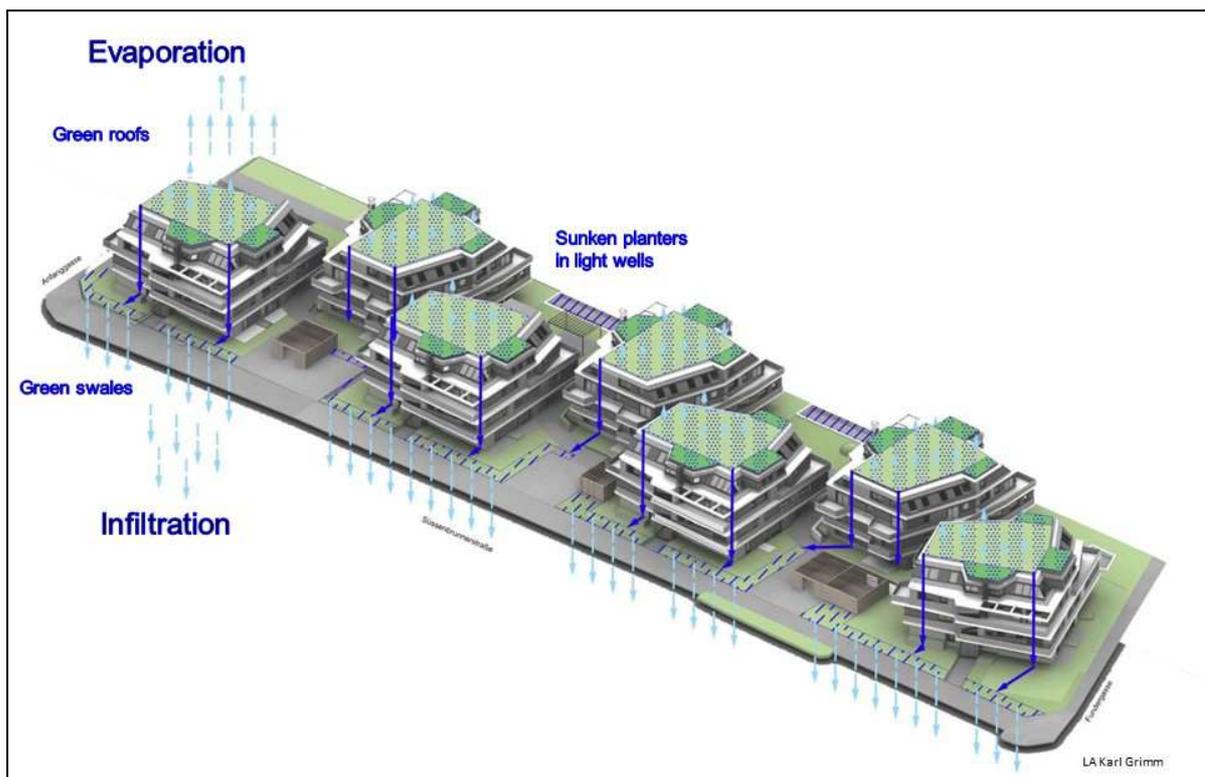
Fig. 3: Pilot project for rainwater management within the cost frame of affordable housing, Süßenbrunner Straße, Vienna, Austria. (Open-space planning: Jakob Fina; Rainwater management: Karl Grimm; Architecture: Thomas Moosmann).

In these projects, the function as a usable open space is in the foreground of design decisions, but the projects also focus on the water cycle and stormwater management. The time of realization spans from 2010 to 2019. These projects are older than the ones in group A and group C. The focus was on rainwater collection, retention, and discharge, and to some extent on purification too. In this group there are three different types of open spaces (residential open space, urban plaza, and campus). These open spaces have to cater to a wide range of uses and provide a variety of open-space qualities, like shade, light, protection from wind, ventilation, diversity of use and equipment, and communicative and aesthetic qualities. There are no streets in this group.

Owing to the size of the projects, several NBS were implemented, and they fulfil various functions, e.g. green swales for purification or green roofs for water retention. The aim in many cases is to develop "management trains" (Roehr&Fassmann-Beck 2015).

This approach can be best explained with the project Süßenbrunner Straße. It was a pilot project in Vienna for rainwater management within the cost frame of affordable housing.

The design combines NBS in a management train, and various functions and elements are integrated in the architecture and open-space design: retention of the runoff by green roofs, downpipes on the outside walls, retention in the planters, runoff in open flumes, retention and infiltration in infiltration trenches, and sunken planters in the light wells to provide daylighting in the garage. The project was the winner of the City of Vienna Environmental Prize 2017.

5.3 Group C: 13 projects –the sponge city tree principle is integrated in an overall design of the open space.

6 plazas

6 streets

1 residential open space

All 13 projects were constructed between 2018 and 2023. Two projects were in the course of urban expansion, but most of the projects were realized in the context of redevelopments in the existing city. All of them are design projects integrating diverse open-space needs and multiple functions. Trees are important design elements and NBS, and long-term tree health and the water supply of trees are key topics. During this period, climate-change adaptation became an important issue (BMNT 2017) and was considered in design projects. In one project, the financing was supported with an EU programme aimed at supporting the creation of micro open spaces, cooling measures, and tree planting to improve the quality of the open space.

Quality improvement of open space was achieved in almost all projects by redistributing the available space. The implementation of NBS is closely connected with the design of open spaces, although even in these projects the sponge city principle for trees is not necessarily a basic design approach but a subsequent functional addition.

The attitude towards the urban water cycle has changed from primarily integrating rainwater by infiltration to evaporation and the provision of water to urban trees. In all projects, the sponge city tree principle was applied. The water is collected from streets, plaza surfaces, and roofs. In five projects, water features were integrated as a new design element for play and for cooling the surroundings. The runoff is used for watering the trees.

Even in these projects, the design approaches regarding water are restrained. Purification of rainwater is often necessary in connection with street runoff. "Showcasing" and "integration" are only applied for sunken planters in connection with purification. Sponge city trees, whether they are fed by unpolluted stormwater or by a water feature, practically always follow the design approach "concealment" (Fig. 4).

The applied NBS are almost invisible, and the users of the open spaces cannot experience and comprehend the complex interplay of the NBS and the qualities of the open space.

436

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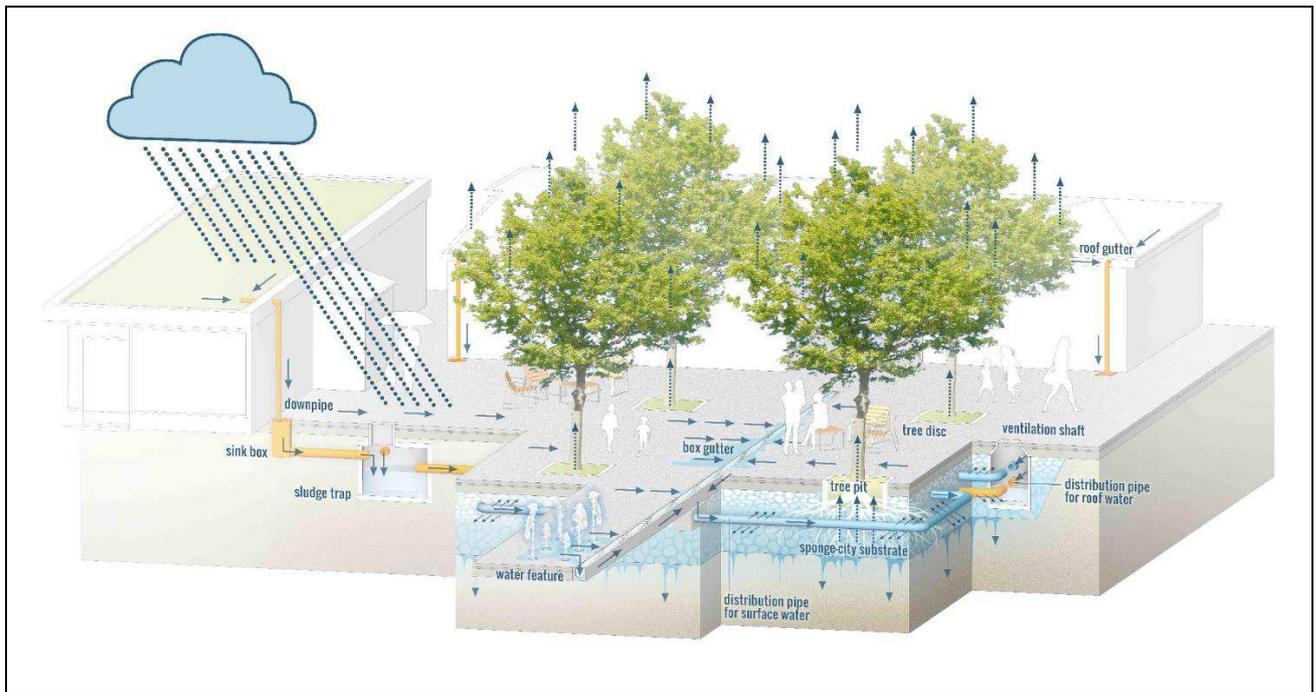
Fig. 4: Using rainwater and a water feature to improve the site conditions for urban trees and create an open space for the neighbourhood. Example: Johann-Nepomuk-Vogl-Platz, Vienna. Design: Karl Grimm Landscape Architects

The 13 projects in this group incorporate the findings of research on climate-fit trees. In some cases, use is made of traditional tree species (i.e. those already used in recent decades) whose suitability for urban climates has been confirmed. Alternatively, "new" tree species or varieties are planted that have been identified as climate-fit and have never or seldom been planted in the past. Classic street tree species that are not considered climate-fit were not used in these projects.

6   CONCLUSION

Until the mid-2010s, it was the aim of rainwater management to close the water cycle by infiltration and groundwater recharge. Subsequently transpiration through trees became important as part of urban heat island measures for improving the microclimate. Now the focus is moving to water retention in the soil for supplying water to vegetation in increasingly longer dry periods. Following the shift in targets the "sponge city principle for trees" emerged as a design solution. Its main characteristic is the use of structural soils to improve site conditions for urban trees, including water storage. It can reasonably be assumed that the sponge city principle for trees will play an important role in tapping and storing different on-site sources of water (stormwater, water features) for the irrigation of trees. This helps close the local water cycle with increased evapotranspiration and improve heat-affected microclimates through adiabatic cooling. Infiltration to the aquifer is also strengthened as a side effect, because surplus water from the supply of vegetation seeps into the groundwater.

The sponge city principle for trees has the potential to become an essential NBS in future urban green infrastructure systems and stormwater management cascades. The systems implemented so far have a certain experimental character and serve to gather experience. Two projects are being monitored.

Investigation shows that the sponge city principle for trees is a NBS with low design impact: "concealment" and "integration" strategies predominate. "Showcasing" has only occurred in conjunction with sunken planters for purification. This powerful NBS with development potential deserves to be made more visible in order to have a public presence. Although stormwater management is integrated in the design of several projects, incorporating NBS into the overall design of an open space has untapped potential, in particular for raising awareness of the connectedness of the urban water cycle and urban vegetation, especially trees.

Landscape architecture merges rainwater management, planting design, and irrigation planning. This means optimizing an NBS system for various functions, incorporating these in a design concept, and – usually – working within a tight cost frame. However, it is not a stand-alone challenge but rather a task for landscape architects, urban designers, architects and engineers, who can combine to mobilize the full potential of NBS.

7 REFERENCES

ALIZADEH, Behdad; HITCHMOUGH, James D.: Designing sustainable urban landscape and meeting the challenge of climate change: a study of plant species adaptation and fitness under different climate change scenarios in public landscape of UK. In: Landscape Research, Vol. 45, Issue 2, pp. 228–245, DOI: 10.1080/01426397.2019.1606185, 2020.

BASSUK, Nina; DENIG Brian R; HAFFNER Ted; GRABORSKY Jason; TROWBRIDGE Peter: CU-Structural Soil®: A Comprehensive Guide. Urban Horticulture Institute, Cornell University Ithaca, NY, 2015.

BMNT – BundesministeriumfürNachhaltigkeit und Tourismus: The Austrian strategy for adaptation to climate change. Vienna, 2017.

BROMBACH, Hansjörg; GRUBER, Günter; MAURER, Max: Kanalisation – Status quo und quo vadis? In: Institut für Siedlungswasserwirtschaft und Landschaftswasserbau der TU Graz: Aqua Urbanica 2011 Niederschlags- und Mischwasserbewirtschaftung im urbanen Raum, 2011.

BUND DEUTSCHER BAUMSCHULEN (BdB) e.V.: Zukunftsbäume – Auswahl aus der GALK Straßenbaumliste.https://epaper.galk.de/index.html#0, (n.d.).

ECHOLS, Stuart; PENNYPACKER, Eliza: Artful Rainwater Design: Creative Ways to Manage Stormwater, Island Press, 2015.

EMBRÉN, Björn; ALVEM, Britt-Marie; STÅL, Örja; ORVESTEN, Alf: Planting Beds in the City of Stockholm: A Handbook. Stockholm, 2009.

EUROPEAN RESEARCH EXECUTIVE AGENCY:https://rea.ec.europa.eu/funding-and-grants/horizon-europe-cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment/nature-based-solutions_en(n.d.).

EC ENERGY, CLIMATE CHANGE, ENVIRONMENT:https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en (n.d.).

GALK Arbeitskreis Stadtbäume: Positionspapier Wassersensible Straßenraumgestaltung, March 2023 status.

GALK Deutsche Gartenbauamtsleiterkonferenz e.V.: Straßenbaumliste.https://galk.de/arbeitskreise/stadtbaeume/themenuebersicht/strassenbaumliste/galk-strassenbaumliste(n.d.).

GEIGER, Wolfgang; DREISEITL, Herbert: Neue Wege für das Regenwasser, Oldenburg/Munich, 1995.

GRIMM, Karl: Regenwasserbewirtschaftung in der Stadtgestaltung. Vortrag bei Weltkongress Gebäudegrün – WGIC 2017, Berlin, 2017. https://www.gebaeudegruen.info/fileadmin/website/downloads/wgic_vortraege/Grimm_Karl.pdf.

GRIMM, Karl: Stadt Salzburg – Studie Regenwassermanagement. Grundlagen, Maßnahmen und Empfehlungen. Salzburg, 2018.

GRIMM, Karl; MURER, Erwin; SCHMIDT, Stefan: Das Schwammstadtprinzip für Stadtbäume in Österreich – Entstehung, Funktionsweise, Herausforderungen, Umsetzungen. In: Tagungsband Aqua Urbanica 2021, Schwammstadt – Versickerung 2.0?,Vienna, 2021.

GRIMM, Karl; MURER, Erwin; SCHMIDT, Stefan; ZEISER, Anna: Das Schwammstadtprinzip für Bäume: Entwicklung und Umsetzung in Österreich. In: Stadt+Grün, pp.19–25, 2022.

HELMREICH, Brigitte (2022). Neue Richtlinien und neue Chancen zur Regenwasserversickerung.In: Tagungsband 5. bdlaPflanzplanertage, 27 September 2022.

KRUSE, Elke: Integriertes Regenwassermanagement für den wassersensiblen Umbau von Städten. Dissertation,Hafencity Universität Hamburg, Fraunhofer IRB Vlg., 2014.

METTE, Tobias; BRANDL, Susanne; KÖLLING, Christian: Climate Analogues for Temperate European Forests to Raise Silvicultural Evidence Using Twin Regions.In: Sustainability, Vol 13, Issue 12. 2021.

MOSER, Astrid; RÖTZER,Thomas; PAULEIT,Stephan; PRETZSCH, Hans: Stadtbäume: Wachstum, Funktionen und Leistungen – Risiken und Forschungsperspektiven. In: Allgemeine Forst- und Jagdzeitung, Vol. 188,Issue 5/6. 2017.

ÖNORM L 1112: Anforderungen an die Bewässerung von Vegetationsflächen; edition: 2022-11-15.

RICHTER, Michael; DICKHAUT, Wolfgang; ESCHENBACH, Annette; KNOOP, Lena; PALLATSCH, Matthias; VOSS, Tomke: Können Straßenbaumstandorte durch Regenwasserbewirtschaftung verbessert werden? In: ProBaum 01/2021, Berlin/Hanover, 2021.

ROEHR, Daniel; FASSMANN-BECK,Elizabeth: Living Roofsin Integrated Urban Water Systems. London, 2015.

SCHMIDT,Marco: Ecological design for climate mitigation in contemporary urban living. In: International Journal ofWater, Vol. 5, Issue 4, pp.337–352. 2010.

SCHÖNFELD, Philipp: Klimabäume – welche Arten sind zukunftsfähig?.In: Tagungsband 5. bdlaPflanzplanertage, 27 September 2022.

YIN,Robert K.: Case study research design and methods (5th ed.). Thousand Oaks, CA, 2014.

ZEISER, Anna; WENINGER, Thomas, SCHMIDT, Stefan; KUMPAN, Monika; STRAUSS, Peter; MURER, Erwin: Schwammstadt für Stadtbäume – Funktionsorientierte Substratentwicklung am Beispiel des multifunktionalen Wurzelraums. In: Tagungsband Aqua Urbanica 2021, Schwammstadt – Versickerung 2.0?,Vienna, 2021.

ZEISER, Anna; RATH, Sebastian; GRIMM, Karl; SCHMIDT, Stefan;KLAMMLER, Gernot; ZIMMERMANN, Daniel; MURER, Erwin; ROTH, Thomas; STRAUSS, Peter; WENINGER, Thomas: Überlegungen zur Dimensionierung und Ausführung des Systems Schwammstadt für Bäume. In: Österreichische Wasser- und Abfallwirtschaft,2023. https://doi.org/10.1007/s00506-023-00962-0.

Intelligent Social Network

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1 ABSTRACT

Recently emerged social networks are gaining momentum and are becoming an integral part of modern life. The introduction of artificial intelligence methods, such as ChatGPT, show the importance of this field of science in computer technology, science and social life.

With more than 20 years of experience in the application of AI methods, we consider it appropriate to share ideas for their application in the interests of everyday human activities. Our main proposal concerns the creation of decision support systems based on social networks, localized in the interests of a particular person.

The main technologies that we apply are the following: Scenario Approach, which includes the Ontology System, Inference Machine, a Visual Integrated Development Environment, and a number of mathematical approaches that implement machine learning and DSS. First of all, these are: Singular Value Decomposition and Method of United Randomize Indices. Unlike neural networks, these methods have a clear mathematical interpretation and controlled accuracy. Also for their application there is no need for very large statistics.

Keywords: Intelligent Social Network, Artificial Intelligence, Inference Machine, Ontology, Scenario Approach

2 INTRODUCTION

The earliest online social networks appeared almost as soon as the technology could support them. E-mail and chat programs debuted in the early 1970s, but persistent communities did not surface until the creation of USENET in 1979 [17]. USENET began as a messaging system between Duke University and the University of North Carolina, but it rapidly expanded to other American universities and government agencies. USENET allowed users to post and receive messages within subject areas called newsgroups. Initially, there was no standard convention for the naming of newsgroups [17]. This led to confusion as the number of newsgroups grew throughout the 1980s. In 1987 USENET groups were reorganized into broad hierarchies such as news, talk, misc (for miscellaneous), and alt (for alternative; the last was created for newsgroups that dealt with taboo or niche topics, and it was the most populous category on USENET) [17].

The first companies to create social networks based on Web technology were Classmates.com and SixDegrees.com, Classmates.com, founded in 1995, used an aggressive pop-up advertising campaign to draw Web surfers to its site [17].

Others were quick to see the potential for such a site, and Friendster was launched in 2002 with the initial goal of competing with popular subscription-fee-based dating services such as Match.com. [17]. It deviated from this mission fairly early on, and it soon became a meeting place for post-"bubble" Internet tastemakers [17]. The site's servers proved incapable of handling the resulting spike in traffic, however, and members were faced with frequent shutdowns [17].

Overview of social networks. The statistics for 2023 show that there are 4.48 billion active social media users worldwide [18]. Let us note the most popular and well-known social networks and give them a brief description.

LinkedIn – more than 700 million active users per month. This professional networking site is great for B2B marketing. The audience on LinkedIn focuses on sharing professional content instead of personal. It is useful for professionals in various subject areas [18].

Facebook – around 3 billion active users per month. Easily the most popular platform on our list, Facebook is where you'll find most social media users actively engaging with brands [18].

It doesn't just allow you to connect with your peers; you can also use Facebook to sell your products through Facebook Shops and promote your brand through Facebook Ads. It's also a favorite among businesses, as reports show that approximately 70% of brands find new customers through Facebook [18].

Instagram – around 1 billion monthly active users.

Owned by Facebook, this app-based platform is a must for brands prioritizing Influencer Marketing. With features like Instagram Stories, IGTV, and Instagram Live, marketers can make the most of video content to engage with their audience [18].

Creating a business profile will let you integrate Instagram Shopping and Insights too [18].

YouTube – Monthly Active Users: 2.3 billion Currently the second-largest global search engine, YouTube is a pot of gold for content creators. If video marketing is your thing, don't miss out on this platform [18].

Brands can add YouTube advertising to their social strategy and share quality content easily across the globe. Stick to the community guidelines, and you'll not connect with your audience but also monetize your videos in no time [18].

TikTok – Monthly Active Users: 1 billion. Still new to the social scene, ByteDance's TikTok has garnered a huge user base since its inception in 2016. If your target demographic includes Gen Z, you have to master this application [18].

It's easy to go viral on TikTok, but that's also why the social platform is heavily saturated [18].

Telegram – Monthly Active Users: 500 million. A secure messaging application, Telegram can be used to create chatbots, broadcast messages to the audience, and provide customer support [18].

Brands can create large group chats (for around 200,000 members) to announce launches or simply interact with their audience [18].

Founder Pavel Durov has plans to introduce Telegram's ad platform soon [18].

Twitter – Monthly Active Users: 353 million Twitter has surprisingly lesser users when compared to other networks on this list. However, that doesn't mean that it isn't influential. In fact, 54% of users have taken action after seeing the brand mentioned on Twitter [18].

Using ads, integrating customer service, and growing an active customer following. You can do all of this with Twitter [18].

WhatsApp – Monthly Active Users: 2 billion. Originally created for connecting with family and friends, this platform now offers a WhatsApp Business application and WhatsApp Business API to create business profiles [18].

Brands can showcase their catalogs and offer quick customer service through this messaging application. That's not all. Unlike most messengers, WhatsApp is ad-free [18].

3 ADVANTAGES AND DISADVANTAGES OF SOCIAL NETWORKING

Just as the invention of the revolver (pistol) at one time created the illusion of human equality, so the widespread use of the Internet and social networks (SN) created the illusion of informational equality and freedom, social justice. Each person can become almost instantly widely known to the world audience without the need to wade through social steps, filters, often without wasting time on education and development of real creative principles in oneself. And this is a kind of "trap" of social networks, when the whole point is to collect likes from social pseudo-friends.

Social networking can affect individuals and corporations positively and negatively. That is why it is important to weigh the advantages and disadvantages of using these social media sites before getting too heavily involved. Various analysis variants can be found on the Internet. One of them is shown below.

3.1 Advantages [12]

- Social networking allows individuals to make and stay in contact with family and friends that distance and lost connections would otherwise prohibit.

Pietro Elisei, Darinka Golubovic-Matic, Pierre Laconte, Vasily Popovich, Tatiana Popovich, Manfred Schrenk, Vladimir Shutkov, Artem Zagvozdkin

- People can also connect with unknown individuals who share the same interests and develop new relationships.

- Social networking also allows companies to connect with new and existing clients.

- Companies can create, promote, and increase brand awareness through social media.

- Companies can capitalize on customer reviews and comments promoting products, services, and brands. The more customers post about a company, the more valuable the brand authority can become. This can lead to greater sales and a higher ranking by search engines.

- Social networking can help establish a brand as legitimate, credible, and trustworthy.

- Companies may use social networking to demonstrate the quality of their customer service and enrich their relationships with consumers. For example, if a customer complains about a product or service on Twitter, the company may address the issue immediately, apologize, and take action to make it right.

3.2 Disadvantages [12]

- Social networking can facilitate the spread of misinformation about individuals and companies.

- Due to its online nature, falsehoods can spread like wildfire. This became increasingly prevalent after 2012. One study found that misinformation is 70% more likely than factual information to be shared on Twitter.

- The detrimental impact of misinformation can create a virtual headache for a company's public relations (PR) department.

- The anonymous aspect of newfound personal relationships requires caution.

- Building and maintaining a company profile takes hours each week. Costs add up quickly.

- Businesses need many followers before a social media marketing campaign starts generating a positive return on investment (ROI). For example, submitting a post to 15 followers does not have the same effect as submitting the post to 15,000 followers.

3.3 Purpose of Social Networking

Social networking connects individuals and businesses by allowing them to share information, ideas, and messages. Companies also use social networks to create and strengthen brand recognition, promote products and services, and answer customer queries and concerns [13].

3.4 Benefits of Social Networks

The benefits of social networks include their ability to help people connect and stay in touch with family, friends, and new contacts; the opportunity they offer businesses to market their brands; their ability to spread useful, even vital, information instantly to individuals and institutions [13].

3.5 Importance of Social Networks

Social networks are important because they allow people to develop relationships that might not be possible due to distances of place and time. They also help boost business productivity when used for public relations, marketing, and advertising purposes [14].

4 ARTIFICIAL INTELLIGENCE FOR SOCIAL NETWORKS

Before moving on to our AI-related technologies, let us look at a typical algorithm for creating a social network, which can be easily found on the Internet:

a. Set your networking goals [15,16]

To help navigate through the networking process and to ensure you're using your time and resources wisely, set goals for yourself. Decide what you aim to accomplish by connecting with industry professionals. Potential reasons to build your network could be to gain job opportunities, enhance your industry knowledge or receive career advice.

b. Craft a compelling elevator pitch [15]

Before you meet with any professionals, have an elevator pitch prepared, which is a 30- to 60-second speech mentioning your strengths, value and background. If you're networking for potential job opportunities, emphasize your value and why you'd make a great fit for a company.

c. Reach out to current connections [15]

No matter where you are in your professional journey, you should already have a network. Contact people you know who could help you advance in your career. These can be friends, classmates, current or previous co-workers, family members or colleagues. Cultivate and grow these relationships by reaching out to them directly or connecting on social media.

d. Join local and national organizations [15]

Expand your network further by finding local and national organizations in your industry that interest you. Conduct research and make a list of potential organizations that appeal to you and align with the networking goals you set for yourself. Consider organizations targeted both toward where you currently are in your career and where you aim to be, such as groups for entrepreneurs, remote employees or business-to-business professionals.

f. Use social media to find new connections [15]

You can use social media to locate and reach out to potential connections. It's also a great solution to start out with if you're anxious to attend events and talk in person. Connect with industry professionals who hold similar values, aspirations and interests as you. Send a message to them that briefly outlines who you are and why you'd like to connect.

Continue your communication with them by commenting on posts or maintaining a casual conversation back and forth through social media. Once you establish a professional online relationship with them, you can feel more comfortable meeting them in person one day.

g. Attend industry events [15]

Many of the organizations you join may often host industry events. Attend these gatherings to meet some of your online connections in person. Some of these may be educational events or classes to help learn a new skill or develop your abilities. Try to meet new people regularly at these events and make as many connections as possible. You can also research industry events online to find those happening in your area, like conferences, conventions or seminars.

The algorithm for creating a social network recommended above (on the Internet) is focused primarily on business development. Meaning that the SN is created to support of an existing business, or to be exact the SN is created as a business itself. Here we consider the SN as a type of business aimed, first of all, at meeting the needs of the individual, and, in particular, to support the various kinds of decision-making in everyday life, including in business. At the current time, we do not consider ISN as a tool in the interests of business companies, but such an application is not excluded.

4.1 Main technologies of artificial intelligence

Our history of development and application of these technologies counts more than 20 years. Based on these technologies, maritime transport monitoring systems and decision support systems have been developed and are being successfully produced. The good example is the integration of DMSS in the Smart City project [1]. In our opinion, these technologies can be successfully applied in the intelligent social networks. In this case, their main focus is an ego-centric approach to a particular person, regarded as the main element of society. There is an obvious contradiction here, but we will not consider it in this article. Let us briefly review the technologies we offer.

4.1.1   Scenario Approach

The scenario approach has been described in detail in our previous publications. It has hardly changed, except for the development tools. The main difference is that instead of the Protege system, we have developed our own ontology system and a lower-level Scenario editor based on the Drools logic programming language built into the IntellIdea software development environment. The Scenario system is developed based on a client-server architecture, as a web-client. The Rete Inference Machine is part of the

Drools language. With the use of the scenario system, the main business analytics of the individual is described. Basic scenarios are created by experts and can be used as prototypes. Basic scenarios can also be generated automatically if there is a sufficiently complete source statistics.

4.1.2 Machine learning tool and a classifier

It is based on the Singular Value Decomposition (SVD) and the Method of United Randomized Indices (URI), which are also applied in almost all of our flagship products. The essence of these approaches is also described in detailed in our previous publications.

This toolkit can be used on the principle of neural networks application, processing huge amounts of data, and can be used on the basis of a repository formed by experts. Both options are possible, when at the first stage the experts' repository is used, and in the process of work the repository is corrected based on self-learning. This is one of the important advantages of SVD and URI over machine learning methods based on neural networks and similar approaches.

5 DECISION MAKING SUPPORT SYSTEM FOR SOCIAL NETWORKS

The most important element of ISN from the point of view of the user, or network member, is decision support in various situations. Any decision is made in case of availability of information. First of all, there are the following base classes: the decision maker itself, his goals, thoughts, ideas that should be maximallty clearly defined, the environment in a broad sense of the term, available resources and many different kinds of natural and artificial obstacles and restrictions.

The basis of any DMSS is the so-called. "management cycle", consisting of a number of fundamental stages:

- an intention (primary idea, desire or some challenge);

- suggestions (additional information that allows you to clarify the intention and form it as a task or a goal);

- a decision (a clearly formulated goal of actions, that takes into account various factors and restrictions, with various qualitative and quantitative assessments of various kinds);

- a plan (spatio-temporal assessment of achievement of a clearly formulated goal in the decision, the sequence of steps (actions) to achieve the goal;

- implementation of the plan (implementation of the plan, assessment of each stage regarding time, space, resources and trends directed towards achieving the goal, continuous assessment of the feasibility of the plan and its correction if necessary). If at the previous stages of the control cycle (CC) we can set some regulatory time requirements, then the last stage is, as a rule, already a real-time system. And for real systems, CC is the implementation of a situational control system. Definition of situational management or analysis of tactical situations can be found in the specialized literature, as well as in our previous works [2].

To implement the DMSS in the situational management (SM) variant, it is necessary to have an appropriate initial level of information and online access to the necessary information. All information and basic entities must be formalized. The first level of formalization is a system of ontologies, which describes non-overlapping sets of subject areas that interact with each other. The most complex ontology is the ontology of the individual using the ISN. This is due to an obvious contradiction: the need to formalize and enter personal data, on the one hand, and, on the other hand, ensure the confidentiality of personal data. Two groups of individual data are very important: static, or "a profile" of an individual [5], dynamic, or "a trace" of an individual [5]. This problem has a number of solutions and is not fatal, but depends on many factors. In this article, we will not consider this problem.

The second level is the development of business analytics for the selected abstractions of the ontology system. In fact, this is the implementation of the SM. The third level is the circulation of data, information and knowledge in the control loop. As the basis one can use the JDL model [12], which we also considered earlier in a number of papers regarding DMSS.

We expect that in our next paper a version of the working prototype will be presented.

6 CONCLUSIONS

The proposed version of ISN, in fact, can be an add-on over one of the versions of existing networks. For example, Telegram bot can used. In the proposed approach, it is not the SN itself that is important, but the ability to provide decision support using AI tools and methods. The Internet and a typical SN are used as an environment, an entourage in which the existence of an ISN add-on is possible.

At the moment, the development of a prototype of ISN is underway. Several subject areas have been selected, in which individual decision support will be provided. We also justify the localization of ISN data in order to solve the age-old problem of confidentiality with purpose to avoid "the Big Brother looking over one's shoulder". At the same time, this problem is solved not only and not so much by localization, but mostly by the development of a special technology that allows you to avoid external interference with individual data, information and knowledge without the knowledge of their owner.

We are also considering the involvement of general public, both organizations and individuals, in this venture project on a pro bono basis.

7 REFERENCES

[1] Pietro Elisei, Vasily Popovich, Manfred Shrenk, Oksana Smirnova, Tatiana Popovich. Smart City and Digital Humanities. CORP 2022, 14-16, November, 2022 Vienna, Austria.
[2] V.V. Popovich, G.L. Zykov, A.A. Rimashevsky, O.V. Smirnova, M.V. Tsvetkov, T.V. Popovich. Knowledge centric approach in information systems. //Marine Radio Electronics. #4 (74), pp. 10-16. December, 2020. St. Petersurg.
[3] V. Popovich, T. Popovich, O. Smirnova. Intelligent Decision Making Support System for Smart City Governance and Management. Proceedings of the ISAECT Conference, Roma, Italy. 27-29 Nov. 2019. Inspect Association Number: 19536136.
[4] P. Elisei, V. Popovich, M. Schrenk. CRISALIDE. Concept of Corporative Information System Governance and Management of Digital City. Corp 2019, 12-14, April, 2019 Karlsruhe, Germany.
[5] Popovich, V., at all. Intelligent Decision-Making Support System with Regard to Anti-terrorist Activity in Harbor and Coastal Waters // Proceedings of WSS2008, Copenhagen, August, 2008.
[6] Popovich, V., Hovanov, N., Hovanov K., Schrenk, M., Prokaev, A., Smirnova, A. Situation Assessment in Everyday Life // Proceedings of CORP2008, Edited by Manfred Schrenk, Vienna, May 19-22, 2008.
[7] Tarakanov A.O., Skormin V.A., Sokolova S.P. Immunocomputing. Principles and applications, Springer, 2003.
[8] Hovanov N., Kornikov V., Seregin I. Randomized synthesis of fuzzy sets as a technique for multi-criteria decision making under uncertainty // Proceedings of the International Conference "Fuzzy Logic and Applications". Zichron Yaakov (Israel), May 18–21, pp. 281-288, 1997.
[9] Hovanov N., Fedotov Yu., Zakharov V. The making of index numbers under uncertainty // Environmental Indices: Systems Analysis Approach. Pykh Yu., Hyatt D., Lenz J. (eds.). Oxford (UK), EOLSS Publishers Co.1999.
[10] Charles Forgy, Rete: A Fast Algorithm for the Many Pattern/Many Object Pattern Match Problem, Artificial Intelligence, 19, pp. 17-37, 1982.
[11] Holger Knublauch, An AI tool for the real world. Knowledge modeling with Protégé, JavaWorld.com, 06/20/03.
[12] Das, S. (2008). High-Level Data Fusion. Norwood, MA: Artech House Publishers. ISBN 978-1-59693-281-4.
[13] Daniel Hampton How does your networking status affect your career? 2022-10-06 URL: https://www.dot.net.au/how-does-your-networking-status-affect-your-career
[14] Ellen Moore What is network society? 6 July 2023 URL: https://istanbulbear.org/what-is-network-society-3908
[15] Indeed Editorial Teem 7 Tips for Building a Strong Professional Network April 8, 2023 URL: https://www.indeed.com/career-advice/career-development/building-networking
[16] Indeed Editorial Teem The Benefits of Networking: 14 Reasons To Start Your Network July 22, 2022 URL: https://www.indeed.com/career-advice/career-development/benefit-of-networking
[17] Michael Ray Social Network. From USENET to 21st-century social networks February 3, 2011 URL: https://wwwkunblog.blogspot.com/2011/02/social-network.html
[18] Chandraveer Singh SocialPilot 20+ Most Popular Social Networking Sites in 2023 July 5, 2023 URL:

Investigating the Environmental and Economic Benefit of Waste to Energy Project: a Case Study of Methane Gas at the Thohoyandou Landfill Site

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1 ABSTRACT

The increasing power outage in South Africa and other developing countries, coupled with the global challenge of fossil fuel depletion, highlights the need for urgent alternative energy sources. Despite various studies being conducted, there is minimal application of waste-to-energy projects. The waste-to-energy projects have emerged as a potential solution to address both waste management and energy provision challenges. This study aims to investigate the environmental and economic benefits of using methane gas from the Thohoyandou landfill site in the Thulamela local municipality as an alternative energy source to the coal-powered grid. The research methodology was a content analysis to examine the sustainability benefits. The results suggest that the technology is economically feasible, considering the sales of electricity generated and Certified Emission Reductions (CER) (carbon credits). In addition, the project has the potential to reduce greenhouse gases (GHGs) from coal-power stations, resulting in improved air quality in nearby communities. This paper recommends that the Thulamela Local Municipality should scale up the innovative waste-to-energy projects as they offer best practice solutions.

Keywords: Sustainable Benefit, Methane Gas, Landfill Site, Environment, Waste to Energy

2 INTRODUCTION

Municipality solid waste management challenge is experienced in both developed and developing countries. This challenge continues to grow with population growth, which is rapid, as a result of no proper stringent methods to divert the waste from the landfill so that it can be processed into other by-products or recycled. Despite that waste reclaimers and waste management services, either public or private are available at the disposal of the municipality, the challenge is still widely experienced. The lack of public-private partnerships hinders tons of waste from being diverted from the source. Referring to Jeff Delmon (2015) states that the solid waste sector is not naturally fit for public-private partnerships as compared to other sectors due to the fact that the fees for waste collection are relatively low. In some instances, in developing countries such as South Africa, residents do not pay service fees for waste collection, which results in the emergence of illegal dumping sites.

The concern when it comes to fast-growing illegal dumping sites is due to the population. It poses a lot of strain on the local government because of the lack of development, provision of energy, and waste management. Supported by Hoornweg and Bhada-Tata (2012), Municipal Solid Waste (MSW) production globally is currently over 1.3 billion tons per year, with projections of 2.2 billion tons per year by 2025. Therefore, there is an urgent need to properly manage and recycle waste. This cannot be overstated, because the increase in tonnages of waste annually causes the local government to encounter a crisis of airspace in the landfill site. Landfill site airspace, also known as landfill capacity is defined as the amount of volume a site has for disposal (J. Collins, 2020). The shortage of airspace makes it difficult for municipalities to render their waste management services. The difficulties in the management of landfills emerge from the lack of resources, and funds to sustain and manage the waste (Viljoen, et al., 2019). This results in the creation of backlogs which influence open dumping and burning of the waste by community members especially those that are residing in the informal settlements and rural areas.

In the Vhembe district municipality, 18470 tons of waste is left in open spaces, without any collection (District, 2021). This shows that there is a need for alternative solutions to the waste left in open places, which poses social and environmental threats such as contamination of soil and underground water. The contamination of the environment is also experienced in the landfill site, due to a lack of proper management and innovative strategies to utilize wastewater, methane, and waste by-products (Shareef & Abdelazim, 2019). In most small landfill sites, the facility for leachate collection and treatment is often not part of the design of landfill sites.

Relatively within the energy provision, there is a challenge of service delivery because innovative strategies are not implemented. The fossil fuels globally are decreasing due to a lack of management of the natural resources, lack of infrastructure, and development of alternative energy to supplement that which is already being supplied to the citizens. Thus Baraka Obama (2017) stated that the current generation is still utilizing the energy infrastructure that was developed to cater to the 19th-century population, which puts a strain on production The lack of improvement of the energy system especially in Africa has resulted in countries experiencing power outages or load-shedding over 24 hours per day (Agency, 2020). In the local concept of South Africa, the citizens experience six hours daily without electricity (Aljazeera, 2022), this is not applicable to those communities without electrification at all in remote areas. With this challenge expected to increase, it calls for urgent implementation of alternative energy such as waste-to-energy which will address both the waste and energy crisis that the country is currently experiencing daily. Wasteto-energy (WtE) projects are defined as projects that recycle substances and energy from solid waste through particular management methods and technical processes (UNECE, 2018).

The waste-to-energy projects are an essential solution globally through addressing the challenge of waste. Despite that more research has been conducted but there is less implementation of this project. For instance, a feasibility study for the waste-to-energy project has been done across the 62 political territories in Africa. That mentioned only 7 territories have installed the technology and have the potential to advance their project whilst in South Africa the WtE project has been implemented in 3 metropolitan cities of the country: Cape Town, Durban, and Johannesburg (Chrtina, 2013). This raises concerns about why this technology is not being replicated in other cities of the country. The WtE project can be produced in a thermal or non-thermal way, where the thermal is used to heat or for the combustion to treat wastes such as incineration, whilst the non-thermal is a process whereby the methane and carbon dioxide are produced and then captured using anaerobic digestion (Purser.R., 2011). The diagram below illustrates the different stages of waste-to-energy projects and the area where the energy can be utilized. This shows how the municipality can implement this WtE project.
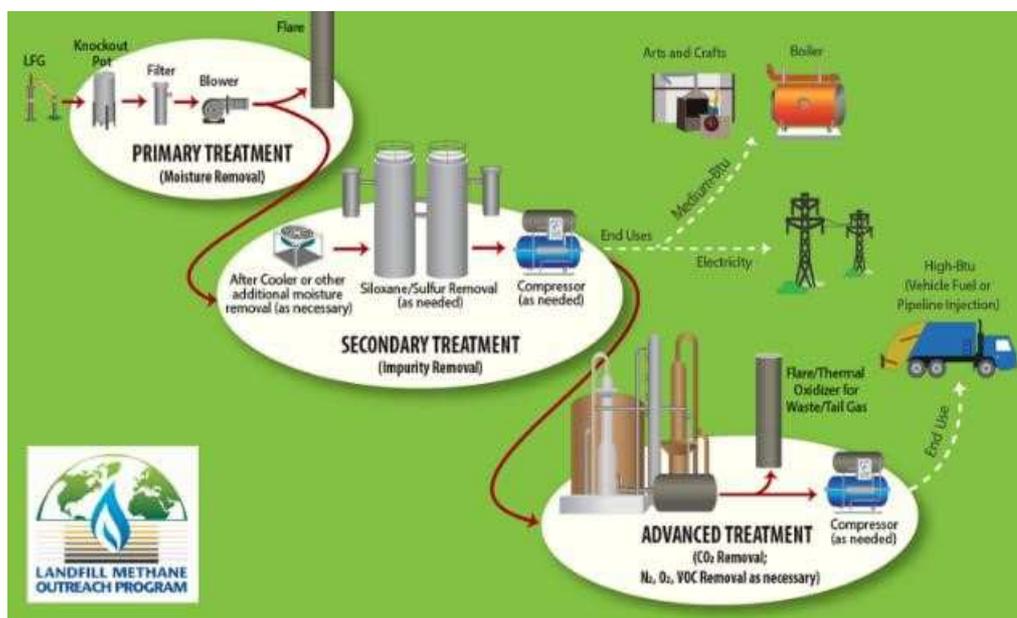
Figure 1 WTE potential usage by Landfill Methane Outreach Program

3 LOADSHEDDING IN SOUTH AFRICA

As the population in our township and industries continue to increase on a daily basis, the demand is increasing resulting in ESKOM not being able to cater to the energy demand. The Electricity Supply Commission (Eskom) is a state-owned company that was established in 1923. The company is responsible for supplying 90% of its electricity to South Africa and 30% to other African countries. It generates, transmits, and distributes electricity to industrial, mining, commercial, and agricultural sectors (BASE, 2023). This illustrates that this organization provides a vast amount of energy across the country, hence the challenge in providing electricity. In the past couple of years, South Africa has been facing a lot of challenges of power cuts, which are caused by various factors of corruption and lack of maintenance of

446

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power plants. These power cuts are also referred to as load shedding. Load shedding is a deliberate shutdown of electric power in parts or parts of a power distribution system, generally to prevent the failure of the entire system when the demand strains the capacity of the system (Reporter, 2023).

This occurs because there is a shortage of coal to generate electricity or failure in power plants. For instance, in September 2022 South Africa had a bout of load shedding and this has continued till date resulting in 3.9 THw of energy being shed. This is double the electricity shed in 2021 (CSIR, 2022).

With all the different stages of load shedding experience, this is how communities are affected by the power cuts. Stage one load shedding means consumers will be deprived of electricity 3 times in 4 days at an interval of every 2 hours or 3 times in 8 days at an interval of every 4 hours. Stage two involves depriving consumers of electricity 6 times in 4 days at an interval of every 2 hours, or 6 times in 8 days at an interval of every 4 hours. Stage three involves depriving consumers of power supply 9 times in 4 days at an interval of every after 2 hours, or 9 times in 8 days at an interval of every after 4 hours. Stage four involves depriving consumers of electricity 12 times in 4 days at an interval of every 2 hours or 12 times in 8 days at an interval of every 4 hours. Stages five to eight indicate consumers not having electricity 12 times in four days at an interval of 4 hours. This is a clear depiction of how the electricity is shedding through the different stages.

There are various factors that affect the production of energy, which are the electricity generation capacity storage, where the organization is not able to meet the demand required due to the high demand. This is also affected by the delay in the construction of new power plants and updating of old power plants (Omarjee, 2022), thus people are still dependent on the old plants which is no longer efficient to cater to the current generation. There is a cause of financial strains due to the fact that the operation cost is really high, whilst the revenue is low (Pueyo, 2018). The low revenue collection is a result of illegal connections by communities and the debts owed by local municipalities. Lastly, the other factor causing load shedding is environmental concern (Courses, 2023), as the plants rely heavily on coal for electricity generation leading to environmental concerns and climate change.
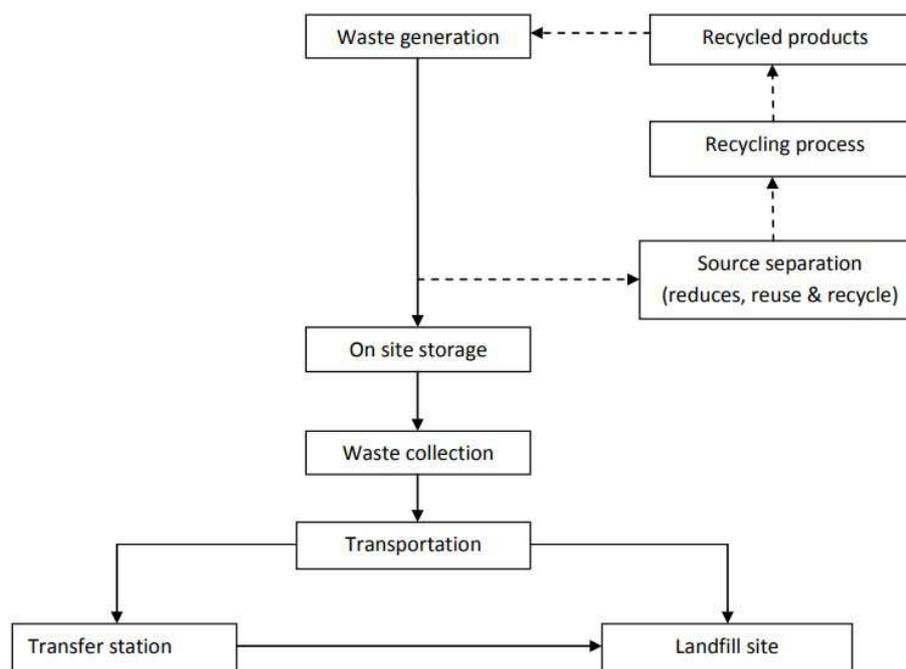
Figure 2 Flow Diagram of the Solid Waste Management In South Africa, Author University of Pretoria

4   MUNICIPAL SOLID WASTE MANAGEMENT

South African municipalities have the mandate to provide basic services to their community members as per the constitution of the republic. These services form part of the constitution of the country, which includes the right to clean water, sanitation, a clean environment, electrification, and waste management just to mention a few. The provision of services has a great potential to assist in the achievement of the National Development Plan 2030 as well as the Sustainable Development Goals related to the conservation of the environment, such as goal number 3 of clean energy (Nkosi, 2014). The Thulamela local municipality

provides waste management of collection, disposal and transportation of waste. Covering a surface area of 2 893.936 km² from 59097 households (Municipality, 2022). The Municipal Solid Waste Management (MSWM) performs activities related to the generation, storage, collection, transfer, transporting, processing, and disposal of solid waste which requires efficient and effective management (Bonolo, 2016). Below is a systematic flow chart of how the waste management service by municipalities is conducted in South Africa commencing from the collection till the last stage of disposing the waste at the landfill site.

One of the strategic objectives implemented by the municipality is to provide quality basic services and infrastructure to the citizen to enhance the quality of life of individuals residing in the community, which include solid waste management services (Tshwane, 2015). As of Schedule 5 Part 8 of the South African constitution, each municipality of the country has a mandate for refuse removal, refuse dumping, and solid waste management.

5 THOHOYANDOU LANDFILL SITE

The use of renewable energy has been on a prominent rise since the 19th century by governments and organizations, thus in most countries globally there have been various experiments when it comes to the utilization of renewable energy such as wind, kinetic, nuclear, solar, and biogas energy. This aims to diversify the energy sectors through having various alternatives and to address the environmental problem (Panwar, et al., 2011). The urgent need to find sustainable solutions when it comes to energy is critical because the power outage is affecting the economy and infringing on the basic rights of South African citizens. As it infringes on the constitutional right the provide clean energy and stay in a clean environment so that they could be able to perform and develop effectively in their settlement (Mannak, 2015). As a way to find a solution to the issue of power outages, it is with this objective that the paper aims to investigate the potential environmental and economic benefits of using methane at the Thohoyandou Landfill Site.
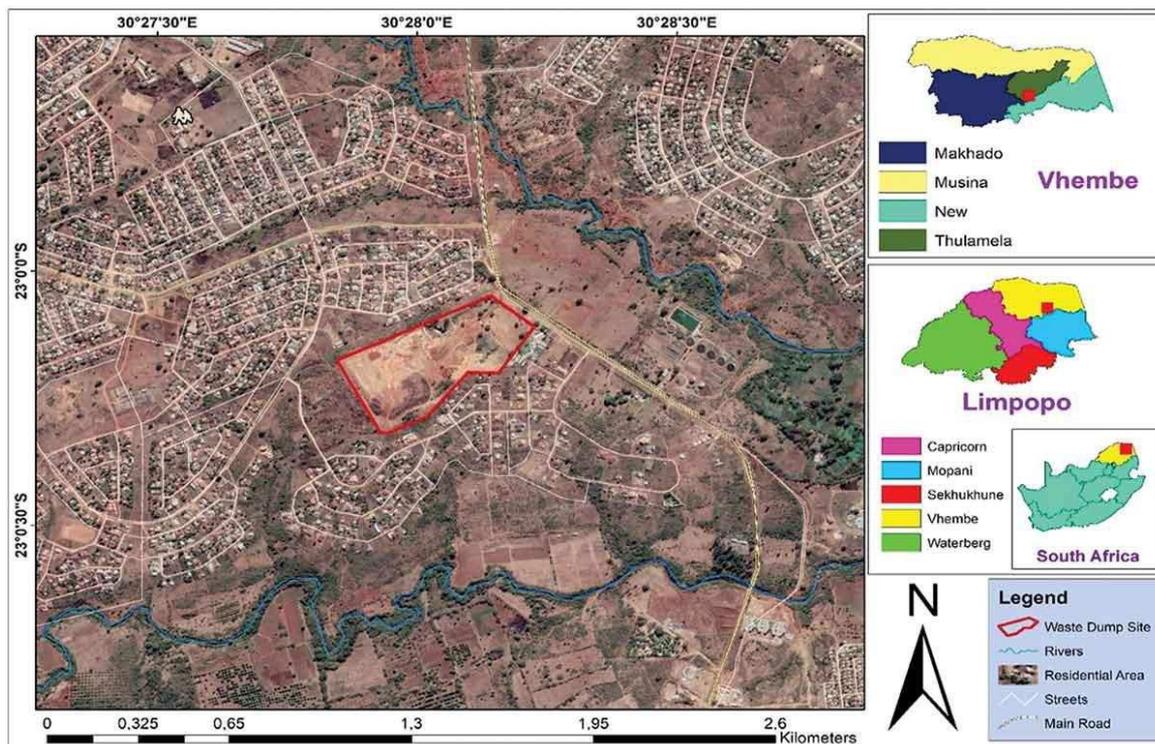
Figure 3:Map of Thohoyandou Landfill Site, Author Google Maps

The Thohoyandou landfill site is situated within the Vhembe District municipality under the Thulamela local municipality. This landfill site has been in operation since 2004 and is located 180km from Polokwane and in the gateway to Kruger National Park (Njoku, et al., 2020) and it remains the main landfill for the local municipality. It lies on the geographic coordinates of 23°00'12.0" S longitude and 30°27'55.3" E. latitude (Edokpayi, 2018). Despite the municipality having four licensed landfill sites, the Thohoyandou Landfill Site, also known as Tswinga Mulendane landfill site is the one that carries the most capacity of waste because it caters to many urban and rural settlements and industrial areas (District, 2021). For instance, in

2014, the landfill site was able to receive 210000 tons of waste. This landfill site is located adjusted to the Thohoyandou wastewater treatment and residential areas just around the facility, which imposes environmental and health hazards to the community. This harm is also influenced by the fact that the Thohoyandou landfill site has 4 cells but currently only one is functional (Njoku, et al., 2020). Below is the map of the landfill sites, with legends the man-made and environmental elements found near the landfill site.

6 THE OBSTACLES OF WASTE TO ENERGY PROJECT IN THE MUNICIPALITY

The use of WtE possess so many advantages in terms of the economy and the environment, hence the need to shift into the utilization of the WtE in the different municipalities. WtE is defined as a technology that consists of any waste treatment process that creates energy in the form of electricity or heat from several types of waste (Change, 2020). This is waste such as organic waste, waste water, human excreta and landfill waste. Despite that the benefits of this have been illustrated from various decades and also from other countries implementing them such as Indian and Germany. The government has not been increasing its interest in the use of energy, despite that there is a desperate need to supplement electricity provision especially due to the power cuts. In the various municipalities despite that they owe ESKOM a lot of money, the policies and bylaws for using methane are not implemented (Victoria O'Regan, 2022). The other challenge obstacle in the implementation of the WtE projects is that there is a lot of substrate to utilize in the generation of the waste but unfortunately, the lack of separation at the sources hinders the local municipality from implementing the WtE (Wang, 2023).

New technology is emerging and has great potential to assist the municipality in reaching its service delivery. There is a need to further conduct studies on how it will assist in assist in reaching the mission and vision of the municipality when it comes to energy supply and waste management (S. Matos., 2013). Unfortunately, the local municipality has limited research when it comes to the WtE project, especially focusing on the landfill site, this lack of research in terms of the project makes it difficult for the municipality to venture into WtE as they are not much concrete data that would be used in supporting that the WtE benefits (P. Mukumba, et al., 2016). Furthermore, there is inadequate expertise for construction and maintenance, for instance, within the local municipality a lot of this WtE is mostly being monitored by the University of Venda. This illustrates that there is a gap of expertise within the WtE in the municipality. This is furthermore supported by the fact that there are no technical or vocational schools that provide such training so the market can be diverse (P. Mukumba, et al., 2016). New technology comes with a new design that needs to be procured by the local municipality. One of the obstacles that the Thulamela local municipality faces is the high initial cost required for the construction and installation of the WtE digester. This is a challenge as most departments are under-financed. This is mostly the challenge in developing countries which are struggling with waste management and lack of energy supply (A., et al., 2021).

7 THE ENVIRONMENTAL BENEFIT OF USING METHANE AT THOHOYANDOU LANDFILL

Landfill sites will remain the final destination for waste collected that is not being recycled, thus despite being supposed to be a solution to avoid waste being disposed of in open spaces, it also has a few challenges such as the contamination of the underground water and soil decay. To combat some of the reactions that are occurring at the landfill site with regards to greenhouse gases. it is best to utilise the resources effectively such as methane gas and carbon dioxide, which will have a benefit to the environment. Environmental benefit is defined as the economic appraisal of policies and projects concerned with the improvement in the provision of environmental services or actions that have a direct impact on the environment and community members (Atkinson & Mourato, 2008). When waste is disposed at the landfill site by the municipality, a process occurs whereby gases are emitted. The gas that is emitted is referred to as landfill gases (LFG), which is defined as a natural by-product of the decomposed organic material in the landfill, which compromises 50% methane, 50% carbon dioxide, and a small component of nonmethane compound (Agency, 2023). This LFG can be captured and used as renewable energy, because of the high potential of methane that is found. If the LFG is captured in the Thohoyandou landfill site, it will assist in reducing the odor especially because they are settlements located 80m away from the landfill site, which is not environmentally acceptable (Agency, 2023).

According to Dudek (2010), the LFG provided a lot of opportunities such as being used directly using it in the landfills for bowlers, generating electrical power, bio-methane production, and lastly for automobile fuel.

This opportunity contributes immensely towards the sustainable development goal and usage of natural resources in a sustainable manner. This is an agreement made during the Brundtland Commission conference. Another environmental benefit of using the methane gas from the Thohoyandou landfill site is that it will reduce the emission from the MSW landfill to achieve the near-term beneficial impact in the mitigation of global climate change, especially with the municipality vision for 2030 of achieving a City Status through urban regeneration and comprehensive rural development. As South Africa is facing the challenge of landfill sites reaching their airspace, the capturing of methane possesses the great benefit of extending its lifespan. especially because this is the main landfill site, the airspace has reached a capacity that a study conducted by Nelwomondo stated that by the year 2022, the airspace would be at 16391m³. Therefore, the use of methane could help in avoiding the construction or extending the landfill site, In terms of the Thulamela local municipality, the landfill site tender bid has been projected to be costing R16000000 (Municipality, 2022).

8 ECONOMIC BENEFITS OF USING METHANE GAS AT THOHOYANDOU LANDFILL

Economic benefits are defined as tangible benefits that can be measured in terms of the revenue generated or money saved through the implementation of policies or innovative strategies (Wells, 2021). The need to generate revenue through the utilization of wasteto-energy projects, especially with the economic state of the country and the Eskom crisis. Henceforth the utilization of methane gas in the Thohoyandou landfill site as will provide the economic benefit of providing a reliable energy source because landfill gas is generated 24 hours a day, every day of the year. This will be reliable energy because according to the LFG calculator done by (Njoku, et al., 2020), stipulated those simulations from Afvalzorg's model CH4 peak emissions for Thohoyandou landfill were 3336 Mg/year. Which is sufficient for providing energy. The world is facing the depletion of fossil fuel, which makes the buying prices high, thus using methane will reduce the demand and dependence on fossil fuel and nuclear energy. This when it comes to the municipality will be beneficial because according to Daily Maverick (2022), the Limpopo local municipalities already owe ESKOM R1062095. The reduction in the dependence can lead to the selling of greenhouse gas offsets, through the carbon credit method (Guy, 2016). Table 1 illustrates how to leverage the methane.

	REIPPP Feed in Tarriff (FIT) unit rate (2015)	Eskom Avg Mega flex unit rate (2016)	Units
Average output per MW installed	7 095 600	7 095 600	KWh/year
Average capacity/load factor experienced in SA projects	81	81	%
Anticipated/global average capacity factor	92	92	%
Tariff for landfill gas	1	0.85	ZAR/KWh
Annual income/MW installed	7 095 600	6 031 260	ZAR/MW
Annual income minus op costs	4 967 600	3 903 260	ZAR/MW
Revenue over 15 year lifespan (12 – 20 years avg lifespan)	106 434 000	90 468 900	ZAR/MW
Capital cost/MW (estimated avg. including wells)	19 300 000	19 300 000	ZAR/MW
Operational costs per year (figure indicative)	2 128 000	2 128 000	ZAR/MW
Operational costs (over 15 years)	31 920 000	31 920 000	ZAR/MW
Revenue minus costs (over 15 years)	55 214 000	39 248 900	ZAR/MW
Revenue minus costs (average annual)	3 680 933	2 616 593	ZAR/MW
Payback/break even – number of years	3.89	4.94	Years

Table 1 Simple payback analysis for LFG to electricity project by Ferry et al 2016.

The other economic benefits are available from the potential to use the methane from the landfill site. Making reference to Njoku's Study (2020) indicates that the engine generator set will generate an average electricity of approximately 9,366,635.263 KWh/year and will supply an average of approximately 4130 households every year. This will help to reduce the pressure on the coal-powered grid. In a municipality with a high number of unemployment, this equates to 47.7% (District, 2021). The use of the waste-to-energy project in the landfill site can assist with job creation in the municipality through having engineers, operators, maintenance officers, and various employment opportunities. This will be beneficial to the

municipality by making this project localized by employing local people procuring from local shops and working in partnership with the University of Venda and Makwarela Tvet College with their experts. This is because the WtE projects turn to source people from abroad to come and assist in design and assembling. The utilization of methane by the municipality can be used directly in the municipal vehicle fleet, as a way to have an alternative to the use of gasoline for their vehicle. The use of this gas possesses more benefits to the municipality as it solves environmental problems whilst generating revenue for the operation of the municipality which they have the opportunity to leverage on it.

9 CONCLUSION

At the rate the population is growing and the vision that Thulamela local municipality aims to achieve by 2030 will require stringent measures to be implemented. This will assist in addressing the issue of waste management and energy delivery within the landscape. Thus, this paper recommends that Thulamela local municipality should implement the waste-to-energy project at the Thohoyandou landfill sites, as it poses more environmental and economic benefits to the municipality and makes the municipality contribute towards the common goal set by the United Nations to achieve sustainable usage by the year 2030.

10 REFERENCES

Agency, I. E., 2020. Electricity Market Report 2020, IEA.
Agency, U. S. P., 2023. Basic Information about Landfill Gas, EPA.
Aljazeera, 2022. South Africa's persistent power cuts: What you need to know, Al Jazeera Media Network.
Atkinson, G. & Mourato, S., 2008. Environmental Cost-Benefit Analysis. Annual Review of Environment and Resources, Volume 33, pp. 317-344.
Bonolo, L., 2016. The Role of Innovations In Municipal Solid Waste Management to Attain Sustainable Cities. SAPI Conference.
Chrtina, T., 2013. Waste to Energy: Summary and Conclusions from the IEA Bioenergy ExCo71 Workshop. Cape Town, IEA Bioenergy.
Delmon, J., 2015. From trash to treasure: Public-Private Partnerships can help with waste management, World Bank Blogs.
District, V., 2021. 2020/2021 Draft IDP Review, Vhembe: Vhembe District Municipality.
Dudek, J., 2010. Landfill gas energy technologies.
Edokpayi, J., Durowoju, O. & and Odiyo, J., 2018. Assessment of Heavy Metals in Landfill Leachate: A Case Study of Thohoyandou Landfill, Limpopo Province, South Africa.
Guy, E., 2016. Biomass Energy
Mannak, M., 2015. The Economic Impact of South Africa's Energy Crisis, Cape Town: The African Exponent.
Maverick, D., 2022. How Much Mzansi Provinces Owe ESKOM, Daily Maverick.
Municipality, T. L., 2022. Thulamela Local Municipality IDP2020/21-2022/23, Thohoyandou
Njoku, P., Edokpayi, J. & Odiyo, J., 2020. Modeling landfill gas potential and potential energy recovery from Thohoyandou landfill site, South Africa. Taylor Francis Online, 70(8), pp. 820-833.
Nkosi, L., 2014. An Evaluation of the Municipal Solid Waste Management System in the City of Tshwane Metropolitan Municipality, in Mamelodi East Township, Gauteng Province. Pretoria: University of Pretoria.
Obama, B., 2017. Smart Cities, Smart Mobility: Transforming the Way We Live and Work, Kibworth Beauchamp: Troubador.
Panwar, N., Kaushik, S. & Kothari, S., 2011. Role of renewable energy sources in environmental protection: A review. Elsevier, 15(3), pp. 1513-1524.
Pikitup, 2018.
Purser.R., 2011. A Financial Feasibility Study of Waste to Energy Generation in City of Cape Town, Cape Town: University of Cape Town.
Shareef, N. & Abdelazim, M., 2019. Waste Management in Mena Region.Springer Water.
Tshwane, C. O., 2015. City of Tshwane Waste Management Services. Pretoria, s.n.
UNECE, 2018. Guidelines on People-first PPPS for waste to energy projects, s.l.: UNECE.
UNEP, 2021. Solid Waste Management, Washington DC: United Nations.
Viljoen, J. et al., 2019. The management of South Africa's landfills and waste pickers on them: Impacting lives and livelihoods. Development Southern Africa, 36(1), pp. 80-98.
Wells, K., 2021. Economic Benefit :Definition, Study.com.

Investigating the Main Factors of Neighbourhood Morphology Affecting Social Cohesion: SEM-PLS Analysis Approach

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1 ABSTRACT

In a particular geographic location, a collection of individuals who share the same services and a certain amount of social cohesion is referred to as a neighbourhood. This research was conducted to present a model that examines several hypotheses regarding the impact of neighbourhood morphology and its main factors on the social cohesion of a neighbourhood and its subdimensions. To assess the extent of each factor of neighbourhood morphology affecting social cohesion and its subdimensions, a mixed research approach was followed. A structured questionnaire survey was undertaken on a random sample of residents of two neighbourhoods in New Borg Al-Arab City in Egypt with the involvement of 193 participants. After performing a measurement model analysis on the gathered information, the data were then subjected to a structural model analysis using Smart PLS 3.2.6. Internal consistency reliability, convergent validity, and discriminant validity are evaluated during the assessment of reflective measurement models in PLS-SEM. After proving the reliability and validity of the measurement models, the structural model is evaluated including examining the model's prediction ability and the links between its constructs. Regarding the main hypothesis, we concluded that neighbourhood morphology significantly affects social cohesion. Moreover, the subdimensions of neighbourhood morphology affect the subdimensions of social cohesion resulting in 22 hypotheses.

Keywords: New Borg Al-Arab City, SEM-PLS, Design Constraints, Social Cohesion, Neighbourhood Morphology

2 INTRODUCTION

Contemporary neighbourhoods are built for the sole purpose of housing and parking cars. Residents have to rely on their cars because they cannot conveniently get the necessities. Egypt's new cities are a great illustration of these kinds of contemporary neighbourhoods. Egypt's New Borg Al-Arab City is one example. In the 30 years between 1977 and 2006, the city was supposed to have 1,258,200 residents, but only 500,000 actually called it home. This is due to a lack of adequate infrastructure, including adequate housing, recreational facilities, public transportation, sidewalks, etc., as well as poor planning and design. The strength of the relationships within different networks is sometimes used as a proxy for the health of society as a whole. This causes cities to fall short in meeting the requirements of their residents, drives up the price of supporting infrastructure for parks, and boosts land values without improving community life in residential areas. (Mohamed et al., 2022)

By reviewing previous studies, this research finds that Dempsey (2009), examined the claim that there is an association between good-quality neighbourhoods and social cohesion. This is done through a mixed research approach starting by investigating the theoretical background of such claims and then providing empirical evidence on how the urban form and the built environment's features influence social cohesion in local neighbourhoods. The empirical stage is divided into two phases: physical site survey and household questionnaire. Statistical methods were used to examine the data, most extensively the SPSS statistical software for the social sciences (SPSS). Descriptive analyses, Spearman's rank-order correlation coefficient, multiple linear regression, binary logistic regression, factor analysis, and analyses of variance (both one-way and two-way ANOVA) were utilized.

On the other hand, this research developed a model to understand the effect of neighbourhood morphology (and its subdimensions) on social cohesion (and its subdimensions). The model was fabricated from a comprehensive analysis of the literature review of both the main neighbourhood design characteristics and the main dimensions and subdimensions of social cohesion. The model was analyzed using SPSS and the Partial Least Square analysis of SEM (PLS-SEM) technique. This technique combines factor analysis and multiple regression analysis to investigate the nature of the relationship between the empirically observable

and the more nebulous "latent" variables. Due to its ability to estimate various and interrelated dependencies in a single analysis, this technique is much more favoured.

3 NEIGHBOURHOOD MORPHOLOGY AND SOCIAL COHESION

The literature dealing with the relationship between the morphological composition of the residential neighbourhood and its social cohesion and how to measure this relationship has been numerous. This is evident in Table 1, which summarizes some of this literature and the usual measurement methods used.[1]

Research	Contribution
Are good-quality environments socially cohesive? Measuring quality and cohesion in urban neighbourhoods	Studying factors for both quality of the built environment and social cohesion For measuring: -Physical site survey -Household questionnaire survey
Built environment, urban vitality and social cohesion: Do vibrant neighbourhoods foster strong communities?	Tests a model in which urban vitality link between the built environment and social cohesion For measuring: -Survey and geospatial data
Urban Design, Public Spaces, and Social Cohesion: Evidence from a Virtual Reality Experiment	Investigates the impact of design alternatives on social cohesion through a virtual reality experiment
Social Cohesion in Cairo: Toward a Better Understanding Of The Potential Role Of Urban Design	The potential role of urban design in contributing to the social cohesion among the different components of the society in Cairo -Literature Review
Public Space Design and Social Cohesion: An International Comparison	Main concepts of public space, urban design and social cohesion the intersection of urban design and planning and social cohesion Explores how public behavior evidences ideas about social cohesion
European public space projects with social cohesion in mind: symbolic, programmatic and minimalist approaches	This paper characterizes three distinct open space design approaches – Symbolic, Programmatic and Minimalist – that governments and designers have put forward as best practices to enhance social cohesion
Urban planning, neighbourhoods and social cohesiveness: A socio-cultural study of expatriate residents in Dubai	Assess and analyze the role of the physical planning of the built forms, layout and design in creating socially cohesive neighbourhoods in the multicultural city of Dubai. For Measuring:- -Observation and Spatial Analysis using GIS -Surveys, and semi-structured interviews
Neighbourhood Form and Social Cohesion: What Can We Learn Before and During Social Distancing	This research identifies the importance of suburban neighbourhood form in promoting social cohesion. For Assessing socio-physical relationship for different patterns -Cross-sectional surveys and follow-up interviews
Neighbourhood open spaces for social cohesion	Measure and compare the open spaces in selected neighbourhoods in Europe and India according to Unitary Theory of Production For Measuring:- -On-site observation -Surveys

Table 1: Neighbourhood Morphology and Social Cohesion in Literature Review. Source: Researchers.

4 METHODS

4.1 Scales

Based on the previous analysis, The developed model in this research is comprised of two main variables which they are Neighbourhood Morphology and Social Cohesion.

Neighbourhood Morphology's main dimensions are Street System and Block System. The Street System is branched into the subdimensions of neighbourhood morphology which they are Street Network, Street Type, Pedestrian Network, and Access Points. The Block System is branched into Perceived Density, and Mixed-land Use.

The main dimensions of Social Cohesion are Participation/Solidarity, Safety/Trust, and Neighbourhood Attachment. Participation/Solidarity is branched into Community, Political, and Solidarity. The Safety/Trust is branched into General Trust and Institutional Trust. Finally, Neighbourhood Attachment is branched into Identity, Ownership and Memory, and Belonging.

4.2 Sample and Data Collection

For the purpose of this research, a structured questionnaire was conducted on a random sample of 193 participants (see Appendx). The participants are the residents of two selected neighbourhoods of New Borg Al-Arab City in Egypt, 95 participants from Neighbourhood Two and 98 participants from Neighbourhood Three. These neighbourhoods differ from each other in their structural composition as shown in Figure 1 and

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[1] as an integral part of this paper

454

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Figure 2. The structured questionnaire investigates the inhabitant's perception of both neighbourhood morphology and social cohesion's sub-dimensions. It's divided into thirteen sections: Street Network (6 items), Street Type (4 items), Pedestrian Network (2 items), Access Points (2 items), Perceived Density (2 items), Mixed-land Use (2 items), Community (2 items), Political (2 items), Solidarity (2 items), General Trust (2 items), Institutional Trust (2 items), Identity (2 items), Ownership and Memory (2 items), and Belonging (2 items). A five-level Likert scale with "Strongly Disagree" until "Strongly Agree", comprises the measurement level of the questionnaire. A Partial Least Square analysis of SEM (PLS-SEM) is followed in this study. Analyses are performed in two phases: first, a Measurement Model analysis (Reliability and Validity Test) is performed, and then, a Structural Model Analysis is performed (Hypothesis Testing).

Fig. 1: Neighbourhood Two. Source: Google Earth, Fig. 2: Neighbourhood Three. Source: Google Earth.

4.3 Research Hypothesis

According to the developed model, there are three scales of hypothesis testing which resulted in 55 hypotheses: Hypothesis Testing for the main Variables (1 hypothesis), Hypothesis Testing for the main Dimensions (6 hypotheses), and Hypothesis Testing for the main Sub-Dimensions (48 hypotheses).

4.3.1 Hypothesis Testing for the main Variables

H1: There is a significant relationship between Neighbourhood Morphology and Social Cohesion

4.3.2 Hypothesis Testing for the main Dimensions

H2: There is a significant relationship between Street System and Participation

H3: There is a significant relationship between Street System and Trust

H4: There is a significant relationship between Street System and Neighbourhood Attachment

H5: There is a significant relationship between Block System and Participation

H6: There is a significant relationship between Block System and Trust

H7: There is a significant relationship between Block System and Neighbourhood Attachment

4.3.3 Hypothesis Testing for the main Sub-Dimensions

H8: There is a significant relationship between Street Network and Community

H9: There is a significant relationship between Street Network and Political

H10: There is a significant relationship between Street Network and Solidarity

H11: There is a significant relationship between Street Network and General Trust

H12: There is a significant relationship between Street Network and Institutional Trust

H13: There is a significant relationship between Street Network and Identity

H14: There is a significant relationship between Street Network and Ownership and Memory

H15: There is a significant relationship between Street Network and Belonging

H16: There is a significant relationship between Street Type and Community

H17: There is a significant relationship between Street Type and Political

H18: There is a significant relationship between Street Type and Solidarity

H19: There is a significant relationship between Street Type and General Trust

H20: There is a significant relationship between Street Type and Institutional Trust

H21: There is a significant relationship between Street Type and Identity

H22: There is a significant relationship between Street Type and Ownership and Memory

H23: There is a significant relationship between Street Type and Belonging

H24: There is a significant relationship between Pedestrian Network and Community

H25: There is a significant relationship between Pedestrian Network and Political

H26: There is a significant relationship between Pedestrian Network and Solidarity

H27: There is a significant relationship between Pedestrian Network and General Trust

H28: There is a significant relationship between Pedestrian Network and Institutional Trust

H29: There is a significant relationship between Pedestrian Network and Identity

H30: There is a significant relationship between Pedestrian Network and Ownership and Memory

H31: There is a significant relationship between Pedestrian Network and Belonging

H32: There is a significant relationship between Access Points and Community

H33: There is a significant relationship between Access Points and Political

H34: There is a significant relationship between Access Points and Solidarity

H35: There is a significant relationship between Access Points and General Trust

H36: There is a significant relationship between Access Points and Institutional Trust

H37: There is a significant relationship between Access Points and Identity

H38: There is a significant relationship between Access Points and Ownership and Memory

H39: There is a significant relationship between Access Points and Belonging

H40: There is a significant relationship between Perceived Density and Community

H41: There is a significant relationship between Perceived Density and Political

H42: There is a significant relationship between Perceived Density and Solidarity

H43: There is a significant relationship between Perceived Density and General Trust

H44: There is a significant relationship between Perceived Density and Institutional Trust

H45: There is a significant relationship between Perceived Density and Identity

H46: There is a significant relationship between Perceived Density and Ownership and Memory

H47: There is a significant relationship between Perceived Density and Belonging

H48: There is a significant relationship between Mixed-land Use and Community

H49: There is a significant relationship between Mixed-land Use and Political

H50: There is a significant relationship between Mixed-land Use and Solidarity

H51: There is a significant relationship between Mixed-land Use and General Trust

H52: There is a significant relationship between Mixed-land Use and Institutional Trust

H53: There is a significant relationship between Mixed-land Use and Identity

H54: There is a significant relationship between Mixed-land Use and Ownership and Memory

H55: There is a significant relationship between Mixed-land Use and Belonging

5 RESULTS

5.1 Data Examination

Missing data, outliers, normality, and Common Method Bias (CMB) are all things that should be checked in the gathered data, as suggested by the literature (Hair et al., 2017). The key data concerns were therefore examined using SPSS in this study. There were no issues discovered after looking at the missing data and the outliers. Researchers can identify the CMB using Harman's single-factor test; the percentage of factors explaining the variance in the data determines the presence or absence of the bias. Common method bias is not an issue if the overall variance attributable to the factor is less than 50%. To our dismay, we found that the first component explained only 17.601% of the total variance. Given that the number was under 50%, it's possible that the CMB issue was overlooked. As displayed in Table.2, Skewness levels between -2 and +2 and kurtosis values between -7 and +7 are regarded as acceptable in displaying normal distribution (Hair et al. 2014; Bryne 2016).

Construct	Notation	N	Skewness	Kurtosis
Street Network	SN	193	-0.463	1.907
Street Type	ST	193	0.354	-1.178
Pedestrian Network	PN	193	-0.574	-1.023
Access Points	AP	193	-0.489	0.187
Perceived Density	PD	193	-0.311	2.53
Mixed Land Use	MLU	193	0.052	-1.342
Community	COM	193	1.331	5.01
Political	POL	193	1.202	1.107
Solidarity	SOL	193	-0.82	0.924
General trust	GT	193	-0.037	0.657
Institutional trust	IT	193	-0.344	-0.806
Identity	IDE	193	-1.633	2.852
Ownership & Memory	OM	193	-1.042	0.596
Belonging	BEL	193	-1.023	0.86
Street System	SS	193	-0.373	-0.653
Block System	BS	193	-0.043	-1.005
Participation	PAR	193	0.416	0.932
Trust	TRU	193	-0.359	-0.503
Neighbourhood Attachment	NA	193	-1.138	0.306
Neighbourhood Morphology	NM	193	-0.128	-1.074
Social Cohesion	SC	193	-0.553	0.248
Remark: Normality assumption attained				

Table 2: Normality diagnostics

5.2 Measurement Model Assessment

PLS-SEM calls for assessing internal consistency reliability, convergent validity, and discriminant validity to validate reflective measurement models.

The Internal Consistency and Reliability of the measurement model evaluate a construct to determine whether or not all of the indicators connected with it are truly measuring the construct. Despite its widespread use, Cronbach's alpha has been called into question due to its implicit assumption of equal outer loadings among all indicators (Hair et al., 2017), and because the number of indicators affects the calculation of Cronbach's alpha, with a smaller value being obtained for scales with fewer than 10 items (Pallant, 2010, Hair et al., 2017). Hence, additional methods of internal consistency assessment, including composite reliability (CR), are recommended. Values above 0.6 are also considered acceptable for CR, but 0.7 is the established norm (Fornell and Larcker, 1981; Hair et al., 2017; Taber, 2018). Values for internal consistency are shown in Figure 3 as composite reliability (CR). While evaluating internal consistency, the composite reliability takes into consideration the fact that each indicator has a unique external loading.

The Convergent Validity assesses the degree to which the variables used to measure one construct are correlated with one another. The Convergent Validity was assessed using AVE and Item Loadings. The AVE, also known as the grand mean of the squared loadings of the indicators measuring a construct, is a standard measure that is used to show convergent validity. Values for average variance (AVE) are shown in Figure 3. Although values of AVE greater than 0.5 are preferred, those greater than 0.4 are also acceptable so long as CR values are greater than 0.6. (Fornell and Larcker, 1981). Another measure of Convergent Validity is the item loading, and the minimum outer loading that must be met is 0.70. (Hair et al., 2014, Hair et al., 2017). When an item's outer loading is 0.70, it means that the construct can explain approximately 50% of the item's variance (Hair et al., 2017). On the other hand, the authors proposed that if the outer loading is

between 0.4 and 0.7, the effect that indicator deletion has on the reliability of the internal consistency should be investigated. the reflective indication ought to be kept if the deletion does not result in an increase in a measure above the threshold. As a result of low factor loadings, three items were eliminated from the analysis (Q4, Q10, and Q11), but all of the remaining items in figure 4 satisfy the criterion.

Discriminant Validity is tested by looking at how the construct compares to other constructs. The fornell-Larcker criterion is commonly used to demonstrate discriminant validity, which guarantees that the indicator only loads highly on the construct it is linked with. Indicators sometimes load to many constructs; however, the loading on the target construct must be greater than any other correlations the indicator may have with other constructs. The Fornell-Larcker criterion compares the square root of AVE to the correlations of the construct. The AVE of the construct should be greater than any of the construct's correlations with other constructs, as measured by its square root. As the square root values of the AVE for the construct were greater than the construct's correlations with other constructs, as shown in table 3, the discriminant validity was developed using these principles as a basis.
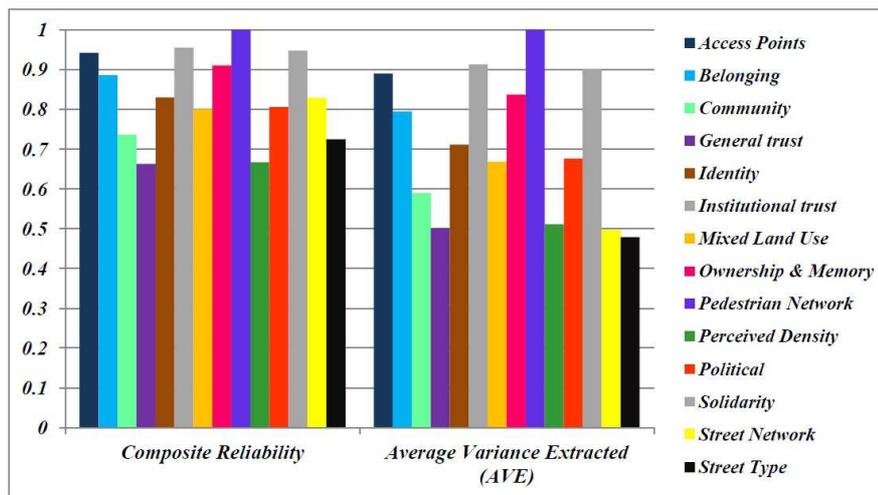
Fig. 3: Summary of internal consistency reliability and convergent validity. Source : By Researchers
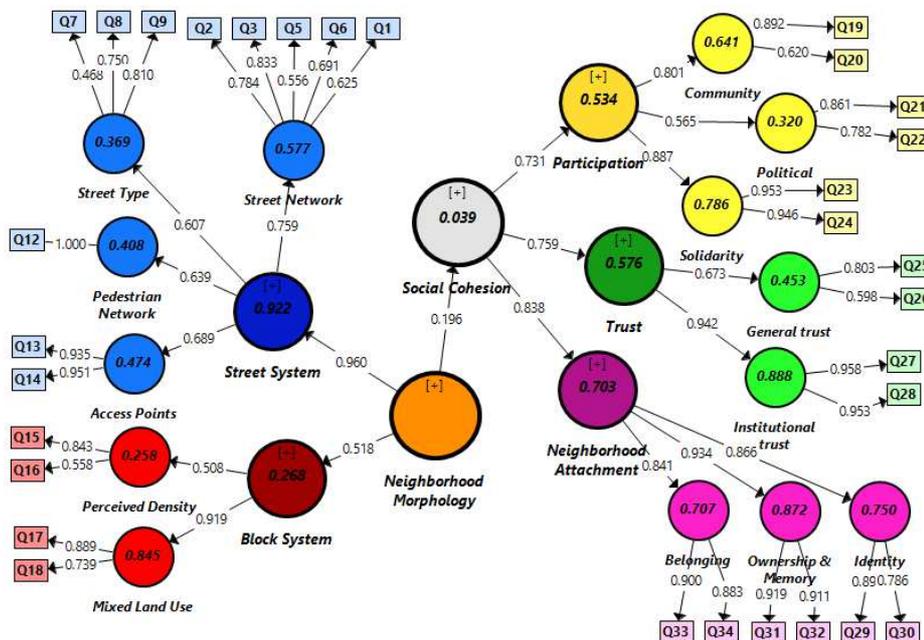
Fig. 4: Measurement model assessment (factor loadings). Source: Researchers.

	AP	BEL	COM	GT	IDE	IT	MLU	OM	PN	PD	POL	SOL	SN	ST
AP	**0.943**													
BEL	0.085	**0.892**												
COM	-0.128	0.145	**0.768**											
GT	0.137	0.299	0.151	**0.708**										
IDE	0.219	0.549	0.183	0.257	**0.843**									
IT	0.04	0.312	0.338	0.387	0.402	**0.956**								
MLU	0.053	-0.14	-0.015	-0.023	0.099	-0.138	**0.817**							
OM	0.101	0.677	0.127	0.304	0.764	0.339	-0.004	**0.915**						
PN	0.39	0.215	-0.075	0.173	0.319	0.052	0.343	0.25	**1**					
PD	-0.133	-0.086	-0.075	-0.149	-0.115	-0.155	0.138	-0.194	0.086	**0.715**				
POL	-0.049	0.078	0.339	0.061	0.069	0.234	0.08	0.084	-0.065	-0.093	**0.822**			
SOL	0.18	0.341	0.551	0.387	0.386	0.446	-0.22	0.367	0.056	-0.227	0.247	**0.95**		
SN	0.338	0.14	0.197	0.262	0.236	0.105	-0.055	0.131	0.176	-0.038	-0.139	0.241	**0.705**	
ST	0.12	0.122	-0.002	0.206	0.28	-0.008	0.579	0.244	0.509	0.23	-0.164	0.016	0.235	**0.692**

Remark: Discriminant validity through the Fornell-Larcker criterion attained

Table 3: Discriminant Validity (Fornell-Larcker criterion). Source: Researchers.

5.3 Structural Model Assessment

The structural model was analyzed using path coefficients, collinearity diagnostics, the coefficient of determination (R2), effect size (f 2), predictive relevance (Q2), and goodness of fit criteria.

Estimates of the relationships between model constructs are referred to as "Path Coefficients" (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014). These coefficients lie on a scale from +1 to -1, with plus one indicating a highly positive relationship, zero indicating no relationship at all, and minus one indicating a highly negative relationship (Garson, 2016). Studies should also report the path coefficients alongside the significance level, t-value, and p-value when evaluating the PLS path (Hair, Sarstedt, Ringle, & Mena, 2012). It has been determined whether or not there is a statistically significant relationship between the two constructs by evaluating the hypotheses pertaining to the signs, sizes, and statistical significance of the calculated path coefficients. In general, bigger effects between a predictor and a predicted variable are indicated by higher path coefficients. It is possible to evaluate the reliability of the estimated path coefficients by comparing their p-values to two predetermined thresholds, set at 0.05 and 0.01. This procedure establishes the significance of the hypothesized relationships (Henseler et al., 2009; Hair et al., 2017). Conclusions were formed for each hypothesis later by comparing their p-values to the aforementioned traditional thresholds. The results of the hypothesis testing for the main hypothesis, main dimensions, and subdimensions are shown in Figures 5, 6, and 7, and in table 4.
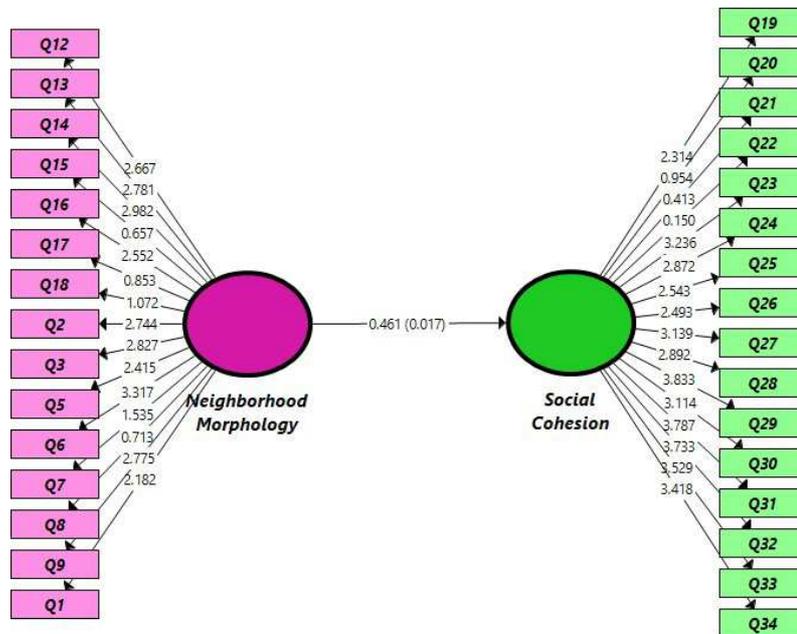
Fig. 5: Structural model for the main hypothesis. Source: Researchers.
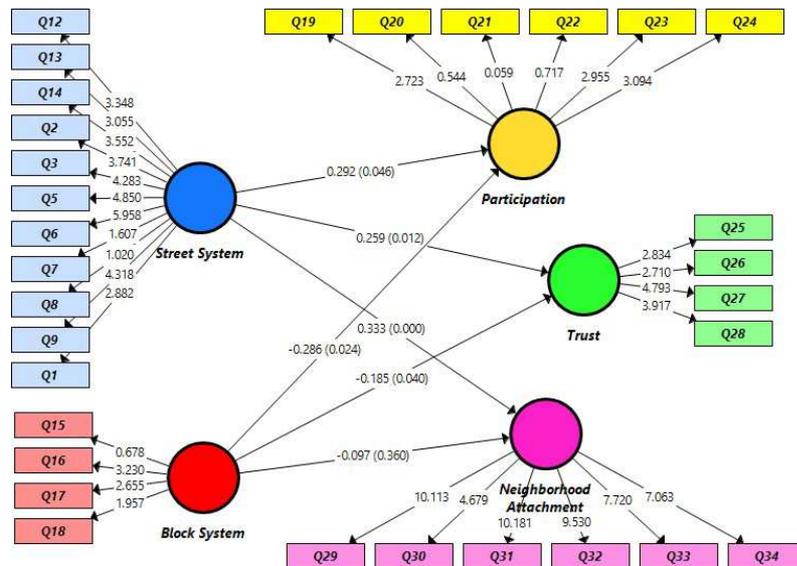
Fig. 6: Structural model for testing the hypotheses concerning the dimensions of the variables. Source: Researchers.

The effect of the subdimensions of neighbourhood morphology on social cohesion's subdimensions was the subject of 48 hypotheses. Therefore, another test was conducted as shown in figure 7, and disregard the non-significant association for the sake of clarity.

Hypothesis	B	t-value	P-value	Remark
H1: Neighbourhood Morphology -> Social Cohesion	0.461	2.389	0.017	Supported
H2: Street System -> Participation	0.292	1.993	0.046	Supported
H3: Street System -> Trust	0.259	2.523	0.012	Supported
H4: Street System -> Neighbourhood Attachment	0.333	4.115	0	Supported
H5: Block System -> Participation	-0.286	2.258	0.024	Supported
H6: Block System -> Trust	-0.185	2.058	0.04	Supported
H7: Block System -> Neighbourhood Attachment	-0.097	0.916	0.36	Rejected
H8: Street Network -> Community	0.382	4.468	0	Supported
H10: Street Network -> Solidarity	0.222	2.586	0.01	Supported
H11: Street Network -> General trust	0.315	4.361	0	Supported
H17: Street Type -> Political	-0.264	2.67	0.008	Supported
H21: Street Type -> Identity	0.229	2.812	0.005	Supported
H22: Street Type -> Ownership & Memory	0.304	3.915	0	Supported
H23: Street Type -> Belonging	0.344	3.751	0	Supported
H29: Pedestrian Network -> Identity	0.209	2.501	0.012	Supported
H32: Access Points -> Community	-0.259	2.832	0.005	Supported
H37: Access Points -> Identity	0.206	2.783	0.005	Supported
H46: Perceived Density -> Ownership & Memory	-0.253	2.974	0.003	Supported
H49: Mixed Land Use -> Political	0.203	2.178	0.029	Supported
H50: Mixed Land Use -> Solidarity	-0.191	2.224	0.026	Supported
H52: Mixed Land Use -> Institutional trust	-0.16	2.063	0.039	Supported
H55: Mixed Land Use -> Belonging	-0.271	2.715	0.007	Supported

Table 4: Results of Hypothesis testing. Source: Researchers.

There are interpretation problems caused by Collinearity when there is a high correlation between two constructs (Hair, Hult, Ringle, & Sarstedt, 2017). The variance inflation factor (VIF) is a measure of collinearity. High collinearity is indicated by a VIF value of 5 or higher (Hair, Ringle, & Sarstedt, 2011; Hair, Hult, Ringle, & Sarstedt, 2017). All VIF values in Table 5 are below the threshold, indicating that collinearity does not exist amongst the several independent constructs.

Path	VIF	Path	VIF
Neighbourhood Morphology -> Social Cohesion	1	Mixed Land Use -> Political	1.157
Block System -> Neighbourhood Attachment	1.015	Mixed Land Use -> Solidarity	1.02
Block System -> Participation	1.015	Pedestrian Network -> Identity	1.52
Block System -> Trust	1.015	Perceived Density -> Ownership & Memory	1.006
Street System -> Neighbourhood Attachment	1.015	Street Network -> Community	1.097
Street System -> Participation	1.015	Street Network -> General trust	1
Street System -> Trust	1.015	Street Network -> Solidarity	1.02
Access Points -> Community	1.097	Street Type -> Belonging	1.157
Access Points -> Identity	1.195	Street Type -> Identity	1.299
Mixed Land Use -> Belonging	1.157	Street Type -> Ownership & Memory	1.006
Mixed Land Use -> Institutional trust	1	Street Type -> Political	1.157
Remark: No problem exists			

Table 5: Variance inflation factors. Source: Researchers.

460

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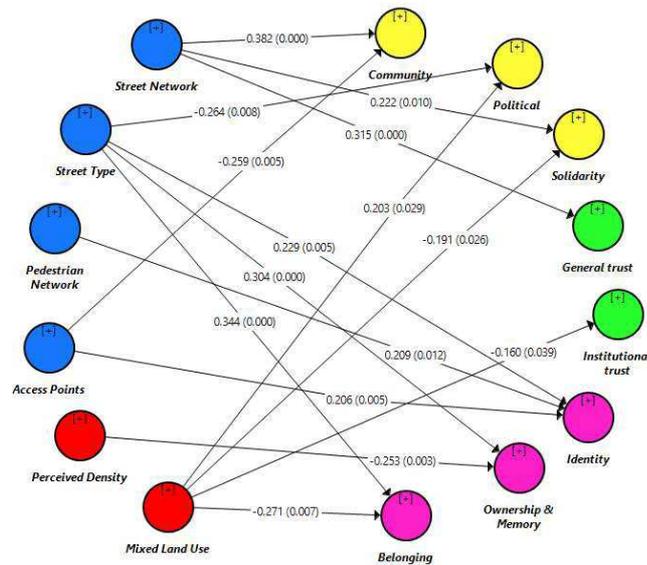
Fig. 7: Simplified structural model for testing the hypotheses concerning the SUB-dimensions of the variables. Source: Researchers.

Coefficient of determination (R²) is a structural model quality measure that assesses the effect of independent factors on dependent latent variables (Hair, Sarstedt, Ringle, & Mena, 2012). (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014). From 0 to 1, coefficient of determination estimates range from low to high explained variance. Researchers used a different cutoff. Chin (1998) classified values below 0.19, 0.19-0.33, 0.33-0.67, or above 0.67 as very low, low, moderate, or high. Falk & Miller (1992) defined R² as negligible if R²<0.1 and adequate if R²>0.1. Table 6 shows that most R Square values were adequate. The R-Square of Social Cohesion was 0.213, indicating that Neighbourhood Morphology explained 21 % of its variation. Identity R Square was highest and Institutional trust lowest.

Dependent Variable	R Square	R Square Adjusted
Social Cohesion	0.213	0.209
Neighbourhood Attachment	0.128	0.119
Participation	0.187	0.178
Trust	0.113	0.104
Belonging	0.123	0.114
Community	0.154	0.145
General trust	0.099	0.094
Identity	0.225	0.212
Institutional trust	0.026	0.021
Ownership & Memory	0.144	0.135
Political	0.071	0.062
Solidarity	0.097	0.088

Table 6: R Square and Associated R Square Adjusted. Source: Researchers.

The effect size f² measures how much the endogenous construct will affect the model if an exogenous construct is eliminated. A construct has a small influence if its value is between 0.02 and 0.14, a medium effect between 0.15 and 0.34, and a high effect above 0.35. An endogenous construct with a value < 0.02 has no effect (Hair et al., 2017). Table 7 shows construct effect size f². Neighbourhood Morphology has moderate effect on Social Cohesion (f²=0.27). Street network affects community moderately (f²=0.157). Except for block system-neighbourhood attachment (f²=0.011), all other effect sizes were accepted since.

Path	F²	Path	F²
Neighbourhood Morphology -> Social Cohesion	0.27	Mixed Land Use -> Political	0.038
Block System -> Neighbourhood Attachment	0.011	Mixed Land Use -> Solidarity	0.04
Block System -> Participation	0.099	Pedestrian Network -> Identity	0.037
Block System -> Trust	0.038	Perceived Density -> Ownership & Memory	0.075
Street System -> Neighbourhood Attachment	0.125	Street Network -> Community	0.157
Street System -> Participation	0.103	Street Network -> General trust	0.11
Street System -> Trust	0.075	Street Network -> Solidarity	0.053
Access Points -> Community	0.072	Street Type -> Belonging	0.116
Access Points -> Identity	0.046	Street Type -> Identity	0.052
Mixed Land Use -> Belonging	0.072	Street Type -> Ownership & Memory	0.107
Mixed Land Use -> Institutional trust	0.026	Street Type -> Political	0.065

Table 7: f² Effect Size. Source: Researchers.

The out-of-sample prediction capability of the model is represented by the Predictive Relevance Q2 value. If a model is stated to have predictive power or predictive relevance, this indicates that it is able to reliably forecast data that was not used in the process of estimating the model. The Q2 values that were determined from the research are detailed in Figure 8. As the values of Q2 are more than 0, it is safe to say that the study model has a good predictive relevance.
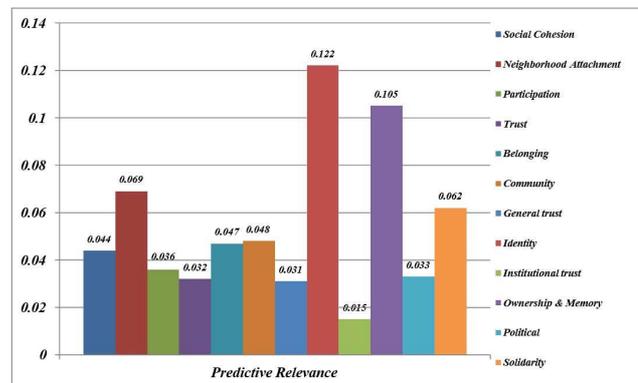
Fig. 8: Predictive Relevance. Source: Researchers.

The geometric mean of the average and average variance retrieved from endogenous variables is the Goodness of Fit (GoF), a global fit indicator established by Tenenhaus et al. (2005). GoFs consider the measurement and structural models throughout the research process, focusing on model performance (Henseler & Sarstedt, 2013). The criteria for determining whether GoF values are unacceptable, small, moderate, or large for a globally adequate PLS model are as follows: GoF less than 0.1, no fit; 0.1–0.25, small; 0.25–0.36, medium; and 0.36+, large. These criteria and the GoF value (0.306) indicate that the GoF model is moderate to sufficient viable global PLS model.

6 DISCUSSION AND CONCLUSION

The main goal of this research was to investigate the influence of Neighbourhood Morphology and its subdimensions on Social Cohesion and its subdimensions and which subdimensions affects the other. Depending on extensive literature review, a structured questionnaire was conducted on a random sample consists of 193 participants of two neighbourhoods in New Borg Al-Arab City in Egypt. The questionnaire was divided into 3 scales which they are: the main variables, the main dimensions, and the subdimensions.

After that the data collected were analyzed using SEM-PLS model which is comprised of two phases. Phase 1 the measurement model assessment and phase 2 the structural model assessment. The model developed resulted in 55 hypothesis, only 21 of them are supported which are demonstrated in table 8.

Hypothesis	Remark
H1: Neighbourhood Morphology has a statistically significant effect on Social Cohesion	Supported
H2: Street System has a statistically significant effect on Participation	Supported
H3: Street System has a statistically significant effect on Trust	Supported
H4: Street System has a statistically significant effect on Neighbourhood Attachment	Supported
H5: Block System has a statistically significant effect on Participation	Supported
H6: Block System has a statistically significant effect on Trust	Supported
H8: Street Network has a statistically significant effect on Community	Supported
H10: Street Network has a statistically significant effect on Solidarity	Supported
H11: Street Network has a statistically significant effect on General trust	Supported
H17: Street Type has a statistically significant effect on Political	Supported
H21: Street Type has a statistically significant effect on Identity	Supported
H22: Street Type has a statistically significant effect on Ownership & Memory	Supported
H23: Street Type has a statistically significant effect on Belonging	Supported
H29: Pedestrian Network has a statistically significant effect on Identity	Supported
H32: Access Points has a statistically significant effect on Community	Supported
H37: Access Points has a statistically significant effect on Identity	Supported
H46: Perceived Density has a statistically significant effect on Ownership & Memory	Supported
H49: Mixed Land Use has a statistically significant effect on Political	Supported
H50: Mixed Land Use has a statistically significant effect on Solidarity	Supported
H52: Mixed Land Use has a statistically significant effect on Institutional trust	Supported
H55: Mixed Land Use has a statistically significant effect on Belonging	Supported

Table 8: Hypothesis testing summary. Source: Researchers.

7 ACKNOWLEDGEMENT

8 REFERENCES

Mohamed, A. N., Elmokadem, A.A.E., Ali, S.M. and Badawey, N., 2022. Improve Urban Form to Achieve High Social Sustainability in a Residential Neighbourhood Salam New City as a Case Study. Buildings, 12(11), p.1935.

Dempsey, N., 2009. Are Good-Quality Environments Socially Cohesive? Measuring Quality and Cohesion in Urban Neighbourhoods. The Town Planning Review, pp.315-345.

Abdi, H. (2010) Partial Least Squares Regression and Projection on Latent Structure Regression (PLS-Regression): Wiley Interdisciplinary Reviews, Computational Statistics Data Analysis, 2 (1), 97-106.

Ali, F., Rasoolimanesh, S. M., Sarstedt, M., Ringle, C. M., Ryu, K. (2018). An Assessment of the Use of Partial Least Squares Structural Equation Modeling (PLS-SEM) in Hospitality Research. International Journal of Contemporary Hospitality Management, 30(1), 514-538.

Benitez-Amado, J., Henseler, J., Castillo, A. (2017). Development and Update of Guidelines to Perform and Report Partial Least Squares Path Modeling in Information Systems Research. 21 Pacific Asia Conference on Information Systems (PACIS 2017), (pp. 1-15). Langkawi.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. Modern methods for business research, 295(2), 295-336.

Cohen, J. (1988), Statistical Power Analysis for the Behavioural Sciences , Taylor and Francis Group, New York.

Falk, R. F., Miller, N. B. (1992). A primer for soft modeling. University of Akron Press.

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics (4th Ed.). (M. Carmichael, Ed.) London: SAGE.

Fornell, C., Larcker, D. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research, 18(1), 39-50.

Garson, G. D. (2016). Partial Least Squares: Regression and Structural Equation Models. Asheboro, NC, USA: Statistical Associates Publishers.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. (2014). Multivariate Data Analysis. (7th Ed.) Pearson.

Hair, J. F., Celsi, M., Money, A., Samouel, P., Page, M. (2016). Essentials of Business Research Methods. New York: Routledge.

Hair, J. F., Hult, G. T., Ringle, C. M., Sarstedt, M. (2017). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) (2nd Ed.). Los Angeles, CA: SAGE.

Hair, J. F., Ringle, C. M., Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. Journal of Marketing theory and Practice, 19(2), 139-152.

Hair, J. F., Sarstedt, M., Hopkins, L., Kuppelwieser, V. G. (2014). Partial Least Squares Structural Equation Modeling (PLS-SEM): An Emerging Tool in Business Research. European Business Review, 26(2), 106-121.

Hair, J. F., Sarstedt, M., Ringle, C. M., Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. Journal of the Academy of Marketing Science, 40(3), 414–433.

Hair, J., Hollingsworth, C. L., Randolph, A. B., Chong, A. Y. (2017). An Updated and Expanded Assessment of PLS-SEM in Information Systems Research. Industrial Management Data Systems, 117(3), 442-458.

Henseler, J., Sarstedt, M. (2013). Goodness-of-fit Indices for Partial Least Squares Path Modeling. Computational Statistics, 28, 656-580.

Henseler, J., Ringle, C. M., Sarstedt, M. (2015). A New Criterion for Assessing Discriminant Validity in Variance-Based Structural Equation Modeling. Journal of the Academy of Marketing Science, 43(1), 115-135.

Henseler, J., Ringle, C. M., Sinkovics, R. R. (2009). The Use of Partial Least Squares Path Modeling in International Marketing. Advances in International Marketing, 20, 277-319.

Kline, R. B. (2005) Principles and Practice of Structural Equation Modelling, 2nd edition, New York: The Guilford Press.

Kline, R. B. (2016). Principles and Practice of Structural Equation Modeling. New York: Guilford Press.

Mackenzie, S. B. Podsakoff, P. M. 2012. Common method bias in marketing: causes, mechanisms, and procedural remedies. Journal of Retailing, 88, 542-555.

Nachtigall, C., Kroehne, U., Funke, F., Steyer, R. (2003). Pros and cons of structural equation modelling. Methods Psychological Research Online, 8(2), 1-22.

Pallant, J. (2010). SPSS survival manual, 4th. England: McGraw-Hill Education.

Ringle, C. M., Sarstedt, M., Straub, D. (2012). Editor's Comments: A Critical Look at the Use of PLS-SEM in MIS Quarterly. MIS Quarterly, 36(1), iii-xiv.

Ringle, C. M., Sarstedt, M., Mitchell, R., Gudergan, S. P. (2018). Partial Least Squares Structural Equation Modeling in HRM Research. The International Journal of Human Resource Management, 1-27.

Sarstedt, M., Mooi, E. (2014). A Concise Guide to Market Research: The Process, Data, and Methods Using IBM SPSS Statistics. Springer-Verlag Berlin Heidelberg.

Schlomer, G. L., Bauman, S., Card, N. A. (2010). Best Practices for Missing Data Management in Counseling Psychology. Journal of Counseling psychology, 57(1), 1-10.

Sekaran, U., Bougie, R. (2016). Research Methods for Business: A Skill-Building Approach (6th ed.). (7, Ed.) Chichester, UK: Wiley Sons Ltd.

Sue, V. M., Ritter, L. A. (2012). Conducting Online Surveys (2nd Ed.). London: Sage Publications, Inc.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. Research in Science Education, 48(6), 1273-1296.

Tenenhaus, M., Esposito Vinzi, V., Chatelinc, Y.-M. Lauro, C. (2005) PLS Path Modelling, Computational Statistics Data Analysis, 48 (1), 159-205.

Wetzels, M., Odekerken-Schroder, G. and Van Oppen, C. (2009) Using PLS Path Modeling for Assessing Hierarchical Construct Models: Guidelines and Empirical Illustration. MIS Quarterly, 33, 177-195.

Xiong, B., Skitmore, M., Xia, B. (2015). A critical review of structural equation modelling applications in construction research. Automation in construction, 49, 59-70.

9 APPENDIX

Domain		Subdomain	Questions (Qs)
Neighbourhood Morphology (by researchers)	Street System	Street Network	The Visual Permeability in the street network is high The Physical Permeability in the Street network is high I can remember the streets that I have passed through before There are many junctions in the neighbourhood where I live There are many landmarks in the neighbourhood where I live I feel that the streets and open spaces are well defined by the buildings
		Street Type	The street where I live is Narrow The street where I live has shopping services The street where I live is a Cul de sac The street where I live is pedestrian only
		Pedestrian Network	There are enough crossings in the neighbourhood I live I am satisfied with the quality of the pavements in my neighbourhood
		Access Points	The access points are well distributed in the neighbourhood The access points are clear and well defined
	Block System	Perceived Density	I feel that my neighbourhood is overcrowded There is lack of parks in my neighbourhood
		Mixed Land Use	There is a mix of land uses where I live The neighbourhood center isn't so far from my home/work
Social Cohesion (Aliaa, Yuki et al., Gianmaria)	Participation/ Solidarity	Community	I take part in social activities in my district (Greetings in holidays, weddings, new practice openings …) I participate in cultural events in my district (concerts, exhibitions, festivals…)
		Political	Vote in the elections of community organizations such as neighbourhood committees and village committees I volunteer in charitable associations
		Solidarity	I contact my neighbours constantly I participate with neighbours in solving the building/ street problems
	Safety/ Trust	General trust	I spend much time in public places (parks, squares, etc.) I witness crimes against myself or others in public spaces
		Institutional trust	When I witness an accident, I report to the police When I witness a domestic problem, I report to family/ child services
	Neighbourhood Attachment	Identity	I feel attached to where I live\ work My place is well identified
		Ownership & Memory	I have the feeling of ownership due to the long stay The place around reminds me of good old times
		Belonging	I feel an urge to move out of this neighbourhood I feel isolated in this neighbourhood

Table 9: The structured questionnaire that conducted on a random sample of 193 participants. Source: Researchers.

Investigating Urban Regeneration and Sustainable Cities Development Nexus in the City of Pietermaritzburg, South Africa

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1 ABSTRACT

The World Cities Report (2016) states that cities are the drivers of economic growth and development, but they also face numerous challenges such as urban decay which can hinder growth and negatively impact the quality of life for residents. Urban decay refers to the deterioration and decay of buildings and older areas due to various factors such as neglect, crime, and lack of economic support. Gordon (2003), as cited in Ndlebe (2017), highlights the same challenge in the city of Pietermaritzburg. The research aims to identify means of regenerating the Pietermaritzburg Central Business District while incorporating the concepts and principles of smart and sustainable cities development. The objectives include analyzing the conceptualization of smart cities, sustainable development, urban decay, and urban regeneration concepts and evaluating their impact on the urban environment, assessing the current state of the Pietermaritzburg Central Business District through urban decay and regeneration, determining the potential of community and public participation in planning for urban regeneration, and establishing a smart and sustainable regeneration strategy. The research methodology used in investigating the regeneration of the Pietermaritzburg Central Business District (CBD) is a qualitative descriptive case study approach, which enables multiple perspectives on the issue of urban decay and regeneration in the city to be incorporated. The research findings suggest that successful urban regeneration requires a planned, team-based strategy that includes community engagement and stresses social inclusion, open space, and environmentally friendly transportation. The case studies of successful regeneration programs in Singapore and Kwa-Zulu Natal highlight the importance of having a clear goal and being adaptable to changing circumstances. The study's results show that 30 municipal officials who were interviewed in October 2022 in Pietermaritzburg are aware of urban decay in the city center and suggest enforcing council ordinances, carrying out ongoing clean-up projects, raising public awareness, fostering local economic development, and coordinating between various municipal agencies as potential solutions. The officials believe that smart and sustainable city growth is necessary for urban regeneration in Pietermaritzburg, but it requires a concerted effort from multiple stakeholders. In conclusion, this study highlights the feasibility of urban regeneration in Msunduzi but underscores the need for a concerted effort from multiple stakeholders to achieve sustainable and smart city growth.

Keywords: Urban decay, Urban Regeneration, Smart City, Sustainable Development, Spatial Planning

2 INTRODUCTION

This paper focuses on the topic of urban regeneration in the context of smart and sustainable city development. The Integrated Urban Development Framework predicts a significant increase in urban migration by 2050, posing challenges for governments in supporting the growing population. To address this, industries are being decentralized from inner cities, leading to urban decay and hindered economic growth. Urban regeneration initiatives are being implemented to tackle these issues. The purpose of this research is to develop a strategy and alternatives for implementing smart and sustainable city development through urban regeneration within the Msunduzi Municipality, with a specific focus on regenerating the Pietermaritzburg Central Business District. The objectives of the study include analyzing the concepts of smart cities, sustainable development, urban decay, and urban regeneration, evaluating their impact on the urban environment through international and local case studies, assessing the current state of the Pietermaritzburg Central Business District in terms of urban decay and regeneration, determining the potential of community and public participation in urban regeneration planning using the concept of smart cities and sustainable development, and establishing a comprehensive strategy for smart and sustainable regeneration. The paper discusses various concepts related to urban decay, smart cities, and sustainable development, providing definitions and highlighting their significance. It also presents case studies of smart city initiatives in urban

regeneration, examining the efforts made by cities like Toronto and Korea to use advanced technologies and innovative strategies to improve various urban aspects. The paper concludes by focusing on the city of Pietermaritzburg in Kwa-Zulu Natal and presenting discussions on urban regeneration in the Msunduzi Municipality, incorporating insights from interviews with municipal officials regarding the existence of urban decay, its causes, and potential solutions. The concept of smart city development is also explored as a means to improve the urban decay situation in the area.

3 LITERATURE REVIEW

3.1 Refining the concept or urban decay and smart cities

Urban decay encompasses various aspects of persistent disorder within urban areas, including abandoned buildings, deteriorating infrastructure, and compromised living conditions (White, Sepe, & Masconale, 2014). This phenomenon is closely linked to social, economic, and physical changes in cities (Alias, Zyed, & Chai, 2016). It manifests through ill-kept properties, vandalism, social unrest, and economic decline, ultimately driving decentralization as people and businesses relocate to more functional areas (Clark, 2013; Alias et al., 2016). The concept of a smart city, as defined by multiple sources, involves leveraging information and communication technologies to enhance livability, sustainability, and efficiency (Roy, 2016; World cities report, 2016; British Standards Institute, 2014). Smart city development incorporates resource efficiency, innovative economies, sustainable mobility, intelligent urban planning, and improved citizen governance (Galati, 2018). The overarching goal is to create technologically advanced, inclusive urban environments that address urban challenges and promote community well-being (Moura & Silva, 2019).

3.2 Smart city initiatives in urban regeneration

The research that follows provides a comprehensive review of urban regeneration programs that have been put in place in West Don Lands project in Toronto, Dubai and Singapore as best examples for smart city initiatives in urban regeneration.

3.2.1 The West Don Lands Project in Toronto

Urban decay refers to the deterioration of urban areas due to a combination of social, economic, and environmental factors. In Toronto's case, the rapid growth of the city coupled with inadequate urban planning and development strategies has contributed to pockets of urban decay. As the largest city in Canada with a population of around 6 million, the challenges of providing sufficient housing, transportation, and infrastructure have become increasingly complex (Statistics Canada, 2016). The West Don Lands area, despite its prime waterfront location, fell victim to neglect, underutilization, and deteriorating infrastructure, reflecting broader issues in urban management.

The West Don Lands Urban Regeneration project aims to revitalize the 32-hectare area by creating residential units, mixed land uses, and job opportunities while prioritizing sustainable and smart development. One of the fundamental strategies employed is the adoption of smart growth policies, aligning with the city's commitment to sustainable development goals (OECD, 2015). Smart growth emphasizes efficient land use, transportation options, and community engagement to combat urban decay. One of the notable successes of the West Don Lands project lies in its community-wide approach to planning. The city invested two years in the initial planning stage, focusing on extensive community participation, transparency, and sustainability audits (Toronto, 2021). This inclusive approach ensured that the project addressed both opportunities and challenges, garnering support from stakeholders and minimizing potential conflicts. The project's design phase involved detailed block plans that facilitated resolution to building properties, street patterns, stormwater management, and utility services (Toronto, 2021). This comprehensive approach helped lay the groundwork for a functional and aesthetically pleasing urban environment. Furthermore, the integration of transit systems along Cherry Street highlights the emphasis on accessible and efficient transportation, a crucial aspect of smart cities.

466

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3.2.2 Aligning with Smart City Concept

City Strategies	Alignment with Smart City Concepts	Importance and Benefits
Sustainability	Sustainable designs, stormwater management, and efficient infrastructure minimize environmental impact and optimize resource use.	Reduced carbon footprint. Enhanced urban resilience. Improved quality of life
Community Engagement	Extensive community participation and transparency align with smart city's citizen-centric approach.	Greater social cohesion. Informed decision-making. Reduced conflicts and opposition.
Transportation	Integration of transit systems addresses mobility challenges and aligns with smart city's intelligent transportation solutions.	Reduced congestion. Improved accessibility. Enhanced economic activity
Mixed Land Uses	Creation of mixed land uses supports diverse and inclusive communities, a key aspect of smart cities.	Vibrant and resilient neighborhoods. Economic diversification. Enhanced cultural exchange.
Gaps	**Considerations and Mitigation**	**Implications and Risks**
Digital Inclusion	Equitable distribution of smart technology benefits to bridge the digital divide.	Preventing socio-economic disparities. Ensuring access for marginalized communities. Fostering digital literacy

3.2.3 Korea: a case study of Seoul and Pohang cities

The phenomenon of urban decline in Korean cities, including Seoul and Pohang, can be attributed to a combination of population decline, shifts in industries, and deindustrialization. According to Lee (2019), Seoul's new town development project was a response to the failure of previous redevelopment policies and aimed to address housing decline and inadequate infrastructure. Pohang, on the other hand, witnessed a decline in its city center, necessitating revitalization efforts led by the local government and public firms (Oh, 2020; Smart City Korea, 2021). Collaborating with public firms, the local government aims to introduce information and communication technologies in the central area, alongside establishing an industry hub for young entrepreneurs and redeveloping old housing to attract more visitors. The project includes a comprehensive platform incorporating smart city technologies, such as IoT in transportation, environment, and energy sectors, as well as AI-based solutions. These efforts target improving citizen security, disaster response, and enhancing existing public facilities. Despite these ambitions, resident preferences for tourism facilities and lower evaluations of energy-related amenities indicate potential disparities in policy goals and directions between public and private entities (Oh, 2020; Smart City Korea, 2021). Both cities recognized the potential of smart technology to address urban decay and foster sustainable development. The Korean government's enactment of the "Special Act on the Promotion of and Support for Urban Regeneration Act" in 2013 marked a significant step toward urban revitalization (Kim et al., 2020). This led to a slew of urban regeneration projects, aimed at integrating technology and smart solutions to create vibrant and efficient urban areas (Kim et al., 2020). Pohang's case is particularly noteworthy, as it showcases the city's endeavor to transform into a smart city by integrating information and communication technologies into various sectors (Oh, 2020; Smart City Korea, 2021).

3.2.4 Alignment with Smart City Concepts

Strategies	Alignment with Smart City Concepts	Importance and Benefits
Sustainability and Efficiency	Integration of smart technologies and infrastructure in projects for optimized resource use, enhanced urban efficiency, and sustainable growth.	Reduced resource consumption. Improved urban efficiency. Fosters sustainable development.
Community Engagement	Use of smart solutions to encourage citizen participation and engagement, promoting inclusivity and informed decision-making.	Empowered citizenry. Increased civic participation. Nurtures community cohesion.
Innovation and Economic Growth	Embrace of technology to attract businesses, entrepreneurs, and tourists, stimulating economic growth and fostering innovation.	Enhanced local economy. Expanded entrepreneurial opportunities. Catalyses innovation.
Infrastructure Enhancement	Implementation of IoT and AI technologies to enhance city services, bolster public safety, and fortify disaster response capabilities.	Improved service delivery. Strengthened public safety. Enhanced disaster management.

Gaps	Considerations and Mitigation	Implications and Risks
Public-Private Alignment	Addressing discrepancies between public and private entities' goals through improved alignment and communication.	Misaligned priorities may hinder project success.
Equitable Development	Ensuring the equitable distribution of benefits, especially to marginalized communities, through policy interventions.	Unequal distribution could exacerbate disparities.

3.3 Theoretical framework

The theoretical framework underlying this study encompasses four theories: Communicative Theory, Just City Theory, Modernization Theory, and New Urbanism Theory. Grant and Osanloo (2014) define theoretical frameworks as essential components relying on formal theory and philosophical thinking. Urban regeneration, often referred to as a theory, seeks to address urban decay and changes in the urban form, influenced by planning discussions and community involvement (Roberts, 2000). Communicative Theory emphasizes communication processes in urban development, with a focus on public participation (van Ruler, 2018). Just City Theory promotes equity in spatial relations and advocates for marginalized voices (Fainstein, 2000, 2005), while Modernization Theory examines societal development and can lead to gentrification (Goorha, 2017; Yeh, 1989; Ghertner, 2013). New Urbanism Theory, emerging in the 1980s, aims to combat urban sprawl and enhance community cohesion (Dwamena, 2015), but faces challenges related to spatial disparities and private development (Fainstein, 2000). These theories shape the study's exploration of urban regeneration's impact on social inclusion, spatial disparities, and the balance between private interests and societal benefits. Below is a table indicating the theoretical framework to assess the study area:

Theoretical Framework	Key Concepts	Implications for Study Area
Communicative Theory	Public participation, democracy	Investigate community engagement in planning and decision-making processes to ensure equitable urban regeneration.
Just City Theory	Equity, spatial relations	Analyze how urban regeneration initiatives address spatial inequalities and promote social inclusion.
Modernization Theory	Social evolution, development	Examine the effects of economic growth-focused urban regeneration on social issues and property ownership patterns.
New Urbanism Theory	Community, mixed uses	Evaluate the success of new urbanism-inspired plans in creating livable, cohesive communities in the study area.

4 STUDY AREA

The city of Pietermaritzburg is located within the province of Kwa-Zulu Natal, along the N3 national road. The study area serves as the capital city in the province and sits within u-Msunduzi Municipality. Furthermore, the study area is located within the CBD of Msunduzi municipality known as the CACEN plan. The inner city of Msunduzi is dealing with challenges such as incompatible land uses regarding economic and social development (Msunduzi Spatial Development Framework, 2015). map 1 showing location of the study area within the inner city which is Pietermaritz and Downtown Street identified as experiencing high levels of urban decay.
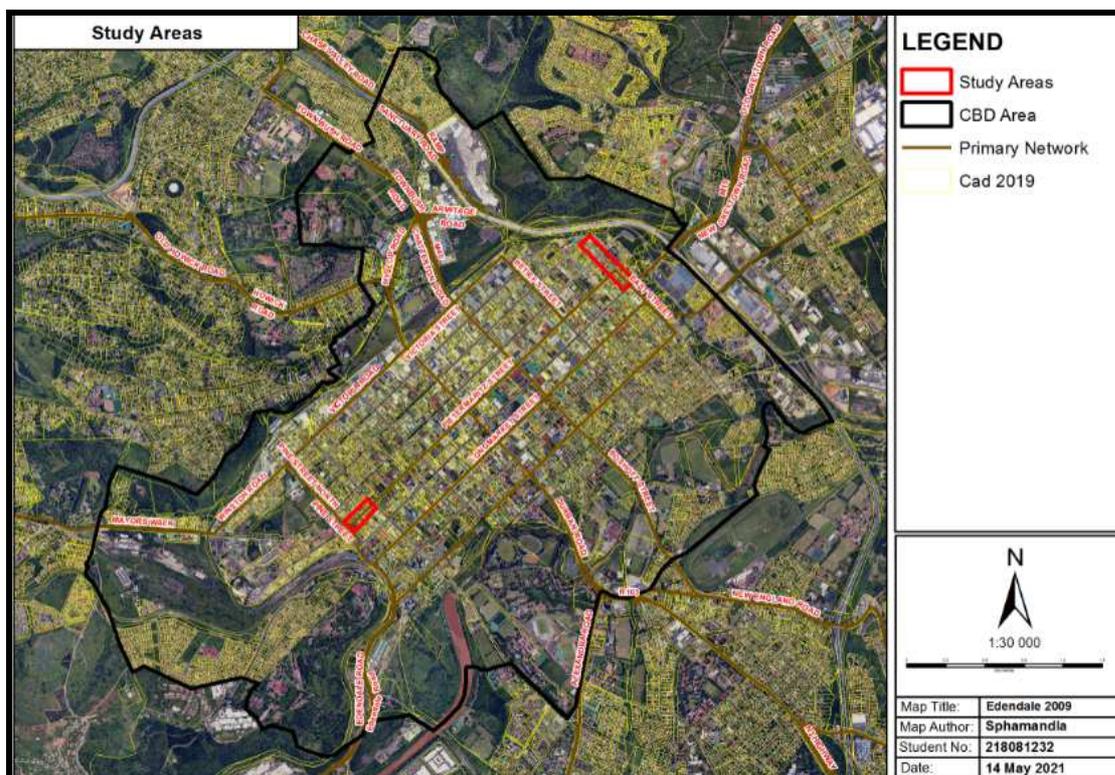
Map 1 Location of study area within Inner city of Msunduzi

5 RESEARCH METHODOLOGY

The researchers have adopted a research methodology that encompasses both exploratory and descriptive elements. This choice is driven by the scarcity of studies on urban regeneration in the city of PMB, coupled with a specific emphasis on integrating smart city and sustainability concepts. To address these gaps, the study employs a descriptive qualitative case study approach, which involves comparing how other international and local cities have tackled similar challenges. To gather relevant information and perspectives on urban regeneration in Msunduzi Municipality, the researchers employ qualitative primary data collection instruments. These include making observations and conducting open-ended interview questionnaires with 30 municipal officials during October 2022. Through these methods, the researchers have gathered valuable insights and data on the subject matter.

6 DISCUSSIONS ON URBAN REGENERATION IN MSUNDUZI MUNICIPALITY

Based on the data gathered from 30 interview questionnaires conducted in October 2022, the study collected information from various municipal departments within Msunduzi Municipality. The participants were asked about their perceptions regarding urban decay in the area, the factors contributing to this problem, and their recommendations for the municipality to address it. The participants' views were sought on whether they believed that smart city development could help improve the state of urban decay in the area.
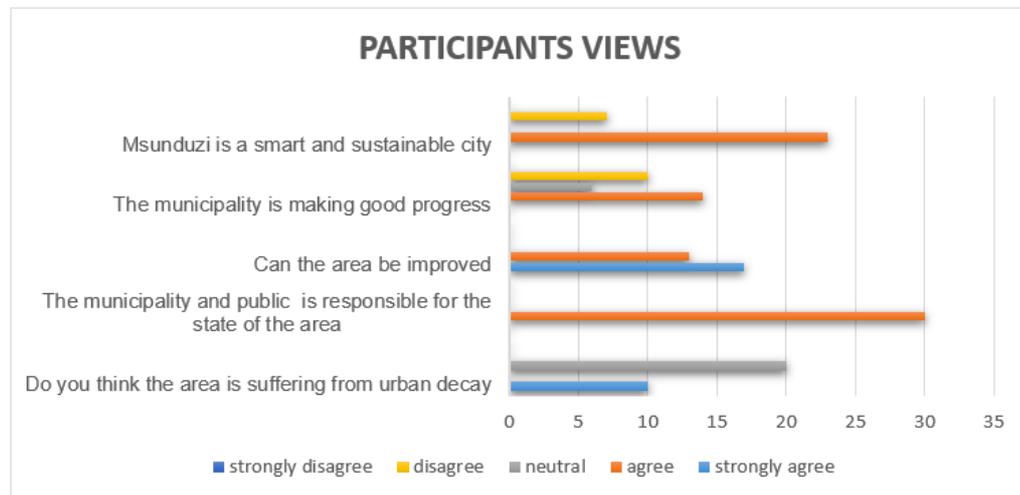
Out of the 30 officials who responded to the questionnaires, a significant portion of 10 officials strongly agreed that the area is indeed experiencing urban decay. Their agreement indicates that they perceive several underlying problems in the area, including the violation of municipal bylaws, an alarming rise in poverty and crime rates, the presence of drug addicts residing within the city, and inadequate management of buildings. This consensus among the officials highlights their recognition of the multifaceted nature of urban decay and the various factors contributing to it. All 30 authorities unanimously acknowledged that both the municipality and the public share responsibility for the current state of the area. This collective acknowledgment emphasizes the officials' awareness of the importance of involving the general population in concerted efforts to address and resolve the concerns related to urban deterioration. It signifies their understanding that effective solutions require collaborative actions and engagement from multiple stakeholders.

Regarding the potential for improvement, 13 respondents expressed agreement, while 17 of them strongly agreed that the area has the capacity for positive change. This consensus among policymakers indicates their belief that with appropriate strategies and interventions, the situation can be improved. It highlights their optimism and confidence in the possibility of implementing effective measures to reverse the urban decay trends in the area. However, opinions among the officials were not entirely unanimous. While 14 officials expressed that the municipality is progressing well in addressing urban decay, 10 others disagreed. This discrepancy suggests the existence of divergent perspectives and varying assessments regarding the advancements being made. It also implies that there may be room for improvement in certain areas or aspects of the municipality's efforts to combat urban decay. While 7 respondents disagreed, a significant majority of 23 officials stated that Msunduzi is a wise and sustainable city. This collective viewpoint reflects the

prevailing sentiment among most elected officials who believe that Msunduzi possesses the potential to evolve into a smart and sustainable city. However, the acknowledgment of some dissenting opinions suggests that there may be specific challenges or issues that need to be addressed to translate this potential into a tangible reality.

The responses from the officials indicate their recognition of the existence of urban decay in the area, with an understanding of the underlying problems contributing to it. The unanimous agreement on shared responsibility emphasizes the importance of inclusive approaches to address urban deterioration. The varying perspectives on the municipality's progress and the majority's belief in Msunduzi potential as a wise and sustainable city highlight the need for continuous efforts, collaborative actions, and targeted resolutions to overcome the challenges of urban decay and achieve a thriving and sustainable urban environment.

The officials identified several factors that contribute to the urban deterioration in Msunduzi. These include the disregard for local ordinances, an increase in poverty and crime rates, the presence of drug users in the city, and the mismanagement of structures. Additionally, breaking ordinances can result in environmental damage, health risks, and hazardous situations. The presence of drug users exacerbates the deterioration and leads to further detrimental circumstances, while poverty and crime contribute to a pervasive sense of fear and neglect. The officials also highlighted that poorly maintained buildings, due to a lack of care and upkeep, eventually lead to deterioration and disintegration. To address these problems, the officials proposed potential solutions. One approach is the enforcement of council ordinances to ensure cleanliness, safety, and proper maintenance of the city. By strictly adhering to these regulations, the city can be kept in better condition and prevent further deterioration. Another option is the implementation of ongoing clean-up projects aimed at alleviating environmental deterioration and enhancing the overall image of the city. These projects can contribute to a cleaner and more appealing urban environment.

The officials stressed the importance of working closely with the public to promote awareness about the value of city upkeep and adherence to legislation. By fostering a sense of responsibility and involvement among the citizens, the city can experience positive changes. The officials also recommended regularly monitoring property owners and conducting annual visits to assess whether they are adequately maintaining their properties. This proactive approach ensures accountability and encourages property owners to take proper care of their buildings. According to the officials, urban regeneration in Msunduzi can be enhanced through smart and sustainable city development. However, this requires the municipality to undertake ongoing, creative infrastructure-maintenance initiatives. By embracing innovative approaches, the municipality can effectively address the challenges of urban decay and facilitate positive change.

In order to carry out urban renewal in Msunduzi, the officials provided several suggestions. One recommendation is to educate the general population about urban planning and the importance of maintaining a sustainable city. This entails raising awareness about the value of abiding by the law, taking care of one's property, and actively participating in clean-up initiatives. Additionally, promoting local economic development was highlighted as a strategy to address urban decay. This can be achieved by encouraging investment, boosting tourism, and providing support to small enterprises, ultimately leading to job creation and city expansion. The officials also emphasized the need for collaboration among different agencies to overcome the challenges of urban development in Msunduzi. This underscores the importance of coordination and cooperation between various municipal entities to ensure the effective and efficient utilization of resources. By working together, these agencies can provide comprehensive solutions to the multifaceted problems faced by the city.

7 FINDINGS AND LESSONS LEARNT

The findings from the study conducted in Msunduzi Municipality reveal that:

(1) Urban Decay Existence: The study confirms the presence of urban decay in the area, as indicated by the consensus among officials, with a significant number strongly agreeing with this assessment. This finding highlights the urgent need for interventions to address the deteriorating state of the city.

(2) Multiple Factors Contributing to Urban Decay: The officials identified several factors contributing to urban decay, including violations of municipal bylaws, increasing poverty and crime rates, the presence of drug users, and poorly managed buildings. These findings underscore the complex and interconnected nature of urban decay, emphasizing the importance of addressing multiple challenges simultaneously.

(3) Shared Responsibility: All officials unanimously recognized that both the municipality and the public share responsibility for the current state of urban decay. This finding emphasizes the need for collaboration and engagement between the local government and the community to effectively tackle the problem. It highlights the importance of inclusive approaches that involve multiple stakeholders in finding and implementing solutions.

(4) Belief in Potential for Improvement: The majority of officials expressed their belief in the potential for positive change in the area. This optimism suggests that officials are hopeful and motivated to implement effective strategies and interventions to reverse the urban decay trends. It underscores the importance of maintaining a positive outlook and actively seeking solutions to address urban decay challenges.

(5) Divergent Perspectives on Progress: While some officials expressed confidence in the municipality's progress in addressing urban decay, others disagreed. This finding reveals the existence of differing opinions and assessments regarding the advancements being made. It highlights the importance of ongoing evaluation, transparency, and continuous improvement in the municipality's efforts to combat urban decay.

(6) Potential for Smart and Sustainable City Development: The officials recognized the potential of smart and sustainable city development to improve the urban decay situation. This finding emphasizes the significance of adopting innovative approaches, incorporating technology, and ensuring long-term sustainability in urban planning and development initiatives.

8   ASSESSMENT OF THE STUDY AREA THROUGH THEORETICAL LENS

Theory	Key Concepts	Implications for Study Area
Communicative Theory	Community engagement, participatory planning, collaboration	The officials' unanimous agreement on shared responsibility for urban decay highlights the significance of involving the public in addressing urban deterioration. Collaborative approaches that consider citizens' voices and perspectives can lead to more effective and sustainable solutions.
Just City Theory	Equity, social inclusion, spatial relations	The officials' recognition of factors contributing to urban decay, such as poverty, crime, and mismanagement, resonates with the principles of the Just City Theory. Addressing spatial inequalities and promoting social inclusion through urban regeneration initiatives can foster a more equitable and thriving city environment.
Modernization Theory	Social evolution, economic growth, development, property ownership	The officials' identification of factors like poverty, crime, and mismanagement as contributors to urban decay reflects the complexities described by Modernization Theory. The theory's critique of economic growth-focused policies and their potential effects on social issues is relevant to the study area, where addressing urban decay requires a balance between development and social well-being.
New Urbanism Theory	Community, mixed uses, sustainable development, social cohesion	The officials' recommendations for collaborative actions, public involvement, and integration of local economic development align with New Urbanism Theory. This theory emphasizes creating cohesive, mixed-use communities through sustainable development approaches. Implementing mixed-use areas, promoting local businesses, and fostering community cohesion can contribute to urban regeneration in the study area.

9   ASSESSMENT OF THE STUDY THROUGH THE LENS OF CASE STUDIES

As per the case studies explored regrading smart technology for urban regeneration to combat the issue of urban decay, an implementation plan for Msunduzi Municipality has been established:

Urban Decay	Smart Technology	How It Addresses Urban Decay
Deteriorating Infrastructure	Smart Infrastructure Monitoring	Utilize IoT sensors and data analytics to monitor the condition of roads, bridges, and public facilities. Detect issues early, enabling prompt maintenance and reducing urban decay.
Inadequate Security	Smart Surveillance Systems	Install smart cameras with AI-powered anomaly detection for real-time security monitoring. Enhance public safety, deter crime, and create a safer urban environment.
Lack of Community Engagement	Smart Citizen Engagement Platforms	Develop mobile apps and online platforms for citizens to report issues, provide feedback, and participate in urban planning. Increase community involvement and empowerment.
Economic Decline and Unemployment	Innovation and Entrepreneurship Promotion	Create innovation hubs and incubators to support local entrepreneurs. Foster economic growth, create jobs, and attract investments to revitalize urban economy.
Poor Waste Management	Smart Waste Management Solutions	Implement IoT-enabled bins for efficient waste collection. Monitor fill levels and optimize routes, reducing litter, environmental hazards, and overall urban decay. (This should be communicated between spatial planning and waste management departments).
Neglected Public Spaces	Smart Public Space Management	Deploy sensors and smart lighting to enhance public space usability and safety. Create vibrant, well-maintained spaces that encourage community gatherings and activities.

10 CONCLUSIONS AND RECOMMENDATIONS

Urban decay is a pervasive issue plaguing Pietermaritzburg and other cities, manifesting in the deterioration of buildings and spaces within the city center. The study conducted in Msunduzi Municipality has provided valuable insights into the presence of urban decay in the area, as officials have identified a range of contributing factors. Neglect, high crime rates, and limited economic assistance are among the key drivers of

this decay. The findings emphasize the shared responsibility that both the municipality and the public bear in addressing and mitigating urban decay, emphasizing the necessity of collaborative approaches. Despite variations in opinions regarding the progress made thus far, officials exhibit a sense of optimism and hold firm belief in the potential for improvement. This research holds promise in shaping the future of urban regeneration in Pietermaritzburg and beyond. The insights gleaned provide a solid basis for informed decision-making, policy formulation, and strategic planning. In Pietermaritzburg's journey towards becoming a smart, sustainable city, the lessons learned and recommendations provided in this study serve as a roadmap for policymakers, urban planners, and community stakeholders to collaborate effectively. The officials involved in the study have put forth several recommendations to address the urban decay situation in Msunduzi Municipality. These recommendations aim to tackle the identified factors contributing to the decay and pave the way for a more sustainable and thriving urban environment.

(1) Enforce Council Ordinances: One of the recommendations is to strengthen the enforcement of council ordinances. By ensuring strict compliance with local regulations, the municipality can promote cleanliness, safety, and proper maintenance throughout the city. This step is essential in curbing activities that contribute to urban decay, such as violations of bylaws and disregard for regulations.

(2) Implement Ongoing Clean-up Projects: The officials suggest the implementation of ongoing clean-up projects aimed at addressing environmental deterioration. These projects can help improve the overall image of the city and alleviate the negative impact of decay. By actively engaging in initiatives that promote cleanliness and environmental stewardship, the municipality can create a more appealing and vibrant urban landscape.

(3) Promote Public Awareness and Participation: The officials emphasize the importance of working closely with the public to promote awareness of the value of city upkeep and adherence to legislation. By fostering a sense of responsibility and involvement among residents, the municipality can enhance community ownership and engagement in maintaining the city's well-being. This recommendation highlights the significance of education campaigns, public outreach programs, and community-based initiatives.

(4) Monitor Property Owners and Maintenance: The officials recommend regular monitoring of property owners and conducting annual visits to assess the maintenance of their properties. This proactive approach ensures accountability and encourages property owners to take proper care of their buildings. By holding property owners accountable for maintaining their properties, the municipality can prevent further decay and deterioration.

(5) Embrace Smart and Sustainable City Development: The officials recognize the potential of smart and sustainable city development in addressing urban decay. They suggest that the municipality should embrace innovative approaches and creative infrastructure-maintenance initiatives. By incorporating technology, sustainable practices, and long-term planning, the municipality can foster positive change and improve the overall urban environment.

(6) Collaborate with Multiple Agencies: To overcome the challenges associated with urban development and regeneration, the officials recommend fostering collaboration among different municipal agencies. This emphasizes the need for coordination and cooperation between various entities responsible for urban planning, infrastructure, public safety, and social services. By working together, these agencies can pool their resources, expertise, and efforts to provide comprehensive solutions to the complex issues of urban decay.

11 REFERENCES

Alias, A. Zyed, Z, and Chai, W.W. (2016). Revitalising critical components of urban decay features. Journal of building performance. Available: http://spaj.ukm.my/jsb/index.php/jbp/index

Amanzimtoti CBD Node Regeneration Plan. (2011). Vision and conceptual framework report. Available: www.durban.gov.za

Amsler, S.T. 2011. A study of urban waterfront revitalisation as a catalyst for real estate development: Porto Maravilha, the redevelopment of Rio de Janeiro' historic downtown port district. New York: Columbia University.

Arata III, H.J and Hale, B.L. (2018). The Cyber Defence Review. Available: http://www.jstor.org/stable/26427377.

City of Victoria. (2017). Official Community Plan: Section 20 Local Area Planning. Available: https://www.victoria.ca/assets/Departments/Planning~Development/Community~Planning/OCP/Replaced/OCP_Sec20_Jul2017_web.pdf (Accessed 25 March 2021).

Couch, C. Skyes, O. and Borstinghaus, W. (2011). Thirty years of urban regeneration in Britain, Germany, and France: the importance of context and path dependency. Available: www.elsevier.com/locate/pplann

Dameri RP (2017) Smart city implementation. Springer, Heidelberg

472

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Dwamena, R.A.2015. The Role of urban regeneration initiatives in the creation of sustainable inner cities: a case study of the Durban Point regeneration initiative. Master in Town and Regional Planning: University of KwaZulu-Natal.

eThekwini City Density Strategy. (2013). Available: www.durban.gov.za

eThekwini draft integrated inner-city local area plan and draft Warwick precinct. (2016). Available: www.durban.gov.za

eThekwini Inner City LAP. (2016). Available: www.durban.gov.za

eThekwini Metropolitan Municipality. (2016). eThekwini Inner City Local Area Plan. Durban: eThekwini Metropolitan Municipality.

Galati SR (2018) Funding a smart city: from concept to actuality. In: Smart cities. Springer, Cham, pp 17–39

Ghertner, A.S. 2013. India's urban revolution: geographies of displacement beyond gentrification. Environment and Planning, 46(A2014): 1554 – 1571.

Hak, T. Janouskova, S. and Moldan, B. (2015). Sustainable development goals: a need for relevant indicators. Available: www.elsevier.com/locate/ecolind

Mnikathi, Z.P. 2016. An analysis of the socio-economic impact of inner-city urban regeneration as a strategy against urban decline: The Case of Durban Point Precinct Development. Masters of Town and Regional Planning: University of KwaZulu-Natal.

Moura, F. and Silva, J. 2019. Smart Cities: Definitions, Evolution of the Concept and Examples of Initiatives. Switzerland: Springer. Available: https://www.researchgate.net/publication/335239465_Smart_Cities_Definitions_Evolution_of_the_Concept_and_Examples_of_Initiatives/link/5e342c0ca6fdccd9657adad1/download (Accessed 3 December 2021).

Ndlebe, T.A. (2017). Assessing the impact of urban decay on the residential land-uses: the case study of Durban South Beach, South Africa (Masters Thesis). Durban, Kwa-Zulu Natal- University of Kwa-Zulu Natal. Available: https://www.ukzn-dspace.ukzn.ac.za/handle/10413/15866

Chichilnisky, G. (1997). What is sustainable development? Journal on land economics. 73(4) 467-491. Available: https://www.jstor.org/stable/3147240

Cuthbert, A. (2017). Urban decay and regeneration: context and issues. Journal of urban design. Doi: 10.1080/13574809.2017.1288873

Dwamena, R.A.2015. The Role of urban regeneration initiatives in the creation of sustainable inner cities: a case study of the Durban Point regeneration initiative. Master in Town and Regional Planning: University of KwaZulu-Natal.

Fainstein, S. 2005. Planning Theory and the City. Journal of Planning Education and Research, 25, 121-130.

Fainstein, S. 2010. The just city. NY: Cornell University Press.

Fainstein, S. S. 2000. New Directions in Planning Theory. Urban Affairs Review, 35 (4): 451-478.

Ghertner, A.S. 2013. India's urban revolution: geographies of displacement beyond gentrification. Environment and Planning, 46(A2014): 1554 – 1571.

Goorha, P. 2017. Modernization Theory. Oxford Research Encyclopedia of International Studies, October (2017:1-25.

Jawad, W.K. 2019. Case study of Dubai as a Smart City. International Journal of Computer Applications, 178(40):35-37.

Joose, O. (2020). Smart City as a Tool of Citizen-Oriented Urban Regeneration: Framework of Preliminary Evaluation and Its Application. Sustainability, 2020(12-6874):1-20. Available: https://www.mdpi.com/2071-1050/12/17/6874 (Accessed 25 March 2021).

Kim, H.W., McCarty, D.A. and Lee, J. 2020. Enhancing Sustainable Urban Regeneration through Smart Technologies: An Assessment of Local Urban Regeneration Strategic Plans in Korea. Sustainability, 2020 (12): 1-23.

Lee, H. 2019. A Study on the Characteristics of New Towns and the Redevelopment of Project-Cancelled Areas: A Case Study of Seoul, South Korea. Sustainability, October (2019): 1-18.

Lee, H. 2019. A Study on the Characteristics of New Towns and the Redevelopment of Project-Cancelled Areas: A Case Study of Seoul, South Korea. Sustainability, October (2019): 1-18.

Msunduzi Municipality. (2012). Terms of reference. Preparation of Local Area Plans and Allied Planning Work for Central Area and CBD Extension Node. Pietermaritzburg: Msunduzi Municipality.

Msunduzi Municipality. (2015). Msunduzi Municipality Spatial Development Framework. Pietermaritzburg. Msunduzi Municipality.

Rabari, C. and Storper, M. (2015). The Digital Skin of Cities: urban theory and research in the age of the censored and metered city, ubiquitous computing and big data. Cambridge J Regions Econ Soc, 8 (1): 27-42. Available: https://academic.oup.com/cjres/article/8/1/27/304079/The-digital-skin-of-cities-urban-theory (Accessed 25 March 2021).

Roberts, P. 2000. The evolution definition and purpose of urban regeneration. In P. S. Roberts, urban regeneration (First Edition ed.). London: Saga publication.

Roberts, P. 2000. The evolution definition and purpose of urban regeneration. In P. S. Roberts, urban regeneration (First Edition ed.). London: Saga publication.

Van Ruler, B.2018. Communication Theory: An Underrated Pillar on Which Strategic Communication Rests. International Journal of Strategic Communication, 12(4):367-381.

Land l(i)eben – künftig alles smart? Chancen und Herausforderungen der digitalen Transformation für regionale Entwicklung am Beispiel des Landkreises Kusel

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1 ABSTRACT

Die Digitalisierung ist einer der globalen Megatrends des laufenden Jahrhunderts. Deutschland hat im europäischen Vergleich einen großen Nachholbedarf hinsichtlich der Digitalisierung des öffentlichen Sektors, der Wirtschaft und der Gesellschaft. Im Jahr 2022 lag der Digitalisierungsgrad in Deutschland laut DESI-Index bei 52,88 und damit knapp über dem EU-Durchschnitt von 52,28. Führende Länder wie Finnland oder Dänemark sind mit Werten von fast 70 weit voraus[1]. Nicht zuletzt aus diesem Grund fördert das Bundes-ministerium für Wohnen, Stadtentwicklung und Bau (BMWSB) sog. "Modellprojekte Smart Cities (MPSC)". Gefördert werden kommunale, interdisziplinäre, räumliche Smart-City-Strategien und deren Umsetzung sowie die notwendigen Kapazitäten in den Kommunen. Die Kommunen werden dabei unterstützt, sich auf die digitale Transformation einzustellen und die damit verbundenen Chancen zu nutzen. Der größte Anteil der geförderten "Smart Cities" sind Groß- und Mittelstädte. "Smart Regions" in Form von interkommunalen Verbünden oder Landkreisen, die in ländlichen Regionen liegen, werden von dem Förderprogramm kaum erfasst. Dabei kann gerade für Kommunen in ländlichen Regionen die Digitalisierung ein wichtiger Ansatzpunkt zur Verbesserung der Lebensqualität sein.[2] Dennoch ist die Digitalisierung im ländlichen Raum mit anderen Herausforderungen verbunden als in Städten: Neben der nach wie vor bestehenden Herausforderung der Verfügbarkeit von leistungsfähigen Internetzugängen im ländlichen Raum, stellen die begrenzten Kapazitäten bzw. die Fragmentierung der öffentlichen Verwaltungen und eine im Vergleich zur städtischen Bevölkerung verbreitete skeptischere Haltung der Bevölkerung gegenüber digitalen Angeboten weitere Herausforderungen im ländlichen Raum dar.

Der vorliegende Beitrag konzentriert sich daher auf die bisherigen Fortschritte des Landkreises Kusel als eines der wenigen ausgewählten Modellprojekte für eine Smart Region im Rahmen des Programms. Mit nur 69.949 Einwohnerinnen und Einwohnern ist er einer der kleinsten und mit 122 Einwohnerinnen und Einwohnern pro km² auch einer der am dünnsten besiedelten Landkreise in Deutschland. Mit seinen 98 Ortsgemeinden ist er sehr ländlich geprägt, in den meisten Ortsgemeinden leben weniger als 500 Einwohner.[3] Mit der Teilnahme am Förderprogramm verfolgt der Landkreis Kusel das Ziel, durch die Digitalisierung eine positive und nachhaltige Entwicklung in der Region zum Wohle der dort lebenden und arbeitenden Menschen zu bewirken. Das Förderprogramm gliedert sich in zwei Phasen: die Strategie- und die Umsetzungsphase, wobei sich Kusel derzeit in der Übergangsphase zwischen beiden Phasen befindet.Die Digitalisierung soll in mehrfacher Hinsicht genutzt werden: (1) zur Digitalisierung der Beteiligung aller relevanten Akteurinnen und Akteuren und der Bevölkerung am Strategie-entwicklungsprozess, (2) zur laufenden Kommunikation und zum Austausch über Vorhaben und Projekte der öffentlichen Hand mit Akteurinnen, Akteuren, Bürgerinnen und Bürgern, (3) zur Verbesserung der Verfügbarkeit, der Erfassung, des Austauschs und der Visualisierung von Daten in der öffentlichen Verwaltung, (4) zur Vereinfachung des Verwaltungshandelns und (5) zur Digitalisierung von Dienstleistungen zur Sicherung der Daseinsvorsorge.

Im Mittelpunkt dieses Beitrags steht die Analyse des Strategieprozesses auf dem Weg zur „Smart City Kusel" im Hinblick auf

- die Herausforderungen der Gestaltung des Digitalisierungsprozesses in einem ländlichen Landkreis in allen Handlungsfeldern,

- die Ansätze zur Gestaltung des Prozesses hin zu einer smarten Region und

- erste Ansätze für smarte Maßnahmen zur nachhaltigen Entwicklung des Landkreises.

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[1]STATISTA (2022)
[2]WIEDMANN/KLUG (2021)
[3]STATISTISCHES LANDESAMT RHEINLAND-PFALZ(2022)

Keywords: digitaler Wandel, Digitalisierung im ländlichen Raum, smart region, Daseinsvorsorge, Raumplanung

2 DIGITALISIERUNG UND SMART CITY IN DEUTSCHLAND

Die Digitalisierung ist allgegenwärtig – Smart-City-Konzepte sind längst fester Bestandteil im Kontext von Stadt- und Raumentwicklung. Doch gehen mit dem digitalen Wandel nicht nur Entwicklungspotenziale, sondern auch strukturelle wie gesellschaftliche Herausforderungen einher. Das Konzept der Smart City versucht die mit diesem Trend verbundenen Chancen aufzugreifen. Im Hinblick darauf bewegt sich die Smart City im Spannungsfeld zwischen Chancen zum Lösen von Herausforderungen (z.B. im Bereich der Daseins-vorsorge) und Risiken durch das Aufkommen digitaler Kluften oder im Bereich der Datennutzung und Kontrollierbarkeit.[4] Im nächsten Schritt werden die Dimensionen, Chancen und Risiken des digitalen Wandels sowie die Initiierung und Etablierung von Smart-City-Konzepten in Deutschland aufgezeigt.

2.1 Digitaler Wandel

Der digitale Wandel bezieht sich auf die Veränderungen, die durch den Einsatz digitaler Technologien in verschiedenen Bereichen der Gesellschaft, der Wirtschaft und des täglichen Lebens hervorgerufen werden. Er umfasst die Transformation von analogen oder traditionellen Prozessen, Methoden und Strukturen in digitale Formen. Die Digitalisierung hat dabei einen tiefgreifenden Einfluss auf viele Bereiche, darunter Kom-munikation, Bildung, Gesundheitswesen, Handel, Industrie, Unterhaltung und vieles mehr. Durch den Einsatz digitaler Technologien wie Computer, Internet, Mobilgeräte, künstliche Intelligenz, Big Data, Cloud Computing oder das Internet der Dinge („Internet oft hings" - IoT) werden neue Möglichkeiten geschaffen, um Informationen zu erfassen, zu verarbeiten, zu speichern und zu teilen.[5]

Die Digitalisierung und der digitale Wandel sind daher auch mit erheblichen Auswirkungen auf die Raumentwicklung verbunden. Im Kontext der Raumentwicklung beziehen sich diese Begriffe auf den Einsatz digitaler Technologien, die mögliche Veränderung räumlicher Bewegungsmuster und den damit verbundenen Auswirkungen auf die Art und Weise, wie Städte und Regionen geplant, entwickelt und verwaltet werden.[6] Hinsichtlich der Kompetenzen und Tätigkeitsfeldern von Stadt- und Regionalplanerinnen sowie Stadt- und Regionalplanern sind durch den digitalen Wandel Veränderungen zu erwarten: Das Zentrale-Orte-Konzept bedarf einer digital-angepassten Neuinterpretation, Abläufe und Verfahren formeller Instrumente gilt es weiterzu-entwickeln und nicht zuletzt ist ein zusätzlicher Kompetenzaufbau für den Umgang mit Daten und den Einsatz digitaler Medien erforderlich.[7]

Ein wichtiger Aspekt der Digitalisierung in der Raumentwicklung ist die Erfassung und Analyse großer Datenmengen. Durch den Einsatz von Sensoren, Geoinformationssystemen und anderen digitalen Technologien können umfangreiche Daten über den Zustand eines Raumes, seine Nutzungund viele andere Faktoren gesammelt werden. Durch Analyse dieser Daten können Erkenntnisse und Informationen gewonnen werden, die in die Planungs- und Entscheidungsprozesse einfließen und Entscheidungsträgerinnen und Entscheidungsträger unterstützen können.Dabei müssen die Wirkungen auf die einzelnen Phasen solcher Prozess differenziert betrachtet werden, um ein angemessenes Verhältnis zwischen Chancennutzen und Risikobegrenzung zu erreichen.[8] Denn ein „[...] Mehr an Daten und Informationen führt nicht ohne Weiteres zu ‚besseren' Planungsergebnissen [...]"[9].

Darüber hinaus ermöglichen digitale Technologien neue Formen der Bürgerbeteiligung und des Engagements. Durch Online-Plattformen, soziale Medien und andere digitale Werkzeuge können Bürgerinnen und Bürger aktiv in die Planung und Entwicklung von Projekten einbezogen werden. Dies fördert eine breitere Partizipation und ermöglicht eine stärkere Berücksichtigung verschiedener Interessen und Bedürfnisse. Dabei ist jedoch zu beachten, dass eine rein digitale Beteiligung auch zum Ausschluss einzelner Bevölkerungsgruppen führen kann – unabhängig ihres Ausschlussgrunds (z.B. fehlende Affinität

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[4] vgl. WEITH (2020), S. 415
[5] vgl. BMWK (2022)
[6] vgl. ARL (2022), S. 3
[7] vgl. SPELLERBERG (2021), S. 5
[8] vgl. ARL (2022), S. 13
[9] ARL (2022), S. 13

aufgrund von Alter, sozialer Ausschluss oder Gegenkulturder sog. „Offliner"[10]). Gleichzeitig ist ein Anstieg der Ansprüche an Planungsprozesse in Bezug auf Mitwirkung und Transparenz verbunden.[11]

Insgesamt bieten die Digitalisierung und der digitale Wandel in der Raumentwicklung viele Chancen, um Städte und Räume effizienter, nachhaltiger und lebenswerter zu gestalten. Gleichzeitig sind jedoch auch Herausforderungen zu bewältigen, wie der Schutz der Privatsphäre und die Sicherheit digitaler Infrastrukturen. Die erfolgreiche Integration digitaler Technologien erfordert daher eine ganzheitliche und abgestimmte Herangehensweise, bei der verschiedene Akteurinnen und Akteuren aus dem Bereich der Stadt- und Regionalentwicklung, der Technologie und der Bürgerschaft zusammenarbeiten.

2.2 Smart-City-Konzept und Förderung in Deutschland

Die Idee der Smart City geht mit der Nutzbarmachung digitaler Technologien einher und stellt zugleich eine Reaktion auf die wirtschaftlichen, sozialen und politischen Herausforderungen (u.a. Nachhaltigkeits-bewegung) dar, mit denen postindustrielle Gesellschaften um die Jahrtausendwende konfrontiert sind. Das Konzept hat seine Ursprünge in den 1990er Jahren und wurde von verschiedenen Akteurinnen und Akteuren und Entwicklungen geprägt.Diese verschiedenen Einflüsse haben dazu beigetragen, das Konzept der Smart City zu formen und die Vision einer vernetzten, technologisch fortschrittlichen und nachhaltigen Stadt zu entwickeln. Es ist wichtig anzumerken, dass das Konzept der Smart City weiterhin wächst und sich weiterentwickelt, da neue Technologien und innovative Ansätze eingeführt werden.Als konzeptionelle Leitvorstellungen der Smart City können

- die Verbesserung der Innovationskraft und Wettbewerbsfähigkeit von Städten als Produktions- und Dienstleistungsstandorte,

- die Verbesserung der Energie- und Ressourceneffizienz von Gebäuden, Infrastrukturen, städtischer Mobilität oder Produktionsprozessen,

- die Optimierung der Verträglichkeit von Funktionen sowie der Anpassungs- und Reaktionsfähigkeiten urbaner Systeme (insbesondere Infrastrukturen),

- die Sicherung der sozialen Versorgung der Bevölkerung (Ausbildung, Bildung, Gesundheit, Sicher-heit) und Verbesserung der sozialen Teilhabe sowie

- die Verbesserung von Steuerungs- und Koordinationsprozessen in und zwischen Politik, Verwaltung und Dienstleistungen (Smart Governance und Smart Government)identifiziert werden.[12]

In der deutschen Smart-City-Charta wird folgende Zielstellung formuliert: „Smarte Technologien sollen dazu beitragen, Ressourcen zu schonen, Mobilität umweltverträglicher zu machen, für mehr Inklusion und Mitwirkung zu sorgen oder neue Geschäftsmodelle zu ermöglichen. Digitalisierung ist […] kein Selbstzweck, sondern ein Instrument, um kommunale Ziele zum Wohle der Gemeinschaft zu erreichen."[13] Die Handlungs-felder umfassen dabei je nach Verständnis und Interpretation zahlreiche Themenbereiche. Im deutschen Sprachraum häufig zitiert sind die sechs von der TU Wien identifizierten Dimensionen einer Smart City: smart economy, smart mobility, smart environment, smart people, smart living sowie smart governance.[14]

Es bestehen international und national zahlreiche finanzielle Fördermittel zur Umsetzung von Smart-City-Konzepten – häufig angestoßen, durchgeführt oder unterstützt durch private IT-Unternehmen.[15] Die hohe Anzahl unterschiedlicher Fördermittelprogramme resultiert u.a. daraus, dass Städte in zahlreichen Ländern in ihrer Stadtentwicklung über ein hohes Maß an Selbstbestimmung verfügen. In Deutschland manifestiert die Selbstverwaltungsgarantie (Art. 28 Abs. 2 GG) die kommunaleSelbstverwaltung von Kommunen. Föderale Ebenen (bspw. der Bund) können daher nur Anreize schaffen, um auf eine Stadt- oder Regionalentwicklung im Sinne einer Smart City/Region hinzuwirken bzw. durch Förderungen deren Handlungsfähigkeit stärken.Im Sinne einer nachhaltig-integrierten Entwicklung fördert die Bundesregierung seit dem Jahr 2019

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[10]vgl. CACHELIN (2017), S. 1043 ff.
[11]vgl. ARL (2022), S. 14
[12]vgl. LIBBE (2018), S. 431
[13]BBSR/BMI (2021), S. 5
[14]vgl. LIBEE (2018), S. 432
[15]vgl. DAMM/SPELLERBERG (2021), S. 63

insgesamt 73 Modellprojekte mit 820 Millionen Euro in drei Staffeln. Die jüngste Förderrunde mit einem Fördervolumen von 300 Millionen Euro für 28 Modellprojekte bei94 Bewerbungen startete im Jahr 2021.Hinsichtlich der Größe und administrativen Zuordnung werden bislang 27 Großstädte, zwölf mittlere Städte, zehn Kleinstädte und Landgemeinden sowie 24 interkommunale Kooperationen und Landkreise als Modellprojekte gefördert – ein Großteil dieser ist im städtischen oder im erweiterten städtischen Raum zu verorten.[16]

Die Förderung eines Modellprojekts umfasst dabei kommunale, fachübergreifende und raumbezogene Smart-City-Strategien, deren Umsetzung und den dafür notwendigen Kompetenzaufbau in den Modellkommunen. Ziel des Förderprogramms ist es, „die im Rahmen der Modellprojekte entwickelten Lösungen sicher, interoperabel und übertragbar zu gestalten und dabei die finanziellen und personellen IT Ressourcen in den Kommunen möglichst effizient zu nutzen"[17]. Die eingerichtete „Koordinierungs- und Transferstelle/Modell-projekte Smart Cities" ist mit der fachlichen Begleitung und dem Wissenstransfer zur Digitalisierung und Stadtentwicklung beauftragt. Mit der entwickelten Nationalen Dialogplattform Smart Cities wurde zudem ein Vernetzungs- und Austauschformat für die Modellprojekte sowie Expertinnen und Experten aus Gemeinden, Städten und Kreisen, Politik, Wissenschaft, Wirtschaft sowie der Zivilgesellschaft geschaffen.[18]

2.3 Herausforderungen der Digitalisierung im ländlichen Raum

Der digitale Wandel und die Digitalisierung bringen speziell im ländlichen Raum (häufig in Verbindung mit Strukturschwäche, geringerer Siedlungsdichte, Bevölkerungsrückgang) eine Reihe von Herausforderungen mit sich, die sich von denen urbaner Räume unterscheiden.[19] Als für diesen Beitrag relevant aufzuführen sind an dieser Stelle…

- die unzureichende Infrastruktur für Breitband-Internetzugang: Viele ländliche Gebiete verfügen immer noch nicht über eine schnelle und zuverlässige Internetverbindung, was die Umsetzung digitaler Technologien und Dienstleistungen erschwert.

- der Mangel an Fachkräften im Bereich der Informationstechnologie: Es fehlt oft an qualifizierten Arbeitskräften, die über die erforderlichen Fähigkeiten verfügen, um digitale Technologien zu implementieren und zu nutzen.

- die digitale Kluft zwischen Stadt und Land: Viele Menschen im ländlichen Raum haben keinen Zugang zu digitalen Geräten oder fehlende digitale Kompetenzen, um von den Vorteilen der Digitalisierung zu profitieren. Dies kann zu einer sozialen Ausgrenzung führen und den Zugang zu Bildung, Gesundheitsversorgung und anderen wichtigen Dienstleistungen einschränken.

- wirtschaftliche Herausforderungen: Traditionelle Branchen wie Landwirtschaft und Handwerk können durch Automatisierung und digitale Technologien beeinflusst werden, was zu Strukturveränderungen und dem Verlust von Arbeitsplätzen führen kann. Es ist wichtig, Strategien zu entwickeln, um die ländliche Wirtschaft zu diversifizieren und neue digitale Geschäftsmöglichkeiten zu schaffen.

- Fragen der Datensicherheit und des Datenschutzes: Es ist wichtig, angemessene Sicherheits-vorkehrungen zu treffen, um persönliche Daten zu schützen und Cyberkriminalität zu verhindern. Im ländlichen Raum kann dies aufgrund begrenzter Ressourcen und mangelnder technischer Expertise eine besondere Herausforderung darstellen.

Diese Herausforderungen zeigen, dass der digitale Wandel im ländlichen Raum sorgfältig geplant und um-gesetzt werden muss, um sicherzustellen, dass niemand zurückgelassen wird und dass die Vorteile der Digi-talisierung gerecht verteilt werden. Trotz dieser und weiterer Herausforderungen besteht eine unabdingbare Notwendigkeit der Digitalisierung auch im ländlichen Raum. Zunächst soll dadurch das Auseinandertriften zwischen ländlichen und urbanen Räumen abgemildert werden. Diese Aufgabe wird nicht zuletzt durch das Postulat gleichwertiger Lebensverhältnisse in allen Teilräumen in Deutschland deutlich, das im Grundgesetz

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[16] BMWSB (o.J.)
[17] BMWSB (2023)
[18] vgl. BMWSB (2023)
[19] vgl. DAMM/SPELLERBERG (2021), S. 74

in Art. 72 Abs. 2 verankert ist. Die Digitalisierung wird in diesem Zusammenhang (der Diskussion um Werte- und Normenkontexte) als ein vielversprechender Ansatz zur Herstellung gleichwertiger Lebensverhältnisse angesehen.[20]Eine digitale Anbindung ist dabei nicht nur als Grundvoraussetzung Teil der Daseinsvorsorge, sondern bietet auch großes Potenzial zur Gewährleistung bzw. Sicherstellung der Erreichbarkeit andere Bereiche der Daseinsvorsorge. So kann beispielsweise das Zurücklegen großer physischer Entfernungen, die im ländlichen Raum häufig nur mit Hilfe des Individualverkehrs überwunden werden können, durch digitale Alternativen abdingbar werden.[21] Die Herausforderung, Angebote der Daseinsvorsorge für alle Menschen physisch erreichbar zu machen oder diese Angebote zu allen Menschen "nach Hause" bringen zu müssen, wird durch digitale Lösungsansätze abgemildert. So kann durch die Digitalisierung und der Nutzung damit verbundener Chancen gerade im ländlichen Raum ein wichtiger Beitrag zur Gewährleistung der Daseinsvorsorge und Steigerung der Lebensqualität geleistet werden.[22] Oder anders ausgedrückt: Durch die gezielte Steuerung und Nutzung der Digitalisierung auch im ländlichen Raum ist es möglich und erforderlich, „keine Unterschiede in der Smartness zwischen städtischen und ländlichen Regionen zuzulassen"[23].

3 DER LANDKREIS KUSEL AUF DEM WEG ZUR SMART CITY

Zur Verdeutlichung der mit Smart City verbundenen Herausforderungen und Chancen im ländlichen Raum, wird in diesem Beitrag exemplarisch die aktuelle Entwicklung des – als eines der wenigen Modellprojekte für eine Smart Region ausgewählten – Landkreises Kusel dargestellt.

3.1 Rahmenbedingungen, raumstrukturelle Ausgangssituation und Herausforderungen[24]

Der Landkreis Kusel liegt im westlichen Teil des Bundeslandes Rheinland-Pfalz und gehört zur Region Westpfalz. Mit nur 69.949 Einwohnerinnen und Einwohnern ist er einer der kleinsten und mit 122 Einwohnerinnen und Einwohnern pro km² auch einer der am dünnsten besiedelten Landkreise in Deutschland. Im Regionalen Raumordnungsplan Westpfalz IV ist er als ländlicher Raum mit disperser Siedlungsstruktur eingestuft.[25]Mit seinen 98 Ortsgemeinden in drei Verbandsgemeinden ist er sehr ländlich geprägt – in den meisten Ortsgemeinden leben weniger als 500 Einwohnerinnenund Einwohnern. Die Landschaft des Kreises ist geprägt durch das Nordpfälzer Bergland. Hier finden sich ausgedehnte Waldgebiete sowie zahlreiche Wiesen, Felder und landwirtschaftlich genutzte Flächen.Im Zentrum des Landkreises, angebunden an die Bundesautobahn A62 und eine regionale Bahnstrecke, liegt die Kreisstadt Kusel, die zugleich die größte Stadt des Kreises ist. Gemeinsam mit der Stadt Lauterecken bildet sie einen mittelzentralen Verbund kooperierender Zentren. Als Grundzentren ausgewiesen sind die Gemeinden Wolfstein (VG Lauterecken-Wolfstein) sowie Glan-Münchweiler, Schönenberg-Kübelberg und Waldmohr (VG Oberes Glantal).[26]Zahlreiche Herausforderungen ergeben sich bereits durch die räumliche Ausprägung der Siedlungsstruktur: Durch die disperse, kleinteilige Verteilung der Einwohnerinnen und Einwohner auf viele kleinere, dünn besiedelte Ortsgemeinden bestehen zum einen geringe „Nutzerzahlen" für beispielsweise Versorgungsangebote, wodurch die Tragfähigkeit gefährdet wird und zum anderen große Entfernungen zwischen den verschiedenen Standorten der Daseinsgrundfunktionen.

In den vergangenen zehn Jahren entwickelte sich die Bevölkerung des Landkreises insgesamt rückläufig (-3,4%)– teilweise um mehr als 5% in einzelnen Ortsgemeinden. Im selben Zeitraum weisen lediglich 6 von 98 Gemeinden Bevölkerungswachstum auf. Die rückläufige Bevölkerungsentwicklung ist in ca. zwei Drittel der Ortsgemeinden auf Wanderungsverluste, insbesondere durch Abwanderung junger und qualifizierter Bevölkerungsgruppen (Bildungswanderung) sowie Abwanderung älterer Bevölkerungsgruppen (Alters-wanderung), zurückzuführen. Damit einhergehend ist eine Zunahme der über 65-Jährigen und ein Rückgang

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[20] vgl. WEITH (2020), S. 420
[21]vgl. DAMM/SPELLERBERG (2021), S. 63
[22] vgl. THAPA et. al. (2020), S. 5
[23]WEITH (2020), S. 421
[24]vgl. KREISVERWALTUNG KUSEL (2023), S. 52-87
[25]PGW (2012), S. 5
[26]PGW (2012), S. 14 ff.

der unter 20-Jährigen zu beobachten, was insgesamt das Bild einer alternden Bevölkerung mit diesbezüglichen Herausforderungen verdeutlicht.[27]

Die regionale Wirtschaft im Landkreis Kusel ist geprägt von kleinen und mittelständischen Unternehmen, insbesondere im Handwerk, in der Landwirtschaft und im Tourismus. Zwar ist die wirtschaftliche Leistungsfähigkeit gemessen am Bruttoinlandsprodukt in den letzten zehn Jahren angestiegen (ca. 24 %), jedoch wird die Diskrepanz zum rheinland-pfälzischen Durchschnittswert stets größer[28], was ein geringeres wirtschaftliches Wachstum kennzeichnet. Über alle Branchen erkennbar sind zum aktuellen Zeitpunkt erste Anzeichen des drohenden Fachkräftemangels, beispielsweise durch eine Vielzahl nicht besetzter Ausbildungsstellen im Handwerk. Zudem liegt der Anteil der Beschäftigten mit akademischem Abschluss deutlich unter dem Landesschnitt. Herausforderungen im Hinblick auf eine potenzielle Chance durch Digitalisierungsprojekte sind u.a.:

- das Aufzeigen von Berufswegen etc. für Schülerinnen und Schüler zur Nachwuchsförderung,
- die Etablierung multifunktionaler Arbeits- und Begegnungsorte (im Sinne von Co-Working-Spaces) zur Schaffung neuer Arbeitsorte und -möglichkeiten,
- die Einführung von Förderungsmöglichkeiten zur Qualifizierung von Unternehmen als attraktive Arbeitgeberzur Bindung bestehender und Gewinnung neuer Fachkräfte im Landkreis sowie
- die Attraktivierung des öffentlichen Verkehrs (u.a. durch Bündelung und Verknüpfung).

Die Verteilung der Bildungseinrichtungen im Landkreis Kusel verdeutlicht die von Norden nach Süden abnehmende Einwohnerdichte. Während in einigen Ortsgemeinden keine Kindertagesstätten zur Verfügung stehen und Grundschulen bereits deutliche Konzentrationseffekte zeigen, weist die Verteilung im zentralen Bereich des Landkreises eine dispersere Verteilung dieser Einrichtungen auf. Hinsichtlich der digitalen Ausstattung verfügen nicht alle Bildungseinrichtungen innerhalb des Landkreises über eine ausreichende Versorgung mit WLAN. Zentrale Herausforderungen sind in diesem Feld:

- die Etablierung außerschulischer Lernorte für alle Altersstufen bis hin zur Erwachsenenbildung,
- die Vernetzung von Schülerinnen und Schülern bzw. Schulabgängerinnen und Schulabgängern mit Unternehmen zur frühzeitigen Bindung junger Fachkräfte an den Landkreis sowie
- der Aufbau einer digitalen Ausbildungsmesse sowie eines digitalen Ausbildungs- und Stellenportals.

Eine wohnortnahe Versorgung mit Dingen des täglichen Bedarfs (Nahversorgung) ist vor allem für alternde und mobil eingeschränkte Bevölkerungsteile ein wichtiger Standortfaktor und entsprechend wichtig für lebenswerte Kommunen. Kurze Wege zur Versorgung mit Gütern des täglichen Bedarfs sind dabei ressourceneffizient, bilden jedoch gerade im ländlichen Raum – so auch im Landkreis Kusel – nicht das tatsächliche Bild ab, welches geprägt von weiten Wegen ohne ÖPNV-Nutzungsmöglichkeit und einer Konzentration weniger Versorgungseinrichtungen ist. Herausforderungen im Smart-City-Kontext sind u.a.:

- der Aufbau von personalfreien Angeboten (Automatenläden, Selbstbedienungsläden, click&collect) zur Erweiterung des Angebots (bei geringem personellem und finanziellem Einsatz),
- die Ermöglichung lokaler Online-Bestellungen (in Kooperation mit lokalen Einzelhandelsbetrieben)
- sowie die Einrichtung einer digital unterstützen Nachbarschaftshilfe (Mitbring-App).

Die Versorgung mit Gesundheits- und Pflegeangeboten rückt durch die Sicherstellung der Erreichbarkeiten von Standorten dieser in das Aufgabengebiet politischer wie auch planerischer Entscheidungsträgerinnenund Entscheidungsträger .Im Landkreis Kusel gibt es ein Klinikum in der Kreisstadt, Hausarztpraxen sowie Praxen von Fachärztinnen und Fachärzten sind über das Kreisgebiet verteilt, sodass sich eine durchschnittliche Versorgungslage von 723 Einwohnerinnen und Einwohnern pro Ärztin oder Arzt ergibt – ein Verhältniswert der weit über dem rheinland-pfälzischen Durchschnittswert von 569 liegt und sich durch einen errechneten altersbedingten Nachbesetzungsbedarf von 50 Prozent bis zum Jahr 2027 noch weiter verschärft.[29]Herausforderungen mit Potenzial zur Verbesserung durch digitale Angebote sind:

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[27]vgl. STATISTISCHES LANDESAMT RHEINLAND-PFALZ (2022)
[28]vgl. STATISTISCHES LANDESAMT RHEINLAND-PFALZ (2022)
[29]KASSENÄRZTLICHE VEREINIGUNG RHEINLAND-PFALZ(2022)

480

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

- die digitale Vernetzung aller Akteurinnen und Akteure der Gesundheitsvor- und -versorgung,

- Etablierung der Digitalisierung in der privaten und ambulanten Pflege und die entsprechende Ausstattung von betreuten Wohnangeboten (z.B. Wearables und Überwachung von Vitaldaten, ambient assistedliving Angebote) sowie

- die Einführung telemedizinischer Angebote und Möglichkeiten (Telemonitoring, Online-Videosprechstunden, Telediagnostik) in Kooperation mit medizinischen Angebotsträgern.

Ein zentrale Rolle im Hinblick auf die skizzierten Angebote der Daseinsvorsorge bzw. im Speziellen die Angebote der Versorgung nimmt die Erreichbarkeit dieser (ausgehend vom Wohn- und/oder Arbeitsort) ein. Dem öffentlichen Verkehr kommt dabei im Hinblick auf die Attraktivität des Wohnstandorts für alle Bevölkerungsgruppen sowie dem Umwelt- und Klimaschutz eine stets bedeutsamere Rolle zu. Innerhalb des Landkreises bestehen wenige Bahnanbindungen – der öffentliche Verkehr wird über Busverbindungen abgewickelt. Dieses stellt zwar in jeder Ortsgemeinde mindestens einen Haltepunkt bereit, allerdings ist die Attraktivität aufgrund geringer Anzahl der Abfahrten, schlechter Taktung und mangelnder Linien bzw. Zielauswahl teilräumlich stark begrenzt. In großen Teilen des Landkreises ist die Bevölkerung auf den Individualverkehr in Form des Pkw angewiesen.[30] Durch den Einsatz digitaler Tools bestehen insbesondere Entwicklungspotenziale durch die Verknüpfung verschiedener Mobilitätsformen (Intermodalität).

Die umfassende Digitalisierung erfordert hochleistungsfähige Netze, die Geschwindigkeiten im Gigabit-pro-Sekunde-Bereich (im Down-/Upload), zuverlässige echtzeitfähige Übertragungen und sichere Internetdienste in hoher Qualität ermöglichen.[31] Die Verfügbarkeit von leistungsfähigen Breitbandanschlüssen mit einer Geschwindigkeit von mindestens 100 Mbit/s ist im Landkreis Kusel nur in wenigen Gemeinden gegeben.[32] Neben der infrastrukturellen Verfügbarkeit spielen die Offenheit und Akzeptanz digitaler Möglichkeiten in Alltag und Berufsleben eine wegweisende Rolle im digitalen Wandel. Eine in der Kreisverwaltung Kusel durchgeführte Befragung zur digitalen Affinität, zum E-Government und zur Verwaltungsdigitalisierung zeigt bisher einen hohen Nachholbedarf diesbezüglich, mit Blick auf die Zukunft jedoch eine insgesamt hohe Bereitschaft (ca. zwei Drittel) zur Nutzung digitaler Infrastrukturen verbunden mit bei der überwiegenden Mehrzahl der Beschäftigten bereits vorhandenen hohen digitalen Kenntnissen.[33]

3.2 Prozess zur Smart Region

Mit der Teilnahme am Förderprogramm Smart City verfolgt der Landkreis Kusel das Ziel, durch die Digitalisierung eine positive und nachhaltige Entwicklung in der Region zum Wohle der dort lebenden und arbeitenden Menschen zu bewirken. Das Förderprogramm gliedert sich in zwei Phasen: die Strategie- und Umsetzungsphase, wobei sich der Landkreis Kusel derzeit in einer Übergangsphase zwischen beiden Phasen befindet. Die Gewinnung von Fachkräften startete sofort nach Bewilligung der Fördermittel und formte schließlich die Stabstelle der Kreisverwaltung mit folgenden Rollen: Chief Digital Officer (CDO), Sachbearbeitung, Partizipation und Teilhabe, Öffentlichkeitsarbeit sowie Datenanalyse und Digitallotsen.[34]Besonders zu Beginn bedarf der Konzeption und Koordination des Prozesses ein großer Stellenwert, wozu eine Kerngruppe aus internen und begleitenden externen Akteurinnen und Akteuren eingerichtet wurde. In Ergänzung des Teams der Stabstelle Smart City waren darin Mitarbeiterinnen und Mitarbeiter der Kreisverwaltung aus zentralen Abteilungen eingebunden. Externe wissenschaftliche Unterstützung lieferten u.a. Expertinnen und Experten des Deutschen Instituts für Künstliche Intelligenz (DFKI), des Lehrstuhls Regionalentwicklung und Raumordnung der Rheinland-Pfälzischen Technischen Universität Kaiserslautern-Landau (RPTU) sowie der Hochschule Worms.

Die Smart-City-Strategie im Landkreis Kusel wurde in einem offenen und partizipativen Verfahren vor Ort entwickelt. Die Beteiligung der Bevölkerung zur Erstellung einer Entwicklungsstrategie in einem Landkreis mit insgesamt 98 Ortsgemeinden ist eine Herausforderung, die im Falle der Smart-City-Strategie zusätzlich durch Einschränkungen, die aufgrund der Covid-19-Pandemie zu berücksichtigen waren, überlagert wurde. Der Prozess startete mit einer Auftaktveranstaltung in rein digitaler Form.Während der Phase der Erstellung

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[30]vgl. STABSTELLE „LAND L(I)EBEN" LANDKREIS KUSEL (2022)
[31] BMWK (2023)
[32]BNetzA(2022)
[33]STABSTELLE „LAND L(I)EBEN" LANDKREIS KUSEL (2022)
[34]vgl. STABSTELLE „LAND L(I)EBEN" LANDKREIS KUSEL (2022)

der Bestandsaufnahme im Rahmen der Strategie wurden verschiedene Zielgruppen durch online-gestützte Befragungen beteiligt: Bürgerinnen und Bürger, Beschäftigte der Kreisverwaltung, Vereine, Bildungseinrichtungen, Museen sowie Orts- und Stadtbürgermeisterinnen sowie Orts- und Stadtbürgermeister. Ziel der Befragungen war es einerseits niederschwellig Informationen, die nicht statistisch aufbereitet vorliegen, zu generieren und andererseits Einschätzungen durch zentrale Akteurinnen und Akteure zu erhalten. Begleitender Effekt war hier auch die weitere Bekanntmachung des Projekts sowie die Erregung von Aufmerksamkeit für das Projekt bei Multiplikatorinnen und Multiplikatoren. Insgesamt konnten die Ergebnisse der Befragungen in Kombination zu statistischen Analysen einen wichtigen Beitrag in der Informationssammlung leisten. Zudem konnten die Ergebnisse im Rahmen der sieben hybrid durchgeführten Workshops mit Bürgerinnen, Bürgern und anderen Akteurinnen und Akteuren rückgekoppelt bzw. vertieft diskutiert werden.Im Anschluss an die Strategie-Workshops haben sich Arbeitsgruppen gebildet, um die Handlungsoptionen und Ideen, die im Rahmen der Workshops diskutiert wurden, weiter auszuarbeiten.[35]

Als eines der ersten Projekte, die bereits während der Strategiephase umgesetzt werden, wurde die Etablierung einer digitalen Partizipationsplattform für Bürgerinnen und Bürger festgelegt. Diese ist seit Juli 2022 unter dem Leitsatz „MITMACHEN – Landkreis Kusel im Bürgerdialog" freigeschaltet und wird seitdem zunehmend genutzt und bespielt. Die Partizipationsplattform bietet derzeit die Möglichkeiten (1) sich über das Gesamtvorhaben oder einzelne Themenfelder zu informieren, (2) Projekt-/Maßnahmenideen in den Themenfeldern der Strategie-Workshops zu formulieren sowie (3) bereits formulierte Projekt- bzw. Maßnahmenideen zu diskutieren.[36]

Unter Berücksichtigung aller eingebrachten Belange der beteiligten Akteurinnen und Akteure entwickelte die Stabstelle des Landkreises schließlich die Smart-City-Strategie. Diese befindet sich zum aktuellen Zeitpunkt in der Endphase des Aufstellungsprozesses und wurde im Juni 2023 durch den Kreistag beschlossen und beim Fördermittelgeber eingereicht.

3.3 Herausforderungen der Gestaltung des Digitalisierungsprozesses

Die Rahmenbedingungen zur Erstellung einer tragfähigen und innovativen Smart-City-Strategie in einem Landkreis mit 98 Ortsgemeinden (und 98 ehrenamtlichen Ortsbürgermeisterinnen und Ortsbürgermeister), die in drei Verbandsgemeinden organisiert sind und dementsprechend neben dem Kreistag und der Kreisverwaltung zwei weitere politisch-administrative Ebenen "vereinen muss", sind andere als in einer kreisfreien (Groß-) Stadt. Generell bedarf es eines größeren Abstimmungsbedarfs, was zum einen den Organisationsaufwand, zum anderen jedoch auch die notwendige inhaltliche Diskussion einer großen Zahl an Einzelinteressen („Kirchturmdenken") erhöht – häufig fehlt es bei kleinteiligen administrativen Strukturen an gemeinsamen Visionen und der Bereitschaft den interkommunalen bzw. regionalen Erfolg über den eigenen zu stellen; kommunale Einzelinteressen und interkommunale Konkurrenz prägen das Bild.[37]

Parallel dazu unterscheiden sich auch die raumstrukturellen Ausgangslagen einzelner Teilräume innerhalb eines Landkreisgebiets mit einer höheren Varianz. Gerade in ländlich geprägten Landkreisen kann dabei die Divergenz zwischen einem städtischen Zentrum und peripheren Teilen mit geringer Bevölkerungszahl und -dichte von großer Bedeutung für die zukünftige räumliche Entwicklung sein. Im Landkreis Kusel müssen entsprechend raumstrukturelle Unterschiede von 5.594 Einwohnerinnen und Einwohnern in der Kreisstadt Kusel bis hin zu 54 Ortsgemeinden mit unter 500 Einwohnerinnen und Einwohnern vereint werden. Die Aufstellung einer Strategie und vor allem die Definition von konkreten Projekten und Maßnahmen, die die Breite der Handlungsbedarfe in (möglichst) allen Teilräumen aufgreifen, auf Akzeptanz in der Bevölkerung und Zustimmung in den politischen Gremien treffen, sind daher eine große Herausforderung.

Zudem sind die kleinteiligen Verwaltungsstrukturen der Kommunen in ihrem personellen und finanziellen Handlungsspielraum noch eingeschränkter als der Verwaltungsapparat einer Großstadt. Die durch die Förder-ung zur Verfügung stehenden Mittel zum Personal- und Kompetenzaufbau müssen entsprechend aufwändig in die Kreisverwaltung integriert werden. Die eingerichtete Stabstelle der Kreisverwaltung ist zwar mit Abschluss der Strategiephase in voller Stärke besetzt, allerdings gestaltete sich die Gewinnung von

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[35]vgl. KREISVERWALTUNG KUSEL (2023), S. 26-51
[36]vgl. STABSTELLE „LAND L(I)EBEN" LANDKREIS KUSEL (2022)
[37]vgl. STIEWING/WEBER/FASTNER/BERCHTOLD (2022), S. 379

Fachkräften in einem relativ neuen Handlungsfeld im ländlichen Raum – bei ohnehin anhaltendem Fachkräfte-mangel in nahezu allen Branchen – als große Herausforderung, die zu Beginn durchaus unterschätzt wurde. Bzgl. der Hemmnisse der Verwaltung kommt erschwerend die bisher über weite Teile fehlende Digitalisierung dieser hinzu. Zeitintensive analoge Prozesse und Abläufe innerhalb der Verwaltung oder im Austausch mit Bürgerinnen und Bürgern bedürfen einer aufwändigen Digitalisierung zur Vereinfachung, Entlastung und Entbürokratisierung.[38]

Als generelle Hürde bzw. Herausforderung stellte sich zudem der Begriff „Smart City“ heraus. Viele Bürgerinnen und Bürger des ländlich geprägten Landkreises, die im Durchschnitt weniger digital affin (u.a. aufgrund der Altersstruktur) als in städtisch geprägten Räumen sind, können sich mit der Begrifflichkeit nicht identifizieren. Smart City ist ein Label, das „[…] von einem primär technischen und weniger von einem sozialen Innovationsverständnis ausgeht“[39] und in erster Linie mit negativen Auswirkungen (z.B. Überwachung, mangelnder Datenschutz) in Verbindung gebracht wird. Internationale, utopische Smart Cities, wie New Songdo City in Südkorea, prägen das Bild der Smart-City-Idee, lassen sich jedochvonNicht-Expertinnen und Nicht-Experten nur schwierig auf den Landkreis Kusel übertragen. Nicht zuletzt dadurch sind auch Partizipationsverfahren im ländlichen Raum eine größere Herausforderung. Die Strategiephase des Landkreises Kusel verdeutlichte, dass einerseits aufgrund der geringeren digitalen Affinität der Bevölkerung ein erhöhter Bedarf an analoger Beteiligung erforderlich ist – allerdings andererseits auch, dass aufgrund der großen räumlichen Distanzen innerhalb des Landkreises, analoge Beteiligungsformate mit einem großen Verkehrsaufwand einhergehend mit einem zeitlichen und finanziellen Mehraufwand der Bevölkerung verbunden sind. Das Risiko, dass aus diesen Gründen selbst bei hybriden Beteiligungsformaten bestimmte Personengruppen (z.B. Ältere) ausgeschlossen sind, ist entsprechend hoch.

Der Landkreis Kusel hat aufgrund dieser Herausforderungen und Hindernisse eine Verlängerungvon sechs Monaten für die Strategiephase beantragt und von Seiten des Fördermittelgebers bewilligt bekommen.

3.4 Smart-City-Strategie und Ansätze für smarte Maßnahmen zur nachhaltigen Entwicklung des Landkreises

Im zuvor skizzierten kooperativen Prozess wurde schließlich die Smart-City-Strategie als Rahmen für die Umsetzungsphase und die zukünftige Entwicklung des Landkreises erarbeitet. Als gemeinsames Verständnis fungiert die bereits in Rahmen der Antragsphase entwickelte Vision "Land l(i)eben – digital. gemeinsam. vor Ort.". In der Strategie wurden sechs integrierte Zielbilder formuliert, die die Stoßrichtungen der zukünftigen Entwicklung vorgeben:

(1) Beteiligung und Teilhabe aller Menschen an den Vorhaben von Land l(i)eben ermöglichen

(2) Testen, inwiefern digitale Möglichkeiten das Leben im Landkreis Kusel erleichtern, zukunftsfähig und attraktiv gestalten

(3) Sicherung der Daseinsvorsorge mit Hilfe neuer Technologien

(4) Förderung bedarfsgerechter Mobilitätsangebote im Landkreis

(5) Förderung des Miteinanders, das Austesten von Innovationen und das Entdecken der Region

(6) Kompetenzgewinn, Generierung und souveräner Umgang mit Daten

Bereits während der Strategiephase gingen die drei Starterprojekte „E-Partizipationsplattform“, „Kulturelle Teilhabe in Wohneinrichtungen“ sowie „Digitalwerkstatt für Kinder und Jugend“ in die Umsetzung. Insbesondere die entwickelte Partizipationsplattform ist dabei als wegweisende Querschnittsmaßnahme des gesamten Smart-City-Prozesses zu bewerten. Inhaltlich wurden die gesammelten Projektideen in fünf sogenannte integrierte Maßnahmen geclustert: „Gemeinschaft l(i)eben“, „Liebenswertes Kuselerland“, „Medi-KUS“, „Mobilität im FoKUS“ sowie „Schlauer Landkreis“, die alle zahlreiche Chancen für eine digitale, nachhaltige und gesunde Kommunal- und Regionalentwicklung bieten. Auf die vollständige Darstellung der Maßnahmen wird aufgrund des für dieses Paper gewählten Fokus' an dieser Stelle verzichtet.

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[38] vgl. STABSTELLE „LAND L(I)EBEN“ LANDKREIS KUSEL (2022)
[39] LIBBE (2018), S. 441 f.
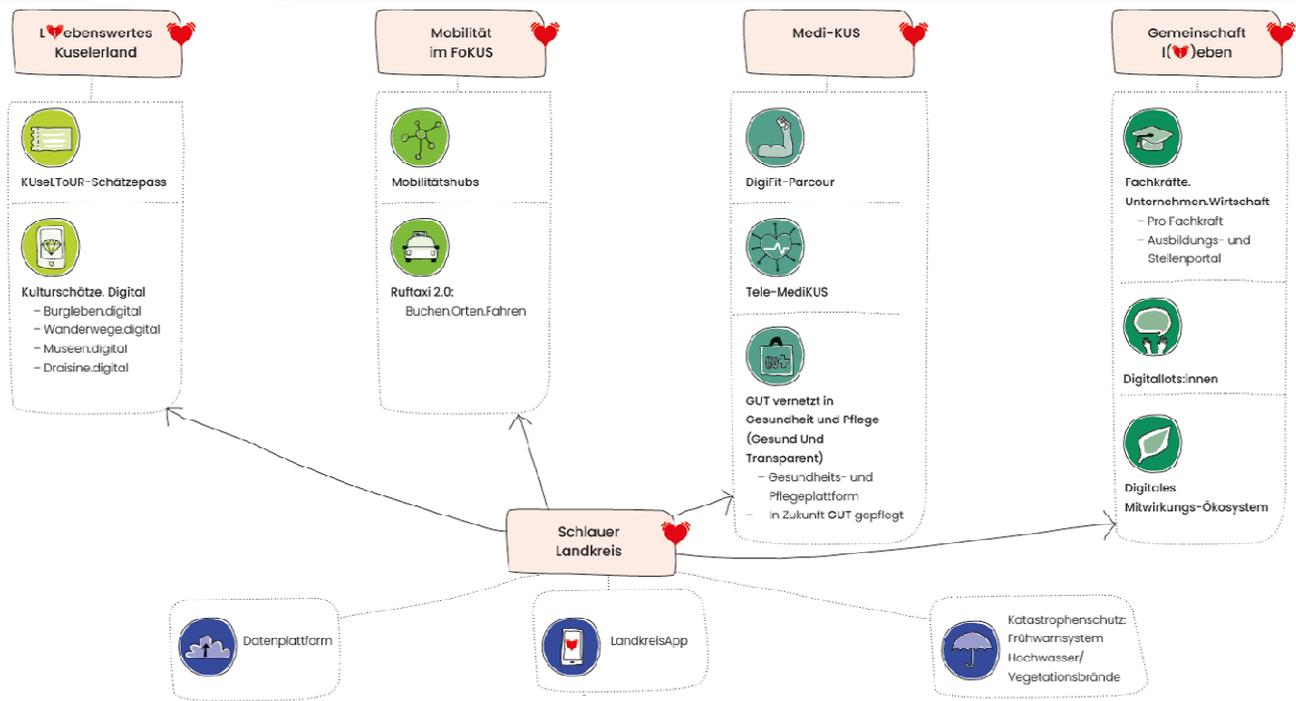
Abb. 1: Überblick über Maßnahmen und Projekte der Smart-City-Strategie des Landkreises Kusel. Quelle: KREISVERWALTUNG KUSEL (2023), S. 234-235

Exemplarisch für die Chancen einer nachhaltig-digitalen Kreisentwicklung werden die Projektvorschläge der integrierten Maßnahme „Schlauer Landkreis" aufgegriffen, die unter Beachtung des Querschnittsgedankens u.a. auf die Digitalisierung von Informationen und Prozessen sowie den notwendigen Kompetenzaufbau reagiert. Als erste Teilmaßnahme ist der Aufbau einer zentralen Datenplattform zur Bündelung und Katalogisierung aller relevanten Daten (Open Data, Verwaltungsdaten, Daten aus IoT-Infrastrukturen, Geodaten, Strukturdaten usw.) an einer zentralen Stelle („Hub"), die sowohl verwaltungsintern als auch externen Akteurinnen und Akteuren zur Verfügung steht. Die Entwicklung der Datenplattform erfolgt in interkommunaler Kooperation mit anderen Smart-City-Modellprojekten aus dem Südwesten Deutschlands. Neben direkten Mehrwerten, z.B. der einfacheren Handhabung von Daten oder der Möglichkeit zur Verknüpfung von Datensätzen, dient die Datenplattform zusätzlich als Grundlage für alle weiteren Schritte des landkreisweiten Dateninfrastrukturaufbaus. Durch diese Teilmaßnahme besteht für die Landkreisentwicklung der Zukunft eine stark positiv veränderte Ausgangssituation: Der Einbezug zahlreicher Daten stellt sich vor allem in der Verknüpfung und Interpretation dieser als bedeutsame Grundlage zielgerichteter Kommunal- und Regional-entwicklung dar. Ein weiteres Teilprojekt, um vor allem der Bevölkerung die Handhabung des digitalen Wandels zu erleichtern, ist die Entwicklung einer Landkreis-App. Hierin wird ein Teil der gesammelten Daten visuell aufbereitet und den Nutzerinnen und Nutzern in unterschiedlichen App-Modulen zugänglich gemacht, um insbesondere im Landkreis vorhandene Angebote abzubilden.Ziel der Maßnahme ist es, mit der App einen zentralen digitalen Anlaufpunkt im Sinne einer „all in one"-Lösung zu schaffen. Darin inbegriffen sind u.a. Module in den Bereichen Mobilität, Kultur und Tourismus, verwaltungsbezogener Bürgerservice, Gesundheit und Pflege sowie Ausbildung und Arbeitsmarkt. Das dritte Teilprojekt umfasst die Entwicklung eines flächendeckenden Frühwarnsystems für Hochwasser und Vegetationsbrände im Bereich Katastrophenschutz. Hierzu gilt es ausreichend Sensoren in der Fläche einzusetzen, die kontinuierlich im Hinblick auf bestimmte Schwellenwerte analysiert werden und im Notfall frühzeitige Warnungen an den Katastrophenschutz absenden. Angedacht ist die Verknüpfung der Sensorik mit der Landkreis-App zur direkten Information der Bevölkerung.[40]

4 FAZIT UND AUSBLICK

Der Prozess der Digitalisierung ist allgegenwärtig, bestimmt maßgeblich die zukünftige räumliche Entwicklung und muss in allen Teilräumen – unabhängig der jeweiligen Ausgangssituation – mitgedacht

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[40]vgl. KREISVERWALTUNG KUSEL (2023), S. 119-141

werden. Er eröffnet dabei neue, vielfältige Möglichkeiten zur Gewährleistung der Erreichbarkeit von Angeboten der Daseinsvorsorge und trägt einen wichtigen Teil zur Schaffung gleichwertiger Lebensverhältnisse bei. Für die jeweilige räumliche Ebene werden eine Verbesserung der Standortfaktoren, ein Imagegewinn und eine vereinfachte und verbesserte Versorgung mit öffentlichen Dienstleistungen erwartet.[41] Insbesondere im ländlichen Raum bieten innovative, digitale Angebote in verschiedenen Bereichen große Chancen, beispielsweise zur Überwindung von physischen Wegen und großen Entfernungen. Einfach gesagt: Wenn Patientinnen und Patienten nicht zu Ärztinnen und Ärzten und wiederum Ärztinnen und Ärzte nicht zu Patientinnen und Patienten kommen können, dann kann eine digitale Möglichkeit die Lösung sein. Dies gilt gleichermaßen für die weiteren in diesem Beitrag aufgezeigten Strukturbereiche. Durch den verstärkten Einsatz digitaler Tools in allen gesellschaftlichen Bereichen besteht jedoch auch das Risiko einer entstehenden bzw. sich verstärkenden „digitalen Kluft" hinsichtlich Nutzbarkeit und Akzeptanz zwischen unterschiedlichen Bevölkerungsgruppen, insbesondere für ältere Teile der Bevölkerung. Entsprechend bieten digitale Beteiligungsformate zwar exorbitante Möglichkeiten zur Erweiterung der klassischen Partizipationsmethoden, allerdings besteht immer die Gefahr eines Ausschlusses von Personengruppen.

Die (digitale) Beeinflussung der zukünftigen Entwicklung von ländlichen Räumen ist dabei nicht nur an die digitale (infrastrukturelle) Ausstattung gekoppelt. Diese stellt die Grundvoraussetzung für die Initiierung digitaler Projekte, aber noch nicht die finale Lösung, dar – entscheidend für das Gelingen ist jedoch in erster Linie der Mensch vor Ort. Es braucht Strategien, Konzepte, Angebotsträger und vor allem Nutzerinnen und Nutzer für den Erfolg eines (digitalen) Projekts.

Die Umsetzung des im Rahmen der Smart-City-Förderung notwendigen Strategieaufstellungsprozesses gestaltet sich in interkommunalen – im Besonderen im ländlichen Raum – Modellprojekten durchaus schwierig und bedarf eines zeitintensiveren Prozesses als in (groß-) städtischen Einzelkommunen. Die Herausforder-ungen bestehen insbesondere durch vielfältige Interessenslagen der unterschiedlichen administrativen Ein-heiten sowie zusätzlichen Abstimmungsbedarfen mehrerer administrativer Ebenen. Dabei gilt die Priorisierung eigenerer (lokaler) Interessen gegenüber gemeinsamer (interkommunaler/regionaler) Interessen gleicher-maßen als Problem politischer Entscheidungsträgerinnen und Entscheidungsträger wie auch der Bürgerinnen und Bürger. Gerade in Bezug auf die Projektinitiierung ist das bekannte „Kirchturmdenken" einzelner Gemeinden prägend. Dies muss berücksichtigt werden, um die Digitalisierung als Chance für Innovation in ländlichen Räumen zu sehen und nicht als zusätzlichen Faktor des Auseinanderdriftens von städtischen und ländlichen Räumen.

Trotz der vielfältigen Herausforderungen ist es dem Landkreis Kusel gelungen auf Basis umfassender Analysen und eines breit angelegten Partizipationsprozesses eine innovative Smart-City-Strategie als Leitplanke der zukünftigen räumlich-digitalen Entwicklung aufzustellen. Ob die identifizierten integrierten Maßnahmen in der Umsetzung erfolgreich sind und dadurch eine zukunftsfähige Regionalentwicklung gelingt, wird die nun fünf Jahre laufende Strategiephase zeigen. Klar ist, die potenziellen und tatsächlichen Wirkungen der zunehmenden Digitalisierung auf die Stadt- und Raumentwicklung sind bei Weitem noch nicht ausgelotet. Insgesamt stehen dem Landkreis durch das Programm jedoch verhältnismäßig große finanzielle und personelle Ressourcen zur Verfügung, um die digitale Transformation voranzutreiben und diese für eine langfristig nachhaltige Kreisentwicklung zu nutzen.

5 REFERENCES

AKADEMIE FÜR RAUMENTWICKLUNG IN DER LEIBNIZ-GEMEINSCHAFT [ARL]: Raumwirksamkeit der Digitalisierung. Positionspapier aus der ARL 136. Hannover, 2022.
BUNDESINSTITUT FÜR BAU-, STADT- UND RAUMFORSCHUNG [BBSR] IM BUNDESAMT FÜR BAUWESEN UND RAUMORDNUNG/BUNDESMINISTERIUM DES INNERN, FÜR BAU UND HEIMAT [BMI]: Smart City Charta. Digitale Transformation in den Kommunen nachhaltig gestalten. Bonn/Berlin, 2021.
BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ [BMWK]: Den digitalen Wandel gestalten, https://www.bmwk.de/Redaktion/DE/Dossier/digitalisierung.html . Berlin, 2022.
BUNDESMINISTERIUM FÜR WOHNEN, STADTENTWICKLUNG UND BAUWESEN [BMWSB]: Deutschlandatlas https://www.deutschlandatlas.bund.de/DE/Karten/Unsere-Gesundheitsversorgung/120-PKW-Hausaerzte.html. Berlin, 2019.
BUNDESMINISTERIUM FÜR WOHNEN, STADTENTWICKLUNG UND BAUWESEN [BMWSB]: Smart Cities, https://www.bmwsb.bund.de/Webs/BMWSB/DE/themen/stadt-wohnen/staedtebau/smart-cities/smart-cities-node.html . Berlin, 2023.

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[41] vgl. DAMM/SPELLERBERG (2021), S. 75

BUNDESMINISTERIUM FÜR WOHNEN, STADTENTWICKLUNG UND BAUWESEN [BMWSB]: Modellprojekte Smart Cities https://www.smart-city-dialog.de/modellprojekte . Berlin, ohne Jahr.

CACHELIN, Joel Luc: Die digitale Transformation, die Offliner und die Notwendigkeit der Erneuerung unseres gesellschaftlichen Betriebssystems. In: HILDEBRANDT, Alexandra/LANDHÄUSSER, Werner (Hrsg.): CSR und Digitalisierung – Der digitale Wandel als Chance und Herausforderung für Wirtschaft und Gesellschaft. Berlin, 2017.

DAMM, Gerd-Rainer/SPELLERBERG, Annette: Modellvorhaben: Smart Cities und Smart Regions. In: AKADEMIE FÜR RAUMENTWICKLUNG IN DER LEIBNIZ-GEMEINSCHAFT [ARL] (Hrsg.): Digitalisierung in ländlichen und verdichteten Räumen. Arbeitsberichte der ARL 31, S. 63-79. Hannover, 2021.

KREISVERWALTUNG KUSEL: Smart City Strategie Landkreis Kusel 2023. Kusel, 2023.

LIBBE, Jens: Smart City. in: RINK, Dieter/Haase, Annegret (Hrsg.): Handbuch Stadtkonzepte, S. 429-494. Opladen/Toronto, 2018.

PLANUNGSGEMEINSCHAFT WESTPFALZ [PGW]: Regionaler Raumordnungsplan Westpfalz IV. Kaiserslautern, 2012.

SPELLERBERG, Annette: Digitalisierung in ländlichen und verdichteten Räumen. Eine Einführung. In: AKADEMIE FÜR RAUMENTWICKLUNG IN DER LEIBNIZ-GEMEINSCHAFT [ARL] (Hrsg.): Digitalisierung in ländlichen und verdichteten Räumen. Arbeitsberichte der ARL 31. Hannover, 2021.

STATISTA GMBH: Digitalisierungsgrad der EU-Länder nach dem DESI-Index* im Jahr 2022, https://de.statista.com/statistik/ daten/studie/1016565/umfrage/digitalisierungsgrad-der-eu-laender-nach-dem-desi-index/ . Berlin, 2022.

STATISTISCHES LANDESAMT RHEINLAND-PFALZ: Mein Kreis, meine kreisfreie Stadt, Landkreis Kusel, https://infothek.statistik.rlp.de/MeineHeimat/content.aspx?id=101&l=1&g=07336&tp=2Bad Ems, 2022.

STIEWING, Marvin/WEBER, Tobias/FASTNER, Lena/BERCHTOLD, Martin: Gamification in der Regionalplanung: ein Ansatz zur Aktivierung formeller Planungsstrategien. In: SCHRENK, Manfred et. al. (Hrsg.): REAL CORP 2022 Proceedings/Tagungsband 14-16 November 2022. Wien, 2022.

THAPA, Basanta/OPIELA, Nicole/ROTHE, Michel Stephan: Ländlich, digital, attraktiv – digitale Lösungsansätze für ländliche Räume. Berlin, 2020.

WEITH, Thomas: „Smart Countryside" im Osten? Zum Wandel ländlicher Räume und den Herausforderungen der Digitalisierung. in: BECKER, Sören/NAUMANN, Matthias (Hrsg.): Regionalentwicklung in Ostdeutschland – Dynamiken, Perspektiven und der Beitrag der Humangeographie. Berlin, 2020.

WIEDMANN, Marco/KLUG, Petra: Attraktive ländliche Räume durch digitale Kommunen, in: MERTEN, Artzr/AHREND, Klaus-Michael/KOPSCH, Anke/STORK, Werner: Smart Region – Die digitale Transformation einer Region nachhaltig gestalten. Wiesbaden, 2009.

486

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Living and Working in a Healthy Environment: How Sensor Research in Flanders can Help Measure and Monitor Exposure to Certain Environmental Factors

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1 ABSTRACT

People's daily living environment has an important influence on their physical and mental health. That living environment consists of many different components, as it is both a spatial or physical environment, and the result of many other processes (socio-cultural, economic context and individual characteristics and lifestyles). Overall, the pressure on the physical environment is very high, especially in densely populated and highly urbanised area's such as Flanders, the northern part of Belgium. In urban environments, for instance, many spatial demands come together (space for housing, economy, mobility, green and blue infrastructures, etc.). The spatial layout of our cities can influence our health (e.g. whether or not we live nearby green spaces or in an environment that promotes active mobility, social contacts, if there are sources that impact the air quality, etc.), and of course our behaviour.

The relation between health, living and working environment and spatial planning is complex. Therefore, the Flemish Department of Environment & Spatial Development has prepared a framework in 2019 to better capture that complex relationship, which we will briefly discuss in this paper. Broadly speaking, a policy committed to healthy environments may choose to make interventions that protect people's health from certain external factors (e.g. air pollution or environmental noise) or that enable and promote healthy lifestyles (e.g. physical activity, food,…). Next to that, providing citizens with up to date information is an important task of the government.

In this paper, we discuss the research that the Environment and Health research team at the Flemish Department of Environment & Spatial Development conducts in order to measure human exposure to certain factors via sensors. Those particular factors were chosen mainly because they are part of themes around which the Flemish Department can make policy. We will consider three ongoing cases: measuring the quality of the indoor environment in different types of semi-public locations (such as schools, residential care centres, cultural centres,…), measuring radiofrequency radiation from fixed transmitting antennas in urban environments and measuring noise pollution. Partnering with international research & development organizations such as IMEC (Interuniversity Microelectronics Centre) and VITO (Flemish Institute for Technological Research), they supplied us with innovative and high-quality sensor technology. The sensors can transmit their measurement data in real time and participating parties can track the data on dashboards allowing immediate feedback and action when necessary. The results are intended to feed further research. Although not all case studies are equally advanced, we will conclude each one with possible policy actions.

Keywords: exposure, sensor network, living and working environment, real time data, health

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2 WHY DOES A HEALTHY LIVING ENVIRONMENT MATTER AND HOW DOES IT RELATE TO SPATIAL PLANNING?

Health goes beyond the absence of disease: it is a state of physical, mental and social well-being. Health is an interplay of various personal factors such as genetics, age, lifestyle, as well as circumstances such as family and social network, working and living conditions and general socio-economic and cultural context. Health in All Policies (WHO, 2014) ensured that attention to health – in the broad sense of the word – in spatial policy and research is gradually increasing. In the Netherlands for example, the National Institute for Public Health and the Environment (RIVM) has contributed to the National Spatial Agenda (NOA) by describing the relationship between the living environment and health and by identifying future challenges and opportunities for healthy living environments (Rijksinstituut voor Volksgezondheid en Milieu, 2017).

The SARS-CoV-2 period made certain aspects of the healthy living and working environment all the more obvious: the need for high-quality green space, for social contacts, the need for good indoor air quality, etc. The way we organise and also use our available space (where we live, work, preserve nature, provide agricultural land, or deal with the built environment and density, transport, etc.) has an impact on our health. "Land use affects mobility, nature, green space, the quality of water, air and soil" (Teughels et al., 2022). But how can we grasp this more precisely?[1] In 2019 the Flemish Department of Environment & Spatial Development has prepared a framework to capture the complex relationship between health and factors that spatial planning can influence (Gommers et al, 2019). Figure 1 shows this relationship by using the intermediate step of healthy living and working environments. In those environments, the pressure on health by certain stressors (chemical, physical, biological) is minimised, physical safety is ensured as much as possible (from e.g. dangerous traffic situations, or natural disasters) and stress prevention plays an important role. In addition, people have access to healthy food, are invited to move actively and social interaction is made possible.

In terms of heath, the role of (spatial) policy might be seen as a combination of two themes: protecting or minimising health risks as much as possible and promoting healthy lifestyles and behaviour by providing the means to do so (e.g. active mobility, healthier nutrition).
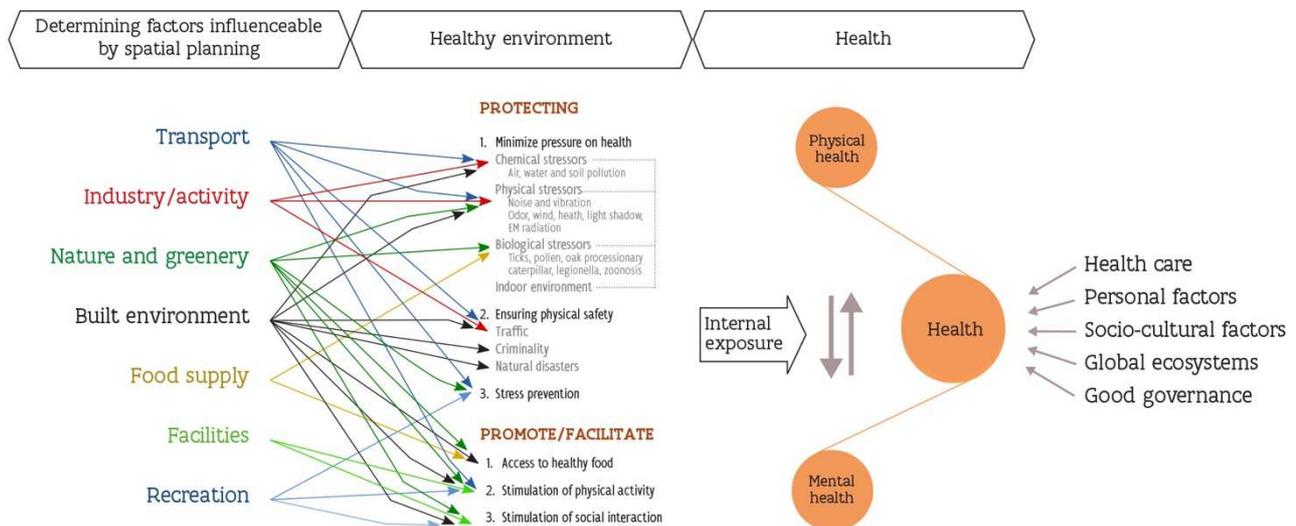
Fig. 1: the complex relation between health, healthy living and working environments and factors that spatial planning can influence (Teughels et al., 2022)

In line with the first theme around protection, the Environment and Health research team at the Flemish Department of Environment & Spatial Development has been working for years to measure human exposure to certain factors, mainly concerning the exposure to certain substances and poluents in the indoor air and in the ground (in the context of gardening) and exposure to sources of non-ionising radiation (radiofrequency

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[1] Some caution about measurable impact between health and spatial impact is in order. It would seem that the scientific literature is far from unanimous on cause-and-effect relationships between spatial interventions and health effects. Links are demonstrated in cross-sectional studies where observations are made at a single point in time (e.g. between the walkability of a neighbourhood and activity levels of that neighbourhood). However, few longitudinal studies exist examining the effect of a measure on behaviour and health. (Gommers et al, p. 17)

Sophie De Mulder, Michel Goethals, Mart Verlaek, Liesbeth Gommé, Niels De Kempeneer, Tine Van Hoof, Maja Mampaey, Philippe Van Haver, Caroline Teughels, Geert Van Haute, Karen Van Campenhout

(RF) and electromagnetic fields (EMF)). Next to this, the team is working around green infrastructure (types, proximity, perception,...) and human biomonitoring (including in the context of European Human Biomonitoring Network HBM4EU). Over the years, the team has accumulated a lot of knowledge on these various topics. However, this paper will focus on a few recent studies, which have a policy and societal question behind them. We will consider three ongoing cases. The first one is measuring the quality of the indoor environment in different types of semi-public locations (such as schools, residential care centres, cultural centres,…), which required rapid policy action in SARS-CoV-2 times. The second is measuring radiofrequency radiation from fixed transmitting antennas in urban environments, an important topic to follow up on, partly because oft he recent technological evolutions in telecommunications. And last is noise exposure, which is gaining importance internationally, as an factor with health impacts (e.g. Elmenhorst et al, 2019).

The finality of the different measurement campaigns varies: it is intended both to feed further research and legislative trajectories (e.g. in terms of standardisations, evaluation of standards), but also to provide very practical advice to participating partners (e.g. in terms of behaviour). Last but not least, in addition to raising awareness, it is also intended to provide correct information to people about certain important exposures, and so, reducing possible concerns.

3 RESEARCH ON HOW TO MEASURE EXPOSURE TO CERTAIN FACTORS

For the past 5 years, there was an accelerated technological development, which led to, among other things, the development of new types of sensors. Also in terms of data transmission, there were developments that allow instantaneous transmission of very large quantities of of data. This enables a different kind of measurement: where previously measurements were made with certain devices at a certain place and time, it is now possible to monitor a certain place for much longer, and collect more measurement data. In partnership with international research & development organizations such as IMEC (Interuniversity Microelectronics Centre) and VITO (Flemish Institute for Technological Research), we have started to develop different types of innovative and high-quality sensors. Depending on the factor we need to measure, the sensors can be placed outside or inside a building, or even on the human body. All sensors have in common that they can transmit their measurement data in real time and we collect the data in-house with the dataplatform Thingsboard. Interested parties can — in line with GDPR —track the data on dashboards allowing immediate feedback and action when necessary. For further global analysis, the data are anonymised. It is important to note that each sensor is calibrated at regular intervals, and updated when new technologies are available.

3.1 Indoor air quality & environment: the importance of people's behaviour and general knowledge at the start of building projects or reconversions

3.1.1 Introduction

In Figure 1, indoor air environment is a combination of chemical, physical and biological stressors, that can affect the health and well-being of its occupants or the people present in the room or building. It comes from three main sources: (1) the outside air (derived from how we organise our spatial lay-out, where we organise certain activities etc.), (2) the building materials of the built environment, especially when they consist of new building materials and at last (3) the sources inside the building envelope (people as a source of bio-effluents, including exhaled CO_2 and moisture but also bio-aerosols such as viruses and bacteria, furniture, smoking, use of ventilation when cooking, use of certain detergents or cleaning products etc). The building envelope functions between indoor and outdoor air quality. It can block certain pollutants from outside, but also keep certain pollutants from indoor sources inside, depending on the use of ventilation or aeration. Ventilation means that the air inside the builing is continuously refreshed, whereas aeration is briefly letting in a large amout of air by opening the doors or windows during a short amount of time. There exists four kinds of ventilalion types: (1) system A with natural supply and extraction, (2) system B — which is very rarely used in Flanders — with mechanical air supply and natural air extraction, (3) system C with natural air supply and mechanical air extraction and at last (4) system D with mechanical air supply and extraction.

In Flanders, people spend on average 85% of the day indoors. Because indoor air quality can affect the overall personal exposure of the building occupants, it is an important environmental determinant of health

(High Health Council Belgium, 2017). Since 2007, the Flemish Department of Environment & Spatial Development has been conducting research regarding indoor air quality in homes and schools to inform policy. One of the main conclusions of the research regarding the relation between the outdoor and indoor air quality is that the indoor air contains a number of pollutants, usually with greater diversity, and for certain pollutants in higher concentrations than outdoors. In addition, the research shows that ventilation is important: rooms that are mechanically ventilated often have better air quality, than non-mechanically ventilated rooms.

3.1.2   Why indoor air quality matters: research and measuring campaigns with the sensor boxes

The main research question regarding indoor environement quality is the following: when is the indoor environment healthy, and what measures help to achieve a healthy situation? To answer this, the Flemish Department of Environment & Spatial Development, together with VITO, developed 15 sensor boxes to continuously measure a number of pollutants and other parameters (Lazarov et al., 2019). The sensor box measures particulate matter (PM), carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), volatile organic compounds (VOC), temperature and relative humidity.

Indoor air quality contains many different substances and parameters. With the corona pandemic between 2020 and 2022, a big focus in Belgium and in Flanders has been on CO2 values[2] and how efficiently ventilation is carried out. CO_2 values are considered a good proxy to monitor the quality of the ventilation and aeration, and an important preventive measure to limit potential contamination via airborne transmission of viruses. The higher the CO_2 concentration, the higher the concentration of aerosols (microdroplets produced by breathing) that can contain micro-organisms, bacteria and viruses. In the absence of ventilation in enclosed spaces, these micro-organisms accumulate in the room. Effective ventilation and aeration reduces the concentration of micro-organisms in a room, and so limiting their spread through the air. In addition, the concentration of all other chemical and biological agents with indoor sources also decreases with effective ventilation; this is beneficial for good indoor air quality – needed for general health and well-being.

During the corona period, public indoor locations, where many people congregated, needed quick insight into the situation of CO_2 levels, how ventilation was happening and whether it could also be improved. Locations with vulnerable populations and/or that bring many people together, such as schools, residential care centres for elder people, sport halls and concert or cultural event halls were particularly targeted. Therefore, the Department of the Environment & Spatial Development, together with other government partners (from several government departments, such as health, education and sports & culture), started several measurement campaigns from 2020, and the last one planned in schools in autumn 2023. The measurement campaigns varied between 2 weeks (for sports halls) to 4 months (for residential care centres), and continued in both summer and winter. The hypothesis is that people tend to ventilate and aerate less during cold winter days, as there are colder outdoor temperatures, and residents want to keep the draughts out (and reduce energy bills). On hot summer days too, people tend to keep the heat out, and so, doors and windows are kept closed.

We processed the results from the measurements in several final products: (1) each participant (school, residential care centre, cultural house) received a report with results that also contained concrete advice, (2) we made an (anonymised) overview report per sector, (3) we made a website for schools where they can get targeted advice via questions and (4) we gave direct input to our partner governments to make policy frameworks on ventilation. The Departement of Health adopted a policy regarding ventilation in residential care centres.

3.1.3   Results: giving pratical advise and input to policy makers

About the different measurement campaigns in the different sectors, we can draw some overarching conclusions. As Figure 2 illustrates, it is clear that people's behaviour has an impact on air quality: keeping windows and doors closed increases CO_2 levels in a classroom, opening them almost immediately has a

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[2] The general guideline values were: if the CO_2 concentration is below 900 ppm (or 500 ppm above outdoor concentration), we consider the room well ventilated. In practice, 900 ppm for an adult engaged in standard light activity corresponds to a ventilation flow rate of 40 m³.h.person of fresh outdoor air. This means that an amount of fresh air of 40m³ should be provided per person present in the room per hour. For values between 900 and 1.200 ppm, measures are needed to fall back below 900 ppm. Exceedances above 1.200 ppm are in principle not allowed.

490

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decreasing effect. This knowledge was very useful during the corona pandemic: we were able to provide immediate practical advice to e.g. schools, depending on their situation (e.g. new building, type of windows) and whether or not they had a mechanical ventilation system. It is also possible to link actions to certain trends from the graphs: e.g. for rooms without mechanical ventilation, one could match room occupancy to the surface of the open or tilted windows. The results gave direct input to the policy makers during the corona pandemic, e.g. wether or not the different sectors could implement certain measures regarding CO_2 levels.

Next to behaviour, there are the technical aspects of the ventilation or aeration. When installing the sensor boxes in the field, we noticed that people on site – regardless of the type of sector – often have little knowledge about the presence of a ventilation system or the way it works, and when was the last maintenance. Inspection, maintenance and correct settings of ventilation systems are necessary for it to function correctly. It seems essential to sensitise and inform various target groups, in particular architects, technical staff, school teachers, residents of care centres etc., about possible interventions that help improve indoor air quality. Attention to possible complaints from the occupants of the room (e.g. draught, heat, noise...) and obstacles for the staff (e.g. extra workload, possibility of safely opening windows) is recommended, as ventilation and aeration should not be at the expense of well-being. Architects are an important target group as well, as ventilation systems are usually installed when renovation or new construction takes place. It is therefore essential to attach importance to the implementation of ventilation from the start of the (re)construction project.

Based on our findings, we conclude that investing in demand-controlled (mechanical) ventilation ¬ a system that measures and monitors CO_2 values — contributes to improved air quality and consistently lowers CO_2 concentrations in the indoor environment, and so helps reduce airborne viral transmission. Generally, regardless of the outside temperature and the saison, we noticed that rooms that are equipped CO_2 ventilation systems of type D (mechanical air supply and extraction) are more effective at keeping the CO2 levels low, in comparison to the other types of ventilation systems. However, we have little insight into the reasons for the potential reduced performance of other ventilation types. This aspect will be included in upcoming studies in 2023, by conducting a technical screening of the ventilation systems.
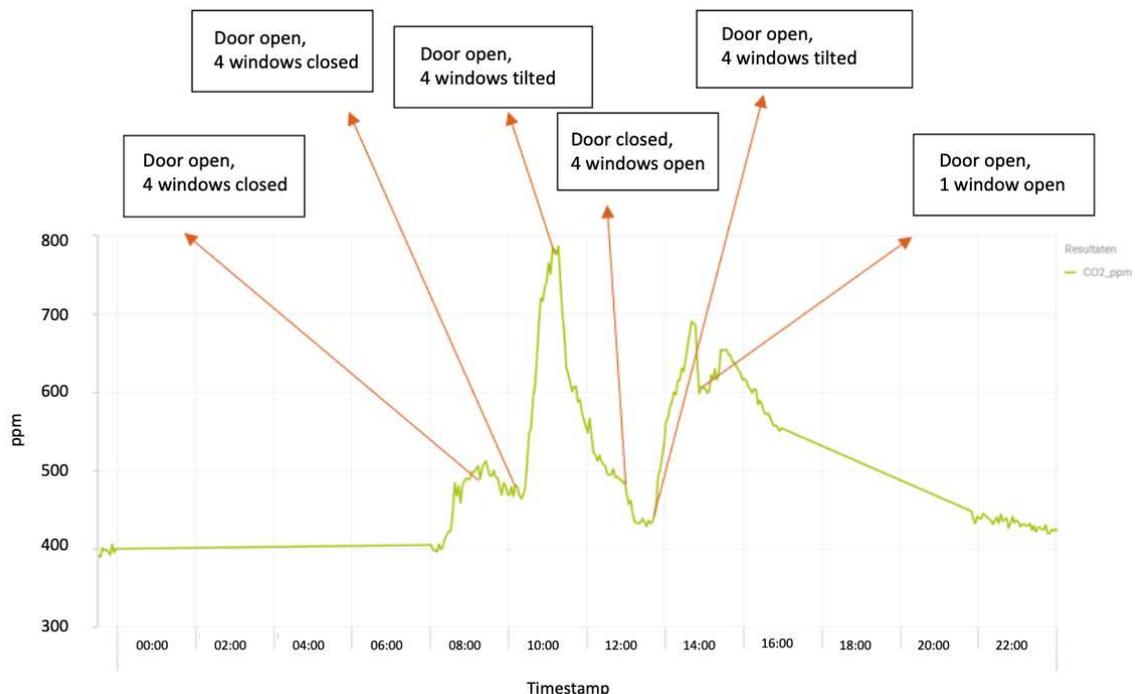

Fig. 2: the relation between CO_2 values (ppm) and measures to ventilate and aerate a classroom during a schoolday (own translation to English of the source: Taskforce Ventilation, 2021)

3.2 Exposure to radiofrequency radiation from fixed transmitting antennas: more accurate exposure maps to better inform the general public

3.2.1   Introduction

Transmitting antennas, equipped with the latest techonology, make it possible to transmit more and faster data, stimulating the development of interconnectivity, digital services, smart meters, etc. Several studies (e.g. the SmartSantander use-case in Spain (Diez et al, 2017) and the ongoing GOLIAT-5G project in Swisterland) addresses the health impact, by mapping exposure. In turn, we would also like to get a better idea of this in Flanders.

In Belgium, legislation around transmitting antennas is a regional competence. This means that in Flanders, operators of transmitting antennas apply for conformity certificates from the Flemish Department of Environment & Spatial Development before a transmitting antenna is put into service or modified . With these certificates, the Flemish government ensures that the requested condition complies with the standard for exposure to non-ionising radiation from fixed transmitting antennas. Referring to Figure 1, this theme relates to protecting from physical stressors.

In 2010, Flanders drafted its first legislation to limit exposure to electromagnetic fields from transmitting antennas (=radiofrequency or RF radiation). Since mobile telecommunications technology evolved significantly over the past 10 years, an adaptation of the legislation in 2022 was needed. Both times, the choice of the standards were based on international guidelines (ICNIRP), scientific research and on the precautionary principle. To test the impact of the new standards for the 2022 legislation, the Flemish Department of Environment & Spatial Development has simulated the virtual roll out of 5G in 2019 (Gommé et al, 2023). As input data we used the information from the confirmity certificates. These simulations resulted in exposure maps, which do not necessarily correspond to what actually happens in the field: the simulations are based on worst-case exposure. From the perspective of precautionary principle, this is a good approach. However, we still do not know what is happening in the field. By carrying out site measurements, we can get a better picture of what is happening in the field, e.g. peaks or fluctuations in exposure during the day etc. And so, with the sensor measurements we can create more accurate real time exposure maps. The subject of non-ionising radiation can raise concerns in society, and through more accurate and accessible information, we want to reduce concerns.

3.2.2   Spatial analysis of the transmitting antennas and the 5G roll out

Generally speaking, the location of the transmitting antennas follows the population pattern. About half of the sites for transmitting antennas are located in urban (core) area's, and almost one in 4 sites is located on an industrial/business/office parks.[3] In 2019, urban area's made up about 11% of the total area in Flanders and 72% of the population lived there (Pisman et al, 2021). Antennas are more closely spaced together in urban environments, while outside these area's, in more sparsely populated areas, less antennas transmit higher powers. Today, 5G technology is present in about half of the sites for transmitting antennas, but there are spatial differences. When comparing sites with or without 5G technology per type of area, there is a larger share of sites that contain 5G in large urban (core) area's (57%), than outside urban environments (46%).

Figure 3 illustrates these findings. It is a zoom map of the eastern part of Flanders, with Antwerp as the major urban area on the north-west of the map and Mechelen on the south-west (pink urban cores on Figure 3), surrounded by the port of Antwerp industrial zone to the northeast (purple area on Figure 3). The rest of the map consists of smaller urban areas or cores (dark grey areas). The business parks or industrial areas often connect to those cores of (smaller) urban areas, or they are located near major infrastructures, such as highways and canals. Compared to the rest of the map, there is a clear concentration of sites for transmitting antennas in the urban area of Antwerp. In addition, it is noticeable that there is a large mix of sites with both 5G technology (blue dots) and with other technologies (yellow dots), with a slight overweight of sites with 5G technology. In some other, smaller cores, the sites with other technologies are more prevalent, especially in the north-eastern part of the map.

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[3] The legislation regulates that certain types of transmitting antennes do not need a comformity certificate, when they operate under a certain Effective Isotropic Radiated Power (EIRP, as a measurement of radiated output power from an ideal isotropic antenna in a single direction) and less than a certain amount of days. However, these antenna's still need to conform to the legal standard to limit exposure to electromagnetic fields.

Sophie De Mulder, Michel Goethals, Mart Verlaek, Liesbeth Gommé, Niels De Kempeneer, Tine Van Hoof, Maja Mampaey, Philippe Van Haver, Caroline Teughels, Geert Van Haute, Karen Van Campenhout
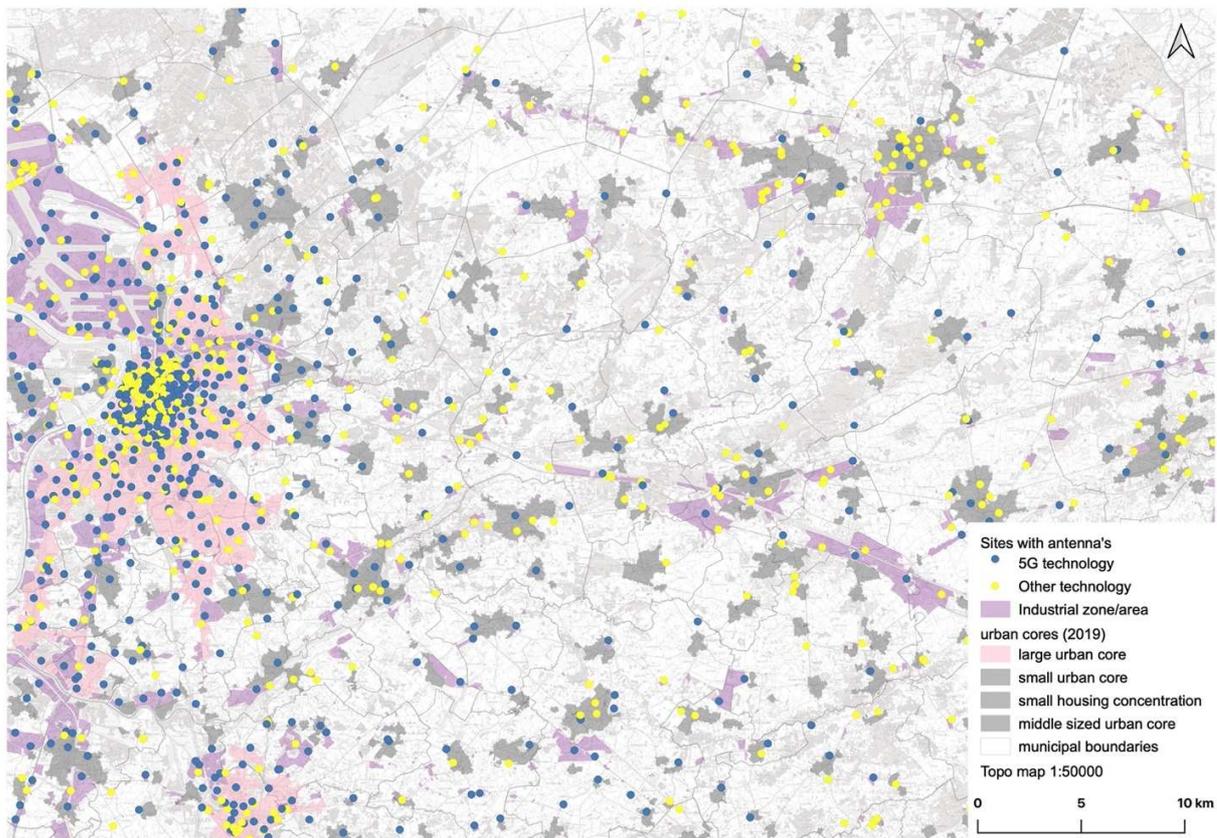
Fig. 3: distribution of sites with 5G and other technologies in Flanders, according to a classification into urban areas/cores and industrial/business areas (own data from conformity certificates)

3.2.3 Research and results

As mentionned in the previous paragraph, the impact of the new legislation, adopting the precautionary principle, was investigated by means of simulations before it came into effect. Now we want to put into practise an exposure monitoring network in Flanders. The ultimate goal of the monitoring network is to map time-dependent exposure to RF radiation based on measurement data collected by sensor boxes and interpolating in zones located between the sensor boxes.

The Flemish Department of Environment & Spatial Development has 27 RF sensor boxes — developed in cooperation with IMEC — that continuously measure exposure to RF radiation from transmitting antennas (Aerts et al, 2022). There is also a data capture platform for receiving the sensor data from the 27 RF sensor boxes. The RF sensor boxes were designed to measure the electric field strength on following four telecom frequency bands: 800 MHz, 900 MHz, 1800 MHz and 3600 MHz.

The research in cooperation with IMEC on the best locations or buildings to place the RF boxes has started in February 2023. An urban environment, specifically the centre of the city of Ghent, was chosen to investigate in this pilot study. The city of Ghent is a suitable location as it reflects well the urban complexity: it is, after Antwerp, the second largest city in Flanders (circa 157 km2, 267.700 inhabitants, 1.695 inhabitants per km2 in 2023). The city centre has quite a dense street pattern, with several markets and squares, which for some parts can be traced back to the Middle Ages. Buildings have different heights, and streets have varying widths (the buildings will attenuate or reflect radiation to some extent). This is in other words a complex environment.

Using a modelled exposure, possible locations for the 27 boxes are proposed, taking into account a variogram analysis to estimate correlation distance and zones where exposure is potentially highest. The plan now is to place the boxes on the facades, roofs or balconies of buildings, mostly with view on the street. To this end, we have enlisted the cooperation of various public or government institutions (university buildings, Flemish government buildings, etc.). The deployment of the sensor boxes will start during the summer and the objective is to collect sensor data during a year, that will be further analysed.

3.2.4   Results

The finality of the study is to feed an interpolation model based on the measurements to come up with an exposure map. This will probably give a different picture than the previous exposure maps based on the conformity certificates. It allows us to take the first steps towards possible monitoring for the whole of Flanders. In addition, it can help us as a government to fulfil our role of monitoring standards[4], and to provide more precise information to citizens.

3.3 Noise exposure getting insight into the causal relationship between noise and health

3.3.1   Introduction: measurements and perception

Noise pollution is categorised in Figure 1 as another physical stressor. International research indicates that noise exposure can cause important health effects such as stress, sleep disturbance and cardiovascular effects (WHO, 2018). If we do not take into account endocrine disruptors, Flemish research cites noise pollution as the second most important factor in calculating DALY (or Disability Adjusted Life Years as a measure of years of life lost due to premature mortality combined with years of healthy life lost due to disability), after particulate matter.

In 2018, the Department of Environment & Spatial Development conducted a five-yearly written environment survey in order to estimate the proportion of inhabitants that are affected by noise, light and odour pollution. It was the fifth survey in a series of identical surveys conducted since 2001. The 2018 survey shows that noise is the main source of annoyance: 29% of Flemish people (or circa 3.299.060 inhabitants) said they felt bothered by noise in and around their homes (categories ranging from moderate (18%) to serious (10%) and extreme noise (2%) annoyance). Traffic and transport noise is the largest source of noise annoyance. More than a third of those with moderate to extreme noise annoyance related this to traffic and transport. People living in urban environments experience the most noise annoyance compared to more rural areas.

Modelled noise pollution maps exist for Flanders:[5] these mainly take into account the main traffic-related sources of noise (e.g. noise from traffic on motorways and other major roads, from high-frequency train connections or from air traffic from airports). However, they remain an estimate of actual noise exposure. To better map effective exposure, the Department of Environment & Spatial Development is collaborating with the University of Ghent, the Provincial Institute of Hygiene and Scivil (Flemish knowledge center for citizen science) on two 24-month projects of Public Procurement Innovation (PPI) with sound sensors, linking on-site outdoor nighttime noise measurements with health effects, sleep disturbance and human perception. The focus is on (1) better capturing personal and dynamic exposure, and relating this to health effects and sleep quality of the participants (PPI I) and (2) mapping environmental noise in Flanders on strategic locations and the appreciation of that environment by rolling out a measurement network of sensors in a citizen science project (PPI II).

3.3.2   Research with sensors: getting insight into the causal relationship between noise during the night and health

Both research projects are currently ongoing. In a first phase, the aim is to search for best-in-class sensors and establish measurement protocols through two pilot studies, so that this can be applied on a larger scale in Flanders in a citizen science project to be launched in a second phase.

The measurement protocols being developed for this is based on literature, but also on ongoing research. This will be done simultaneously with field testing in the form of two pilot studies, with 10 subjects each that live in several spatial environments (urban, suburban and more rural environments). The measurement protocols are designed to correlate noise exposure during the night with health impacts, sleep disturbance and noise pollution. The study allows the analysis of short-term effects on health and sleep and it allows to get insight into the causal relationship between noise and health, without taking confounding factors into account (e.g. air quality). To achieve this, biological response measurements are performed, thanks to an

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[4] The sensors have a precision of measurement of more or less 5dB. They can indicate whether a standard has been exceeded. In that case, our enforcement services intervene and can measure with more accurate devices on site.

[5] These maps are based upon a weighted 24-hour annual average sound pressure level, with evening and night levels being relatively more heavily weighted (L_{den})

Sophie De Mulder, Michel Goethals, Mart Verlaek, Liesbeth Gommé, Niels De Kempeneer, Tine Van Hoof, Maja Mampaey, Philippe Van Haver, Caroline Teughels, Geert Van Haute, Karen Van Campenhout

ECG and actimetry device that the participants carry on their body (heart rate variability, motility,…). As mentioned in the introduction, perception is an important factor when we are dealing with annoyance. Therefore, the project uses a survey, in the form of self-reported noise annoyance and sleep disturbance among the pilot project participants.

In addition, noise at night is measured both inside and outside the home. That simultaneous measurement makes it possible to differentiate between indoor en outdoor noise (and to analyse the difference in impact on sleep), and also to identify the source of the ambient noise. The latter is important knowledge for policy: by knowing the sources, certain measures can be taken if necessary.

3.3.3   Results

Both PPI projects are ongoing. The first one that deals with health effects and sleep quality of the participants, is expected to be completed in December 2023. This project wants to monitor the impact of noise on health. A measurement protocol will be drawn up for later roll-out in a subsequent HBM (Human Biomonitoring) campaign. From this, the effect of noise on health (and quality of life) can then be monitored on a larger scale in Flanders. The second PPI project will end in March 2025. The result will be a proof of concept in order to map noise in Flanders more area-wide (in relation to the existing noise maps), classification of noise sources and their appreciation. A concrete plan of approach will be drawn up, to be used afterwards in a large-scale citizen science project. The data from the citizen science project will serve to create an area-wide map, which can also validate modelled noise maps.

So far, the results of the projects mainly focus on the technical aspects, regarding the the technology used, IT applications, problems encountered during the pilots, etc. This information will be processed in order to establish a concrete measurement protocol for later use.

4   OVERARCHING CONCLUSIONS AND REFLECTIONS ON SENSOR-BASED RESEARCH FOR LIVING IN A HEALTHY ENVIRONMENT

4.1 Reflections concerning spatial planning

This paper first and foremost highlighted the relationship between spatial planning and health by introducing the concept of healthy living and working environments. The physical environment has a major influence – both positive or negative — on our well-being and health. For instance, the beneficial effects of green space on physical and mental health are widely accepted and scientifically researched. Conversely, exposure to chemical pollutants present in air, water, soil, food or in certain products can lead to a broad spectrum of health effects that vary in severity and duration. The same applies to exposure to physical stressors such as noise, radiation, and biological stressors such as bio-effluents, including exhaled CO_2 and moisture but also bio-aerosols such as viruses and bacteria. Introducing more health aspects in spatial planning has several benefits. It takes into account the vulnerability of specific groups, such as the elderly, children and the chronically ill. Research shows that health differences exist between socioeconomic groups, and these differences also manifest themselves spatially (RIVM, 2017).

This paper mainly focused on protection, which is an important task of the government, by starting to measure the exposure of different stressors in the field. The underlying question is what measures help to achieve a healthy living environment. In the case of indoor environmental quality, where we focused on more vulnerable groups such as children and elder people, behaviour plays an important role, and sensitisation of different target groups (inhabitants, staff, architects, building contractors) is an important aspect. The measurements have also directly fed policy at other governmental agencies, e.g. the framework around ventilation and aeration in care centres. With non-ionising radiation from transmitting antennas, it is mainly about the legal standards, which must not be exceeded, and informing people correctly and removing any concerns. Finally, with noise exposure, we are only in the early stages of getting a grip on the state of affairs. These insights can give input to policy measures in the future, such as imposing noise standards in certain environments or specific measures to be included in noise action plans.

Flanders is not the only region dealing with measuring and tackling environmental impact on health. Of some factors, such as RF exposure, we know that other regions and countries are conducting studies to monitor this. Of other factors, we do not yet know about how the results of measurements are implemented in the policies of other countries, e.g. for the case of noise exposure. Presumably, our PPI studies on noise

could be relevant as it is conducted within a policy context and rolled out afterwards. In any case, it is interesting to follow up other countries and regions in the future.

Flanders is a densely populated region, and throughout the day everyone is exposed to certain stressors to a greater or lesser extent. Even though exposure partly depends on lifestyle and behaviour, a further exploration of spatial factors in relation to exposure seems interesting. Overall, we know that people living in urban environments are more likely to be exposed to certain environmental stressors, but there may be many differences between urban areas. For example, traffic density, proximity to certain industrial activities (and thus exposure to noise, among other things) play a role and may also occur outside urban areas (or cores) in Flanders. Agricultural activities outside cities, in turn, are a potential source of stressors. These constitute interesting starting points for further spatial research.

4.2 Refections about sensor-based research

Working closely with partners, we were able to develop innovative sensors, which we use in research that supports policy, as well as in policy preparation and standards evaluation. This way of working with sensors has the advantage of being cost-efficient, quick to set up and a step towards an independent and objective measurement network. It also has its challenges because it implies continuous monitoring of the latest technological innovations. The roll-out of different sensors in the field is also a process of learning by doing, that takes some time. It also requires a commitment to building in-house knowledge. Still, it remains worthwhile to enrich our knowledge and models with data in the field. Field measurements allow us to measure many more fluctuations and nuances, and we are closer to people's daily lives.

5   REFERENCES

AERTS, S., VERMEEREN, G., VAN DEN BOSSCHE, M., AMINZADEH, R., VERLOOCK, L., THIELENS, A., LEROUX, P., BERGS, J., BRAEM, B., PHILIPPRON, A., MARTENS, L. & JOSEPH, W.: Lessons Learned from a Distributed RF-EMF Sensor Network. Sensors (Basel), doi: 10.3390/s22051715, 2022.
DIEZ, L., AGÜERO, R. & NUÑOZ, L.: Electromagnetic Field Assessment as a Smart City Service: The SmartSantander Use-Case, in: Sensors 17, no.6:1250. doi: 10.3390/s17061250, 2017.
ELMENHORST, E.-M., GRIEFAHN, B., ROLNY, V. & BASNER, M.: Comparing the Effects of Road, Railway, and Aircraft Noise on Sleep: Exposure–Response Relationships from Pooled Data of Three Laboratory Studies, in: International Journal of Environmental Research and Public Health. International Journal of Environmental Research and Public Health 16, no. 6: 1073. doi: 10.3390/ijerph16061073, 2019.
GOMMÉ, L., VERLAEK, M., DE KEMPENEER, N., GOETHALS, M., VAN HOOF, T., DE MULDER, S. & VAN CAMPENHOUT, K.: Simulations of the virtual roll out of 5G in Flanders with regard to electromagnetic exposure, BioEM 2023, the 2nd Annual Meeting of the BioEM Society, Oxford (United Kingdom), 19-23 June 2023.
GOMMERS, A., VERHAEGEN, K., BAKEN, K. & KOPPEN, G.: Instrumentele analyse van gezondheid in het ruimtelijk beleid, uitgevoerd in opdracht van het Vlaams Planbureau voor Omgeving, 2019.
HIGH HEALTH COUNCIL BELGIUM, Indoor Air Quality in Belgium. Advies nr. 8794. Brussels: HGR, 2017.
LAZAROV, B., ELEN, B., SPRUYT, M, & STRANGER, M.: Long-Term Monitoring of Environmental Pollutants in the Indoor Climate of Various Housing Types, 2019.
PISMAN, A., VANACKER, S., BIESEMAN, H., VANONGEVAL, L., VAN STEERTEGEM, M., POELMANS, L., & VAN DYCK, K. (Eds): Ruimterapport Vlaanderen 2021. Brussels, 2021.
TASKFORCE VENTILATION, Recommendations for practical implementation and monitoring of ventilation and indoor air quality within the framework of COVID-19, 2019. Available at: https://werk.belgie.be/sites/default/files/content/documents/Coronavirus/Implementatieplan_ventilatie.pdf [Accessed August 31, 2023]
TEUGHELS, C., VERHEYEN, V., VERVOORT, P., COERTJENS, D., BIJNENS, E., VOS, S., NAWROT, T., DEN HOND, E., SCHOETERS, G. & VAN CAMPENHOUT, K.: From human biomonitoring research to spatial explicit evidence and policy recommendations. Green space exposure and health effects in Flanders (Belgium). 58th Isocarp World Planning Congress, Brussels (Belgium), 3-6 October 2022.
RIJKSINSTITUUT VOOR VOLKSGEZONDHEID EN MILIEU: Gezonde leefomgeving, gezonde mensen. Bilthoven: RIVM, 2017.
WHO: Environmental noise guidelines for the European Region. 2018. Available at: https://www.euro.who.int/en/publications/abstracts/environmental-noise-guidelines-for-the-european-region-2018 [Accessed June 22, 2023]
WHO: Health in all policies: Helsinki statement. Framework for country action. 2014. Available at: https://apps.who.int/iris/bitstream/handle/10665/112636/9789241506908_eng.pdf [Accessed June 21, 2023]

496

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Local Climate Adaptation Governance and Planning: Challenges to Transformation

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1 ABSTRACT

Climate adaptation has so far been a voluntary topic for municipalities (in Germany), in consequence there is a fundamental challenge to establish the topic in everyday municipal life and to create suitable structures.

From sustainability and transformation research as well as from mainstreaming experiences with the topic of climate protection, a variety of insights can already be gained that are important for integrating the topic of climate adaptation in local governments. While there are many findings from research on sustainable development and climate protection, the introduction of a new produces some further challenges regarding the complexity of structures and processes.

In this contribution, it will be argued that there structural, procedural, and contextual barriers to local climate adaptation in governance and planning. Based on this assumption, experiences in transformation towards climate adaptation in a specific local administration will be analyzed and discussed. The case presented is part of the ReWanKa project in Berlin (Reallabore Regenwasser und Klimaanpassung) which focuses on experimenting with administrative structures.

Keywords: Local Governance, Local Planning, Climate Adaptation, Challenges Transformation, Germany

2 MAINSTREAMING CLIMATE ADAPTATION

Natural and anthropocentric climate change are major challenges affecting all global, national and local societies, economies, and individuals in various ways (EEU 2020). Over the last decades, many efforts have been made on the local, national and international levels already. Concepts and goals varied over time, starting with sustainable (local) development in the 1970s, the topic of climate (protection) in the 1980s, and followed by the topic of climate adaptation in the 1990s (Smithers, Smit 1997). This contribution explores the challenges of mainstreaming climate adaption in local governments.

2.1 State of the Art – Learnings from Research and Practice on sustainable development and climate protection

The first argument of this contribution is that in order to understand the challenges of introducing "climate adaptation" to local governments, a lot can be learned from empirical and practical findings from sustainable development and climate protection activities from different level. In the following, a very short overview of three aspects of transformation will be presented that one keeps coming across in the literature: Complexity, Paradigm Shift, and Place- or Context-Based solutions.

In the literature, it has been acknowledged that comprehensive sustainable development constitutes a multi-level challenge (Geels, Kemp 2012). Furthermore, that it needs to be understood as a long-term and sometimes resource-intensive process (Krellenberg 2016) which has to deal with "highly complex real problems" (Zscheischler/ Rogga/ Weith 2014). In order to deal with such complexity, large parts of the literature postulate that more cross-sectoral and flexible approaches are needed (Clune, Zehnder 2018). It is acknowledged that established silo thinking must be deconstructed (Chu 2016) in order to integrate (new) topics and structures. It is also ackowledged the importance of different forms knowledge as a basis for any successful sustainable development and climate protection (Walter et al. 2007; see also EU 2020).

In addition to acknowledging the complexity, a general shift in paradigms, framings and priorities can be observed: Initially, sustainable development and climate change were being conceived as a mainly environmental problem (Chu 2016) that can be solved with new technical solutions and new legal bindings (Ostrom 2012). But it became obvious that the complexity of the "problem" needs the cooperation and participation of large parts of society (Adger et al. 2013). In consequence, not only internal structures and foci were questioned but different paradigms promoted: This included a general shift from hierarchically organized approaches to participatory, co-creative or even cooperative approaches (Glass, Newig 2019) as well as a shift from the still prevailing approach of reactive to pro-active local governance and planning (Van der Berg 2022).

A third finding is that any approach to effective sustainable development and climate protection must be place- and context-based. In consequence, the concepts must be operationalized in different ways for different places (Elmquist et al. 2019) in order to have a chance to implemented successfully. This takes into account that effects of climate change are different in different places as well the finding that an abstract topic such as climate adaptation can be framed and operationalized differently, for example in the contexts of public health and life quality – or exclusivity and vulnerability.

2.2 Implications for Climate Adaptation Governance and Planning

These three characterics of sustainable development and climate protection embrace complexity, paradigm-shifts and local approaches. But they also highlight "a series of systemic pressures on urban public institutions [among others]" (Chu 2016: 2). Introducing the topic of climate adaptation may underlie similar pressures. First insights are already provided by cities all over the world embracing the topic of climate adaptation in governance and planning (Van der Berg 2022; Araos et al. 2016; EEA 2020).

According to the literature, Climate adaptation is similarly being conceived as a cross-sectoral, complex issue that needs different mindsets, flexible governance as well as context- and place-based solutions (Baker et al. 2012; Van der Berg 2022:18). These findings lead immediately to the question on how to integrate the topic of climate adaptation into existing processes and structures. Or whether it should be prioritized?

The second argument of this contribution is, in consequence, that there are fundamental practical challenges to establish the topic of climate adaptation in municipal governance and planning. This might also explain why local governments are more or less successful in dealing with these challenges. Existing concepts and plans usually stop short before explaining how to practically integrate topics and structures (Van Der Berg 2022:7). The following part of this contribution will explore reasons for such an "uneven uptake". In order to understand, a simple framework will be applied. The argumentation line of this framework is that local climate adaptation cannot be successful "without addressing structural, procedural, and contextual barriers" (Baker et al. 2012: 127). In a first step, I will illustrate a bit further these three aspects and relate them to what was written in chapter 2.1.

Structural aspects: First of all, there still seems to be a misunderstanding that climate adaptation is a separate topic that should best be dealt with with specific policies, objectives and plans. (institutional 'silos'). Another misunderstanding is that it is considered an environmental issue (Baker et al. 2012: 134; Van Der Berg 2022: 1). In consequence, suitable organizational structures are required to integrate climate adaptation in the long term (DIfU 2015). This would include to truly integrate awareness, capacity and resources for the issue of climate adaptation in administrations (Susskind & Kim 2022). But there are indications, that the topic can be pushed better either by strong leadership (with for example key actors and key events; Haupt, Kern 2020) and/or the formulation of explicit (and legitimate) goals (Um 2018; DIfU 2015). But given the complexity of the process, there often is a need for interim steps and solutions which might be contraproductive to the idea of climate adaptation on the long run (Baker et al. 2012).

Procedural aspects: With the understanding that climate adaptation must be supported by large parts of the society, adequate processes must also embrace different perspectives and population groups (Preston et al. 2011). In consequence, new forms of stakeholder engagement are implemented more and more often (Susskind, Kim 2022). But similar to the fact that there is not much empirical evidence regarding the structures and restructuration efforts of local administrations, there is neither much evidence for "the design of public participation efforts" (Uittenbroek et al. 2019).

As mentioned above, local consequences of climate change are rather unknown and suitable structures do not exist yet. One popular approach to deal with this uncertainty is experimentation (Bulkeley, Castán Broto, & Edwards, 2015; Chu 2016). It is said to allow for learning-by-doing (Susskind, Kim 2022), for generating new governance capacities (Healey, 2004), and more effective policy styles (Lesnikowski et al. 2021) - as a pre-stage to formal planning (Schmitt et al. 2019).

Contextual aspects: The integration of a new topic also asks to consider wider structural and content-related contexts. This ranges from the establishment of new internal structures and procedures to the integration of different levels and competing objectives. Which reinforces the argument that, even within an institution, new forms of aggregating and sharing knowledge are needed (DifU 2015). In addition, local adaptation governance and planning are never independent from higher levels (Brooks & Adger 2005) - their concepts,

498

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

plans, legal frameworks and timeframes. For example: One specific climate adaptation measure may be considered state-of-the-art in one administrative unit, but it may have negative consequences on specific natural elements, or people, or socio-economic trends. And one more aspect: While most local administrations have to deal with limited ressources in general, their ressources may be allocated differently between units and departments (Chu 2016), causing further imbalances in capacities. And all these aspects increase the degree of complexity.

3 THE REWANKA PROJECT

ReWanKa (Reallabore Klimaanpassung und Regenwasser – Living Labs Climate Adaptation and Rain Water) is a transdisciplinary project dedicated to introduce the topic of climate adaptation to a specific local government with a focus on developing governance and planning approaches regarding rain water.

The motivation for the project was that, in Berlin, almost all construction projects have so far been planned without using the synergies of decentralized rainwater utilization and climate adaptation measures. Adequate solutions to reduce the effects of droughts and heavy rain events on urban vegetation are well known, but so far these have only been insufficiently incorporated into official action. As a result, during the current construction boom in a growing city, opportunities are repeatedly missed to jointly develop rainwater utilization and climate adaptation measures and to integrate them into higher-level plans and projects.

3.1 Methodological approach

In order to get the process started, the method "constellation analysis" (Konstellationsanalyse) was introduced. It has been developed as a method of innovation research, as a so-called "bridging concept for [problem-oriented] technology, innovation and sustainability research" (Schön, Nölting & Meister 2004: 3). It can be used to depict and analyze relationships between technology and differently organized society - also across different levels. During the ReWanKa project, we used the method for facilitating communication between (science and) practice, structuring of different perspectives, and capturing complex problem constellations (Schön et al. 2007; Ohlhorst, Kröger 2015).

The methodological core of the method is a workshop where invited stakeholders jointly develop a visualisation (they map a constellation) of an actual problem. In the case of ReWanKa, the question was: "How can the ability to act regarding rainwater/climate adaptation be strengthened (within the local administration)?". In this workshops, the participants visualize the quality of a relation between actors, natural elements, signs and codes as well as technical artefacts. Such a visualisation helps to understand how aspects are (not) interrelated and which aspects are missing.

This methodological core can be added to by other formats. In the case of ReWanKa, we did five interviews beforehand with people responsible for specific topics within this sub-unit. The aim was to better understand how this unit is working, to start this discussion process and to identify shared points or terms of reference. Topics were structure, processes and context of their work, their content-related focus and specific challenges in relation to climate adaptation and rain water. The aggregated results of the interviews were discussed and validated during the actual constellation analysis workshop with a group of fourteen people (including some of the Interviewees). And later on, first ideas developed during the workshop have been implemented.

3.2 Intermediary Results

In the following, a short summary of the (intermediary) results of the projects, following the framework that has been presented in chapter 2.2.

Regarding structural aspects: The district administration has embraced the topic of climate change already with several resolutions) and the allocation of personal ressources (climate protection managers). The interviewees refered to a large variety of plans, guidelines and concepts on climate protection and sustainability that are relevant for their work – but not many named the same ones. Decision-making structures and processes, similar to the whole district administration, are well established, but linear in order to be efficient. The recent increase in personal ressources, rather unusual, has helped to attract some comparatively young staff.

The interviewees felt that climate adaptation is an important topic and that steps need to be taken to integrate it into their governance and planning processes. Rain water, in contrast, was a topic that was less well known. While conducting the interviews, it became obvious that introducing two topics at the same time is a rather complex challenge in itself. But in the end, this two-fold focus helped to better understand nuances in structure, process, context. Most of all, it turned out that different staff, units and departments have different perspectives and refer to different (legal) frameworks, content, scope and timeframes with differing data formats, and levels of detail. In addition, professional perspectives may be mixed with individual ones: For example, the interviewees were concerned to a different degree with the issues of climate adaptation and rainwater, they felt that specific aspects of climate change respectively measures were more relevant than others, and they would argue based on different guidelines and plans.

Regarding procedural aspects: Despite high individual motivation, the linear organisation of communication processes as well as the general workload do not allow for much discussion, knowledge sharing, or reflection. So far, to give a typical example, content-relation position statements are delivered according to a transparent but linear structure. Nonetheless, some of the staff already thought a lot about integrating climate adaptation in their work. They are aware that it would be a long-term, complex and ressourceful process – but felt that something needs to be done to promote the topic within the whole district administration.

An idea that was mentioned several times was that there should be more content-related exchange and reflection on the consequences of their linear structure. This idea has been implemented shortly after the workshop, leading to a lively internal discussion about formats and specific aspects of climate adaptation governance and planning – and a continuing demand for regular content-related meetings.

Regarding contextual aspects: As mentioned before, different departments relate differently to the topics of climate adaptation and rain water - even within this comparatively small unit of the local administration. During the workshop, it became obvious that the knowledge about factual climate adaptation/rain water measures is very limited. Which means that it is more difficult to integrate something if one does not have and idea what would be possible. In this specific case it was, most of all, lacking knowledge of the possibilities and synergies of coupling various decentralized rainwater management and climate adaptation measures such as facade and roof greening or evaporation with energy-efficient, intelligent rainwater collection. In addition, the informal discussions helped to better understand specific consequences of administrative decisions. Especially when it comes to understanding wider socio-economic effects of governance and planning decisions.

While these first steps were very promising, the question is what (further) challenges will emerge when trying to establish the topics in a wider institutional context? It became obvious that more personal resources would be needed (this goes not only for climate adaptation). But it remained unclear who should take on coordination respectively leadership for the process. Anyway, the participants of the workshops agreed to continue informal exchanges. But they also felt that the general term "climate adaptation" is – according to the findings - seldomly used successfully in work conversations.

4   DISCUSSION – MAINSTREAMING LOCAL CLIMATE ADAPTATION

The ReWanKa project deals with the transformation issue of structural, procedural and contextual barriers. This short exploration highlighted practical issues – and provides some insight in the complexity of further practical steps to take.

The approach taken in this specific unit of local administration is an informal, explorative approach. But they face a linear, well-established structure that does only little allow for knowledge exchange, experimentation and reflection. Nonetheless, a new generation of public administrators is determined to integrate the topic. And they are aware that it will and must be a long-term and complex process with many steps to take.

It has been agreed that there should be regular, informal meetings with content-related discussions. This might also happen with different departments and different people joining once in a while. At this stage, it is unclear what the most suitable format could be. But it was decided to organize project-based meetings before the actual process of approving a new building application in order to informally exchange professional opinions, ideas and concerns. This, so is the hope, might also help to discuss the integration of the concept of climate adaptation in general at the local level. This clearly shows how content and structure are interrelated.

There are some first steps towards a more reflective structure in this (part of the) local district administration. However climate adaptation, is still a voluntary task for local governments in Germany. In consequence, there will be a large variety of approaches in the future. Despite the assumption that the findings describe a rather typical example of German local administration, it became clear that local administrations are not at all homogenous institutions. And it must be assumed that not every governance or planning approach works in every local administration.

5 CONCLUSION

Reflecting these intermediary results, the project is still very far from jointly developping standard solutions and processes that have great potential for change – as formulated in the application for the project. I presented a short insight into practical problems of local administration, structural, procedural and contextual, as well as some aspects of their interplay. Some useful ideas regarding the transformation of structures and procedures were developped, now facing the challenge of stabilization and mainstreaming.

It also became obvious that members of staff need some (internal and external) inspiration in order to understand the variety of consequences of implementing specific measures. This turned out to be productive. But at the same time, the discourse on rain water in this project has mostly been limited to the interrelations between blue and green infrastructures. But it could also be framed in other ways, too: Local governments could create specif´n incentives to encourage the use and reuse of rainwater, or awareness campaigns on the benefits of rainwater harvesting and how to collect, store, and use it efficiently. But then again - there may be some other important topics too in local administrations. The search continues …

6 REFERENCES

ADGER, W. N., BARNETT, J., BROWN, K., MARSHALL, N., & O'BRIEN, K. (2013). Cultural dimensions of climate change impacts and adaptation. Nature climate change, 3(2), 112-117.

ARAOS, M., L Berrang-Ford, JD Ford, SE Austin, R. Biesbroek and A Lesnikowski, "Climate Change Adaptation Planning in Large Cities: A Systematic Global Assessment" (2016) 66 Environmental Science and Policy 9.

BAKER, I., Peterson, A., Brown, G., & McAlpine, C. (2012). Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. Landscape and urban planning, 107(2), 127-136.

BROOKS, N., ADGER, W. N., & KELLY, P. M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global environmental change, 15(2), 151-163.

BULKELEY, H., Castán Broto, V., & Edwards, G. A. S. (2015). An Urban Politics of Climate Change: Experimentation and the Governing of Socio-Technical Transitions. New York and London: Routledge.

CHU, E. K. (2016). The governance of climate change adaptation through urban policy experiments. Environmental Policy and Governance, 26(6), 439-451. https://doi.org/10.1002/eet.1727

DIFU (Deutsches Institut für Urbanistik gGmbH) (ed.). (2015). KommAKlima - Hinweise 4. Kommunale Strukturen, Prozesse und Instrumente zur Anpassung an den Klimawandel in den Bereichen Planen, Umwelt und Gesundheit. Sonderveröffentlichungen, Köln.
https://repository.difu.de/jspui/bitstream/difu/211161/1/KommAKlima_Hinweise4_final.pdf.

EUROPEAN ENVIRONMENTAL AGENCY (2020). Urban Adaptation in Europe: How Cities and Towns Respond to Climate Change (Copenhagen, European Environmental Agency 2020).

GEELS, F. W., and KEMP, R. (2012). "The multi-level perspective as a new perspective for studying sociotechnical transitions," in Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport, eds F. W. Geels, R. Kemp, G. Dudley, G. Lyons (New York: Routledge), 49–79.

GLASS, L. M., & NEWIG, J. (2019). Governance for achieving the Sustainable Development Goals: How important are participation, policy coherence, reflexivity, adaptation and democratic institutions?. Earth System Governance, 2, 100031.

KRELLENBERG, K., KOCH, F., and KABISCH, S. (2016). Urban Sustainability Transformations (UST) in Lights of Resource Efficiency and Resilient City Concepts.

HAUPT, W., & Kern, K. (2020). Entwicklungspfade von Klimaschutz und Klimaanpassung in Remscheid. Leibniz-Institut für Raumbezogene Sozialforschung (IRS): Erkner.

HEALEY, P. (2004). Creativity and urban governance. Policy Studies, 25(2), 87–102.

LESNIKOWSKI, A., BIESBROEK, R., FORD, J. D., & BERRANG-FORD, L. (2021). Policy implementation styles and local governments: the case of climate change adaptation. Environmental Politics, 30(5), 753-790.

OHLHORST, D., KRÖGER, M. (2014): Konstellationsanalyse. Einbindung von Experten und Stakeholdern in interdisziplinäre Forschungsprojekte mit der Konstellationsanalyse. In: Marlen Niederberger, Sandra Wassermann (Hrsg.): Methoden der Experten- und Stakeholdereinbindung in der sozialwissenschaftlichen Forschung. Wiesbaden: Springer Fachmedien, S. 95-116.

OSTROM, E. (2012). Nested externalities and polycentric institutions: must we wait for global solutions to climate change before taking actions at other scales? Economic Theory 49: 2 (2012): 353–369. /z-wcorg/.

PRESTON, B. L., YUEN, E. J., & WESTAWAY, R. M. (2011). Putting vulnerability to climate change on the map: a review of approaches, benefits, and risks. Sustainability science, 6, 177-202.

SCHMITT, K. M., Ontl, T. A., Handler, S. D., Janowiak, M. K., Brandt, L. A., Butler-Leopold, P. R., ... & Swanston, C. W. (2021). Beyond planning tools: experiential learning in climate adaptation planning and practices. Climate, 9(5), 76.

SCHÖN, S., NÖLTING, B., & MEISTER, M. (2004). Konstellationsanalyse. Ein interdisziplinäres Brückenkonzept für die Technik-, Nachhaltigkeits-und Innovationsforschung. Zentrum Tecnik und Gesellschaft. Techische Universität Berlin. Berlin; Juni 2004.

SMITHERS, J., & SMIT, B. (1997). Human adaptation to climatic variability and change. Global environmental change, 7(2), 129-146.

SUSSKIND, L., & Kim, A. (2022). Building local capacity to adapt to climate change. Climate Policy, 22(5), 593-606. https://www.tandfonline.com/doi/abs/10.1080/14693062.2021.1874860.

UITTENBROEK, C. J., Mees, H. L., Hegger, D. L., & Driessen, P. P. (2019). The design of public participation: who participates, when and how? Insights in climate adaptation planning from the Netherlands. Journal of Environmental Planning and Management, 62(14), 2529-2547.

UM, E. B. W. (2018). Umsetzung der kommunalen Klimaanpassung in die Bauleitplanung im Pilotprojekt der Entwicklung des Geländes der Spinelli Barracks/Grünzug Nordost in Mannheim.

VAN DER BERG, A. (2022). Climate Adaptation Planning for Resilient and Sustainable Cities: Perspectives from the City of Rotterdam (Netherlands) and the City of Antwerp (Belgium). European Journal of Risk Regulation, 1-19.

WALTER, A. I., HELGENBERGER, S., WIEK, A., & SCHOLZ, R. W. (2007). Measuring societal effects of transdisciplinary research projects: design and application of an evaluation method. Evaluation and program planning, 30(4), 325-338.

ZSCHEISCHLER, J., ROGGA, S., and WEITH, T. 2014. Experiences with Transdisciplinary Research: Sustainable Land Management Third Year Status Conference. Systems Research and Behavioral Science, 31(6), 751–756.

Making Green Real – How to Promote Greenery in Real Estate Development

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1 ABSTRACT

Climate change and rising temperatures particularly affect the built environment and intensify the Urban Heat Island (UHI) effect in cities. Nature-based solutions can have a balancing function and reduce overheating. However, greenery still receives too little attention in architecture and is added as an additional element at the end of the planning phase or even after the building has been constructed.

For a climate resilient urban development in the future, in addition to a change in processes, a change in real estate development and in the project management is necessary.

At least, three preconditions must be met for this to happen:

- Sound knowledge base: Many studies already exist proving the positive effects of nature-based solutions for densely built cities. However, the knowledge transfer to real estate companies is still insufficient as they require precise and site-specific information showing effectiveness of greenery on microclimate, building envelope and indoor temperature. At best, analyses apply a system view and consider interrelations with water and energy.

- Greenery-friendly planning framework: Real estate development takes place in compliance with local planning standards and procedures. Planning strategies and regulations, standards, urban development contracts and funding programmes strongly influence urban design and development and hereby have great potential to promote greening.

- Integrated mindset: In architecture and real estate development, it is still not standard to include greenery and nature-based solutions in design, planning and construction. Building optimization also includes greening. Thus, it needs an integrated mindset regarding greenery as natural part of architecture. This requires more awareness and knowledge about climate change and the benefits of nature-based solutions on quality of life and value of real estates in the long run.

The paper summarizes the experience of an interdisciplinary cooperation in the research project GreenDeal4Real and addresses all three aspects in detail. Analyses of the planning framework in Vienna and impacts of greening measures on the microclimate are described and general conclusions for more green in real estate development are drawn.

Keywords: 081

2 INTRODUCTION

The latest IPCC report confirms that worldwide cities are already affected by climate change with negative effects on human health, livelihood and key infrastructure (IPCC 2023). Thus, in order to sustain the liveability in cities, adaptation measures to climate change must be implemented today to proactively counteract negative developments in the future as climate change and its effects on cities in particular is expected to continue through the 21st century (Goodess 2012, Christidis et al. 2015, Qiu and Yan 2020).

Main issues in cities are the above-average warming known as Urban Heat Island (UHI) effect and the increase of heavy precipitation and its resulting runoff intensity (IPCC 2023). Causes are to be found in the

typcial urban structures with sealed surfaces and construction materials with different heat storage capacities than natural ones (Sharifi and Lehmann 2014, Singh et al. 2020), absorbing solar radiation during the day and releasing the energy surplus in the form of sensible heat flux and longwave radiation during the night. The UHI effect is further intensified by anthropogenic heat emissions, which are among others produced by traffic, households, industry and increasingly through air conditioning systems (Sham and Memon 2012).

Climate scenarios and projections show that the climatic situation in cities will even worsen in the future. Brown (2020) researched the present and future heatwave hazard for cities worldwide and found that temperatures are expected to rise during heatwaves by between 3.4 to 6.6 ∘C until 2099 (basis 2006). Although it is proved that more intense and frequent heatwaves result in excess deaths, this is still an "invisible risk" that is not given sufficient attention in policy and planning (Brimicombe et al. 2021).

Thus, it is high time that cities seriously address their vulnerability to climate change and start to transform towards climate resilient urban structures. More and more cities are becoming aware of the impending effects of rising temperature and extreme weather events and strategically plan and start to adapt the urban environment to the upcoming changing framework conditions. Green and blue infrastructure, i.e., a network of green spaces and water permeable surfaces as well as individual plants, green facades or green roofs, and corresponding rainwater management play an essential role for the urban microclimate and represent a possibility to significantly reduce the extent of the UHI effect (MA22 2015, Roehr and Laurenz 2008, Kleerekoper et al. 2012; Norton et al. 2015). Integrating nature-based solutions into urban structures helps to mitigate negative climate change impacts such as heat stress and flooding through natural cooling (evapotranspiration) and water absorption, storage and infiltration (Carter 2018; Everett et al. 2018; Li et al. 2019). Nevertheless, it is not even a matter of course for new buildings that optimal and most effective greening is implemented.

Exactly this issue is addressed in the research project "GreenDeal4Real - Improving the thermal comfort in mixed-use areas through cost-effective green infrastructure", which is funded by the BMK (Austrian Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology) and implemented under the "City of Tomorrow" program. The project researches how positive effects of greening measures can be assessed, quantified, optimised and integrated into planning and construction processes. An actual real estate development project in the 22nd district of Vienna is taken as case study and demonstration site for testing the optimal integration of green measures into the design and construction process. The research project contributes to the construction process in an early planning stage when it is still possible to adapt static and design and to integrate greening into archtitecture. A systemic, integrative approach is pursued, which is also reflected in the composition of the interdisciplinary project consortium consisting of the AIT Austrian Institute of Technology GmbH, 6B47 Real Estate Investors AG, the landscape planning companies grünplan gmbh and Lindle+Bukor, the City of Vienna represented by the MA 18 - Stadtentwicklung und Stadtplanung, the greening company 90deGreen GmbH and the green innovation laboratory GRÜNSTATTGRAU. The exchange in the interdisplinary team allowed mutual learning and revealed regulatory barriers at the interface of private and public sectors that were discussed with city administration. Findings from the analysis for an efficient implementation of urban greening technologies, the microclimate simulations and the planning lab are presented in the following.

3   BENEFITS OF MICROCLIMATE SIMULATIONS IN THE EARLY PLANNING STAGE

In the last decades, microclimate simulation models became an important tool for the assessment of microclimatic performance of urban planning and building projects. While some models support the analysis of selected parameters (e.g. solar radiation, wind comfort), others aim at a holistic representation of physical processes in complex urban environments. In the project "GreenDeal4Real", two different microclimate simulation models were applied. While the Ladybug tool suite (module of the Grasshopper Plug-in of Rhino 3D) was used for evaluating radiation parameters (shading functions, mean radiant temperature in front of facades), ENVI-met as an example for a holistic microclimate model served to quantify the effects of greenery in an early planning stage of the real estate development project. ENVI-met is a three-dimensional model, locating buildings, vegetation and surfaces on a rectangular grid structure and simulating physical processes and interactions, such as radiation, wind dynamics, atmosphere-surface interactions, evapotranspiration and others. It is thus suitable to demonstrate the effects of greenery within this project.

504

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Tanja Tötzer, Martin Schneider, Bosko Bozic, Raoul Bukor, Doris Enzersdorfer, Susanne Formanek, Valentin Gebhardt, Martin Jung, Andreas Lichtblau, Werner Sellinger

While the entire real estate development project is divided into seven construction sites, two of them have been used in the microclimate studies. The 3D model of the buildings and vegetation were designed in Rhino 3D based on the current planning status and directly exported to ENVI-met to guarantee a consistent simulation process in both models. For meteorological boundary conditions, June 10th 2010 was selected as a representative hot summer day from a typical meteorological year (data source: EnergyPlus Weather File).
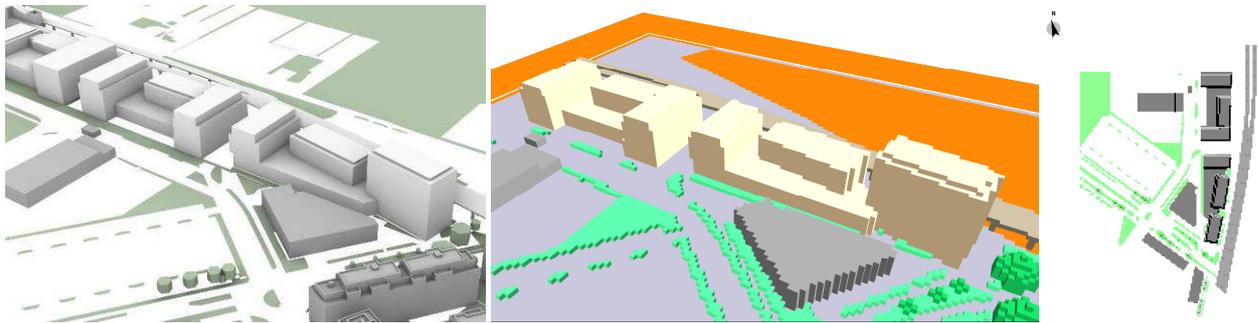
Figure 1: left: Model domain designed in Rhino 3D, middle: Model domain imported to ENVI-Met, right Orientation of domain

Based on the simulation results of a draft version without greenery, the interdisciplinary project team discussed options for façade greening, green roofs (including water management and retention) as well as the economic viability and developed realistic versions of applicable NbS for the site. The close cooperation between real estate developers, landscape architects, greening experts, microclimate experts and local authorities in the project provided the possibility to highlight important aspects from different perspectives in an early planning stage, allowing for consideration of statics, architecture, rainwater management and for relevant adaptations. The consideration of microclimate simulations in an early planning stage proved to be essential for facilitating fruitful discussions about greening measures and adaptations to conventional building design. Such changes towards microclimatic effective NbS have to be taken in an early planning stage when costs of design changes are still low and the ability to impact design is high.

First conducted simulation results focused on the analysis of solar radiation with the Ladybug tool suite. It revealed the shading function of balconies on Southern oriented façades (Figure 2) and suggested to focus façade greening options on west- or east-facing façades. Besides, the roofs were identified as most exposed areas to solar radiation. To provide the necessary thermal comfort and make use of the roof areas at one high-rise and both low-rise parts of the buildings as gardens and recreational zones, NbS were required fulfilling the necessary shading function. Following this recommendation, intensive roof greening including trees and pergolas was included in subsequent simulations with ENVI-met. On the remaining roofs, extensive roof greening was applied (Figure 3).
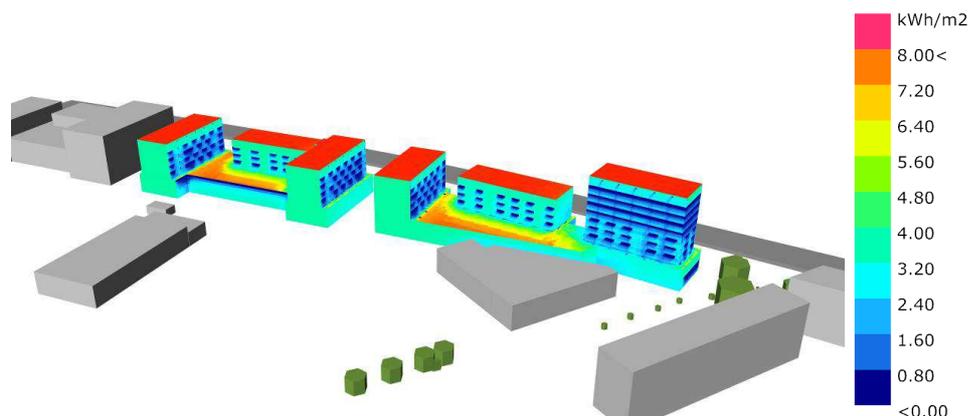
Figure 2: Solar radiation analysis of June 10th, 2010.

With regards to façade greening, various types have been discussed in focus groups:

- Wall-mounted green façade with substrate layer (full and partial coverage)
- Ground-based green façade without substrate layer (full and partial coverage)
- Trough-based façade greening without substrate layer (full and partial coverage)

- Climber systems in front of balconies

In accordance with experts for façade greening, economic viability and fire protection considerations, partially covered wall-mounted and trough-based façade greenings were selected for further microclimate simulations. Sensitivity results focusing on the effects of façade greening on Western and Eastern oriented walls, showed the expected results of strongest effects for Eastern oriented facades during the morning hours and Western oriented facades during the afternoon and evening hours. Due to increased microclimatic effects during the times where cooling effects are desired by residents of the building (afternoon and evening hours), façade greening was focused on west-facing façade areas between balconies on the high-rise buildings in the middle of each construction site. For simulation purpose, each selected type of façade greening (wall-mounted, trough-based) was applied to one building (Figure 3).

To evaluate the effects of both types of façade greening on the outside and inside wall surface temperature, one grid point with applied greening was selected at each building and compared to the draft version without greening (Figure 4). The trough-based version only led to a reduction of the outside surface temperature during sun exposition of max. 2.2 °C. After sunset the surface temperature adjusted to the non-green draft example. However, the effect on the inside surface temperature remained throughout the day without any significant peaks, but an increasing difference to the non-green version during the simulation period. As the same is true for the wall-mounted type, it can be concluded, that the effect of façade greening on inside surface temperature and consequently inside air temperature (not shown) increases during heat wave periods. In contrast to the trough-based façade greening, the wall-mounted type led to reductions of outside façade temperature during the entire day with maximum differences during sun exposition of 17 °C. The larger differences can be explained by the substrate layer, acting as additional insulation layer in the wall construction. The experiments were calculated with a leaf area index (LAI) of 1 (wall-mounted) and 1.5 (trough-based) as they are the default values in ENVI-met. Further sensitivity experiments with higher LAI values suggested even stronger temperature reducing effects for the trough-based type, but similar results for the wall-mounted type of façade greening.

Figure 3: left: ENVI-Met model domain with applied NbS: extensive and intensive roof greening, wall-mounted (left building) and trough-based (right building) façade greening, trees in front of buildings; middle: trough-based greening implemented in ENVI-Met; right: wall-mounted greening implemented in ENVI-Met.
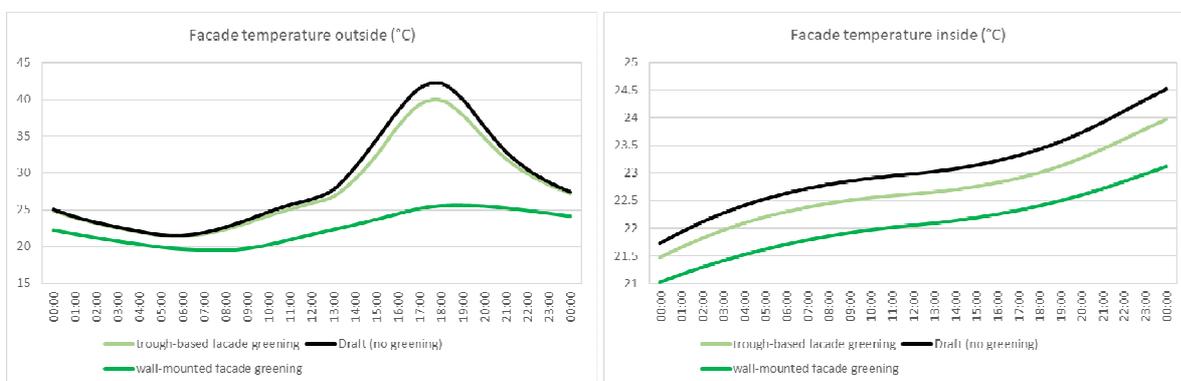
Figure 4: Comparison of façade temperature outside (left) and inside (right) with/without façade greening during one day

Evaluation results of different types, locations and intensities of NbS in the vicinity and directly at the buildings provided profound and decision-relevant information to the real estate developer of the building

506

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

project. Especially in early planning stages, where significant changes can be realised at low cost, compared to later planning stages, microclimate simulations provided an important source of information.

4 RELEVANCE OF THE PLANNING FRAMEWORK

Although microclimate simulations allow for assessing the effectiveness of different greening scenarios and for identifying optimal solutions from a microclimatic point of view, the actual implementation depends on additional framework conditions such as the planning framework. This is also the reason why a standard has been published in Austria in 2021, ÖNORM L1136, which includes the consideration of site conditions. Furthermore, the latest draft of the revision of the Energy performance of buildings directive (EPBD) already integrates green infrastructure. Member States must ensure that "new buildings…adapt to climate change through, inter alia, green infrastructure…" (Article 7 Paragraph 4). However, due to progressing climate change, further adaptations in the planning framework are needed to foster a transformation of cities towards more climate resilience. However, many existing regulations still act as a barrier for an easy and efficient implementation of nature-based solutions. For identifying the best greening solutions for the selected building project, the regulatory planning framework in the City of Vienna was evaluated. In a "planning lab" the project team exchanged with relevant stakeholders from city administration such as urban development, planning neighbourhoods and building inspection on potentials of guidelines, regulations, and urban development contracts.

In the City of Vienna, several guidelines for green roofs and green façades exist and since the amendment of the building code 2018 it is mandatory for new buildings that 20% of the façade oriented towards the street must be greened. However, the stakeholder interviews conducted during the project GreenDeal4Real showed that there are still several challenges in practice and potentials for further improving the planning framework to promote greenery.

In Vienna, the general definition of a mandatory 20% street-side façade greening in new buildings contributes to the promotion of green infrastructure and represents an essential step for greening in the city. However, in the case of street-facing façades that are exposed to the north, it is to be expected that the growth of plants will be impeded, and the microclimatic effect will be rather low. As a further development of the regulation, compliance with a green and open space factor in the construction of new buildings, which is planned to be implemented in the City of Salzburg (Stadt-Salzburg.at 2021) and combines built-up area, building volume, façade and roof greening, would be conceivable. It offers a system of parameters with a clear target but which can be achieved with several "levers" and takes the whole plot into account, which is more relevant for the microclimate than the single building, thus increases the positive effect on the microclimate and gives more flexibility to the design and planning processes.

Even though correct maintenance measures are essential for a well-functioning growth of green roofs and façades, controlling the compliance with required maintenance measures is a complex issue. At present, the current legal situation only requires a civil engineer to confirm the (correct) installation of greening measures. Although in the Austrian standard L1136 a care concept is integrated, a regular listing of maintenance checks in the building logbook could be a way to guarantee a continuous evaluation of the state of greening measures. Furthermore, the controlling bodies need relevant professional knowledge in landscape planning and greening as well as additional human resources.

Climate analyses are useful to assess the effects of building structure and greening measures on the microclimate. In the context of climate change and the resulting consequences for cities, it becomes more and more relevant to gain a deeper understanding of the effects of building projects on the microclimate. Conducting microclimate analyses can help to plan building projects in such a way that the climate resilience of new buildings is as high as possible. Particularly for large construction projects that not only affect the local microclimate but also the neighbouring urban areas and perhaps even wind circulation patterns for the entire city, mandatory microclimate analysis should be taken into consideration to identify the need for optimisation regarding building orientation and height and for greenery to maintain a microclimate at bearable level.

A rather specific but important topic is the fire protection. In the case of the GreenDeal4Real project, several challenges arose in order to comply with the newly issued requirements for fire protection of the City of Vienna. The building is located in a zone for mixed industrial-residential use and apartments are situated

above the ground storeys reserved for light industry and commerce. Thus, they fall into a higher building class which implied restrictions, especially on cost-efficient greening measures.

After several discussions in various committees with the City of Vienna, other consultants and representatives for the OIB 2 guideline (OIB = Austrian Institute of Construction Engineering), it became clear that a better consensus between greening and fire protection technology had to be found. The building inspection MA 39 from Vienna therefore carried out further fire tests with plants (meanwhile more than 90) and was able to revise the regulations. Since May 2023, a new requirement has been published and some of the examples mentioned in GreenDeal4Real have been included.

Now expanded greening options are given (see Figure 5), so that cost-effective ground-based systems can be used over several storeys for greening purposes. Through intensive exchanges with stakeholders misunderstandings and ambiguities could be eliminated and a compromise between safety and climate-resilient planning could be reached.
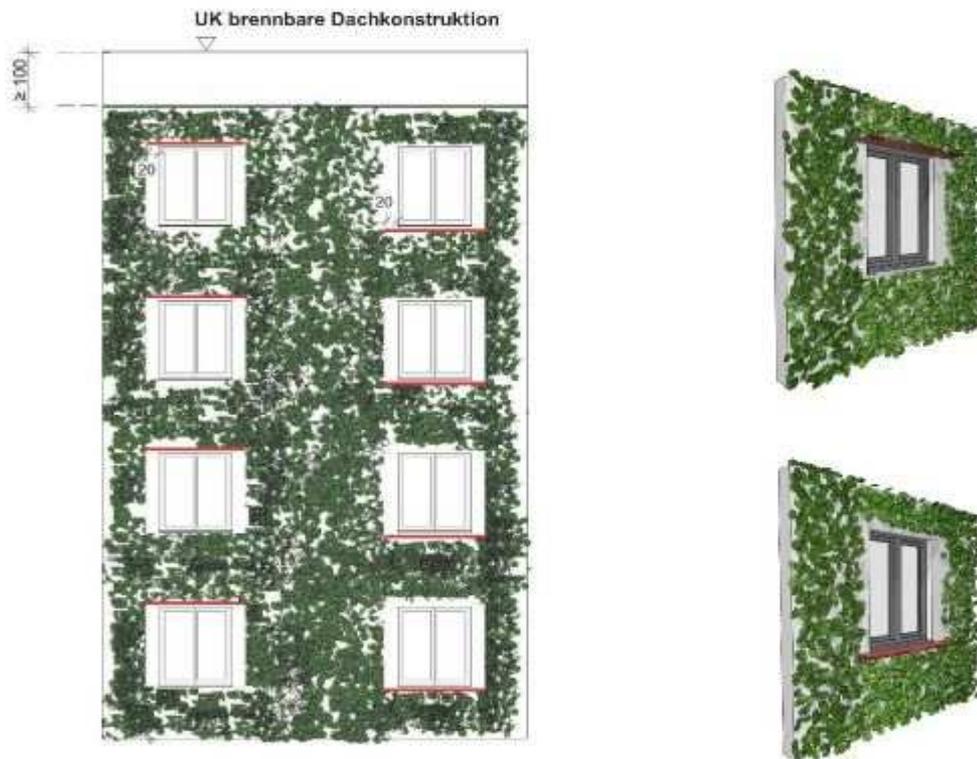
Figure 5: Expanded greening options in the new requirements for fire protection since February 2023; Source: Eder 2023, p.8 Chapter 2.2.6.

5 DISCUSSIONS AND LESSONS LEARNED

Many studies already exist proving the positive effects of nature-based solutions for densely built cities. However, the knowledge transfer to real estate companies is still insufficient as they require precise and site-specific information showing effectiveness of greenery on microclimate, building envelope and indoor temperature. Awareness of the interlinked parameters between built-up area and greening is often lacking, and additionally to the focus on the building itself, the effects on the neighbourhood I increasingly being taken into account. Thus, in the last years, microclimate analyses became an important tool for the assessment of different scenarios of urban planning projects on the local site and its neighbourhood. Even though the broader application of microclimate analysis is important and necessary, the simulation studies conducted in GreenDeal4Real have shown that there are still pitfalls and challenges which have to be considered.

Microclimate analyses are recommended to take place in an early planning stage and proved to be a good means to quantify the microclimatic effects of greening, raise awareness for the positive effects of vegetation for indoor, surface and outdoor temperature and foster a discussion among different disciplines of landscape

Tanja Tötzer, Martin Schneider, Bosko Bozic, Raoul Bukor, Doris Enzersdorfer, Susanne Formanek, Valentin Gebhardt, Martin Jung, Andreas Lichtblau, Werner Sellinger

planners, architects, greening experts, city administratives and microclimate experts. Roof greening and wall-mounted green façade with substrate layer were identified as most effective greening measures regarding cooling effects on the building surface. As such greening measures are not yet a natural part of architecture and can not simply be added to the existing planning design but have to be incorporated into the architecture and static of a building, it is crucial to consider them in an early planning stage. Only then, the potential for impacting the building design ist still high and the costs of design changes are reasonably low.

As the microclimate results from a complex interrelation of multiple parameters such as building height and structure, type of vegetation, water saturation of the soil, surface materials, etc., simplified averaged results are often misleading. Simple spatial and temporal averaging involves the risk to neglect important results and lose meaningful outcome of a study or project. At best, microclimate analyses can be an appropriate approach to apply a systemic view and reveal interrelations between buildings, vegetation, water and energy as well as bring together experts from multiple disciplines (urban, planning, meteorology, physics, statistics). Expertise from different fields is needed to holistically approach the improvement of the local microclimate and to allow suitable and feasible additional climate adaption measures to be recommended, added, and finally realized.

While this process led to several positive developments and best practice examples, the impact of a project on the microclimate of the surrounding areas or even the entire city is still neglected. Climate analyses are useful to assess the effects of building structure and greening measures on the microclimate. In the context of climate change and the resulting consequences for cities, it becomes more and more relevant to learn more about the effects of building projects on the urban climate. Conducting microclimate analyses can help to plan building projects in such a way that the climate resilience of new buildings is as high as possible. Particularly for large construction projects that not only affect the microclimate on-site but also the neighbouring urban areas and perhaps even wind circulation patterns for the entire city, mandatory microclimate analysis would be conceivable to identify the need for optimisation regarding building orientation, height and greenery to maintain a microclimate at bearable level. Depending on the size, location, extension, and execution of the project, it can negatively or positively affect its surroundings. Even positively assessed microclimate simulations on-site can have a negative effect on the urban climate of the surroundings, especially if formerly green areas are sealed, existing buildings are extended in height, cold-air production areas are sealed, or cold-air corridors are blocked. In this case, it is recommended to investigate and quantify the potential impact of construction projects on its surroundings. Further research is needed for identifying a suitable set of criteria that allows cities to decide whether an extended microclimate analysis is required.

Beside a sound knowledge base on the positive effects of green measures on the microclimate, a greenery-friendly planning framework is essential for promoting greenery in building projects. Real estate development is a highly regulated market based on local planning standards and procedures. From a business perspective it involves high initial investments with the potential of reasonable monetary returns. As nature-based solutions in their different forms are not per se cost-neutral, they need to be enhanced and demanded by authorities and regulations to come into effect on a large scale.

When it comes to nature-based solutions in real estate development, not only the initial construction, but also maintenance responsibility, costs and control measures need to be considered. While real estate developers may be held responsible for the proper implementation of greening measures, vegetation can only unfold its full positive microclimatic effects if properly cared for and maintained. Specifications on care and maintenance in the construction instructions ("Baubuch") or even a subsequent assessment of state and growth of plants could help to improve the long-term quality and actual effectiveness of greening measures.

Basically, taking into account the whole life-cycle of a building and the operating costs for heating and cooling as well as the increase in value, would be a significant motivation for real estate developers to implement more green. Our studies showed (see Chapter 3) that wall-mounted green façades lead to the biggest reduction on the wall surface temperature outside as well as inside. This is particularly true for glass façades. Experiments proved that double-glazed facades combined with modular vertical greening significantly reduce indoor temperature and energy consumption in summer (Bao et al. 2022).

Besides life-cycle and maintenance, also vegetation types are a relevant issue for climate resilient greening. With respect to predicted changes in temperature and water availability, plants with high cooling

performance nowadays may not survive future climate conditions without extensive maintenance and irrigation. Nevertheless, with regards to current strategies of biodiversity enhancement, it is also important not to limit greening to a small number of "high-performance plants". In contrast, replacement planting in case of cutting down trees or even deforestation for construction purpose needs strict and quantitative regulations. Large, long grown and climatically effective trees are often required to be compensated. However, small and young replacement trees need decades to reach the performance of the cut down tree. This vegetation performance gap is often neglected in current regulatory frameworks by only requiring a 1:1 replacement. To close this gap, an equivalent number of young trees with the same estimated performance could be enforced as replacement planting. This would not only account for the preservation of the current status, but also for an improvement in the future.

A greenery-friendly planning framework needs to be established to push nature-based solutions on the one side and still provide a flexible framework for real estate developers and architects to develop efficient and effective solutions embedded into the architectural design. Although strict specifications such as mandatory 20% façade greening are needed for monitoring and for implementation to take place, flexibility in the specific design or even additional microclimatic analysis help to find the most effective individual solution. As climate change is proceeding and hence the Urban Heat Island effect in cities, the cooling effect of greenery can be seen as necessary social measure for maintaining the quality of life. That is why greening is also being discussed to be included in urban development contracts. However, the legal basis asks for justifying the requirements in the contract by urban development reasons. Urban planning contracts have so far not been used as a control instrument for promoting greening. If uniform criteria existed that clearly give reasons for greening requirements under specific project conditions, this could change in the future and allow for an implementation in urban development contracts.

Furthermore, an integrated mindset in architecture and real estate development is needed. It is still not self-evident to include greenery and nature-based solutions in design, planning and construction, although there exists the L1131 standard for green roofs since more than 10 years and the ÖNORM L1136 for green walls since 2021. With regard to a transformation towards climate resilient urban patterns, building optimization has to include greening as well. Thus, it needs a new approach to perceive greenery as natural part of architecture. This requires more awareness and knowledge about climate change and the benefits of nature-based solutions on quality of life and value of real estates in the long run and under consideration of a changing climate. Applying microclimate simulations in an early planning stage helps investors, real estate developers and architects to quantify the effects of greenery on the surface temperature outdoor and indoor, as well as on the thermal comfort and air temperature. These aspects are becoming more and more important in the light of climate change and relevant regulations by the European Union such as its EU taxonomy, where climate adaptation is one out of 6 environmental objectives, which have to be met for green, sustainable investments. Consequently, nature-based solutions as effective measures for balancing the Urban Heat Island effect and the increase of heavy precipitation will find their way into architecture and real estate development.

6 CONCLUSION

The project GreenDeal4Real addressed the research question how greenery can be promoted in real estate development for realising climate resilient urban structures. An interdisciplinary team analysed the planning framework in Vienna and described the impacts of greening measures on the microclimate.

Findings from the research project show that although strategies, standards, guidelines and regulations are already in place to promote greenery in real estate development, there is still room for improvement regarding awareness and knowledge about the added value of green, the microclimatic effects, the benefits for outdoor and indoor temperature and for preserving the long-term quality of the property. The interdisciplinary cooperation between researchers, real estate developers, landscape planners, green planners and city authorities led to joint learning and a common understanding of microclimatic effects of greening. Furthermore, it was key that the research project contributed to planning at an early stage, so that adaptations in design, static and materials were still possible.

The research project made it possible to look more closely at microclimate simulations, carry out sensitivity analyses and thus created trust in the quality and reliability of the modelling results. At the same time, the effect of different greening measures for the outdoor and indoor space could be examined and proven based

510

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Tanja Tötzer, Martin Schneider, Bosko Bozic, Raoul Bukor, Doris Enzersdorfer, Susanne Formanek, Valentin Gebhardt, Martin Jung, Andreas Lichtblau, Werner Sellinger

on the microclimate simulations. This allowed to identify the most effective greening measures considering multiple parameters such as building orientation, sun exposure, material, architectural design, type of greening system, leaf area index and fire protection regulations. The cooling effects calculated by the microclimate simulations and the proven effectiveness of green convinced the property developer to plan further measures in addition to the subsidised façade greening. Thus, research projects like GreenDeal4Real can give important impulses for changing the mindset in the building industry and prepare real estate developers to comply with new regulations like the EU taxonomy.

The planning framework appeared to be another important driver for promoting greenery. The parallel planning laboratory allowed for an intensive exchange with stakeholders from the city administration. This also turned out to be very fruitful, as it made it possible to identify opportunities and hurdles in the planning framework. For example, severe constraints imposed by the fire safety regulation were uncovered and discussed constructively. This provided the impetus for further fire experiments to be conducted and the restrictions in the regulation to be withdrawn. The project helped to find a compromise between safety and climate-resilient planning and the new fire protection requirements will foster greening also in mixed industrial-residential areas.

In sum, the project underlines the relevance of interdisciplinary work. The exchange of knowledge between research, real estate developer and city administration is key for urban transformation directing to optimized climate protection and adaptation. Understanding both, the respective point of views and hurdles of each stakeholder is the starting point for essentials dialogues leading to the inevitable transformation.

7 REFERENCES

BAO S, Zou S, Li B, Chen Q, Zhao M: Experiments on the cooling effect of modular vertical greening on double-glazed façade in summer. In: Building and Environment 226 (2022) 109771. 2022.

BROWN S J: Future changes in heatwave severity, duration and frequency due to climate change for the most populous cities. In: Weather and Climate Extremes 30, 100278. 2020.

BRIMICOMBE C, Porter J J, Di Napoli C, Pappenberger F, Conforth R, Petty C, Cloke H L: Heatwaves: An invisible risk in UK policy and research. In: Environmental Science and Policy 116 (2021), pp. 1–7. 2021.

CHRISTIDIS N, Jones G S and Stott P A: Dramatically increasing chance of extremely hot summers since the 2003 European heatwave. In: Nature Climate Change 5, pp. 46–50. 2015.

EDER I: Fassadenbegrünung brandschutztechnische Anforderungen. Stadt Wien, Baupolizei, Kompetenzstelle Brandschutz, Aktenzahl 739611-2021, 11 S., Wien, 23.Februar 2023, https://www.wien.gv.at/wohnen/baupolizei/~pdf/fassadenbegruenung.pdf.

GOODESS C M: How is the frequency, location and severity of extreme events 2012 likely to change up to 2060? In: Environmental Science&Policy 27s, pp. 4-14. 2013.

IPCC: Synthesis report of the IPCC sixth assessment report (AR6). 2023. https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_LongerReport.pdf

KLEEREKOPER L, van Esch M, Salcedo T B: How to make a city climate-proof, addressing the urban heat island effect. In: Resources, Conservation and Recycling 64, pp. 30– 38. 2012.

MA22 (Wiener Umweltschutzabteilung): Urban Heat Island – Strategieplan Wien. 2015. https://www.wien.gv.at/umweltschutz/raum/pdf/uhi-strategieplan.pdf

NORTON B A, Coutts A M, Livesley S J, Harris R J, Hunter A M and Williams N S G: Planning for Cooler Cities: A Framework to Prioritise Green Infrastructure to Mitigate High Temperatures in Urban Landscapes. In: Landscape and Urban Planning 134 (February), pp. 127–38. 2015.

QIU W and YAN X: The trend of heatwave events in the Northern Hemisphere, In: Physics and Chemistry of the Earth 116 (2020), 102855. 2020

ROEHR D and LAURENZ J: Living skins: environmental benefits of green envelopes in the city context. In: Eco-Arch 113, pp. 149–58. 2008.

SHAM J F C, Lo T Y and Memon S A: Verification and application of continuous surface temperature monitoring technique for investigation of nocturnal sensible heat release characteristics by building fabrics. In: En. & Buil. 53, pp. 108–16. 2012.

SHARIFI E and LEHMANN S: Comparative analysis of surface urban heat island effect in central Sydney. Journal of Sustainable Development, 7(3). 2014.

SINGH N, Singh S and Mall R: Urban ecology and human health: implications of urban heat island, air pollution and climate change nexus. In: Urban Ecology, pp. 317–334. Elsevier. 2020.

STADT-SALZBURG.AT: Nachhaltige Stadtplanung macht Salzburg klimafit. https://stadt-salzburg.at/presseaussendungen/2021/nachhaltige-stadtplanung-macht-salzburg-klimafit/

Measuring the Impact of Walking Environments on Brain Activation: Results from an fNIRS Pilot Study

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1 ABSTRACT

Studying the impact of built urban environments on pedestrians' walking experience can improve our understanding of the environmental factors that influence perceived walkability. This can contribute to the design of pleasant urban environments that promote better health and well-being for city residents. However, evidence-based research on perceptions of walkability is still limited. Research has demonstrated that functional near-infrared spectroscopy (fNIRS), an optical brain imaging technique, can measure cortical neural activation. Some studies have employed fNIRS to investigate brain activation by contrasting built and natural environments; however, little research has used fNIRS to investigate the effect of built urban environments on brain activity. Therefore, the aim of this study was to apply fNIRS to measure the effect of different built urban environments on prefrontal cortex activation. The present article presents preliminary results from a pilot study involving five participants (one female, age 31.4 ± 5.1 years). While we measured their prefrontal cortex (PFC) oxyhemoglobin (HbO) and deoxyhemoglobin (HbR), participants watched nine 20-second videos of urban environments from a pedestrian's perspective in a laboratory setting. Viewing pleasant walking environments led to a significant decrease in HbO concentrations in the right and central regions of the PFC, indicating physiological relaxation. This study demonstrates the feasibility of using fNIRS to study the built environment and opens up promising opportunities to explore the relationship between urban environments and pedestrians' experiences.

Keywords: functional near-infrared spectroscopy , built environments, walkability, well-being, neuroscience

2 INTRODUCTION

Walking is considered a sustainable transport mode that benefits society in terms of supporting public health (Hanson & Jones, 2015), social well-being, and environmental sustainability (Silvennoinen et al., 2022).The beneficial effects of walking on physical and mental health have been extensively researched (Hanson & Jones, 2015), including in relation to public transport-related walking (Besser & Dannenberg, 2005; Saelens et al., 2014).As a moderate exercise, walking can help prevent chronic illnesses (McKinney et al., 2016)and promote mental health(Kelly et al., 2018). Walking in urban environments can be a stressful experience for pedestrians, with prolonged stress being linked to long-term mental health and well-being(Lederbogen et al., 2011). Although walking has a well-established positive impact, many streets, neighbourhoods and cities are not designed for pedestrians and do not provide a walkable environment that allows or encourages people to walk.

2.1 Walking and the built urban environment

The walking friendliness of a built environment is referred to as walkability (Frank et al. 2006).Walkability has been increasingly important in research andas a strategic goal in urban design and transportation practice(Forsyth, 2015). Residential density, street connectivity, and land use mix (also known as the 3 or 5 'Ds') are mesoscale environmental variables that have been found to support walking. Research into environmental characteristics on the micro-scale, such as sidewalk quality, street furniture, and the presence of trees and greenery, is relatively recent (De Vos et al., 2022; Otsuka et al., 2021; Silvennoinen et al., 2022; Talen et al., 2022).Of the four commonly identified walkability needs (convenience, safety, comfort, and attractiveness), most research has focused on convenience and safety, whereas comfort and attractiveness have received less attention (Nakamura, 2021; Silvennoinen et al., 2022).Thus, the factors of the built

environment that contribute to the walking experience are not yet well understood or quantified(De Vos et al., 2022; Silvennoinen et al., 2022).

Few studies have investigated the determinants and effects of the built urban environment on walkability, i.e. how pedestrians perceive and experience an environment (De Vos et al., 2022; Silvennoinen et al., 2022). For example, the character of the facades along the pavement is relevant to walking (Ameli et al., 2015; Ewing et al., 2016; Oreskovic et al., 2014; Park et al., 2016; Silvennoinen et al., 2022), the presence of windows on ground level(Ameli et al., 2015; Oreskovic et al., 2014), together with the design of the streetscape and street furniture (Ewing et al., 2016; Shi et al., 2020) and the available shops, services, and amenities (Ewing et al., 2016). Further, the dimensions of street blocks (Singh, 2016), the uniformity of the building pane, the presence of street focal points (Oreskovic et al., 2014), traffic volumes, speed limits, and the density of street and driveway intersections (Petritsch et al., 2006; Schneider, 2015)affect walking. Root et al., (2017)find the overall aesthetics of the environment (i.e. perceived presence of trees, interesting things to look at, attractive sights and buildings) to be associated with walkability.Urban greenery shows a largely positive effect on walking (Ameli et al., 2015; Sarkar et al., 2015; Tsai et al., 2019); however, the impact of greenery on the amount of walking in a particular street remains uncertain(Shuvo et al., 2021).

Nevertheless, there is still a lack of clarity about how walking environments are perceived and which features influence the walking experience. Walkability frameworks often fail to incorporate perceptions of comfort and attractiveness, resulting in a deprioritisation of the micro-level of walkability (Nakamura, 2021; Silvennoinen et al., 2022). Personal reactions, experiences, and interpretations play a crucial role in perceiving environments, making it challenging to assess them objectively (Dörrzapf et al., 2019). A growing number of researchers have proposed frameworks to combine quantitative objective data on the built environment with subjective preferences and perceptions (Dörrzapf et al., 2019; Talen et al., 2022). One approach involves using wearable sensors and other technologies to capture human perceptions and emotions, often through bio-physiological parameters such as skin temperature, heart rate variability (Dörrzapf et al., 2019)or brain activity (Chen et al., 2018; Neale et al., 2019). To this end, the aim of this study is to test a novel methodology for measuring brain activation to investigate the relationship between the built environment and walking experiences. In doing so, we demonstrate the feasibility and potential applications of functional near-infrared spectroscopy (fNIRS) for researching built environments.

2.2 Functional near-infrared spectroscopy (fNIRS)inurban research

Alongside other brain monitoring technologies, such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS) is used to measure brain activation. So far, EEG is the most commonly used method in urban research (Ancora et al., 2022). Functional near-infrared spectroscopy (fNIRS) is a non-invasive technique that uses near-infrared light to measure variations in the oxygen levels in the brain. Light absorption properties enable the assessment of changes in the concentration of oxyhaemoglobin (HbO) and deoxyhaemoglobin (HbR) in the superficial layers of the brain, revealing changes in neural activation through neurovascular coupling (Ferrari & Quaresima, 2012). The oxygen concentration provides information about the active areas of the brain during various cognitive tasks or experiences.fNIRSis a promising methodology for research in urban planning, especially for studying the effects of built environments. It is advantageous because it is safe, non-invasive, portable, and allows for research to be carried out in natural settings. Research in neuroscience and human brain imaging has confirmed fNIRS as a valid method for studying sensory processes, emotional responses, cognitive load and perception (Ferrari & Quaresima, 2012; Hoshi et al., 2011; Yanagisawa & Tsunashima, 2015; Yu et al., 2017).

In a recent study,Ancora et al., (2022) comprehensively reviewed all available research investigating the effect of urban and/or natural environments on brain activity using brain imaging technologies (fMRI, fNIRS, EEG, MEG, PET). A structured literature search identified ten fNIRS studies (see Ancora et al., (2022) for details), of which eight were conducted indoors and two outdoors. The research overview shows that all fNIRS studies so far have focused on the measurement of differences in the relaxation effects of nature (cf. Biophilia, Attention-Restoration Theory) (Horiuchi et al., 2014; Zhang et al., 2020) or the effects of nature in comparison to the more stressful urban environment(Joung et al., 2015; J. Lee, 2017; Ochiai et al., 2020; Song et al., 2018, 2020; Yamashita et al., 2021; Yu et al., 2017). The study design, therefore, often focuses on using stressful and unpleasant urban environments as experiment stimuli. For example,

Yamashita et al., (2021) investigated mood enhancement while participants viewed images of built and urban environments. The images showed a scene with monotonous and unattractive buildings compared to the natural stimuli.Similarly, Song et al., (2018) investigated the differences in physiological effects of forest and urban environments, with the urban scene represented by rather stimulating and stressful urban pictures. Yu et al., (2017) measured the PFC activation while watching urban and natural video scenes, with the urban stimuli recorded in typical Singapore environments. Joung et al., (2015) and Song et al., (2020)conducted in-situ studies, in which the participants were standing and observingurban and forest environments. Two studies focused on the sound-induced effects of forest and urban sounds on the PFC and autonomic nervous system activity. The natural sounds were a recording of a stream, and the urban sounds were traffic noise (Jo et al., 2019; Ochiai et al., 2020).However, the review paper outlines opportunities for future research, for example, in studying environmental complexity, aesthetics, and perception (Ancora et al., 2022).

To ensure awareness of more recent research on fNIRS since the review conducted by Ancora et al. (2022), we have carried out a structured literature search based on the search procedure and terms developed by Ancora et al. (2022). In this context, we repeated their literature search focusing only on fNIRS studies (see the paper for procedure and keywords). The search was performed in May 2023, dating back to May 2022, in PubMed, Scopus, WoS, and ProQuest. As a result, only one relevant article was identified, which examined the effects of walking in urban environments on women's health (Shaoming et al., 2023). The study found the transition between different urban environments to result in alterations of activity in the PFC. Further, spatial openness and mixed traffic flow factors were relevant to participants' perceptions of urban spaces(Shaoming et al., 2023).

3 METHOD

We designed a pilot experiment to investigate the effect of different walking environments on participants' brain activation in the prefrontal cortex using fNIRS. This pilot study aimed at testing the stimuli and selecting fewer stimuli for the full experiment. Data on the participants' subjective perceptions of urban environments and their perceived time was collected. This paper focuses only on the pilot fNIRS data.

3.1 Experiment procedure

Upon arrival at the experimental room, participants were informed of the experimentalprocedure and asked to sign the consent form and complete a brief survey. Participants were then seated at a desk facing a screen and mouse, and the fNIRS cap was placed on their heads as per manufacturers' best practice. After the signal check, participants were instructed to sit still during the experiment and follow the instructions on the screen. PsychopPy software (Peirce et al., 2019) was used to present the stimuli and synchronize with the fNIRS and subjectively reported data. The experimental procedure of the entire pilot experiment is displayed in Figure 1.Notably, this study focuses only on the first part of the experiment (video watching). Following the initial instructions, participants watched nine 20-second videos in a randomized order. In between each video, there was a 12-second break. During the 12-second resting state, the participant views a grey screen with a centredwhite cross. The following procedures, which include time perception tasks and subjective evaluation of videos using Likert scales, were tested for the full experiment. The experiment was concluded with a subjective rating, after which the participants were disconnected from the sensors and debriefed. The experiment had a duration of around 30 minutes.
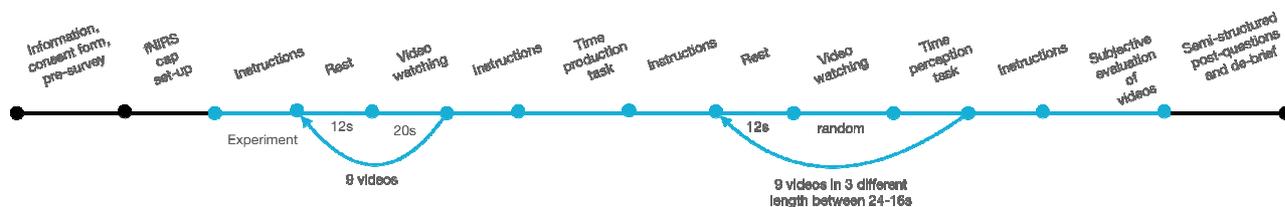
Figure 1: Experimental procedure of the pilot experiment.
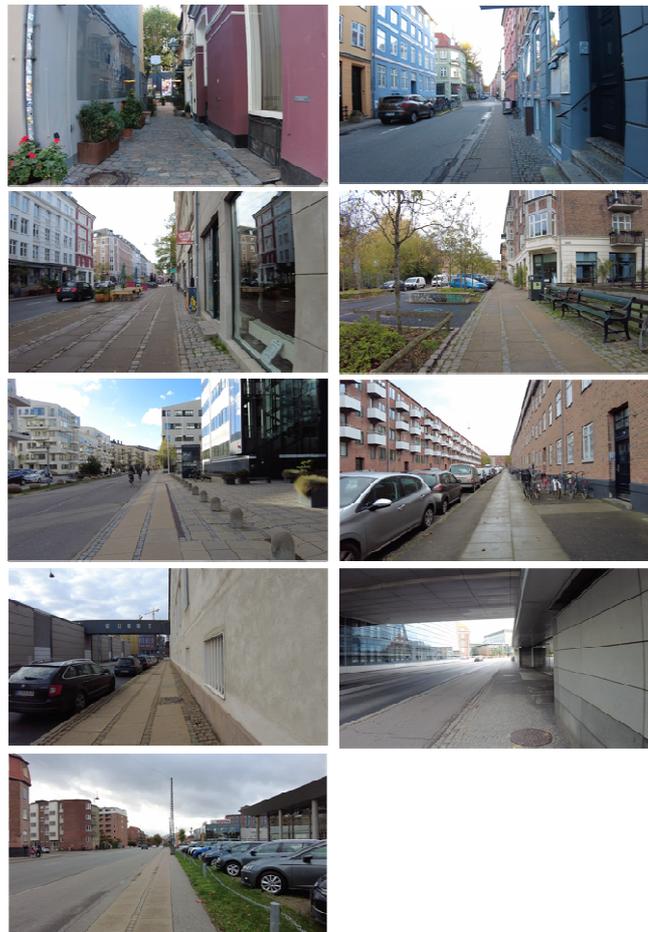
Figure 2: Screenshots of 20s videos recorded in different urban environments in Copenhagen (video 1 upper lect to video 9 bottom left)

3.2 Stimuli

Nine videos of 20 seconds each were used as experimental stimuli. The recordings were captured in 4k resolution using a gimbaled 3-axis stabilised camera (DJI Pocket 2) in the city of Copenhagen in November 2022. All videos underwent editing and stabilisation using Adobe Premiere Pro 2023. The video recordings were taken from a pedestrian's viewpoint and at a typical walking speed (4-5 km/h). For consistency between the videos, they were recorded under similar weather conditions (cloudy to sunny) and without direct encounters with pedestrians. Screenshots of the videos are presented in Figure 2. Considering this is an exploratory pilot study, a systematic overview of the video characteristics will not be provided.However, there are some differences to be noted. The character of the urban environments shown in the videos differs (to varying degrees) in terms of:

- Location (inner city, residential neighbourhood, industrial area)
- Functions (Mixed-use, single-use functions, ground-level use)
- Infrastructure (type of street, speed limit, traffic restrictions, parking, sidewalk, bicycle infrastructure)
- Moving and parked traffic (car and bicycle traffic, pedestrians)
- Urban design and spatial elements (seating, art, spatial elements, light elements, signs)
- Buildings (modern/historical, number, levels, view/lines of vision)
- Facades (openness/transparency, colours, materials, structures, windows, doors)
- Greening (planters, trees, façade greening, plant beds)

3.3 Participants

Five healthy participants (mean age 31.4 years; SD=5.1; 1 female) were recruited for the pilot study from the Faculty of Architecture and Design. Exclusion criteria included high caffeine consumption at the time of the experiment, awareness of atypical neurological conditions (such as autism or ADHD), or usage of medication affecting the nervous system. One participant was left-handed, and the others were right-handed. All participants gave their consent to take part in the study. The study was ethically approved according to local regulations.

3.4 fNIRS data collection and analysis

3.4.1   Data collection

Brain activity was measured with acontinuous-wave system, theNIRSport 2 (NIRx Medical Technologies, Berlin, Germany),that had an 8x8 configuration and short channels. Data from two wavelengths (760 and 850 nm) was sampled at 10.17 Hz. Optodes were arranged in a montage placed on the PFC following the international10-20 system for EEG electrode placement (Oostenveld & Praamstra, 2001); seeFigure 3. The PFC, located in the frontal lobe of the human brain, is associated with higher cognitive processes such as problem-solving and decision-making (Song et al., 2020). Further,the orbitofrontal cortex, located in the PFC,has been identified to play an important role in emotional processes (Rolls & Grabenhorst, 2008).At this early stage of research, it remains unclear which constructs are suitable for studying urban environments. Further research is required to explore and identify the relevant brain regions and constructs for this purpose.
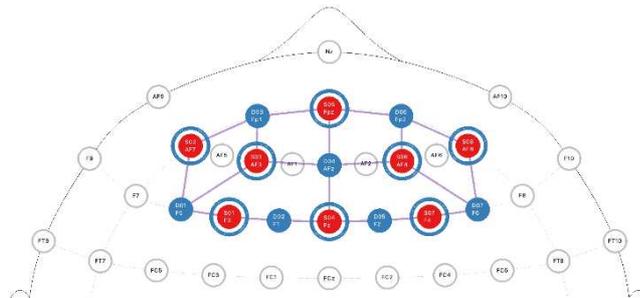
Figure 3: fNIRS montage with 8x8 configuration and short channels (NIRx Medical Technologies)

3.4.2   Data analysis

The fNIRS data wereanalysedwith the NIRS Brain AnalyzIR Toolbox(Santosa et al., 2018)in MATLAB Version: 9.11.0.1873467 (R2021b) Update 3 (The MathWorks Inc., Natick, Massachusetts). Raw light intensities were converted to optical densities. Thereafter, we applied the TDDR algorithm to correct for motion artifacts(Fishburn et al., 2019), before signal quality check. The signal quality was evaluated by computing the Scalp Coupling Index (SCI)(Pollonini et al., 2016)with QT-NIRS (Montero-Hernandez & Pollonini, 2020/2023). QT-NIRS uses a sliding time window of 5 seconds to calculate SCI over the entire time series, and automaticallymarks and rejects low-quality channels based on an overall threshold. We used the default threshold (0.75) for the overall quality threshold, which means that at a given SCI threshold, a channel is marked as good if it attains the SCI threshold at least 75% of the time. We evaluated signal quality at two SCI thresholds. For SCI = 0.8, 69.3% of the data were considered high quality. For SCI = 0.6, 75.7% of the data were considered high quality. Since these are pilot data, we selected the lower SCI threshold of 0.6. When considering that this is pilot data, theoverall channel quality is quite high.

After pruning channels, we converted motion-corrected optical density to hemoglobin concentration changes using the modified Beer-Lambert Law(Delpy et al., 1988)with a 0.1 partial path length factor of 0.1 and extinction coefficient from Jacques(Jaques et al., 2015). For subject-level statistics,the data was first resampled to 4 Hz. Thereafter, we ran ageneralised linear model with autoregressive-based prewhitening followed by iteratively reweighted least-squares(Barker et al., 2013, 2016) and short-channel regressors (Santosa et al., 2020), as this performs best in sensitivity-specificity analyses(Santosa et al., 2020).For group-level statistics,we ran a mixed-effects model includingthe main effect of the condition (i.e., video) andcontrolling for participants. The results presented are the main effects, i.e., the effects of watching videos on hemodynamic activation compared to baseline (i.e., baseline activation when not watching videos). The

Benjamini- Hochberg procedure(Benjamini & Hochberg, 1995)was used to control the false-discovery rate. The corrected p-value is denoted as q.

4 RESULTS

The results section presents the main findings from the fNIRS data collection while participants watched the nine videos. To test the videos in this pilot study, we selected the most interesting findings based on visual inspection of the main findings and contrasting the different videos. As this was a pilot study, we compared all the contrasts. Figure 2 shows the results of the main effects of watching the videos compared to the baseline (resting state). We have chosen to highlight some of the results for illustration.

Some significant HbO and HbR level changes were observed as participants watched the videos. When watching video 2, participants showed a significant decrease in blood oxygen (HbO) in one channel, with the other channels also showing a decrease in HbO. The decrease in HbO levels suggests a reduction in cognitive demand among participants while watching video 2. This finding could be interpreted cautiously as a pleasant response and physiological relaxation.We did not find significant results for videos 3 and 4. However, both videos resulted in a decrease in HbO levels in several channels. In particular, video 4 demonstrated a general decrease in HbO levels in almost all channels. In video 6, a slight increase in HbO is observed in ten channels and a larger increase in one channel. Video 8 shows negligible increases in HbO. In comparing the effects of watching different videos, a significant difference in HbO was found in one channel. Figure 3 presents two examples of contrasts. When comparing video 2 to video 8 and video 2 to video 6, a significant decrease in HbO in one channel is observed in the anterior medial superior frontal gyrus (SFG).

518

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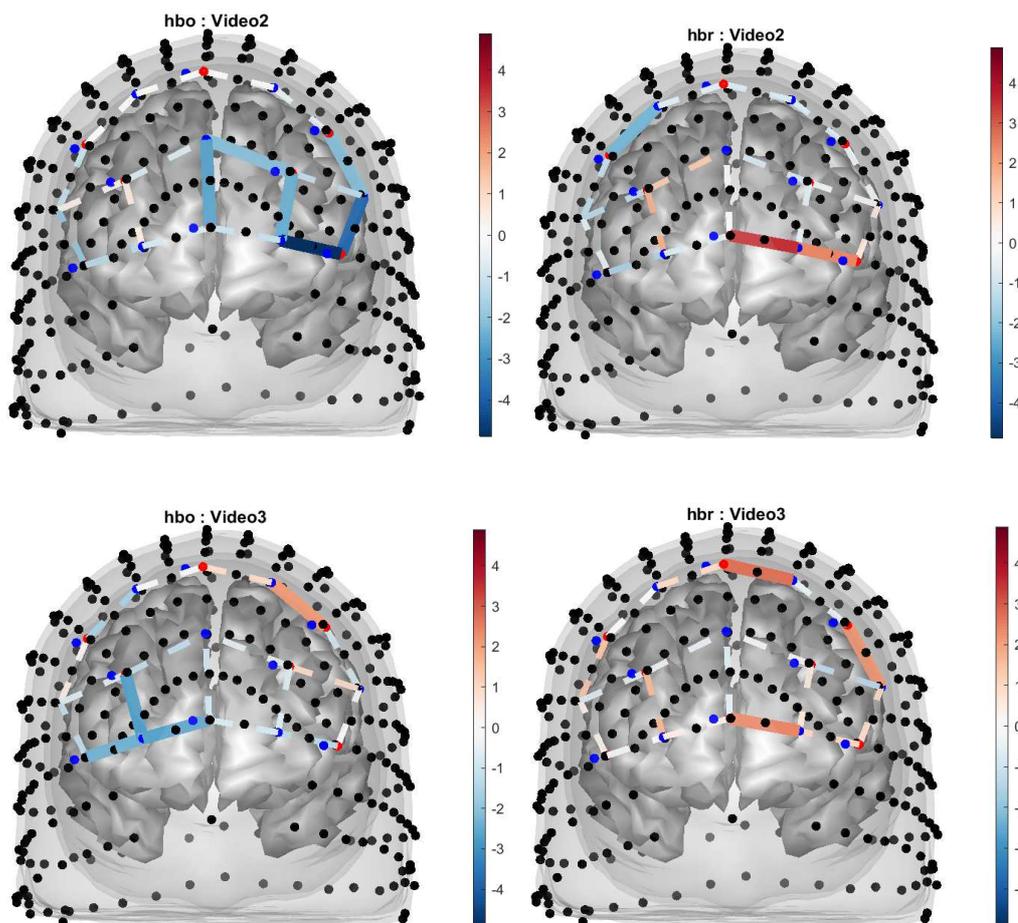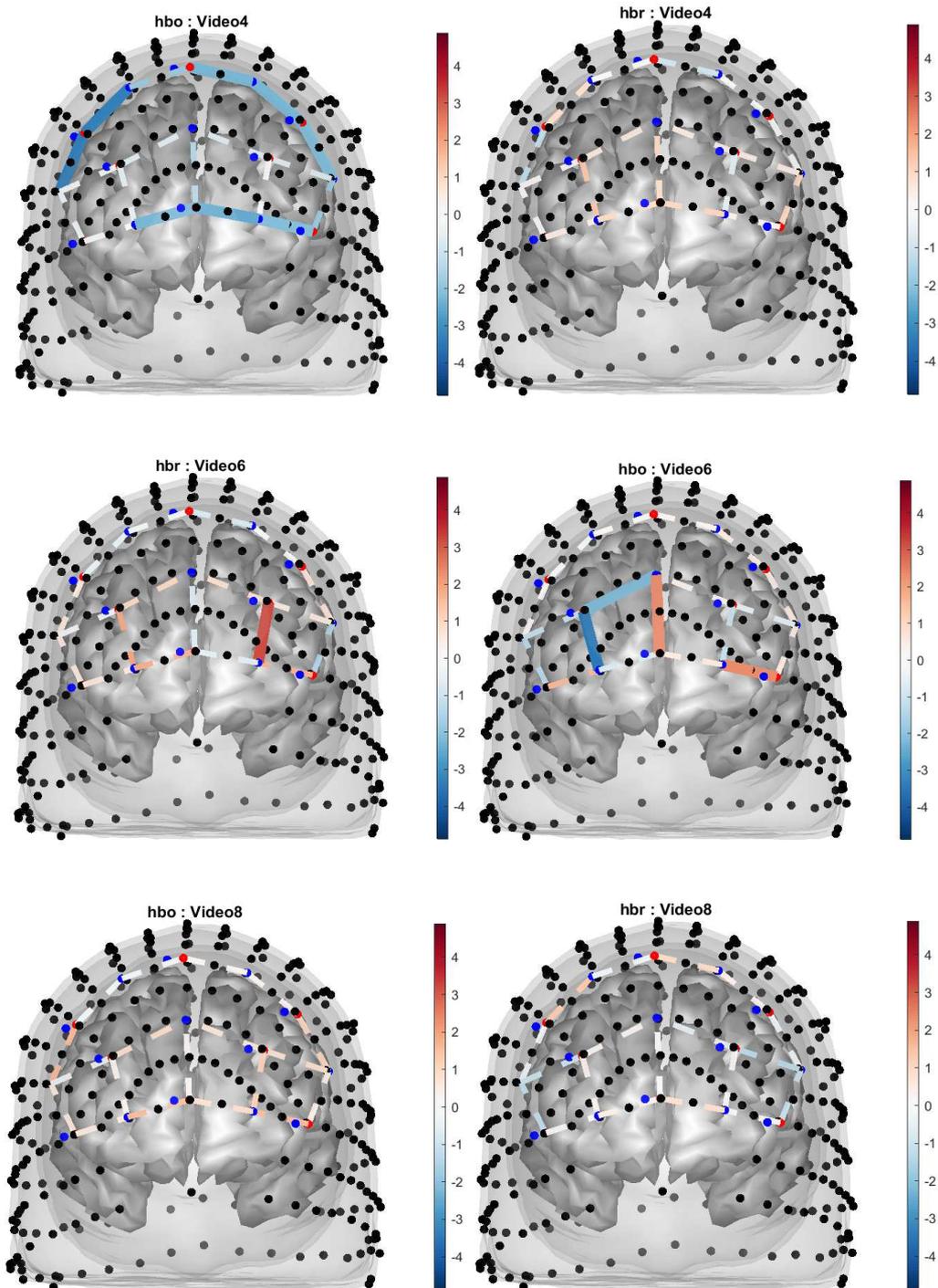
Figure 4: Main effects of watching videos 2, 3, 4, 6, 8HbO (left column) and HbR (right column) levels. The results are illustrated as t-statistic maps plotted onto the colin27 brain atlas, the colour bar represents the t-statistic scaled to [-5, 5], and solid lines indicate statistical significance (q<0.05).
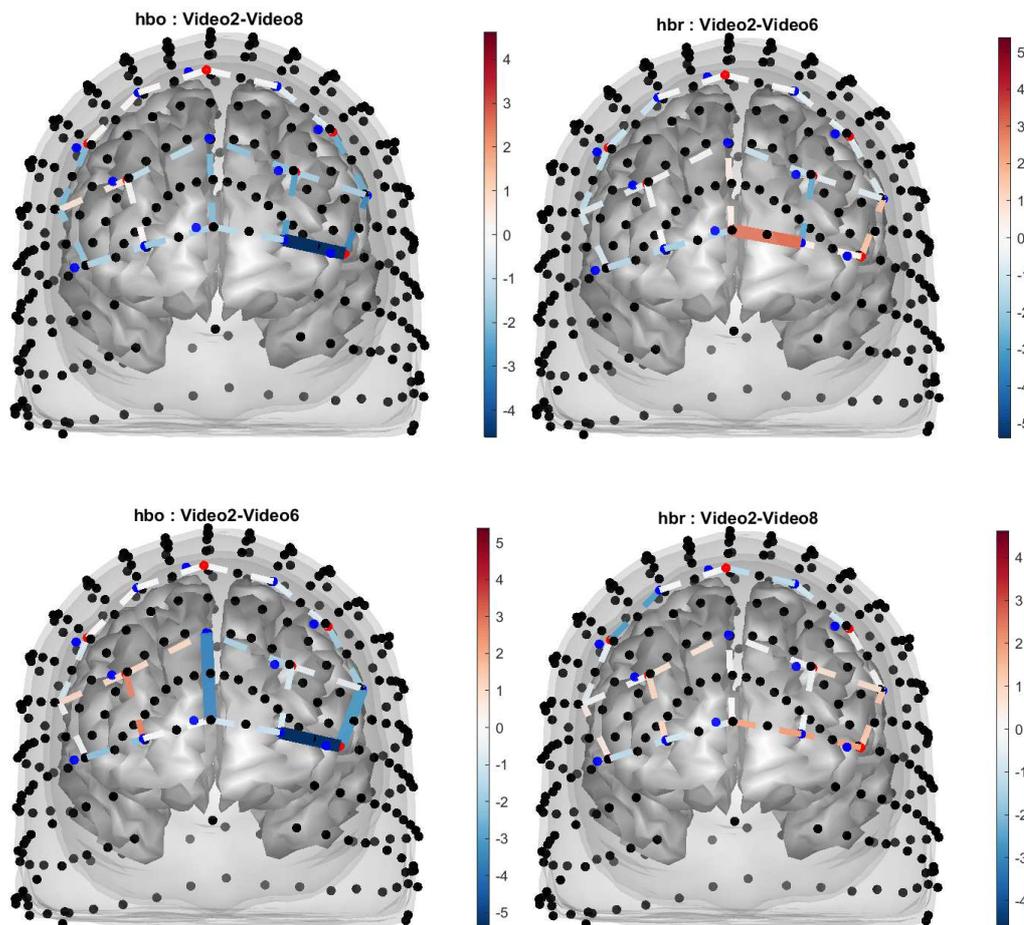
Figure 5: Examples of contrasts, comparing video 2 to videos 6 and 8. Video 2 shows a mixed-use old town street with colourful, diverse, open, and engaging facades and architectural details, small sidewalks but low levels of car traffic due to regulations. Video 6 shows a residential neighbourhood with monotonous architecture in industrialbrick style with no variation or integration of other uses, greening or spatial elements. Video 8 shows an inner city street with high levels of traffic and bicycle infrastructure besides the sidewalk, with monotonous and closed facades, no ground-level use on the street side, high noise levels, and little connection to surroundings due to the underpass situation. The contrastshowed a significant decrease in HbO when participants watched video 2, in comparison to video 6 and video 8.The results are illustrated as t-statistic maps plotted onto the colin27 brain atlas, the colour bar represents the t-statistic scaled to [-5, 5], and solid lines indicate statistical significance (q<0.05).

5 DISCUSSION

The purpose of this pilot study was to test the feasibility of implementing fNIRS for the study of the built environment and to propose fNIRS as a possible interdisciplinary research method for urban planning. Given the small sample size and exploratory nature of this study, we cannot make strong interpretations or conclusions. Despite this limitation, we were able to demonstrate that viewing pleasant walking environments (i.e. video 2, video 3, video 4) was correlated with a decrease in the hemodynamic response in the right and central areas of the PFC. In the context of walkability research, pleasant environments were generally characterised by varied facades, ground-level use, greenery (in video 4), low traffic volumes and the availability of spatial elements (e.g. benches). In contrast, observing less pleasant walking environments (i.e. videos 6 and 8) led to a slight increase in the hemodynamic response. This effect is also noticeable when comparing video 2 with videos 6 and 8. In a direct comparison, video 2 resulted in a significant decrease in HbO levels, i.e. a lower hemodynamic response. Videos 6 and 8 were characterised by monotonous and closed facades, no windows at ground level, no spatial elements or greenery and high traffic volume (video 8). As a result, we can observe differences between more pleasant and relaxing urban environments for walking and more stressful and unpleasant urban environments.

These primary findings are not supported by many other similar studies, but there may be some consistency with previous studies comparing natural and built environments (Song et al., 2020; Yu et al., 2017) or using positive and negative stimuli (Hoshi et al., 2011). Exposure to natural environments (such as forests, parks,

etc.) compared to urban environments has been found to decrease the hemodynamic response in the PFC(Song et al., 2020; Yu et al., 2017). Similarly, exposure to unpleasant emotions was associated with an increased hemodynamic response, whereas exposure to pleasant emotions led to a decreased hemodynamic response in the PFC (Hoshi et al., 2011). Studies of nature exposure often use the Attention-Restoration Theory to explain the relaxing effect of natural environments on hemodynamic response. According to this theory, natural environments lead to reduced attentional effort, mental fatigue and cognitive load (Weber & Trojan, 2018; Yu et al., 2017). Although evidence is still limited, the built environment has also been associated with restorative values, e.g. in terms of architectural features such as lower building height, variation in facades, architectural variation, aesthetic values or historic buildings (Weber & Trojan, 2018).

In the context of our study, research on restorative effects may support our findings on the effects of exposure to different types of built environments; that is, participants showed lower hemodynamic responses when they watched videos of a walk past historic buildings with interesting things to look at (video 2) than when they walked past a monotonous facade (video 6) and a busy street (video 8). More specifically, video 2 resulted in a significantly lower hemodynamic response. The video shows a pleasant walk through a historic part of the city centre, with colourful and open facades, shops, restaurants and cafes with outdoor seating, but no greenery. If the participant perceived the video as pleasant, it could have resulted in physiological relaxation and a consequent decrease in the hemodynamic response. Likewise, video 4 caused a reduction in HbO levels. The video shows a mixed residential area with historic buildings and ground-level use and is the video with the most greenery. The video passes several flower beds, trees and benches. There may be a correlation between the decrease in HbO and the relaxing environment, which is likely due to the presence of greenery. Unlike video 2, viewing both video 6 and video 8 resulted in an increased haemodynamic response. Video 6 shows a walk in a monotonous residential area without spatial elements, open facades or greenery. Video 8 shows a walk along a grey, closed facade, under a building and along a busy road with bicycle and car traffic. An increased hemodynamic response may be a consequence of the stressful and dynamic environment shown in the video. These initial interpretations require further examination in the full study.

This pilot study had some limitations. The participants were limited to a few researchers from the Faculty of Architecture with expertise in architecture and urban planning. The full experiment will include a larger sample size of non-architects, representing different age groups and an equal gender distribution. Moreover, the experimental design exclusively focused on the visual representation of the videos. Future experiments could take into account other senses, particularly the auditory sense. Finally, it is worth noting that although the videos showed the urban environment from a pedestrian's perspective, the participants themselves were seated to avoid motion artefacts on the one hand, and physical activity to influence cognitive outcomes on the other (Miyazawa et al., 2013). Future research may consider employing simulated walking setups in the laboratory (e.g. treadmills) or conducting in-situ experiments. Walking is generally associated with increased activation in the PFC (Herold et al., 2017). Additionally, perceptions of the built environment may be linked to physical and rhythmic experiences from an architectural perspective (Papale et al., 2016).

5.1 Future research

This pilot study opens up promising opportunities to explore the impact of urban environmental features on the pedestrian experience. A full-scale experiment is being conducted with 50-60 participants and an improved experimental design, including additional data on subjective perceptions of the urban environment, mobility behaviour and socio-demographics. The results will provide insights into the effects of four urban environments (Videos 2, 4, 6 and 8) on brain activation and further implications for walkable urban environments. Implementing fNIRS as a research method in walkability research could be a way to learn more about the factors of the built environment that contribute to the experience of walking environments, such as the effects of certain urban design features, façade design, greening, etc. The level of detail of our findings and discussions is unclear at this stage of the research, as we lack references and constructs to work with. Exploratory research is needed into the relevant brain regions and the constructs to be used.

With the prospect of increasing urbanisation, densification and other future challenges, we need a better understanding of how the urban environment affects health and well-being, and how people experience the environment, particularly in terms of emotions and stress responses. Combining fNIRS with health data and physiological sensors has the potential to advance research on urban health and well-being. Considering

social justice, accessibility and feminist planning perspectives, fNIRS appears to be a promising tool for investigating how the environment affects different user groups, including children, older people, people of different genders and identities, people with disabilities, and people from different socio-economic backgrounds. For example, research on diverse groups could explore gender-based differences in perceptions of urban safety, investigate the characteristics of pleasant environments, or gain insight into the perceptions and needs of children and elderly people in the city. To improve the research, scientists should explore the benefits of combining different methods and linking fNIRS data with socio-demographic, health, and qualitative data. The integration of EEG, eye-tracking devices and physiological sensors has great potential for in-situ implementation and the study of urban environments. More pilot studies are required to implement the combination of various methods and technologies, such as virtual and augmented reality.

6 CONCLUSIONS

Understanding the determinants and effects of the built environment on the experience of walking in cities is an important step in creating healthy and liveable urban environments for people. However, more research is needed on the microscaleand perceptions of comfort and attractiveness to understand the contributing factors to walkability. Advances and access to new technologies and methods from the human and cognitive sciences can help to understand pedestrians´ perceptions and effects on the environment.The main objective of this pilot study was to evaluate the implementation and feasibility of fNIRS for studying the built environment and to suggest employing fNIRS as an interdisciplinary research method in urban planning research.Although the study's primary nature and limitations should be considered, observing pleasant walking environments resulted in a significant decrease in HbO in the right and central areas of the PFC, compared to observing boring and stressful walking environments. The environments varied in the facades' character, level of greenery, traffic, and spatial components. These preliminary results could suggest that exposure to positively perceived walking environments results in lower HbO concentrations, which may be interpreted as physiological relaxation and an overall pleasant and less stressful experience for the pedestrian. While further research is needed, this study demonstrates the feasibility of using fNIRS to study the built urban environment and opens up promising opportunities to explore the relationship between people and the urban environment.

7 REFERENCES

Ameli, S. H., Hamidi, S., Garfinkel-Castro, A., & Ewing, R. (2015). Do Better Urban Design Qualities Lead to More Walking in Salt Lake City, Utah? Journal of Urban Design, 20(3), 393–410. https://doi.org/10.1080/13574809.2015.1041894

Ancora, L. A., Blanco-Mora, D. A., Alves, I., Bonifácio, A., Morgado, P., & Miranda, B. (2022). Cities and neuroscience research: A systematic literature review. Frontiers in Psychiatry, 13, 983352. https://doi.org/10.3389/fpsyt.2022.983352

Barker, J. W., Aarabi, A., & Huppert, T. J. (2013). Autoregressive model based algorithm for correcting motion and serially correlated errors in fNIRS. Biomedical Optics Express, 4(8), 1366–1379. https://doi.org/10.1364/BOE.4.001366

Barker, J. W., Rosso, A. L., Sparto, P. J., & Huppert, T. J. (2016). Correction of motion artifacts and serial correlations for real-time functional near-infrared spectroscopy. Neurophotonics, 3(3), 031410. https://doi.org/10.1117/1.NPh.3.3.031410

Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. Journal of the Royal Statistical Society: Series B (Methodological), 57(1), 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Besser, L. M., & Dannenberg, A. L. (2005). Walking to public transit: Steps to help meet physical activity recommendations. American Journal of Preventive Medicine, 29(4), 273–280. https://doi.org/10.1016/j.amepre.2005.06.010

Chen, Z., Schulz, S., Qiu, M., Yang, W., He, X., Wang, Z., & Yang, L. (2018). Assessing affective experience of in-situ environmental walk via wearable biosensors for evidence-based design. Cognitive Systems Research, 52, 970–977. https://doi.org/10.1016/j.cogsys.2018.09.003

De Vos, J., Lättman, K., van der Vlugt, A.-L., Welsch, J., & Otsuka, N. (2022). Determinants and effects of perceived walkability: A literature review, conceptual model and research agenda. Transport Reviews, 1–22. https://doi.org/10.1080/01441647.2022.2101072

Delpy, D. T., Cope, M., Zee, P. van der, Arridge, S., Wray, S., & Wyatt, J. (1988). Estimation of optical pathlength through tissue from direct time of flight measurement. Physics in Medicine & Biology, 33(12), 1433. https://doi.org/10.1088/0031-9155/33/12/008

Dörrzapf, L., Kovács-Győri, A., Resch, B., & Zeile, P. (2019). Defining and assessing walkability: A concept for an integrated approach using surveys, biosensors and geospatial analysis. Urban Development Issues, 62(1), 5–15. https://doi.org/10.2478/udi-2019-0008

Ewing, R., Hajrasouliha, A., Neckerman, K. M., Purciel-Hill, M., & Greene, W. (2016). Streetscape Features Related to Pedestrian Activity. Journal of Planning Education and Research, 36(1), 5–15. https://doi.org/10.1177/0739456X15591585

Ferrari, M., & Quaresima, V. (2012). A brief review on the history of human functional near-infrared spectroscopy (fNIRS) development and fields of application. NeuroImage, 63(2), 921–935. https://doi.org/10.1016/j.neuroimage.2012.03.049

Fishburn, F. A., Ludlum, R. S., Vaidya, C. J., & Medvedev, A. V. (2019). Temporal Derivative Distribution Repair (TDDR): A motion correction method for fNIRS. NeuroImage, 184, 171–179. https://doi.org/10.1016/j.neuroimage.2018.09.025

522

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Forsyth, A. (2015). What is a walkable place? The walkability debate in urban design. Urban Design International, 20(4), 274–292. https://doi.org/10.1057/udi.2015.22

Frank, L. D., Sallis, J. F., Conway, T. L., Chapman, J. E., Saelens, B. E., & Bachman, W. (2006). Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality. Journal of the American Planning Association, 72(1), 75–87. https://doi.org/10.1080/01944360608976725

Hanson, S., & Jones, A. (2015). Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. British Journal of Sports Medicine, 49(11), 710–715. https://doi.org/10.1136/bjsports-2014-094157

Herold, F., Wiegel, P., Scholkmann, F., Thiers, A., Hamacher, D., & Schega, L. (2017). Functional near-infrared spectroscopy in movement science: A systematic review on cortical activity in postural and walking tasks. Neurophotonics, 4(4), 041403. https://doi.org/10.1117/1.NPh.4.4.041403

Horiuchi, M., Endo, J., Takayama, N., Murase, K., Nishiyama, N., Saito, H., & Fujiwara, A. (2014). Impact of Viewing vs. Not Viewing a Real Forest on Physiological and Psychological Responses in the Same Setting. International Journal of Environmental Research and Public Health, 11(10), 10883–10901. https://doi.org/10.3390/ijerph111010883

Hoshi, Y., Huang, J., Kohri, S., Iguchi, Y., Naya, M., Okamoto, T., & Ono, S. (2011). Recognition of Human Emotions from Cerebral Blood Flow Changes in the Frontal Region: A Study with Event-Related Near-Infrared Spectroscopy. Journal of Neuroimaging, 21(2), e94–e101. https://doi.org/10.1111/j.1552-6569.2009.00454.x

Jaques, N., Taylor, S., Azaria, A., Ghandeharioun, A., Sano, A., & Picard, R. (2015). Predicting students' happiness from physiology, phone, mobility, and behavioral data. 2015 International Conference on Affective Computing and Intelligent Interaction (ACII), 222–228. https://doi.org/10.1109/ACII.2015.7344575

Jo, H., Song, C., Ikei, H., Enomoto, S., Kobayashi, H., & Miyazaki, Y. (2019). Physiological and Psychological Effects of Forest and Urban Sounds Using High-Resolution Sound Sources. International Journal of Environmental Research and Public Health, 16(15), Article 15. https://doi.org/10.3390/ijerph16152649

Joung, D., Kim, G., Choi, Y., Lim, H., Park, S., Woo, J.-M., & Park, B.-J. (2015). The Prefrontal Cortex Activity and Psychological Effects of Viewing Forest Landscapes in Autumn Season. International Journal of Environmental Research and Public Health, 12(7), 7235–7243. https://doi.org/10.3390/ijerph120707235

Kelly, P., Williamson, C., Niven, A. G., Hunter, R., Mutrie, N., & Richards, J. (2018). Walking on sunshine: Scoping review of the evidence for walking and mental health. British Journal of Sports Medicine, 52(12), 800–806. https://doi.org/10.1136/bjsports-2017-098827

Lederbogen, F., Kirsch, P., Haddad, L., Streit, F., Tost, H., Schuch, P., Wüst, S., Pruessner, J. C., Rietschel, M., Deuschle, M., & Meyer-Lindenberg, A. (2011). City living and urban upbringing affect neural social stress processing in humans. Nature, 474(7352), 498–501. https://doi.org/10.1038/nature10190

Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., Katzmarzyk, P. T., & Lancet Physical Activity Series Working Group. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. Lancet (London, England), 380(9838), 219–229. https://doi.org/10.1016/S0140-6736(12)61031-9

Lee, J. (2017). Experimental Study on the Health Benefits of Garden Landscape. International Journal of Environmental Research and Public Health, 14(7), 829. https://doi.org/10.3390/ijerph14070829

McKinney, J., Lithwick, D. J., Morrison, B. N., Nazzari, H., Isserow, S. H., Heilbron, B., & Krahn, A. D. (2016). The health benefits of physical activity and cardiorespiratory fitness. British Columbia Medical Journal, 58(3), 131–137.

Miyazawa, T., Horiuchi, M., Komine, H., Sugawara, J., Fadel, P. J., & Ogoh, S. (2013). Skin blood flow influences cerebral oxygenation measured by near-infrared spectroscopy during dynamic exercise. European Journal of Applied Physiology, 113(11), 2841–2848. https://doi.org/10.1007/s00421-013-2723-7

Montero-Hernandez, S., & Pollonini, L. (2023). QT-NIRS (Quality Testing of Near Infrared Scans) [MATLAB]. https://github.com/lpollonini/qt-nirs (Original work published 2020)

Nakamura, K. (2021). Experimental analysis of walkability evaluation using virtual reality application. Environment and Planning B: Urban Analytics and City Science, 48(8), 2481–2496. https://doi.org/10.1177/2399808320980747

Neale, C., Aspinall, P., Roe, J., Tilley, S., Mavros, P., Cinderby, S., Coyne, R., Thin, N., & Ward Thompson, C. (2019). The impact of walking in different urban environments on brain activity in older people. Cities & Health, 4, 1–13. https://doi.org/10.1080/23748834.2019.1619893

Ochiai, H., Song, C., Jo, H., Oishi, M., Imai, M., & Miyazaki, Y. (2020). Relaxing Effect Induced by Forest Sound in Patients with Gambling Disorder. Sustainability, 12(15), Article 15. https://doi.org/10.3390/su12155969

Oostenveld, R., & Praamstra, P. (2001). The five percent electrode system for high-resolution EEG and ERP measurements. Clinical Neurophysiology, 112(4), 713–719. https://doi.org/10.1016/S1388-2457(00)00527-7

Oreskovic, N. M., Charles, P. R. S. L., Shepherd, D. T. K., Nelson, K. P., & Bar, M. (2014). ATTRIBUTES OF FORM IN THE BUILT ENVIRONMENT THAT INFLUENCE PERCEIVED WALKABILITY. Journal of Architectural and Planning Research, 31(3), 218–232.

Otsuka, N., Wittowsky, D., Damerau, M., & Gerten, C. (2021). Walkability assessment for urban areas around railway stations along the Rhine-Alpine Corridor. Journal of Transport Geography, 93, 103081. https://doi.org/10.1016/j.jtrangeo.2021.103081

Papale, P., Chiesi, L., Rampinini, A. C., Pietrini, P., & Ricciardi, E. (2016). When Neuroscience 'Touches' Architecture: From Hapticity to a Supramodal Functioning of the Human Brain. Frontiers in Psychology, 7, 866. https://doi.org/10.3389/fpsyg.2016.00866

Park, S., Choi, K., & Lee, J. S. (2016). Operationalization of Path Walkability for Sustainable Transportation. International Journal of Sustainable Transportation, 11, 00–00. https://doi.org/10.1080/15568318.2016.1226996

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. Behavior Research Methods, 51(1), 195–203. https://doi.org/10.3758/s13428-018-01193-y

Petritsch, T. A., Landis, B. W., McLeod, P. S., Huang, H. F., Challa, S., Skaggs, C. L., Guttenplan, M., & Vattikuti, V. (2006). Pedestrian Level-of-Service Model for Urban Arterial Facilities with Sidewalks. Transportation Research Record, 1982(1), 84–89. https://doi.org/10.1177/0361198106198200111

Pollonini, L., Bortfeld, H., & Oghalai, J. S. (2016). PHOEBE: a method for real time mapping of optodes-scalp coupling in functional near-infrared spectroscopy. Biomed. Opt. Express, 7(12), 5104–5119. https://doi.org/10.1364/BOE.7.005104

Rolls, E. T., & Grabenhorst, F. (2008). The orbitofrontal cortex and beyond: From affect to decision-making. Progress in Neurobiology, 86(3), 216–244. https://doi.org/10.1016/j.pneurobio.2008.09.001

Root, E. D., Silbernagel, K., & Litt, J. S. (2017). Unpacking healthy landscapes: Empirical assessment of neighborhood aesthetic ratings in an urban setting. Landscape and Urban Planning, 168, 38–47. https://doi.org/10.1016/j.landurbplan.2017.09.028

Saelens, B. E., Moudon, A. V., Kang, B., Hurvitz, P. M., & Zhou, C. (2014). Relation Between Higher Physical Activity and Public Transit Use. American Journal of Public Health, 104(5), 854–854. https://doi.org/10.2105/AJPH.2013.301696

Santosa, H., Zhai, X., Fishburn, F., & Huppert, T. (2018). The NIRS Brain AnalyzIR Toolbox. Algorithms, 11(5), Article 5. https://doi.org/10.3390/a11050073

Santosa, H., Zhai, X., Fishburn, F., Sparto, P. J., & Huppert, T. J. (2020). Quantitative comparison of correction techniques for removing systemic physiological signal in functional near-infrared spectroscopy studies. Neurophotonics, 7(3), 035009. https://doi.org/10.1117/1.NPh.7.3.035009

Sarkar, C., Webster, C., Pryor, M., Tang, D., Melbourne, S., XiaoHu, Z., & JianZheng, L. (2015). Exploring associations between urban green, street design and walking: Results from the Greater London boroughs. Landscape and Urban Planning, 143, 112–125.

Schneider, R. (2015). Walk or Drive between Stores? Designing Neighbourhood Shopping Districts for Pedestrian Activity. Journal of Urban Design, 20. https://doi.org/10.1080/13574809.2015.1009014

Shaoming, Z., Yuan, Y., & Linting, W. (2023). Impacts of Urban Environment on Women's Emotional Health and Planning Improving Strategies: An Empirical Study of Guangzhou Based on Neuroscience Experiments. China City Planning Review, 32(1), 17–27.

Shi, X., Bosia, D., & Savio, L. (2020). The Influence Factor for Walkability of Street Furniture: In Case of Turin. In J. Charytonowicz & C. Falcão (Eds.), Advances in Human Factors in Architecture, Sustainable Urban Planning and Infrastructure (pp. 347–357). Springer International Publishing. https://doi.org/10.1007/978-3-030-20151-7_33

Shuvo, F. K., Mazumdar, S., & Labib, S. M. (2021). Walkability and Greenness Do Not Walk Together: Investigating Associations between Greenness and Walkability in a Large Metropolitan City Context. International Journal of Environmental Research and Public Health, 18(9), Article 9. https://doi.org/10.3390/ijerph18094429

Silvennoinen, H., Kuliga, S., Herthogs, P., Recchia, D. R., & Tunçer, B. (2022). Effects of Gehl's urban design guidelines on walkability: A virtual reality experiment in Singaporean public housing estates. Environment and Planning B: Urban Analytics and City Science, 49(9), 2409–2428. https://doi.org/10.1177/23998083221091822

Singh, R. (2016). Factors Affecting Walkability of Neighborhoods. Procedia - Social and Behavioral Sciences, 216. https://trid.trb.org/view/1396002

Song, C., Ikei, H., Kagawa, T., & Miyazaki, Y. (2020). Effect of Viewing Real Forest Landscapes on Brain Activity. Sustainability, 12(16), Article 16. https://doi.org/10.3390/su12166601

Song, C., Ikei, H., & Miyazaki, Y. (2018). Physiological Effects of Visual Stimulation with Forest Imagery. International Journal of Environmental Research and Public Health, 15(2), 213. https://doi.org/10.3390/ijerph15020213

Talen, E., Choe, K. W., Akcelik, G. N., Berman, M. G., & Meidenbauer, K. L. (2022). Street design preference: An on-line survey. Journal of Urban Design, 1–24. https://doi.org/10.1080/13574809.2022.2066512

Timms, P., & Tight, M. (2010). Aesthetic aspects of walking and cycling. Built Environment, 36(4), 487–503. https://doi.org/10.2148/BENV.36.4.487

Tsai, W.-L., Yngve, L., Zhou, Y., Beyer, K. M. M., Bersch, A., Malecki, K. M., & Jackson, L. E. (2019). Street-level neighborhood greenery linked to active transportation: A case study in Milwaukee and Green Bay, WI, USA. Landscape and Urban Planning, 191, 103619. https://doi.org/10.1016/j.landurbplan.2019.103619

Weber, A. M., & Trojan, J. (2018). The Restorative Value of the Urban Environment: A Systematic Review of the Existing Literature. Environmental Health Insights, 12, 1178630218812805. https://doi.org/10.1177/1178630218812805

Yamashita, R., Chen, C., Matsubara, T., Hagiwara, K., Inamura, M., Aga, K., Hirotsu, M., Seki, T., Takao, A., Nakagawa, E., Kobayashi, A., Fujii, Y., Hirata, K., Ikei, H., Miyazaki, Y., & Nakagawa, S. (2021). The Mood-Improving Effect of Viewing Images of Nature and Its Neural Substrate. International Journal of Environmental Research and Public Health, 18(10), 5500. https://doi.org/10.3390/ijerph18105500

Yanagisawa, K., & Tsunashima, H. (2015). Evaluation of pleasant and unpleasant emotions evoked by visual stimuli using NIRS. 2015 15th International Conference on Control, Automation and Systems (ICCAS), 383–388. https://doi.org/10.1109/ICCAS.2015.7364944

Yu, J., Ang, K. K., Ho, S. H., Sia, A., & Ho, R. (2017). Prefrontal cortical activation while viewing urban and garden scenes: A pilot fNIRS study. Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, 2546–2549. https://doi.org/10.1109/EMBC.2017.8037376

Zhang, Z., Olszewska-Guizzo, A., Husain, S. F., Bose, J., Choi, J., Tan, W., Wang, J., Xuan Tran, B., Wang, B., Jin, Y., Xuan, W., Yan, P., Li, M., Ho, C. S. H., & Ho, R. (2020). Brief Relaxation Practice Induces Significantly More Prefrontal Cortex Activation during Arithmetic Tasks Comparing to Viewing Greenery Images as Revealed by Functional Near-Infrared Spectroscopy (fNIRS). International Journal of Environmental Research and Public Health, 17(22), 8366. https://doi.org/10.3390/ijerph17228366

524

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Nature Based Solutions: More than Just Greening the City?

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1 ABSTRACT

Today's relation between humans and nature is arguably still rooted in the enlightenment philosophy, or the "age of reason", asserting that nature exists to be tamed and submitted to the needs and wants of humans(Wallace et. al. 1996). This premise shows scant concern for social, cultural or economic consequences, let alone care for the survival of the planet. Accelerating adverse effects of climate change and rapid decline of biodiversity demonstrate that this exploitation principle of nature by humans has severe limitations (Folkard-Tapp H et.al. 2021). Facing this undeniable evidence, science and technology are envisaging alternative approaches, such as applying Nature-Based Solutions (NBS) to benefit people and nature conjointly(British Ecological Society 2021). This raises the issue whether NBS would be capable of moving away from the antagonism between nature - narrowly understood as the physical world of plants, animals and inorganic matter- and the human-made environment and its uses, and instead to conceive humans and their actions as an integral part of nature.

The paper attempts to explore this question from the perspective of physical planning of cities and territories by identifying the various and possibly contradictory characteristics of NBS and their interventions (Sowinska-Swierkosk et al. 2022) and to discuss whether and how NBS may differ from previous measures to protect the environment and to combat adverse effects of climate change (Stavroula Melanidis et al. 2022).To this end, the paper reflects on academic deliberations on the meaning (Osaka et.al. 2015) and purpose (Kiss et.al. 2019) of NBS and their site-specific, comprehensive, integrated and preferably co-beneficial effects at multiple spatial scales(Johnson et.al. 2022).It aims is to review how NBS currently contribute to the protection of nature and biodiversity by reversing ecosystem degradation, and how they are applied to achieve a more sustainable and liveable built environment. Finally it identifies changes needed for the current fragmented planning system to become more NBS-friendly, and to prevent further inequalities (Herrmann-Pillath C 2022).

The evidence-base of the paper relies on freely available references on the internet in solidarity with academics and professionals who are willing to share their knowledge and experiences widely.

Keywords: city planning, greening, nature-based solutions, urban planning, critical review

2 CLIMATE CRISIS AND UN SUSTAINABLE DEVELOPMENT GOALS

The World Meteorological Organisation forecasts a 98% probability that in the next five years the heat record reached in 2016 will be surpassed driven by the natural phenomenon of El Niño (WMO 2022). This situation will cause global temperatures to rise, alternating intense rains and droughts in some areas of Latin America, Africa and South Asia, with global effects and increasing the temperature of the oceans. The organisation also warns that the average annual temperature on the earth's surface could rise transiently by more than 1.5 degrees Celsius compared to the pre-industrial era, which is what the Paris Agreement COP15 seeks to avoid. At COP27 researchers explained and forecast that global warming is set to break the key 1.5 Celsius limit for the first time before 2027 (McGrath 2023). In 2022, the Intergovernmental Panel on Climate Change provided a summary for policy makers on Climate Change and its impacts, adaptability and vulnerability (IPCC 2022).

The impact of climate change on cities will be formidable in all aspects, making it imperative to reinforce the Sustainable Development Goals (SDGs) proposed by the 2030 United Nations Agenda and adopted in 2015(UN DESA 2015).Relevant specifically to planning and design are SDG 11, Sustainable Cities and Communities, SDG 13 Climate Action and SDG 15 Life on Land. Interrelated and strongly linked to the political dimension, these goals have been transposed into national, regional and local actions, albeit of an ad hoc nature with irregular compliance. At its 7th session in March 2023, The Regional Forum on Sustainable Development for the Economic Commission for Europe region focused on "Ensuring the implementation of the 2030 Agenda for sustainable development in the ECE Region in times of multiple crises" and organised peer learning round tables (UNECE 2023).

Scientific evidence on the acceleration of global warming(IPCC 2007) demands urgent action to counteract its effects on the environment, human welfare and human activity in general. Policies, measures and actions that address the challenges of climate change define a specific cross-cutting area of action, whose implementation should be promoted by all levels of government in the interests of sustainability of the planet as well as human life, fauna and flora. Local governments are responsible for the direct management of these measures in their respective jurisdictions.

From a technical point of view, reducing the adverse effects of climate change on the territory implies alternative measures that are easy to implement and maintain. SDGs and NBS are applied at different scales, globally, at regional, city and neighbourhood level, down to local everyday urban life, relevant to SDG 3 Good Health and Wellbeing, SDG 8 Decent Work and Economic Growth, and SDG 12 Responsible Consumption and Production. In this context, the concepts of sustainability and more specifically of NBS are used extensively by those involved in the built environment.

3 VISIONS OF NBS: TOWARDS A DEFINITION

NBS are one of the most recent approaches to combat global warming, focused on increasing urban resilience by harnessing the ecosystem services of natural capital. NBS differ from the traditional approaches to biodiversity conservation and management promoted since the 1970s in that their implementation must apply jointly to biodiversity and people(Folkard-Tapp et.al. 2021).NBS can be construed as one among many other methods of contributing to more sustainable cities. However, the concrete manifestations of sustainability and NBS are not easy to grasp, let alone to measure, not least because their effects and how to achieve them do not necessarily share commonly agreed criteria.

Scientific evidence has confirmed the role of natural habitats and its preservation and restoration for territorial sustainability in all its dimensions:

- environmental – improving ecosystem functioning, increasing biodiversity, reducing greenhouse gas concentrations, facilitating carbon storage, mitigating flooding, protecting coasts from rising sea levels and hillsides from landslides, reducing urban heat islands, providing clean air;
- economic – generating green jobs, producing business benefits, encouraging circular and regenerative economies;
- social – improving human well-being in all aspects, especially health and food security.

Although the benefits of NBS in either the short or long term have not been fully quantified, their effects are nevertheless undeniable (British Ecological Society 2021). Given the many stated positive effects of NBS on biodiversity and the quality of human life, their use was adopted by the United Nations in 2005 when it launched the Millennium Ecosystem Assessment project to analyse the state of the planet's ecosystems. In 2013, the International Union for Conservation of Nature (IUCN) coined a first definition of the NBS: "actions to protect, manage and address the remains of society in an effective and adaptive manner, while simultaneously providing benefits for human well-being and biodiversity"(IUCN 2022).

This vision was adopted and expanded by the European Commission in 2015, when considering NBS as a planning and urban design tool to re-naturalise European cities. In 2019 and during the UN Climate Action Summit, the European Commission promoted the use of NBS and adopted the European Green Deal, which favours their inclusion in a wide range of policies(European Commission 2021a). In the same vein, the EU Biodiversity Strategy 2030, adopted in 2020, promotes the integration of NBS in urban planning, public spaces, urban infrastructure and the design of buildings and their environment(European Commission 2021b). The launch of specific programmes and projects on the subject has been fruitful: Urban Green Up, Clearing House, Clever Cities, Connecting Nature, EdiCitNet, Grow Green, Nature 4Cities, Naturvation, Regreen, etc. These initiatives gave rise to responses of all kinds, understood as a complement - not a substitute - for other measures aimed at mitigating the effects of climate change. Given their potential, the NBS have been integrated into the agenda of policy makers at different executive levels(Rey Mellado et.al. 2021).NBS are also considered able to offer a transition path in realistic, incremental steps towards a sustainable economy (Maes et.al. 2015).

4 NBS IN PRACTICE: SCOPE AND EXPERIENCES

The numerous NBS experiences in the regions, cities, municipalities and neighbourhoods which have opted for their implementation demonstrate their potential to meet the objectives for which they were intended, while confirming the possibility of their incorporation into urban and territorial policies. Empirical evidence makes it possible to classify concrete NBS projects into two generic types according to their territorial coverage -regional and urban - regardless of the ecosystems on which they operate: soil, water and vegetation. In both cases, their declared aim is to result in socio-economic effects in favour of local or broader communities while fostering biodiversity.

In terms of technical measures NBS focus on improving the impact of the built environment on climate change or, conversely, on how the built environment can be adapted to climate change or mitigate it. Concrete-technical implementations of NBS are applied to the environment at regional level on the one hand (landscape, agriculture, resource extraction, biodiversity, ecosystem services, etc) and to the built environment on the other hand (cities, transportation networks, infrastructure, neighbourhoods, individual buildings and their uses, etc). NBS are also the subject of a more tactical discussion, exploring how NBS distinguish themselves from other interventions to preserve nature and whether they have a specific distinct purpose. For example, the UK House of Lords Science and Technology Committee explored the use of NBS to reduce carbon emissions and sequestering carbon towards zero greenhouse gas emissions and concluded that NBS could play an essential role in compensating residual emissions where total elimination would be impossible to achieve within the targeted timeframe (House of Lords, 2021-22).

4.1 Regional scale

Regional-scale NBS actions are strategic in nature and their implementation is linked to the conditions of the territory when seeking resilience to storms and intensive weather. They tend to be focused on specific issues, such as: erosion protection - combining afforestation (Throp et.al. 2023), reforestation (Webster, 2023) and conservation of natural forests in watersheds, or restoration of herbaceous and shrub vegetation on slopes; inland flood protection - through reforestation of headwater watersheds, regeneration of watersheds affected by forest clearing, regeneration of river banks to reduce flood damage or maintenance of wetlands (Thorslund et al. 2017); protection against coastal hazards and sea level rise- through the construction of natural (Doelle et al. 2021) or artificial (Morales et al. 2021)reefs to stabilise coastlines; or protection of natural resources in hot, dry regions - through agroforestry systems that combine trees, livestock, grasses and crops to reduce erosion, prevent fires and increase soil fertility (Seddon, 2020).

Overall, the impacts of NBS on ecosystems and the regional and/or general socio-economic context are numerous, including diversification of income sources, increased food security, community management of common resources and access to institutional services. Nevertheless, at the regional level biodiversity is a prominent objective of NBS while also focusing on landscape conservation and reinstating nature(WEF, 2022). From the economic perspective, NBS are often seen to contradict growth promoted by governance, although some politicians such as the Irish President Michael Higgins (Leahy, 2023)are contesting the growth paradigm. However, according to the concept of NBS economic security and competitiveness are directly dependent on the sustainable use of natural resources. Maes(2015) proposes specific criteria to focus, guide and evaluate the implementation of NBS towards producing both wider economic and social benefits, essentially provision of jobs and low-carbon technology innovations.

4.2 Urban scale

With regard to the urban scale, as the urban fabric is essentially an anthropic space, the general objectives of NBS are convergent: integrating nature into the city as a mechanism of conserving biodiversity, regulating the climate and promoting socio-economic activities. NBS adopt different approaches depending on space specificities and scale of intervention: cities, neighbourhoods, buildings. Generally, interventions are of a one-off nature, but they may be grouped into systematic proposals: eco-districts and green blue infrastructures. Pineda-Pinto et.al. (2020) carried out a literature review on the potential of NBS to deliver ecologically just cities, with lessons for urban planning. Arup (2014) have produced numerous projects, pamphlets and articles on their approach to NBS, including lessons for urban designers.

The objectives of these interventions focus on biodiversity and habitat conservation, climate change, urban resilience, public health and well-being, and the attractiveness of the built environment. The areas of action

are varied - forests, parks, gardens, urban woodland, orchards, lakes, ponds, drains, wetlands, permeable surfaces, rain gardens. The benefits are substantial: reduced heat island effects and flood risks, improved air quality(Mayor of London 2021), carbon dioxide sequestration, reduced energy use, benefits to public health and well-being, access to food, physical activity, mental health, improved community relations, and contributions to innovation, economic growth and job creation(Kiss et.al. 2019).The latter are also related to more general city greening initiatives (Froy et.al. 2023).Microclimates are capable of moderating climate change, due to their contextual characteristics such as local water management, drainage and permeable surfaces, seasonal shading, riverbank restoration, re-vegetation of brownfield sites, green corridors, which cities are increasingly including in their sustainable planning strategies (Ayuntamiento de Madrid 2016).

Applied to specific built environments, NBS tend to focus on technical-material measures. Akin to well established and practised methods of urban environmental improvements (e.g. ARUP undated), they are resorting to green infrastructure, green roofs, green walls, improved insulation and air tightness of buildings; tree planting in streets, even creating urban forests to reduce heat island effects, as well as managing stormwater to prevent flooding of insufficient drainage, creating sponge cities, building protections against rising sea levels, but also extending wetlands and woodlands to absorb excess water(Thames21, 2020). Other initiatives which could be construed as informal NBS are initiated by inhabitants, such as growing eatable plants on unclaimed spaces. Most urban experiences of NBS tend to be sectoral in nature, with diverse spatial coverage, leading to varied results. Their contribution could be greater if they would be included in comprehensive urban policies to facilitate planning, design and management processes.

Kabisch et.al.(2022) propose 5 principles for urban nature-based solutions capable of contributing to resilient urban futures. In their view NBS (i) require a systemic understanding and need,(ii) benefit both people and biodiversity, (iii)contribute to inclusive long term solutions, (iv) consider context and local conditions, and (v)foster communication and learning. However, NBS rarely include behaviour change, such as reducing energy consumption, motorised and air travel and meat consumption among many others which may have significant effects on urban resilience.

5   CONCEPTUAL RESEARCH: THE LIMITS OF NBS

Based on current, openly available literature on NBS and their implementation, the deliberations on NBS seem to divide functionally into two categories: concrete-technical and conceptual-theoretical. In terms of comparative reviews and case studies, research investigates the various empirical applications of NBS, their impacts on the environment and society, as well as their applicability to planning at regional and urban levels(e.g. Pineda-Pinto et.al. 2020). Scientific research on NBS explores conceptual-theoretical aspects of NBS including how to define them(e.g. Kiss et.al. 2019; Hanson et.al. 2020).

In their comprehensive review of research publications on NBS Hanson et.al. (2020) explored the use and interpretation of the nature based solution concept by science. They discuss various definitions and note that most empirical studies focus solely on environmental benefits delivered by NBS. They found few studies across scientific disciplines which assess social and economic benefits as well, despite both benefits being a central ambition of the NBS concept. They propose four core ideas relevant to planners: how to use NBS in the pursuit of sustainable development by handling societal challenges and how to seek co-benefits by including relevant stakeholders. In the Naturvation Project, another international comparison of NBS, Kiss et.al. (2019) map existing experiences and practices in the use of NBS. Based on 54 NBS interventions in 18 cities, their comparative analysis focused on governance arrangements, public participation, financing mechanisms, innovation patterns and social impacts. Their research concentrated on what is enabling NBS implementation. They noted that NBS, usually applied in complex institutional and governance structures, are multi-functional and resort to public-private collaborative arrangements when addressing sustainability challenges. Their findings show that municipalities are playing a key role in financing policy, but that the distribution of costs and benefits was encountering contradictions regarding transparency, accountability, justice and democracy. Discussing the definition of NBS, Seddon et.al. (2021) acknowledged the benefits of NBS, but affirmed that NBS are not a substitute for rapidly phasing out fossil fuels. Other academic deliberations are related to resilience (Ruiz-Mallen et.al. 2022), a concept intrinsically linked to climate change and the role of NBS. More specifically, Baro et al. (2022) explored the co-benefits NBS could create when making schools resilient to climate change impacts and saw potential in upscaling this approach to city level.

Other researchers are more skeptical about the merits of NBS. Stavroula Melanidis et al. (2022) discussed the competing languages of NBS. Based on contributions to the 2019 UN Climate Action summit and the 2019 UN Climate Change Conference (COP 25) they analysed the narratives connected with proposals for and against NBS and found two opposing standpoints: NBS as a powerful multifunctional instrument to leverage the power of nature; or as dangerous distraction perpetuating the unsustainable, unjust status quo. Others also adopt a critical, even politicised standpoint towards NBS. Marsh & Swyndgebouw (2002) see NBS as socially divisive and inequitable, thus in need of political redress with focus on the most deprived parts of society when implementing them. Hanson et.al. (2020) consider NBS possibly as a buzzword, solely delivering environmental benefits, without the expected economic and social benefits incorporated in the NBS concept, instead of being a pathway to broader and deeper development. Kotsila et.al. (2020) criticise NBS as resting on assumptions from positivist science providing space for neo-liberalisation processes of nature. They reckon that urban nature can serve economic elite players at the expense of widespread socio-ecological benefits. Conversely they see the possibility of NBS laying the ground for open participatory spaces beyond controlled stewardship of nature or market mediated interactions with it. Other researchers position themselves in between those stances when debating the value and limits of NBS (Seddon et.al 2020).

Based on the comprehensive surveys of NBS scientific research, the following key problematic aspects of NBS seem to emerge:

- Definition: There is a lack of a single definition of NBS that determines the conditions to single them out from other approaches. Despite institutional attempts to define NBS, there is no agreement on a single definition. The current diversity of definitions fails to define a specific profile that categorises a wide range of NBS actions and can respond to different objectives and this may be attributable to internal contradictions of the concept of NBS.

- Scope: The use of NBS is applied to a broad diversity of interventions. Most of the empirical studies point to the environmental benefits that NBS provide, while there are few studies that also evaluate their social and economic benefits, despite being a central ambition of the NBS concept (Hanson et al, 2020). Some studies highlight the role of NBS in resilience linked to climate change (Ruiz-Mallen et al. 2022), its application in specific buildings, as well as in the urban environment more generally (Baro et al., 2022). The most relevant contributions of NBS to the urban environment are the ones aimed at reducing the effects of climate change and at increasing the quality of life in public spaces.

- Evaluation: Evaluating the results of NBS in practice encounters many obstacles. A difficulty lies in the lack of appropriate indicators and metrics to assess biophysical, ecological, and socioeconomic effectiveness, which inhibits the creation of appropriate frameworks to estimate the scope of the benefits and long-term monetisation of NBS(Seddon et al, 2020).This may be due, inter alia, to the coexistence of numerous interacting and context-specific factors that vary over time, besides depending on the standpoints and needs of those involved.

- Financing: This is one of the main obstacles to the implementation and monitoring of NBS. Regardless of the origin of investments - public or private agencies, bilateral or multilateral funds, national or international the focus on the economic growth model and the need to obtain short-term benefits tend to reduce the option to implement NBS, exacerbated by the context of budgetary restrictions. The management of NBS projects, based on coordination between different levels of government and stakeholders is difficult to organise and can even contradict other projects. Overcoming these challenges requires strong institutions, well-established planning and stable available structures (Seddon et al. 2020).

- Collateral effects. Although there is consensus that NBS do not replace measures to restrict the use of fossil fuels, nor that they should distract from the need to protect a wide range of ecosystems (Seddon et al, 2020), some authors understand the use of NBS as a multifunctional instrument to harness the power of nature, or as a distraction to perpetuate the unsustainable and unfair status quo (Melanidis, et al. 2022). Others see NBS as socially divisive and inequitable, necessitating political redress with a focus on the most disadvantaged parts of society when implementing them (Marsh & Swyngebouw, 2002). Others view NBS as a buzzword that only offers environmental benefits,

without the expected economic and social benefits that lead to broader and deeper development (Hanson et.al. 2020). Others point out that excessive use of tree planting is an easy measure to implement for which there are no scientific criteria to link its benefits to specific ecosystems and human contexts, and which could eventually amount to "green gentrification". More radical views criticise NBS for relying on assumptions of positivist science that provide space for processes of neo-liberalisation of nature and serving elite economic actors at the expense of widespread socio-ecological benefits, rather than to see NBS as a possibility to lay the foundations for open participatory spaces beyond controlled stewardship of nature or market-mediated interactions (Kotsila et al. 2020). There is also concern about the occurrence of adverse social consequences of implementing NBS without the consent of the communities involved (Seddon et al. 2020).

6 Reducing Uncertainties

Even though the multifunctionality of NBS is recognised, scientific analysis indicates the presence of important conceptual and technical barriers that must be eliminated. The concepts and practices of NBS developed over the last decades have been numerous, including the multifunctionality of NBS. However, despite the benefits NBS bring, their adoption is far from widespread, possibly due to uncertainty about what is meant by NBS and their scope.

With respect to cost-effectiveness, there is some evidence that the benefits of NBS can outweigh the costs of their implementation and maintenance in a variety of contexts and that they may be more cost-effective than engineering alternatives(World Bank, 2019). Nevertheless, lack of funding for NBS which often require long term commitment, is a major obstacle to their implementation and follow-up, especially during severe budgetary constraints.

The issues that encourage uncertainty can be summarised in three generic themes:

- the challenges of measuring the effectiveness of NBS in relation to other alternatives;
- the difficulties in assessing costs and benefits in attracting public and private investment; and
- the institutional barriers that limit the incorporation of NBS into territorial policies.

IUCN adopted a Global Standard in 2020 to reduce these uncertainties. Aimed at national, municipal and local governments, planners, companies, donors, financial institutions and NGOs working on issues of global concern, The Global Standard consists of 8 criteria and 28 indicators valid for both small-scale interventions and large-scale actions, setting out the conditions NBS have to meet to perform their tasks(IUCN, 2022). These criteria give considerable weight to social and governance aspects when assuming the risks that could result from the outcomes of NBS implementation on ecosystem processes. The criteria propose the following principles:

- criterion 1: NBS are to respond effectively to one or more societal challenge(s), identified as a priority for directly affected societies, supported by transparent and inclusive consultation processes.
- criterion 2: The design of NBS will be adapted to the complexity and uncertainty of the context in which they are implemented, taking into account the biophysical or geographical perspective, economic systems, regulatory frameworks, cultural perspectives, synergies between sectors, and the identification and management of the risks involved.
- criterion 3: NBS should produce a net gain in terms of biodiversity and ecosystem integrity, ensuring their protection, functional integrity and connectivity in the long term.
- criterion 4: NBS must be economically viable, both in the design phase and during implementation, distributing costs and benefits equitably in the short and long term.
- criterion 5: NBS are based on inclusive, transparent and empowering governance processes, which delineate responsibilities and legitimise the sharing of burdens and benefits arising from the process in accordance with existing legal and regulatory provisions.
- criterion 6: NBS should strike an equitable balance between the achievement of their objectives, the benefits obtained and the necessary financial rewards based on credible assessments, transparency of information and stakeholder agreements.

530

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- criterion 7: NBS are adaptively managed in response to uncertainty in ecosystem functioning, using data provided by continuous monitoring and periodic assessment.
- criterion 8: NBS are sustainable actions and are integrated into an appropriate jurisdictional context, taking into account existing sectoral and national policy frameworks, strategic communication and promotion of their use.

The application of these criteria is expected to guide both the actions of the institutional and governance bodies in charge of leading the implementation processes of NBS in their respective territorial jurisdictions, as well as the technical process involved in the design of these initiatives. Likewise, the criteria offer a reference framework for private initiatives that address NBS projects in rural territories and urban spaces. The role of urban and regional planning could play a determining role, but for this the NBS concept would have to undergo two structural changes: adopting them into comprehensive urban policies that facilitate their implementation and including them as a specification when drafting further planning instruments.

6 NBS, PLANNING AND GOVERNANCE

What use can planning and planners make of this discussion on research on the current state of NBS in terms of their practical implementation in regions and cities and at conceptual level to rebalance the ecosystem, combat climate change and make cities more sustainable?

The analysis of existing NBS experiences reveals that most of them are punctual and sectoral in nature, applied to very diverse spatial coverage, producing uneven results, but are scarcely included in traditional planning instruments. Instead, NBS tend to be implemented through ad hoc modalities, without anchoring them in the current regulatory structures, although this could also favour their development and acceptance over time and warrant their eventual inclusion in the monitoring and evaluation mechanisms of planning instruments.

The absence of a convergent definition of NBS may explain their slow take-up in plan making and regulations. Conversely, the diffuse meaning of NBS can provide planners with an opportunity to interpret them to their own advantage. The argument that NBS are just another term to describe measures already incorporated in development plans and planning regulations to protect the environment and mitigate climate change may provide incentives to refine and innovate existing planning instruments.

It has to be kept in mind that measures to safeguard and improve the environment have long been part of planning, thus NBS would essentially be an additional instrument, preferably in synergy with existing ones. The special characteristics of NBS demand the adoption of a comprehensive vision including their vertical and horizontal relationships between disciplines and sectors, their funding conditions and their inclusion of community participation, which require the involvement of specialists in the design of proposals, as well as in decision-making. Like any other aspect of spatial planning, the adoption and scope of an active NBS policy would depend on the priorities given to it by the political, economic and social context.

Assuming the potential of NBS in relation to climate change and quality of life, and given that plan making and project design are the key functions of planning, their adaptation into planning instruments requires a transposition of the concept into practice. For this, the role of academic research is essential, in identifying and assessing the environmental, social and economic benefits, as well as the adverse effects and possible contradictions associated with NBS. Such a research effort is directly dependent on adequate funding to advance this subject.

Planning instruments have their own mechanisms of monitoring and evaluating their long-term performance. Experiments with NBS at regional, city and neighbourhood levels could provide lessons for planners to incorporate findings into their approach to site-specific conditions and to adjust planning instruments accordingly.

Insights into the financing and funding of NBS implementation may lead to new ways of assessing environmental protection measures and their efficiency in relation to other planning objectives, in particular those aimed at improving living conditions and greater environmental and social equity. In the longer term, including the necessary public funding for NBS actions in the budgets of plans could foster the confidence of private investors.

A remarkable aspect of the NBS concept is the inclusion of public participation in the design process, a resource open to multiple competences but scarcely implemented. Incorporating NBS in planning would provide a valuable opportunity to reach out towards greater interdisciplinarity and more genuine public engagement from the conception of an intervention to its completion, thus NBS could become a trigger of much needed transformation of planning to become fit for coping with the challenges of the 21st century.

7 BY WAY OF CONCLUSION

As an outcome of this discussion, there are reasons to assume that, even with high costs and implementation difficulties, NBS can contribute positively to the fight against adverse climate change and enhance the sustainability of cities and regional ecosystems. NBS alone will not be able to overcome the lack of connection between a comprehensive application of NBS at regional level and fragmented NBS implementations at city and often only at building levels without being linked to a cohesive integrated policy for sustainable development and climate emergency. Incorporation of NBS into existing planning measures to protect and enhance the environment may provide an opportunity to improve the current fragmented planning system, subjected to multiple, uncoordinated, possibly contradictory policies and governance modes to become more effective in contributing to sustainable development while preventing further inequalities.

8 REFERENCES

ARUP (2014). Cities Alive, Rethinking green infrastructure. ARUP Design Book, Wardour.

ARUP (undated). Bringing nature-based-solutions to life (harness nature to improve flood risk management; use green building facades to lower the temperature; improve disaster recovery; apply climate-positive materials). https://www.arup.com/climate-change/bringing-nature-based-solutions-to-life

Ayuntamiento de Madrid (2016). Programa Madrid + Natural. https://www.madrid.es/UnidadesDescentralizadas/Sostenibilidad/EspeInf/EnergiayCC/04CambioClimatico/4c3Mad+Natural/M+N2019/Ficheros/FichasMad+Natural2019.pdf

Baro, Francesc, David A.Camacho, Carmen Perez del Pulgar, Isabel Ruiz-Mallen, Pablo Garcia Serrano(2022) Nature based climate solutions in European schools: a pioneering co-designed strategy towards urban resilience, Ch 6, Isabel Ruiz-Mallen, Hug March, Mar Satorras (eds), Urban Resilience to the Climate Emergency, Unravelling the transformative potential of institutional and grassroots initiatives, Springer 2022.

Doelle, Meinhard, Tony George Puthucherril (2021). Nature base solutionsto sea level rise and other climate change impacts on oceanic and coastal environments: a law and policy perspective. Nordic Journal of Botany, Bol 2032, Issue1, January 2023, e03051.

European Commission (2021a). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions EMPRY.'Fitfor 55': Delivering the EU's 2030 Climate Target on the way to climate neutrality. COM(2021) 550 final, Brussels 12.7.2021. https://commission.europa.eu/publications/delivering-european-green-deal_en

European Commission (2021b). EU Biodiversity Strategy for 2030. Bringing nature back into our lives. European Union 2021. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

Folkard-Tapp, Hollie, Cristina Banks-Leite, Emma L Cacan(2021). Nature-Based Solutions to Tackle Climate Change and Restore Biodiversity, Journal of Applied Ecology, 2021;58:2344–2348, British Ecology Society, DOI: 10.1111/1365-2664.14059.

Froy, Francesca, Samuel Heroy, Elvira Uyarra, Neave O'Clery(2023). What drives the creation of green jobs, products and technologies in cities and regions? Insights from recent research on green industrial transitions, Local Economy, Vol 0 ahead of print, 2023, Sage Publications, ISSN 0259-0942 https://journals.sagepub.com/doi/epub/10.1177/02690942231170135

Hanson, Helena I, Bjorn Wickenberg, Johanna Alkan Olsson (2020). Working on the boundaries—How do science use and interpret the nature-basedsolution concept? Land Use Policy 90 (2020) 104302 Elsevier.

Herrmann-Pillath, Carsten, Julia Hiedanpaa, Katriina Soini (2022). The co-evolutionary approach to nature-based solutions, a conceptual framework. Nature Based Solutions 2 (2022) 100011, Elsevier.

House of Lords, Science and Technology Select Committee, UK (2021-2022). Nature based solutions – rhetoric or reality? The potential contribution of nature-based solutions to net zero in the UK. 2nd Report of Session 2021-22.

International Union for Conservation of Nature (IUCN) (2022). Global Standard for Nature-based Solutions: first edition.

IPCC (International Panel on Climate Change) (2007). Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather, 2007: Historical Overview of Climate Change. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (International Panel on Climate Change) (2022). Climate Change 2022, Impacts, Adaptation and Vulnerability, Summary for Policymakers. Sixth Assessment Report. WHO UNEP.

Johnson, Brian Alan, Oanhaj Kumar, Naoyuki Okano, Rajarshi Dasgupta, Binaya Raj Shivakoti (2022). Nature-based solutions for climate change adaptation: a systematic review of systematic reviews. Nature Based Solutions 2 (2022) 100042.

KabischNadja, Niki Frantzeskaki, Rieke Hansen (2022). Principles for urban nature based solutions. Ambio 2022, 51:1388-1401. Springer.

532

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Kiss, Bernadett, FilkaSekulova, PanaglotaKotsila (2019). The nature based innovation Naturvation project, international comparison of nature based solutions, project report. Naturvation(cities-nature-innovation): Durham University and 14 EU institutions funded by EU Horizon 2020 research and innovation programme.

Kotsila, Panagiota, Isabelle Anguelovski, James JT Connolly (2020). Nature-based solutions as discursive tool and contested practices in urban nature's neoliberalisation. Environment and Planning E: Nature and Space, Volume 4, Issue 2. Sage Journals.

Leahy, Pat (2023). President condemns 'obsession' with economic growth'. The Irish Times, 28 April 2023.

Maes, Joachim, Jacobs Sander(2015), Nature-Based Solutions for Europe's Sustainable Development. Conservation Letters, doi: 10.1111/conl.12216.

Marsh, Hug, Erik Swyndgedouw (2022). Resilience for All or for Some? Reflections Through the Lens of Urban Political Ecology. Ch 1, Isabel Ruiz-Mallen, Hug March, Mar Satorras (eds), Urban Resilience to the Climate Emergency, Unravelling the transformative potential of institutional and grassroots initiatives, Springer 2022.

McGrowth, Matt (2023). Global warming set to break key 1.5C limit for first time. Environment correspondent. BBC news. https://www.bbc.co.uk/news/science-environment-65602293

Rey Mellado, Raquel, Cristina del Pozo, Teresa Franchini (2021). SolucionesBasadasen la Naturaleza: estrategiasurbanas para la adaptación al cambioclimático. Habitat y Sociedad Nº 14.

Morales, Roberta PL, Borha G Reguero, Ines Mazarrasa, Max Ricker, Jose A Juanes (2022). Nature-Based Solutions in Coastal and Estuarine Areas of Europe, Frontiers in Environmental Science, Vol 19, 29 June 2022.https://doi.org/10.3389/fenvs.2022.829526

Osaka, Shannon, Rib Bellamy, Noel Castree (2015). Framing 'nature-based' solutions to climate change. WIREs climate change, Vol 12, Issue 5. September/October 2021 e729.

Pineda-Pinto, Melissa, Niki Frantzeskaki, Christian A Nygaard (2020), The potential of nature-based solutions to deliver ecologically just cities: lessons for research and urban planning from a systematic literature review, AMBIO 2022, 51: 167-182. Kungl. Vetensjaps-Akademien.

Seddon Natalie, Chausson, A, Berry, P, Girardin, C, Smith, A, Turner, B (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society of London.

Seddon, Nathatlie, Alison Smith, Pete Smith, Isabel Key, Alexandre Chausson, Cecile Girardin, Jo House, Shilpi Srivastavan, Beth Turner (2021). Getting the message right on nature based solutions to climate change. Wiley online library. Glob Change Biol. 2021;27:1518–1546. https://onlinelibrary.wiley.com/doi/10.1111/gcb.15513

Sowinska-Swierkosz, Barbara & Joan Garcia (2022). What are natural based solutions (NBS)? Setting core ideas for concept clarification. Nature-Based Solutions 2 (2022) 100009, Elsevier.

StavroulaMelanidis, Marina & Shannon Hagerman (2022). Competing narratives of nature-based solutions, leveraging the power of nature or dangerous distraction. Environmental Science and Policy 132 (2022) 273-281, Elsevier.

Thames21& London Borough of Endfield (2020). Major new woodlands and wetlands partnership begins; project will create large-scale improvement in Endfield's rivers. https://www.thames21.org.uk/2020/12/major-new-woodlands-and-wetlands-partnership-begins/

Thorslund, Josefin, Jerker Jarsjö, Fernandi Jaramillo, James W Jawitz, Stefano Manzoni, Nandita B Basu, Sergey R Chalov, Matthew J Cohen, Irena F Creed, Romain Goldenberg, Anna Hylin, Zahra Kalantari, Antonis D Koussis, Steve W Lyon, Katarina Mazi, Johanna Mard, Klas Persson, Jan Pietron, CarnenPieto, Andrew Quin, Kimberly Van Meter, Georgia Destouni (2017). Wetlands as large-scale nature-based solutions: status and challenges for research, engineering and management. Ecological Engineering 108 (2017) 589-497. Elsevier.

Throp, Henry, Ana Yanf, Suzannah Sherman, Roberto Waack (2023). How forest bio-economies can support NBS. Sustainability Accelerator briefing paper, Chatham House.

UN DESA (United Nations, Department of Economic and Social Affairs) (2015). Sustainable Development, the 17 Goals [1 no poverty, 2zero hunger, 3 good health and well-being, 4 quality education, 5 gender equality, 6 clean water and sanitation, 7 affordable and clean energy, 8 decent work and economic growth, 9 industry innovation and infrastructure, 10 reduced inequalities, 11 sustainable cities and communities, 12 responsible consumption and production, 13 climate action, 14 life below water, 15 life on land, peace, 16 justice and strong institutions, 17 partnership for the goals. https://sdgs.un.org/goals

UNECE (United Nations Economic Commission for Europe, (2023). Report of the Regional Forum on Sustainable Development for the Economic Commission for Europe region on its seventh session. United Nations. RFSD2023 Report.

Mary G Wallace, Hanna J Cortner, Sabrina Burke (1996). Taming Nature, the enlightenment's legacy for the future, Journal of Forestry, November 1996: 39-44.

Mayor of London Plan (2021), ULEZ (Ultra Low Emissions Zones) expansion to GLA boundaries by August 2023. Greater London Authority.

Webster, Ben (2023). UK airlines' new 'sustainable' fuels may be causing deforestation in Asia, Open Democracy. Exclusive Experts fear lack of industry regulation means virgin palm oil is being passed off as 'used' cooking oil. https://www.opendemocracy.net/en/uk-airlines-sustainable-fuel-used-cooking-oil-deforestation-palm-oil/

World Bank (2019). Nature-based Solutions: a Cost-effective approach for Disaster Risk and Water Resource Management. World Bank https://www.worldbank.org/en/topic/disasterriskmanagement/brief/nature-based-solutions-cost-effective-approach-for-disaster-risk-and-water-resource-management

WEF (World Economic Forum) (2022). BiodiverCities by 2030: TransformingCities' Relationship with Nature. Insight Report, in collaboration with Arup and AphaBeta. WEF_BiodiverCities_by_2030_2022.pdf

WMO (World Meteorological Organisation) (2022). State of the Global Clime in 2022. https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate

Nature-Based Solutions and a Just Transition: Understanding the Jobs, Skills and Training Requirements for NBS to Contribute to the Green Economy

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1 ABSTRACT

This paper evaluates potential for nature-based solutions (NbS) to contribute to a just urban transition, through fair and decent work for people in cities with industrial or high-emitting economies. The idea of a just transition –a move to a zero-emission and sustainable society that does not leave behind the people and places whose jobs and livelihoods rely on high-emitting industries – is gaining signficant attention in international scholarship and policy, including urban policy. However, although there is increasing awareness of the "green jobs" opportunity associated with energy, understanding of the potential for new jobs associated with NbS in the urban economy is more limited. At the same time, there is also a growing acknowledgement that successful urban NbS interventions will require long-term stewardship. Developing a workforce with the skills to maintain and enhance NbS is thus critical if multiple benefits are to be realised.

The role of nature-based solutions in a just transition, and skills requirements for NbS stewardship, are explored through the case of Glasgow in Scotland, United Kingdom. Glasgow is a valuable case as it is a post-industrial former manufacturing and shipbuilding city, which has in recent years suffered deprivation and public health. From an urban planning and policy perspective, city- and national-level climate adaptation and transition plans have given impetus towards a just recovery and transition towards resilience for the Clyde Corridor and for the Glasgow City Region more widely. Glasgow is thus valuable for understanding the jobs, skills and training requirements for NbS, in that it is (a) at a stage where there is a clear policy and planning vision of what NbS deployment in the city region might look like; and (b) home to a large workforce who are likely to need retraining or up-skilling in response to the climate change challenge.

A typology of jobs requried to realise a just urban transition through NbS is developed from review of international scholarly literature, and is used as the analytical framework for the paper. Key job areas that are identified include jobs in construction, land-based sectors, civil engineering and cross-cutting sectors to support societal transformation. Governmental statistics are then used to identify opportunities for particular neighbourhoods or sections of the workforce to benefit from training or upskilling, so that NbS jobs may contribute to just resilience for Glasgow. Existing skilled workers in sectors such as manufacturing and utility supply, which are projected to see declines, may be able to re-skill to support embedding NbS into new-builds and retrofitting in the construction industry. Expanding 'skills passports' to encompass NbS jobs may support this. Data also suggests, however, that in construction- and land-based sectors, there is an ageing workforce and a coming need for replacement labour. Particularly in employment-deprived areas, qualifications in construction, civil engineering and land-based sectors may provide younger people with vocational-level qualifications with an opportunity to develop a sustainable career pathway that will support stewardship for NbS. Moreover, the significance of cross-cutting skills at community level should not be underestimated as support for putting NbS implementation and stewardship into practice.

Reflecting on the urban just transitions and urban NbS policy literature more widely, based on insights from Glasgow City Region, I argue there is a need for particular attention to, and emphasis on, NbS jobs that may be available to sections of the workforce that may be more likely to struggle to find work as traditonal industries are wound down. In other words, there remains a need for more understanding of adaptation and resilience jobs for those with vocational qualifications, alongside the planning and management-type jobs that are perhaps better understood. There is also a need to ensure that understanding of the skills and capabilities for NbS stewardship are integrated into univeristy and college curricula for sectors such as construction and civil engineering, and to protect and update curriucla in areas such as land management and urban ecology Fuller spatial data on workforce skills and adaptation job requirements will help to better understand how the NbS urban green economy opportunity links to the existing and future workforce.

Keywords: climate adaptation; just transition; nature-based solutions; resilience; urban policy

2 INTRODUCTION AND RATIONALE

There is within Scotland and globally rising awareness of the need for consideration of the employment aspects of a resilient net-zero society. The importance of securing fair, decent and environmentally sustainable jobs for workers in sectors likely to be incompatible with climate change obligations in their present form (e.g. oil and gas, steel manufacturing, petrochemicals) has long been argued by trade unions (Rosemberg, 2015) and also by NGOs and political parties with stronger leanings towards environmental and social justice issues (Platform/Friends of the Earth Scotland/Greenpeace, 2020). In Scotland, this trend has been met with acknowledgement at national government level of the imperative to understand the jobs opportunities associated with Scotland's climate response. This interest is reflected in the establishment of a Just Transition Commission, tasked with (among other goals) advising on how Scotland can plan and implement a transition to environmentally and socially sustainable jobs, building on the strengths in Scotland's workforce (Just Transition Commission, 2021). Skills Development Scotland have also produced a climate emergency skills action plan (Skills Development Scotland, 2020) with the goal of identifying opportunities and challenges to developing new, quality green jobs associated with Scotland's response to the climate emergency. At a regional level too, the Glasgow City Region Adaptation Strategy raises the idea of 'just resilience', which includes ensuring workers whose jobs are impacted by climate change are able to requalify and move towards green growth sectors (Climate Ready Clyde, 2021).

The breadth of strategies and policy initiatives outlined above illustrate the growing awareness of the need for quality green jobs and of the opportunities for job creation in areas such as renewable energy and energy efficiency. Nonetheless, bearing in mind that adaptation to a changing climate forms another central component of Scotland's climate response, the potential for jobs associated with climate change adaptation and resilience more widely has perhaps received less explicit attention in Scotland to date.

The purpose of this report is therefore to review elements of recent and ongoing work on "green jobs" in Scotland and the wider UK that are relevant to climate change adaptation and resilience for the Clyde Corridor area of the Glasgow City Region; to characterise the extent to which current policy initiatives and practice may support adaptation- and resilience-linked jobs and training in the Clyde Corridor; and to inventorise programmes which may provide training opportunities for skills related to adaptation and resilience across Glasgow City Region.

Note that a longer and fuller verison of this paper, including underling data tables and fuller discussion (Mabon, 2023) is also hosted as a preprint on SocArXiv DOI: 10.31235/osf.io/fhgm and can be cited as Mabon L (2023) "Jobs and skills for adaptation and resilience in Scotland" SocArXiv DOI: 10.31235/osf.io/fhgm5 Available: https://osf.io/preprints/socarxiv/fhgm5/

3 CHARACTERISING ADAPTATION AND RESILIENCE JOBS

Although jobs related to emissions- and waste reduction tend to be more prominent in the scholarly and policy literature on green jobs, van der Ree (2019) argues that conceptions of 'green jobs' also ought to encompass the protection and restoration of ecosystems and adaptation to the effects of climate change. van der Ree continues that under a changing climate, some new jobs will be created (e.g. natural resource conservation, environmental advisors); some jobs will be eliminated; some jobs will be substituted for others; and that most jobs will be transformed, with workers, operators and managers in sectors including buildings, agriculture and transport learning to manage new technology and operating practices. Skills Development Scotland (2020) similarly categorise jobs under the climate emergency as fitting into: new and emerging jobs (e.g. technologies and actions that did not exist previously); jobs affected by transitions that will need enhanced skills e.g. architects, environmental consultants; and existing jobs that will be needed in greater numbers. Specific to adaptation and resilience, the Green Jobs Taskforce Report (2021) identifies adaptation-related jobs in each of these categories:

- New and emerging jobs: engineering for resilient infrastructure; construction and environmental monitoring; or adaptation finance (insurance and green bonds). Also adaptation jobs and skills for existing sectors such as housing and construction, water, infrastructure, local government, and nature conservation;

- Jobs affected by transitions that will need enhanced skills: heating and cooling (need to consider heat pump installation alongside wider measures for energy efficiency);

536

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- Existing jobs that will be needed in greater numbers: building retrofit sector, to make buildings able to cope with conditions for which they were not designed.

In addition, the Green Alliance categorise adaptation- and resilience-related work as falling within at least two categories: (a) entry-level jobs with transferable skills (e.g. machinery operation, hazard assessment); and (b) high-level academic qualifications at e.g. degree or PhD level for ecological management (Green Alliance, 2021).Typologies and characterisations of 'green jobs' that are explicitly geared towards adaptation and resilience are limited in comparison to those that have been undertaken for climate mitigation and energy efficiency. However, Biagini et al (2014) produce a typology of ten categories of adaptation-related jobs:

- Human or Social Resources or Capital (jobs related to providing training and capacity building);

- Governance and Institutional Management and Planning (jobs related to management and planning for adapting to climate change);

- Changes in or Expansion of Practice or Behaviour (jobs in areas such as land management, rainwater harvesting, invasive species management etc);

- Governance and Institutional Policy Reform (jobs related to mainstreaming adaptation into other areas of policy);

- Information and Communications Technology (jobs linked to developing decision-support tools);

- Climate-Resilient Physical Infrastructure Adaptations (jobs linked to developing physical infrastructure for adaptation and resilience, e.g. retrofitting/constructing buildings, flood defences, sea walls etc);

- Early Warning Systems or Global Climate Observing Systems (jobs linked to developing weather and hydrometeorological systems);

- Climate-Resilient Biophysical or "Green" Infrastructure (jobs in areas such as landscape management and horticulture linked to nature-based solutions);

- Adaptation Related Financial Strategies (jobs related to financing adaptation initiatives and providing insurance);

- Expansion or Introduction of Climate Adaptation-Related Technology (jobs linked to developing technologies needed for adaptation, e.g. water purification).

Biagini et al acknowledge, however, that many of the adaptation actions they identify have in practice so far been focused on awareness raising, public engagement, and capacity-building. The evidence base is therefore more limited for adaptation- and resilience-focused jobs which involve putting adaptation rhetoric into practice through, for example, construction, implementation of nature-based approaches or construction.

4 ADAPTATION AND RESILIENCE JOBS SPECIFIC TO SCOTLAND

The Green Jobs Taskforce Report (2021) identifies adaptation-related green jobs as including flood defences, retrofitting of buildings to be resilient to extreme weather/climate events, nature-based solutions to reduce climate impacts and civil and mechanical engineering for infrastructure adaptation. In their Climate Emergency Skills Action Plan (2020), Skills Development Scotland similarly list a breadth of priority areas, of which three – construction, engineering, and agriculture and land use – are relevant to adaptation and resilience. The aim of this section is therefore to review the existing knowledge and evidence around each of these areas for Scotland and where possible the Clyde Corridor. Table 1 summarises how the 10 types of adaptation actions identified by Biagini et al (2014) map onto the existing skills requirements, supporting policies, and policy/knowledge gaps identified for adaptation- and resilience-focused jobs in Scotland.

Adaptation Category	Examples of Action	Potential relevant jobs for Glasgow City Region	Supporting Policies and Initiatives for Glasgow City Region	Potential Policy and Knowledge Gaps for Glasgow City Region
Capacity building	Training/workshops for knowledge/skills development, public outreach and education, dissemination of info to decision makers/stakeholders, Identification of best	-training and capacity-building; -facilitation; -community development and community-level interventions.	SCS CEAP (2020): need soft skills for e.g. behaviour change, stakeholder engagement, communication	

	practices, training materials			
Management and Planning	Developing an adaptation plan, livelihood diversification, drought planning, coastal planning, ecosystem-based planning, changing natural resource management	-environmental impact assessment; -adaptation planning; -urban ecological planning.	Skills Development Scotland Climate Change Strategy (2020) Business Processes workstream: support for skills in undertaking EIAs. SDS CEAP (2020): Leadership skills to support cultural change and change management as new technologies, behaviours and systems will need embedded.	Frantzeskaki et al (2020): lack of capacity in relation to innovation and entrepreneurship around NBS, so the focus on engineering solutions has led to missed opportunities for biodiversity, open space and health NatureScot (2020): loss of specialists due to austerity.
Practice and Behaviour	Soil/land management techniques; climate-resilient crops or livestock practices, post-harvest storage, rainwater collection, expanding integrated pest management	-woodland restoration and enhancement; -management of invasive species; -ecological engineering.	NatureScot Nature-Based Jobs Report (2020): peatland/woodland restoration; management of invasive species; planning, ecological engineering.	SDS CCAP (2020): need to refresh careers information and pathways into the sector which reflect both future technical requirements and the scope for the sector to contribute significantly towards addressing climate change. This is particularly important in the context of a sector (agriculture/land use) with fewer formal qualification pathways and upskilling opportunities.
Policy	Mainstreaming adaptation into development policies, land-use specific policies, improvement of water resource governance, revised design parameters, ensuring compliance with existing regulations	-adaptation, resilience and environmental management in local (and national) government; -resilience management for business and third sector organisations.	SDS CEAP (2020): Demand for higher-level skills in business and commercial management to respond to changing markets	Frantzeskaki et al (2020): need for skills to foster collaboration across silos and a need for contextual analytical skills relevant to urban planning
Information	Decision support tools, communication tools, data acquisition efforts, digital databases, remote communication technologies	-IT jobs linked to data management and communication; -community engagement on risk and adaptation.		
Physical infrastructure	Climate-resilient buildings, reservoirs for water storage, irrigation systems, canal infrastructure, sea walls	-retrofitting buildings to enhance resilience to extreme events (windproofing, rainwater protection, cooling); -skills for enhancing resilience of new-build construction (new techniques for roofing, integrating green infrastructure elements etc); -inspection and maintenance of built environment; -professional level jobs in planning, design, surveying and management; -flood prevention infrastructure;	Skills Development Scotland CEAP (2020): anticipated increased demand for professional level skills for jobs in planning, design, surveying and management and the deployment of nature-based solutions. SDS Climate Emergency Action Plan (2020): Co-design and development of a Construction Retrofit national training programme.	SDS CEAP (2020): need to demonstrate competence and recognise adaptability and transferability of skills across the sector, for instance through a 'skills passport' scheme. Ageing workforce with a third of construction workers aged 50+, and an estimated 50,000 construction workers retiring by 2029. NatureScot (2020): for flood risk management, major infrastructure players working at national level can find people with nature-based/ecological expertise, recruiting nationally and redeploying.
Warning or observing systems	Developing, testing and deploying monitoring systems, upgrade weather or hydrometeorological services	-scientific and research jobs for understanding risks and developing warning systems; -IT jobs for data management and communication.		
"Green" infrastructure	Revegetation, afforestation, woodland management, increased landscape cover	-restoration, enhancement and maintenance of urban greenspace, forestry, wetlands and community spaces; -urban ecological planning	Skills Development Scotland Climate Change Strategy (2020): 2024: 18,000 hectares of new woodlands created annually NatureScot Nature-Based Jobs Report (2020):	NatureScot Nature-Based Jobs Report (2020): "It is not possible to separately account for all elements in the NatureScot definition of nature-based activities. In particular, it is not possible to obtain specific data on nature-based solutions, environmental green

538

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			peatland/woodland restoration; management of invasive species; planning, ecological engineering.	finance or urban green infrastructure activities." NatureScot (2020): how to stop losing skilled people to commercial forestry?
Financing	Insurance schemes, microfinance, contingency funds for disasters	-education and training in natural capital approaches; -financial management and monitoring; -fundraising and ensuring financial sustainability	Skills Development Scotland Climate Emergency Action Plan (2020): Ensure that natural capital and circular economy considerations are recognised as core skills across all disciplines. NatureScot Nature-Based Jobs Report (2020): existing finance sectors can adapt quickly?	NatureScot Nature-Based Jobs Report (2020): need for understanding of natural capital (and monitoring/ management skills) within finance industry.
Technology	Technologies to improve water use or water access, solar energy capacity, biogas, water purification, solar salt production		Skills Development Scotland CEAP (2020): Increased need for design, analytical and technical skills in new manufacturing processes (eco-design).	Skills Development Scotland CEAP (2020): Current skills shortages of engineers

Table 1: application of typology of adaptation jobs to Clyde Corridor and Glasgow City Region context

4.1 Nature-based solutions to reduce climate impacts

4.1.1 Jobs and skills

- peatland restoration: need field experience as well as academic qualifications; also skills in administrating/monitoring/reporting;
- woodland restoration: financing (especially as sector often charitable or public sector-funded); stakeholder engagement and cross-sectoral working;
- management of invasive non-native species;
- blue carbon;
- flood risk management;
- green finance; understanding of natural capital plus monitoring and management skills;
- planning;
- ecological engineering: natural capital approaches (all NatureScot, 2020);
- importance of skills in maintenance and stewardship of nature-based approaches, as well as initial implementation (Shimizu et al., 2016)
- higher-level skills in business and commercial management to respond to changing markets (Skills Development Scotland, 2020).

4.1.2 Opportunities and challenges

- sector predominantly made up of microbusinesses, with fewer formal qualification pathways and upskilling opportunities (Skills Development Scotland, 2020). Smaller enterprises may also struggle to recruit and retain staff against major infrastructure players (NatureScot, 2020);
- need for retraining and upskilling workforce, and to refresh careers information and pathways into sector to counter ageing workforce (Skills Development Scotland, 2020);
- challenge in creating paid jobs from conservation and restoration sectors that often rely on volunteer labour (NatureScot, 2020);
- risk of losing skilled workers to more lucrative sectors such as commercial forestry (NatureScot, 2020);
- in public sector, austerity and budget cuts mean local governments are likely to have lost people with skills in areas such as ecology (NatureScot, 2020);

- jobs in sectors such as natural capital accounting are likely to be highly skilled, i.e. Masters or PhD level, and in sectors such as financing existing staff may simply adapt or re-train Moreover, for areas such as flood risk management, major infrastructure players can recruit qualified and skilled labour nationally and re-deploy (NatureScot, 2020);

- importance of ensuring higher education remains up-to-date with ecological planning and natural capital approaches (NatureScot, 2020);

- 2023: Regional Land Use Frameworks developed (Skills Development Scotland Climate Change Strategy, 2020);

- 2024: 18,000 hectares of new woodlands created annually (Skills Development Scotland Climate Change Strategy, 2020);

- 2030: At least 250,000 hectares of peatland restored (Skills Development Scotland Climate Change Strategy, 2020).

5 EMPLOYMENT TRENDS IN THE CLYDE CORRIDOR

5.1 Labour market trends

The Green Alliance's report into Levelling Up Through Nature (Green Alliance, 2021) identifies the centre and west of Glasgow as experiencing very high labour market challenges post-pandemic; and the south of Glasgow and Clydebank as experiencing high labour market challenges post-pandemic. The rest of the Clyde Corridor is rated as facing 'average' labour market challenges, with the exception of Greenock, which faces "low" labour market challenges.

Skills Development Scotland's 2021 Regional Skills Assessments for the Glasgow College Region and the West provide a fuller and useful basis for understanding employment trends in the Clyde Corridor and their relation to adaptation and resilience-related jobs.

In the Glasgow College Region (Glasgow, City, East Dunbartonshire and East Renfrewshire), trends with relevance to adaptation and resilience include short- to mid-term declines projected in jobs in electricity, steam, gas and air conditioning supply (-300 by 2031); in financial and insurance (-900 by 2031); and in manufacturing (-3,300 by 2031), albeit with some replacement demand; plus short- to mid-term growth in professional and in construction jobs over the same time period, e.g. +500 in skilled construction, + 900 in science and technology professionals.

Glasgow College region also has Modern Apprenticeship redundancies above the Scottish average (291.4% from 2019-20 to 2020-21, compared to 135.2% over Scotland as a whole), mostly in construction but also in engineering and energy. Nearly half (48%) of the skills requirement for job openings up to 2031 is for people with higher education level qualifications at SCQF 7-10 (i.e. HNC/Modern Apprenticeship up to Degree level) (Skills Development Scotland, 2021a).

Key points to note for the upper Clyde Corridor (i.e. Glasgow City) hence include:

- Potential for current manufacturing jobs to transition to construction or nature-based jobs for adaptation and resilience;

- Potential for declines in utilities and ventilation sectors, plus growth in skilled construction, to support retrofit of buildings to enhance resilience to extreme events;

- Possibility for decline in financial and insurance jobs, coupled with growth in professional positions, to support deployment of adaptation and resilience via financing, natural capital approaches, and management?

- Importance of supporting younger/less qualified workforce in attaining qualifications which can support skills for adaptation and resilience, especially in sectors such as construction with Modern Apprenice workforce and growth projections.

In the West Region (Inverclyde, Renfrewshire, West Dunbartonshire, East Renfrewshire), trends with relevance to adaptation and resilience include short- to mid-term declines in manufacturing (-1,900 by 2031) and financial and insurance (-100 by 2031); plus short- to mid-term growth in professional, scientific and technical (+600 by 2031) and construction jobs (+300 by 2031); especially change in science and technology

540

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professional positions (+200 by 2031). However, there is no growth in some other sectors relevant to adaptation and resilience e.g. skilled construction and building trades. The region is projected to have replacement demand (i.e. jobs to replace those leaving the sector) for agriculture, forestry and fishing (+300 jobs by 2031); also large replacement demand for construction (300 expansion jobs by 2031, plus 2,400 replacement jobs).

For the West Region, Modern Apprenticeship redundancies are well above Scottish average (363.2% from 2019-20 to 2020-21, compared to 135.2% over Scotland as a whole), mostly in construction but also some in engineering and energy. 46% of the skills requirement for job openings up to 2031 is for people with higher education level qualifications at SCQF 7-10 (i.e. HNC/Modern Apprenticeship up to Degree level) (Skills Development Scotland, 2021b).

Key points to note for the lower Clyde Corridor (e.g. downstream coastal areas) hence include:

- Potential for current manufacturing jobs to transition to construction or nature-based jobs for adaptation and resilience;

- Replacement demand for agriculture/forestry and construction may give an opportunity to upskill replacement workforce with capabilities in nature-based solutions and in construction/retrofitting for adaptation and resilience;

- Some limited possibility for decline in financial and insurance jobs, coupled with growth in professional positions, to support deployment of adaptation and resilience via financing, natural capital approaches, and management?

- Importance of supporting younger/less qualified workforce in attaining qualifications which can support skills for adaptation and resilience, especially in sectors such as agriculture/forestry and construction with significant replacement labour requirement projections.

5.2 Existing training and upskilling opportunities in the Clyde Corridor

The Green Jobs Taskforce's (2021) Recommendation 10 is to "map, review and enhance other training pathways […] to ensure they support a diverse, inclusive and net zero-aligned workforce across the UK". To undertake this exercise for the Clyde Corridor in the context of adaptation and resilience jobs, a reviewer was undertaken of the qualifications provided by further- and higher education institutions in the Clyde Corridor which may offer upskilling or retraining for adaptation and resilience-related jobs.

Construction and civil engineering qualifications appear to be well-represented across all levels. However, given the need to integrate future climate projections into present design (Shi and Moser, 2021) and for current buildings to need to be resilient to more extreme events in future (Stewart and Deng, 2015; Grynning et al, 2020), it is vital to ensure that adaptation and resilience content is embedded within curricula in the present – ideally with a specific focus on the conditions likely to be faced in the Clyde Corridor. It is notable that only a small number of institutions offer qualifications relating to landscape management or urban ecology. Given the prominence of nature-based solutions in both the Glasgow City Region Adaptation Strategy and the Glasgow City Open Space Strategy, the limited number of opportunities for building skills in implementation and stewardship (Shimizu et al, 2016) of natural and semi-natural spaces (especially at vocational and further education level) may require attention. It is also notable that at under- and postgraduate level, the Clyde Corridor's higher education institutions offer a breadth of cross-cutting qualifications relevant to the societal dimensions of adaptation and resilience. This could, however, be supplemented with more vocational qualifications in areas such as community development.

6 KEY ISSUES, LIMITATIONS AND FUTURE RESEARCH REQUIREMENTS

A critical challenge raised across several of the policy documents reviewed for this study (e.g. Skills Development Scotland Climate Emergency Skills Action Plan; Green Alliance Levelling Up Through Nature Policy Insight) concerns getting younger people into the workforce for the sectors that are likely to be critical to adaptation and resilience. The Skills Development Scotland regional audits for Glasgow and West note a particular need for workforce replacement in the construction, heating/ventilation and agriculture/land sectors. Recruiting replacements with the skills to implement adaptation actions may necessitate changing perceptions of sectors such as construction and nature-based jobs (Skills Development Scotland, 2020).

There is also a related issue around providing adaptation and resilience-related jobs which bring skilled employment for sections of the population who may struggle to find work (Brocklehurst et al., 2021). Existing research appears to have good awareness of the professional (i.e. degree) level jobs associated with planning and management for adaptation and resilience, whereas evidence on vocational skills and qualifications for sectors such as construction and nature-based adaptation is more limited. There may be particular need to build understanding of the potential for adaptation- and resilience-related jobs in urban areas that are suitable for those with vocational or applied qualifications, in addition to degree-level jobs in urban areas linked to adaptation, which are perhaps already better understood.

Another key challenge is ensuring there is a coordinated central source of data on the labour force, skills, and adaptation/resilience job requirements for the Clyde Corridor and wider Glasgow City Region. NatureScot (2020), in their comprehensive report on nature-based jobs and skills, note that it is not possible to obtain specific data on jobs and skills relating to nature-based solutions, urban green infrastructure and environmental green finance. Whilst Skills Development Scotland and Scottish Government Statistics provide a breadth of data on neighbourhood deprivation, labour force statistics and skills, less well represented are some of the jobs and skills requirements from private sector developers. Further research and enquiry may therefore wish to work with local authorities and private sector developers to quantitatively estimate the size of the jobs opportunity for adaptation-related actions in sectors such as construction, civil engineering and land management over the coming decades, and to break down the distribution of these jobs spatially. Data of this nature will help to provide a fuller picture of how closely the adaptation and resilience jobs opportunity in the Clyde Corridor maps onto locations which may stand to benefit.

7 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are drawn for developing adaptation and resilience-related green jobs along the Clyde Corridor:

- The construction, civil engineering and land-based sectors are likely to be the main sources of adaptation and resilience-related jobs in the Clyde Corridor, along with cross-cutting positions linked to supporting societal interventions for adaptation and resilience-building;

- Communities in the east and west of Glasgow, as well as in West Dunbartonshire and Inverclyde, may benefit from targeted programmes aimed at upskilling or retraining workers to meet employment needs in the construction and nature-based adaptation sectors in particular. Data suggests these areas face high employment deprivation, as well as an above average proportion of either low-qualified adults or highly-qualified adults who are out of work. Particular job requirements may include retrofitting and enhanced maintenance/inspection of the built environment, as well as implementation and long-term stewardship of nature-based solutions;

- Projected labour declines in manufacturing and utility supply may provide a skilled workforce, or a workforce willing to undertake retraining, to meet skills and labour replacement requirements in construction and land sectors along the Clyde Corridor. However, 'skills passports' for more experienced workers and messaging/engagement to shift perceptions of construction/land sectors among younger workers may be required to maximise this potential;

- There already appears to be good awareness of the types of adaptation and resilience-related jobs in the Clyde Corridor that are open to those with degree-level qualifications. However, there may be need for greater empirical evidence, and also greater engagement with workers and trade unions, on the adaptation and resilience job opportunities that are open to workers with vocational qualifications in urban areas;

- Further- and higher education institutions along the Clyde Corridor offer qualification pathways to meet skills and training requirements for adaptation. However, it is imperative to ensure curricula embed adaptation requirements now in order to provide a skilled workforce for the near future. Further education/vocational training provision also ought to be enhanced for landscape and ecology and for community development sectors to support implementation in practice.

542

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9 REFERENCES

Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., & McNeeley, S. M. (2014). A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. Global Environmental Change, 25, 97–108. https://doi.org/10.1016/J.GLOENVCHA.2014.01.003

Brocklehurst, F., Morgan, E., Greer, K., Wade, J., & Killip, G. (2021). Domestic retrofit supply chain initiatives and business innovations: an international review. Buildings and Cities, 2(1), 533. https://doi.org/10.5334/BC.95

Climate Ready Clyde. (2021). Glasgow City Region Climate Adaptation Strategy and Action Plan. https://online.flippingbook.com/view/139900/

Committee on Adaptation to a Changing Climate. (2018). Climate-Resilient Infrastructure: Adaptive Design and Risk Management. American Society of Civil Engineers. https://doi.org/doi:10.1061/9780784415191

Cowley, J., Kiely, J., & Collins, D. (2016). Unravelling the Glasgow effect: The relationship between accumulative bio- psychosocial stress, stress reactivity and Scotland's health problems. Preventive Medicine Reports, 4, 370–375. https://doi.org/10.1016/j.pmedr.2016.08.004

Frantzeskaki, N., Vandergert, P., Connop, S., Schipper, K., Zwierzchowska, I., Collier, M., & Lodder, M. (2020). Examining the policy needs for implementing nature-based solutions in cities: Findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland). Land Use Policy, 96, 104688. https://doi.org/10.1016/j.landusepol.2020.104688

Glasgow City Region. (2020). Clyde Mission. https://glasgowcityregion.co.uk/what-we-do/strategy-and-programmes/clyde-mission/

Green Alliance. (2021). Jobs for a green recovery: Levelling up through nature. www.green-alliance.org.uk/

Green Jobs Taskforce. (2021). Green Jobs Taskforce: Report to Government, Industry and the Skills sector Report to Government, Industry and the Skills Sector.

Grynning, S., Gradeci, K., Gaarder, J. E., Time, B., Lohne, J., & Kvande, T. (2020). Climate Adaptation in Maintenance Operation and Management of Buildings. Buildings 2020, Vol. 10, Page 107, 10(6), 107. https://doi.org/10.3390/BUILDINGS10060107

Just Transition Commission. (2021). Just Transition Commission: A national mission for a fairer, greener Scotland.

Kazmierczak, A., Cavan, G., Connelly, A., & Lindley, S. (2015). Mapping Flood Disadvantage in Scotland 2015: Main Report.

Mabon L (2023) 'Jobs and skills for adaptation and resilience in Scotland' SocArXiv DOI: 10.31235/osf.io/fhgm5 Available: https://osf.io/preprints/socarxiv/fhgm5/

Majekodunmi, M., Emmanuel, R., & Jafry, T. (2020). A spatial exploration of deprivation and green infrastructure ecosystem services within Glasgow city. Urban Forestry and Urban Greening, 52, 126698. https://doi.org/10.1016/j.ufug.2020.126698

NatureScot (2020) NatureScot Research Report 1257 - Supporting a green recovery: an initial assessment of nature-based jobs and skills. https://www.nature.scot/doc/naturescot-researchreport-1257-supporting-green-recovery-initial-assessment-nature-based-jobs-and

Nicol, J. F., & Roaf, S. (2017). Rethinking thermal comfort. Building Research & Information, 45(7), 711–716. https://doi.org/10.1080/09613218.2017.1301698

O'Neill, S., & Tett, S. (2019). MAPPING FUTURE SCOTTISH HEATWAVE EXTREMES: REPORT FOR CLIMATE READY CLYDE.

Platform/Friends of the Earth Scotland/Greenpeace. (2020). OFFSHORE Oil and gas workers' views on industry conditions and the energy transition.

Rosemberg, A. (2015). Sustainable industrial transformation: For whom and where to start? Development (Basingstoke), 58(4), 540–548. https://doi.org/10.1057/s41301-016-0040-2

Scottish Government. (2019). Climate Ready Scotland: Second Scottish Climate Change Adaptation Programme 2019-2024.

Scottish Government. (2020). Clyde Mission. https://www.gov.scot/publications/clyde-mission/

Shi, L., & Moser, S. (2021). Transformative climate adaptation in the United States: Trends and prospects. Science, 372(6549), eabc8054. https://doi.org/10.1126/SCIENCE.ABC8054

Shimizu, H., Takatori, C., & Kawaguchi, N. (2016). Labor Forces and Landscape Management: Japanese Case Studies. Springer Japan.

Skills Development Scotland. (2020). Climate Emergency Skills Action Plan 2020-2025.

Skills Development Scotland. (2021a). Regional Skills Assessments: Glasgow College Region: July 2021.

Skills Development Scotland. (2021b). Regional Skills Assessments: West Region: July 2021.

Stewart, M. G., & Deng, X. (2015). Climate Impact Risks and Climate Adaptation Engineering for Built Infrastructure. ASCE-ASME J. Risk Uncertainty Eng. Syst., Part A: Civ. Eng. https://doi.org/10.1061/AJRUA6.0000809

van der Ree, K. (2019). Promoting Green Jobs: Decent Work in the Transition to Low-carbon, Green Economies. In C. Gironde & G. Carbonnier (Eds.), The ILO @ 100: Addressing and Past and Future of Work and Social Protection (pp. 248–272). Brill | Nijhoff. https://doi.org/10.1163/9789004399013_013

Winter, T. (2016). Active cooling and low carbon comfort. The Journal of Architecture, 21(3), 418–432. https://doi.org/10.1080/13602365.2016.1180631

544

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Nature-Based Solutions through Blue-Green Infrastructure as Measure of Adaptation, Resilience and Liveability to Climate Change: Case Study City Lab Saltillo, Mexico

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1 ABSTRACT

The impacts of the current urbanization and climate change challenges are well documented, as well as, the role of cities and the urgent action that needs to take place at the local level, especially in small and middle-sized cities. As extreme climatic events unfold, there is a need to identify the potential and the strategies that can help municipalities steer urban planning on a more sustainable and resilient track to reach the global climate goals within the next decade. Now more than ever, Nature-based solutions (NbS) such as Blue-green infrastructure(BGI) are proving to be a feasible alternative for cities to adapt their urban environment in response to climate change, while simultaneously obtaining economic, environmental, and social co-benefits.

Anticipating climate challenges in cities makes it vital to change today's traditional urban planning into initiatives that consider greener solutions like BGI. However, some implementation barriers such as the lack of stakeholders' involvement to navigate and co-create a more resilient and adaptive city environment, make difficult the transition.

As part of the Morgenstadt Global Smart Cities Initiative (MGI), financed by the German Government through the International Climate Initiative (IKI), the city of Saltillo located in the Northeast region of Mexico is paving the path towards sustainable urban planning through the City Lab project. In the first phase, the City Lab consisted of an integrated urban analysis, stakeholder engagement, and the co-creation of a roadmap of solutions by experts and local actors to tackle the city's urban challenges. The City Lab process allowed anchoring the identified measures in the planning documents of Saltillo, ensuring the implementation of the roadmap in the long term. Simultaneously, it opened up spaces for co-creation and community engagement valuable to understand the city´s local environment and identify its potential. In the second phase of the City Lab, the implementation of a pilot project based on BGI addressed the most pressing problems of the city such as pluvial floods, water scarcity, and depletion of aquifers. In this regard, the stakeholders were actively involved in analyzing, planning, formulating, developing, implementing, testing, evaluating, and maintaining the pilot project to cope with climate impacts and contribute to sustainable urban development in the short, medium and long term. In this paper, special attention will be given to the process of pilot project implementation, showing the efforts that the City Lab Saltillo is undertaking to implement BGI techniques such as rain gardens, infiltration basins, permeable pavement, and vegetation in a public and urban space as an adaptation measure in response to climate change. This effort is reshaping the city's discourse, shifting the role of urban planning, and highlighting climate action as a shared responsibility among the public, private, academic, and civil society.

Keywords: Urban planning and co-creation, Blue-green infrastructure, Nature-based solutions, Climate change adaptation, Governance of Nature-based solutions

2 INTRODUCTION

In the current race against climate change impacts, urban interventions for mitigation and adaptation gain relevance when dealing with middle-size cities, covering approximately 45% of urban areas in emerging economies like Mexico, and expected to bear the brunt of climate impacts in the coming decades (UN-HABITAT, 2022). On the other hand, the need to update the planning processes and urban interventions calls for immediate action and for pilot concepts that are easily implemented, tested and replicated in case of success. Implementing nature-based solutions (NbS) as actions that aim to protect, sustainably manage, and restore natural and modified ecosystems addressing current societal challenges (IUCN, 2020),is a feasible alternative to address current climate challenges in middle-size cities from emerging economies. NbS is also an umbrella term for a variety of nature-based approaches such as Low-Impact Development (LIDs), Best

Management Practices (BMPs), Green infrastructure or Ecosystem-based Adaptation (EbA) among others (IISD, et al., 2022). For the pilot project in Saltillo, the implementation of NbS has been done through Blue-green infrastructure (BGI). The latter offers the greatest benefits for the provision and control of water quantity and quality as well as biodiversity. Being flood control one of the key services of BGI, it allows substantial hydrological functions easing the interception and allowing the retention of rainwater and stormwater, and at the same time offers benefits along the recreational, cultural, and well-being dimensions (Bacchin, K., et al 2016; Kopp et al, 2021).The implementation of the pilot project in Saltillo is expected to increase and improve green permeable areas in the city, the reduction of floods and their impacts, and promote citizen engagement and participation in urban planning processes.

2.1 Saltillo climatic conditions

The Mexican city of Saltillo has a population of almost one million inhabitants (INEGI,2020). The city located in the desert of Coahuila is a highly vulnerable area exposed to variability in hot temperatures between spring and summer (Fig 1). Nevertheless, during the short rainy season, heavy rainfall and storms are frequent due to mainly intense atmospheric phenomena (Mok et al., 2021). Despite Saltillo´s average annual precipitation of 484 mm, the climatic conditions and extreme weather cause floods and droughts (IMPLAN, 2021). However, these extreme events are not the only ones; the city suffers heat waves during the spring and summer, and cold temperatures in winter.

Fig. 1: Localization city of Saltillo, Mexico.

In addition to the above, the city of Saltillo has had rapid urbanization, growing extensively as a sprawling city. Its urbanization patterns characterized by the concentration of the population in the centre of the city with few green spaces and sealed permeable surfaces, exacerbate the increasing temperature, the urban heat islands (UHIs), and flooding in urban spaces due to the lack of pluvial drainage in most parts of the city and insufficient capacity in areas where it exists. It is expected that the effects and impacts of climate change in Saltillo and the region will be worse than today, and with the combination of rapid and unplanned urbanization, extreme events will be more frequent with many monetary and non-monetary consequences for the population (Mok et al., 2021).

2.2 Pilot project background: Saltillo's city profile and roadmap

Through the first phase of the City Lab, it was possible to identify opportunities to improve the performance of Saltillo in selected sectors and to develop custom-made, sustainable and integrated solutions to improve the urban infrastructure processes or services. This research phase was supported by interviews with local actors and resulted in a city profile as a diagnostic of the city with identified potentials and a roadmap with project ideas that were co-created between the City Lab team and the local actors. In the water sector, the urban assessment highlighted challenges such as flooding, lack of rainwater drainage, and water shortage as pressing in Saltillo. To address these challenges, a recommendation was made to integrate Blue-green infrastructure into the urban space, enhancing the city's green permeable areas and recharging already overexploited aquifers by creating a sponge city effect (Ordonez J.A., et al., 2021).Such a recommendation was taken forward in the pilot project implementation.

546

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3 METHODS AND TOOLS

The pilot project was developed by an international and interdisciplinary team composed of research institutions such as the University of Stuttgart IAT and the Fraunhofer Society and a local team formed by the Municipal Planning Institute (IMPLAN) and the Tecnológico de Monterrey. The international institutions performed the project coordination, and the local team provided the local know-how, conducted the stakeholder management and outreach, and coordinated the research and the pilot project implementation on-site. To achieve the implementation of the BGI techniques such as rain gardens, infiltration basins, permeable pavement and vegetation in a public and urban space as an adaptation measure to climate change five steps were developed (see Fig. 2).
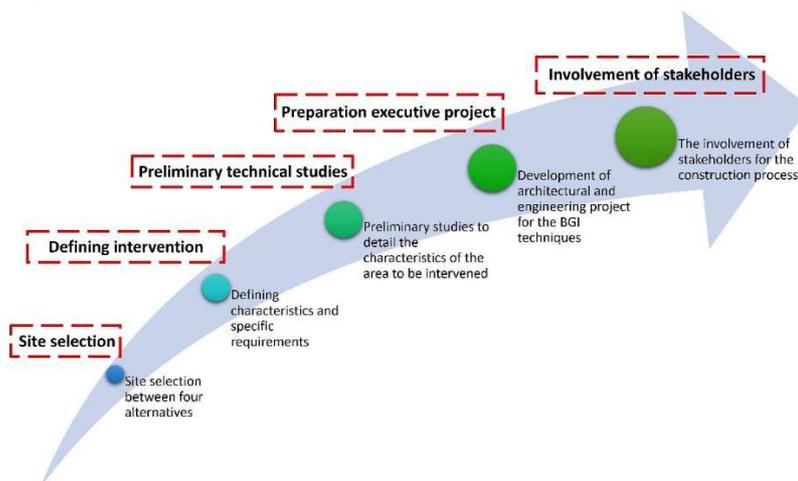

Fig. 2: Diagram process of the implementation pilot project.

For step one, site selection, the team performed a mapping exercise with a Geographical Information System (GIS)to identify public spaces that flooded after rain events and where citizens were affected by them. Then, the sites were evaluated using similar criteria and presented to the Mayor of the city, the Directorate of Public Works, and the Directorate of Urban Development to find the most suitable place to intervene. The following criteria were considered during the evaluation:

- Facilities and networks: No public networks were affected during the construction work.
- Flood risk and frequency: Frequency of flooding events per year.
- Social impact: Number of citizen complaints due to flooding.
- Land use: Public or private space.
- Population density: Benefited citizens.
- Aesthetic urban development: The potential of improvement of the green public space.
- Contribution to the achievement of the City Lab Project objectives: Demonstrative adaptation measure.

To define the intervention, a participatory process was carried out aiming to involve the neighbours in the co-creation of the pilot project. During this exercise, the neighbours were asked about the current use of the public space, their experiences during the flooding events, and their expectations from an urban intervention to improve the area. In the third step, preliminary technical studies were conducted to understand the characteristics of the area to be intervened. Technical studies such as a topographic survey, soil mechanics, hydrological study and vegetal inventory were executed. With this information, the next step consisted of the elaboration of an executive project, appointed through public bidding. The company selected for the implementation was responsible for making architectural and engineering designs for the public square. In this step, the City Lab local team and the selected company carried out a SWOT analysis of environmental and socio-cultural characteristics to be considered in the design process for the integration of BGI techniques. The design proposal, acknowledging the physical characteristics of the selected site, involved the topography, urban trees, landscape, and hydrographic and hydrology conditions of the site. Regarding socio-cultural aspects, the design proposal focused on multiple users and rights holders' involvement. To anchor

the project in the local environment, the fifth step consisted of the involvement of stakeholders that could support the project's implementation and maintenance after the end of the City Lab project in Saltillo.

4 RESULTS

The implementation of the pilot project in Saltillo has been a joint effort that started with the MGI Initiative, and the City Lab project and was followed by city assessments, participatory workshops and the roadmap of project ideas. The integration of the Planning Institute of Saltillo (IMPLAN) in an international cooperation project like MGI drew the attention of local stakeholders and authorities, and the results of the research and the potential of the pilot project idea opened the door to in-kind cooperation from third parties. Regarding the best site for the implementation of the pilot project, mapping with GIS tools to identify the areas with pluvial flood risks showed four potential sites (Fig. 3).
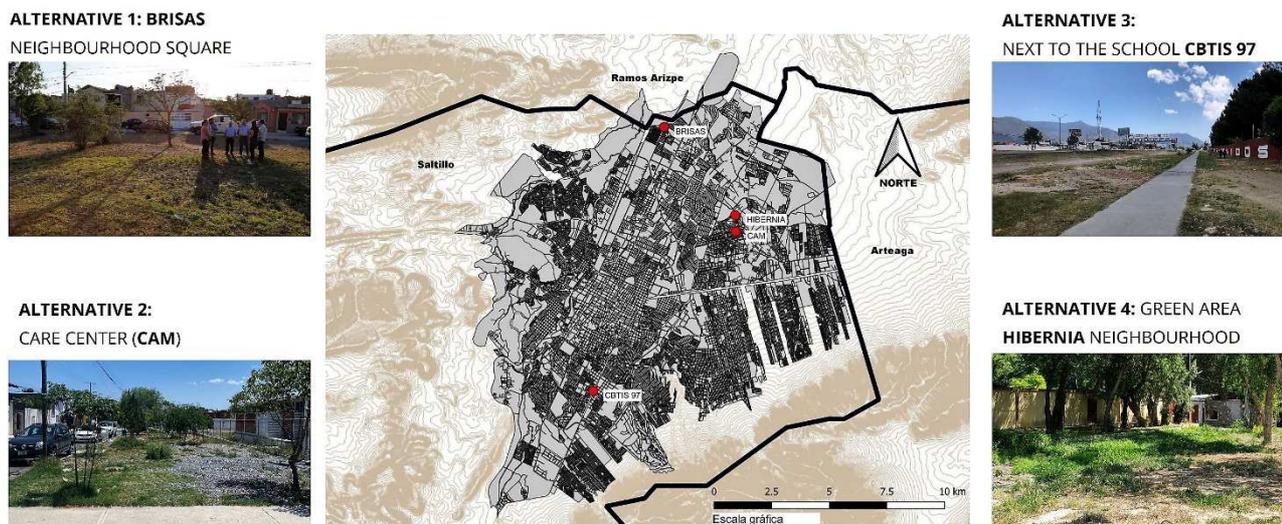
Fig. 3: Pilot sites identified with GIS.

After mapping, the four sites were evaluated using similar criteria (see Table 1). Obtaining the best conditions to introduce BGI techniques was a square in the neighbourhood Brisas where there were no public networks affected, a high risk of flooding, and thus complaints from neighbours. Furthermore, the land use would allow an intervention and it could contribute to the overall MGI project objectives. The square has a total surface area of 0.35 hectares, with a total of 106 people living in 30 private homes. The population density of the area directly benefited by the pilot project is 30,388ha per km², and the housing density is 84 homes per hectare (IMPLAN, 2023). Being this square the site with the highest density of the shortlisted four, these figures highlight the overall low density in the city, one of the main characteristics of Saltillo´s urban fabric.

SELECTION CRITERIA	Alternative 1 BRISAS SQUARE	Alternative 2 CARE CENTER	Alternative 3 CBTIS SCHOOL	Alternative 4 LA HIBERNIA
Technical conditions (no public networks affected)	Good	Good	Good	Good
Flood Risk according to GIS and Saltillo´s Risk Atlas	High	Medium	Medium	High
Social Impact: Number of Citizen complaints due to flooding	High	High	High - Medium	Low
Land Use	Public Green Area	Public Green Area	Public Green Area	Private Residential
Population Density	High	Medium	High	Low
Urban Image Improvement	High	High	Medium	Low
Visibility	High	Medium	High	Low
Contribution to the achievement of the MGI Project objectives	High	Medium	Medium	Low

Table 1: Selection criteria pilot area

548

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With the pilot site selected, a needs assessment with the neighbours of the pilot area was also undertaken. The local team contacted the Secretary for Social Development of Saltillo to gain an understanding of the procedures for citizens' involvement in planning processes. The first approach was done with the support of the Secretary and only to the local neighbours' council who manifested interest in the pilot intervention. After this encounter a workshop was organized for all neighbours to map the needs, the problematic areas after the rain events, and the current uses of the public space where the pilot is taking place. The latter was a crucial step to ensure the acceptance of the intervention and to recognise and incorporate the current dynamics and activities that take place in the pilot area (Fig. 4).

Fig. 4: Participatory processes to identify specific requirements for the neighbours.

To complete the site assessment, the City Lab team conducted technical studies with support from the Secretary of Infrastructure and Public Works of Saltillo. A topographic survey and a soil mechanics study were performed to identify the characteristics of the terrain and to assess the feasibility of the construction of a rain garden and an infiltration basin to tackle the pluvial floods in the selected area. Figure5 summarizes the topographic and hydrologic conditions of the area.

Fig. 5: Topographic and hydrologic conditions of the pilot area (Elaboration: PEW Studio)

The results of the topography survey indicate the runoff accumulates in this area without outlets or storm drains. Only one grate connected to the sanitary sewer with a reduced capacity was identified, which cannot be enlarged because it would cause an overflow through the sanitary pipes into the houses in the area. As a result, runoff accumulates in the area, causing flooding on the avenue, sidewalks and even, in heavy rains, flooding into the houses. This amount of water accumulation remains for days in the area until it is gradually drained through the sanitary sewer and evaporates or is absorbed in the green area.

The estimation from the hydrological study shows that the maximum runoff volume that reaches the property in a two-year return period was 20,135 m3, in 5 years 42,000 m3, and in 10 years 61,740m3. In all cases, the runoff volume estimated is high. This is due to the urban basin with an area of 2.27 km2 being 95% impermeable. The simulation was carried out considering extreme storm situations with a duration of 24 hours, using the HEC-HMS software developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC). Given these scenarios, it was decided to consider a large capacity for the design and size of the rain garden and infiltration basin techniques to reduce flooding events related to a year return period. Besides the technical studies forementioned, to develop the executive project, which included the landscape and engineering design for the public square, two characteristics were considered for the SWOT analysis (see Fig. 6).
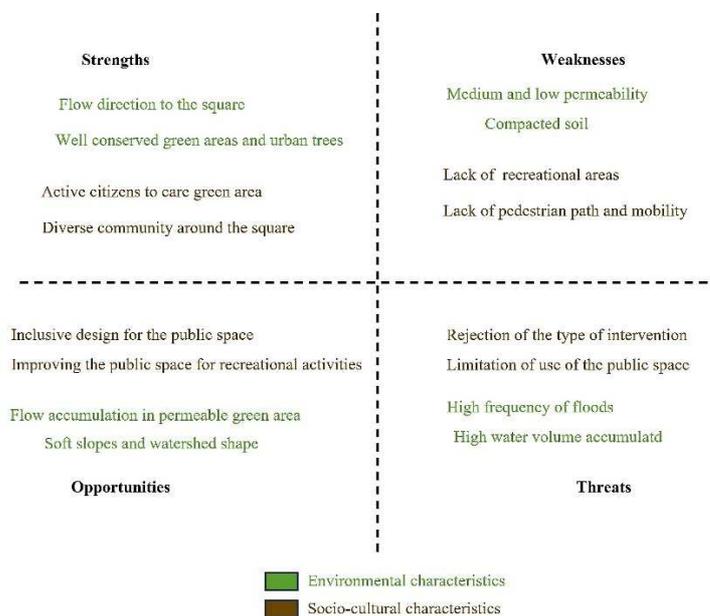
Fig. 6: SWOT analysis for environmental and socio-cultural characteristics.

The analysis highlighted strengths, weaknesses, opportunities, and threats for each characteristic analyzed. The design proposal involved four BGI techniques to cope with the high water volume accumulated after rain events, the lack of pedestrian and path mobility, the limited quality public space, and the medium and low permeability, among other factors. Figure 7 shows the design of the public square integrating a rain garden, an infiltration basin, permeable pavement, and vegetation. The infiltration basin was located in the centre of the square where the run off accumulates after heavy rain. The calculation of its capacity considered the volumes identified in the technical studies. The rain garden was located along the street to mitigate the risk of flooded houses and reduce citizens' complaints. The existing vegetation was maintained and more was added to create comfortable spaces for the neighbours to stay, and permeable pavement was implemented in areas where the neighbours were already doing some activities. The considerations for the last two measures aimed to create inclusive public spaces with improved conditions for recreational activities for the local community.

550

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Fig. 7: Render of the pilot project.

During the implementation phase, a high level of involvement of local stakeholders was achieved. Not only the local community was involved and interested but also the Mayor of the city, various municipal directorates, as well as private sector representatives actively participated. The available budget of the MGI project for the pilot project in Saltillo was only allowing a percentage of the overall project design. Thanks to the outstanding project dissemination during the first phase of the CityLab, and the acknowledged relevance of the project by the local stakeholders, the municipality contributed with technical studies and the landscaping of the square. Private companies contributed to the excavations for the infiltration basin and the rain garden, and the local community contributed knowledge and valuable insights from the pilot area. Stakeholder outreach and management as well as the overall planning was performed by the City Lab team. The company appointed for the design, performed as well the construction and works management to deliver the BGI techniques.

5 DISCUSSION

In times of rapid urbanization, increasing population, resource depletion, degradation of ecosystems, growing pressures on urban land and water resources, and a climate crisis, Nature-based Solutions (NbS) such as Blue-green infrastructure (BGI) provide multiple opportunities for both society and nature to increase their climate resilience (Rizzi and Utkarsh, 2020). These solutions bring diverse natural and semi-natural features and processes into urban and rural landscapes, through locally adapted, resource-efficient, and systemic interventions to provide different ecosystem services that can be useful as adaptation and mitigation measures for climate change (EC, 2020).

Like many cities, Saltillo's future needs to be anticipated, changing from today's urban spaces into blue-green spaces, and implementing BGI as an adaptation measure for the climate crisis. However, the implementation of NbS is not yet well disseminated in certain areas and in some cities of emerging economies is still a mechanism to be explored. This was evident in Saltillo, where this type of infrastructure was not implemented before, and there is a shortage of contractors in the region with expertise on this particular topic.

While international cooperation projects such as the MGI Initiative and the City Lab in Saltillo opened the door for funds, stakeholder engagement, research and co-creation of solutions for sustainable urban development, they are only the first step in a socio-urban transformation that needs to be promoted by the city including all public, private, academia, and civil society sectors. This is a key finding that points to the role of the governance of NbS as the enabler of these types of interventions.

From the global perspective, although BGI plays a key role in sustainable urban development, their design and planning stress the need for multidisciplinary and integrated approaches that are aligned with frameworks of global relevance such as the SDGs(Kopp et al, 2021) and to the strategic planning documents in the city such as Climate Action Plans. On the other hand, despite the efforts of global agreements and instruments to make climate action more inclusive and transparent, in most countries, it continues to be considered primarily a government task. Being NbS a people-centric approach for climate adaptation that

involves decision-making over public goods, the involvement of different stakeholders with different interests is key to ensuring climate justice(GIZ, 2019).

In both phases of the City Lab project in Saltillo, the relevance of intersectoral participation to anchor the project results in the city's environment was evident and thus highlighted the role of the public, private, civil society and academic sectors in the urban transformation of the city. This is a key finding to understand and go beyond the limitations imposed by short-term projects, such as the City Lab, which come with time and financial limitations. The governance of NbS approaches such as BGI needs to be considered to overcome barriers to urban transformation. From the policy perspective, established visions, plans and strategies are necessary and need to be supported with laws that define institutions for the adaptation processes and that establish implementation mechanisms. Policies and laws need to be accompanied by processes that promote public participation and communication, monitoring and evaluation and conflict resolution (Iza A., 2019).

From the social perspective, BGI has the potential to empower communities when involved in the project phases, including their perspective and knowledge in the analysis, design, implementation and monitoring of the intervention (Kopp et al., 2021). The recognition of the current activities performed by the neighbours in the pilot area was crucial to engaging the local community and rights holders in the process. Thanks to the scope and size of the intervention of the pilot project in Saltillo it was easier to reach out to stakeholders with a clear message of what was intended and their replicability potential and benefits for the city.

With the selection of the four BGI measures in this pilot project their replication could be executed even in smaller areas that require less time, costs and effort in its interventions. From the experience of the implementation of the pilot project in Saltillo, the installation of permeable pavements and greening were the least time-consuming measures while the implementation of the infiltration basin and the rain garden required more work, machinery, and earth movements. The latter, of course, is because of the magnitude of the flooding in the area.

In terms of maintenance of BGI, it is important to highlight that each BGI technique is unique in terms of size, shape, components and service delivered, thus requiring specific maintenance actions (Langeveld et al., 2022).According to Vollaers et al. (2021), all BGI´s components could have specific failures that can occur within them, especially on the interfaces, and in some cases the responsibilities to solve them go from one actor to the next, impacting the cost. The experience in the case of Saltillo's pilot project showed that the decisions made by the implementing bodies played a role in how costly or easy would it be to maintain the techniques implemented. Low-cost maintenance should always be considered first since the long-term costs can be much higher than the costs associated with the planning, design, and construction phases. In this sense, it is relevant to involve the citizens and the staff taking care of the area and provide spaces for understanding the maintenance requirements. It is worth mentioning that some guidelines for maintenance activities exist, such as those proposed by Seattle Public Utilities (2019). This guideline recommends the maintenance actions needed before visual inspection. Finally, it is worth highlighting that if the maintenance of BGI is done correctly and promptly, it would dictate whether the long-term benefits intended are achieved.

Through the pilot project implementation, it was also evident that modular approaches with implementation phases make it easier to execute infrastructure projects, especially when time and financial resources are limited. In Saltillo, the modularity of the pilot project concept allowed the management of the financial resources available to give priority to the BGI techniques that would tackle the flooding in the pilot area.

With the implementation of the pilot project in Saltillo and the spaces for citizen participation that were opened, the municipality can work hand in hand with the local neighbours for the maintenance and monitoring of the pilot area. This was possible thanks to the timely involvement of the municipality and the local neighbours and the identification and protection of the current practices and activities of the neighbours in the pilot area. The monitoring of the project provides key input to the municipality to upscale or apply pilot projects like this in other districts of Saltillo.

6 CONCLUSION

The implementation of NbS such as BGI is proving to be a suitable approach to cope with the impacts of climate change in middle-size cities where the most urgent action is required. There are many derived benefits from the ecological, social, and economic perspectives that come along with this type of

552

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intervention. However, the success of BGI depends to a large extent on the governance structures that are conceived for their design, implementation, and maintenance. Actors from all sectors need to be acknowledged and integrated according to their interest level and vulnerability towards climate change impacts. It is crucial to align the scope of the interventions with local and global agendas, but it is also relevant to intervene with a sufficient understanding of the areas of work, the community and the local environment. This opens the door for cooperation, and tailor-made solutions to adapt to the identified climatic risks and offers a solid base to introduce monitoring and evaluation processes that are key to building a solid base in the replication of such measures. While international cooperation and financing mechanisms are essential to kick-start rapid sustainable urban transformation at the local level, they are not sufficient to transform cities in their entirety. Thus, the need to anchor this type of scheme with strategic planning documents and to the local environment of stakeholders is the key to sustainable urban transformation, adaptation, resilience, and liveability in the face of climate change.

7 REFERENCES

BACCHIN, K., T., ASHLEY, R., BLECKEN, G., VIKLANDER, M., & GERSONIUS, B.: Green-blue Infrastructure For Sustainable Cities: Innovative Socio-technical Solutions Bringing Multifunctional Value. In International Low Impact Development Conference, 2016.DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GmbH:Governance for Ecosystem-based Adaptation: Understanding the diversity of actors & quality of arrangements, pp. 64 pp,Bonn, Germany, 2019.

EUROPEAN COMMISSION (EC): Nature-based solutions for climate mitigation. Available at: https://op.europa.eu/en/publication-detail/-/publication/6dd4d571-cafe-11ea-adf7-01aa75ed71a1/language-en., 2020

IMPLAN: Plan De Acción Climática Municipal Saltillo - PACMUN. Instituto Municipal de Planeación. Saltillo, Coahuila, 2021.

IMPLAN: GIS database with access to population density and public areas, accessed: 14.06.2023. Saltillo, Coahuila, 2023

INTERNATIONAL INSTITUTE FOR SUSTAINABLE DEVELOPMENT (IISD), DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GmbH &INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN): Unit 2: What is Ecosystem-based Adaptation (EbA)? In Ecosystem-based Adaptation: Working with nature to adapt to a changing climate [MOOC]. SDG Academy - edx Ecosystem-based Adaptation: Working with nature to adapt to a changing climate | edX, 2022

INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN): IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of NbS: first edition. 21 pp., Gland, Switzerland. https://doi.org/10.2305/IUCN.CH.2020.08.en., 2020

INSTITUTO NACIONAL DE ESTADSTICA Y GEOGRAFIA - INEGI: Censo de Población y Vivienda https://www.inegi.org.mx/programas/ccpv/2020/default.html#Tabulados 2020

IZA A. (ed.).: Gobernanza para la adaptación basada en ecosistemas, UICN, Gland, Suiza, 2019.

KOPP, J., FRAJER, J., LEHNERT, M., KOHOUT, M., JEŽEK, J.: Problems of Sustainable Development, pp. 137-146, Plzeň, Czech Republic, 2/2021.

LANGEVELD, J.G., CHERQUI, F., TSCHEIKNER-GRATL, F., MUTHANNA, T.M., FERNANDEZ-DELGADO JUAREZ, M.,LEITAO, J.P., ROGHANI, B., KERRES, K., DO CEU ALMEIDA, M., WEREY, C., RULLEAU, B.: Asset Management for Blue-Green Infrastructures: A Scoping Review. Blue-Green Systems 4 (2): 272–290. doi:10.2166/bgs.2022.019, 2022.

MOK, S.; VIVAS, A.M.; DÍAZ, C.; JAYAWANT, A.: City Lab Saltillo: Climate Risk and Resilience Assessment developed within the frame of the MGI Morgenstadt Global Smart Cities Initiative. University of Stuttgart, 2021

ORDONEZ, J.A.; DÍAZ, C.; GARCÍA, X.; SANTILLÁN, E.; BECKETT, M.; FERNÁNDEZ, T.; HUERTAS, J.H.; HUERTAS, M.E.; MOK, S.; REYES, R.; STÖFFLER, S.; VIVAS, A.M.; CASTAÑEDA, R.; CRUZ, M.; DE VALLE, G.; GARCÍA, J.C.; HENAO, J.J.; MOGRO, A.; BAEZ, M.; MÜLLER, V.; PUDLIK, M.; SERRANO, O.; VILLAREAL, C.; GIL, M.J.: Summary Report of the full tech¬nical City Profile Saltillo within the Morgenstadt Global Initiative, 2021.

REISE, J.; SIEMONS, A.; BÖTTCHER, H.; HEROLD, A.; URRUTIA, C.; SCHNEIDER, L.; IWASZUK, E.; McDONALD, H.; FRELIH-LARSEN, A.; DUIN, L.; DAVIS, M.: Policy Paper Nature-based solutions and global climate protection Assessment of their global mitigation potential and recommendations for international climate policy. Publisher: German Environmental Agency. ISSN 1862-4359, 2022

RIZZI, D.; UTKARSH, S.: UrbanByNature: The Global Programme for Urban Nature Pioneers. Why do Nature-Based Solutions Matter? Available at: https://www.urbanet.info/urbanbynature-the-global-programme-for-urban-nature-pioneers/, 2020.

Seattle Public Utilities. Green Stormwater Operations and Maintenance Manual. Seattle Municipal Tower, p. 25. Available from: http://www.seattle.gov/util/cs/groups/public/@spu/@usm/documents/webcontent/spu02_020023.pdft, 2019.

TEEB: The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan: London and Washington, 2010

UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME (UN-Habitat): World Cities Report: Envisaging the Future of Cities, 2022.

VOLLAERS, V., NIEUWENHUIS, E., VAN DE VEN, F., LANGEVELD, J. Root causes of failures in sustainable urban drainage systems (SUDS): an exploratory study in 11 municipalities in The Netherlands. Blue-Green Systems 3 (1), 31–48, 2021.

Neuroarchitecture Approach to Female Perception of Safety in Public Space

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1 ABSTRACT

In the creation of public spaces, there is a lack of articulation of specific desired emotion to be elicited or avoided, over and beyond just utilitarian functions. Moreover, there is a lack of metrics to measure such emotions stimulated by certain design features. The neuro-architecture approach - defined as the measure of potential feelings triggered by a designed environment in an organism tested by brain response - was adopted in this study. The feeling of safety is listed as a key element of the design of public space. Women have different experiences when it comes to public space, including their perceptions of safety. Perceptions of a lack of safety in public spaces can make women less likely to occupy these spaces and miss out on the positive effects of public space on their health and wellbeing.

This paper aims to identify the design indicators that address issues of women's fears when walking on foot. In order to validate such indicators, a mixed method approach was used; including mobile electroencephalography (EEG) to understand the impact of street design on women's brain activity, interviews and a questionnaire survey, to provide context for the neuroimaging data. Syria street - an urban mixed-use street - in the city of Alexandria in Egypt was chosen for the study, where a group of women users walk along and rate indicators of safety on a Likert scale. The questionnaire included 7 indicators of safety emergent from the literature: active frontages, lighting, visibility, perimeter protection, informal control, mix of people, locomotive pathways. Results yielded significant correlations between each of the indicators investigated and perceived safety. Moreover, it established the ability of neuroarchitecture, as a tool, to develop designs that elicit specific desired emotion in users of public space.

Keywords: EEG, Perception, Feminist, Neuroarchitecture, safety

2 INTRODUCTION

"The real importance of architecture is its ability to move people's hearts deeply" – Tadao Ando (2016)

The design of public space is perceived as physical entity –a structure or a built form only. However, these are not the only factors involved. The designed environment also has effects on humans at the cognitive and the emotional level (JL Higuera-Trujillo 2021). It is possible to predict this influence in the early stages of design and before the structure is built. An emerging discipline, one that bridges neuroscience and architecture, is beginning to provide more rigorous methodologies and a growing number of research reports that explores the interaction between brain, body, and the environment (EA Edelstein 2012). The discipline derived is termed "neuroarchitecture" which may be used to articulate a testable idea about how a specific feature of design may influence psychological or physiological processes that may in turn be associated with measurable changes that reveal the impact of the designed settings on human health. The modern possibility of recording the neural activity of subjects during exposure to environmental situations, using neuroscientific techniques, provides a promising framework for future design and studies of the built environment (JL Higuera-Trujillo 2021).

Safety as an emotion, overshadows the other basic human needs (such as 'love and belonging', 'self esteem', and 'self actualization') as argued by Maslow (1943) in his seminal paper, 'A Theory of Human Motivation'. Moreover, in the design of public spaces, safety is listed as a key element of sustainable communities and an important contributor to people's wellbeing (Allik & Kearns, 2017).

Women's experience of public space is shaped by their identity which includes their vulnerabilities, specifically to different forms of discrimination and violence and harassment. Addressing these factors is about establishing adequate measures to improve the safety of women (Bhattacharya, 2016). A fundamental step in this process is to identify the factors that affect the 'feeling of safety'(Blumenthal, 2014). Moreover, measuring this 'feeling of safety' to make public spaces inclusive and safe for women is key to the issue.

Recent global prevalence figures indicate that about 35% women worldwide have experienced violence in their lifetime (WHO, 2016). According to a poll conducted by the Thomson Reuters Foundation, Egypt was

the third most dangerous country for women in terms of violence. Moreover, the country topped the list of places that are dangerous for women to visit in a trip by Skyscanner survey released in August 2017. In large part this is due to the verbal and physical harassment that women routinely face there. According to a survey released in 2013 by UN-Women, 99.3% of Egyptian women reported being physically harassed in the street. Finally, a study launched in 2011, "Study on Ways and Methods to Eliminate Sexual Harassment in Egypt," was sponsored by UN Women in partnership with National Planning Institute and Demographics Centre in Cairo. The study showed that 86.5 percent of women in Egypt don't feel safe in public transportation and that it ranks high on the list of unsafe spaces, and is the second-highest place where sexual harassment takes place, with public streets being the highest.

Accordingly, the aim of this study is to identify the design indicators that address issues of women's fears when walking on foot in the Egyptian context. This is accredited by an empirical study for a mixed-use street in Alexandria city to validate the female indicators of safety deducted in the theoretical part. In order to validate such indicators, a mixed method approach was used, including a site analysis as a preliminary stage were the female indicators of safety have been sited on maps of the street; mobile electroencephalography (EEG) to understand the impact of street design on women's brain activity; and questionnaire and self-reported measures to underpin interpretations of the EEG data.

3 LITERATURE REVIEW

"Every significant experience of architecture is multi-sensory; qualities of matter, space and scale are measured equally by the eye, ear, nose, skin, tongue skeleton and muscle." – Juhani Pallasma (1994).

Rapoport (1977) highlighted that perception is the key process to connect people within the surrounding environment (Emel Birer, Pınar Çalışır Adem, 2022). Actual safety is highly important, but it is the perceived safety that impact people's lives (Van der Giessen et al. 2017). Perception of safety (POS) is a concept that refers to an emotion generated by the perception of the potential risks to safety (Ruiter R, Abraham C, Kok G, 2001). As related to the perception of individuals, perceived safety is not directly related to objective measures of crime or of threats to safety (Bedimo-Rung AL, 2005). Low perceived safety is a negative emotional state of anxiety that is often considered as a larger problem than crime itself.

POS is considered as a multifaceted concept; thus, different measures to study the phenomenon may tap various aspects of it (Abbott et al., 2020). Jackson (2005) describes POS as a group of related concepts reflecting emotion, perceived risk, and vulnerability. The British Crime Survey (BCS) resorts to three indicators in the evaluation of POS as a construct, namely: no worry of victimization, perceived order and organization, and perceived risk or personal safety, which focus on both cognitive and emotional dimensions.

Low perceived safety has been shown to affect women's decisions and behaviours, leading to the avoidance of certain places (Miethe T., 1995). A growing research literature has investigated the factors that can affect perceived safety in open space (Maruthaveeran S, van den bosch CC, 2014) (Jansson M, Fors H, Lindgren T, Wiström B., 2013). The international research literature emphasises three groups of factors associated with perceived safety in open space: (1) personal attributes, (2) physical attributes (3) and, social attributes.

A theoretical review has been done in order to identify the factors that affect the 'feeling of safety' that are key elements to make public spaces inclusive and safe for marginalised groups. Since safety is critical to the wellbeing of all citizens, regardless of gender, the position was taken that despite group difference there are some universal principles underlying evaluation which most people share. In order to identify these principles, a literature review was conducted to identify the most effective approaches of several cities around the globe to urban safety. Approaches offers practical tools for how to begin building a safer, more inclusive city and address the causes of different forms of violence and physical harassment.

Each approach suggested various aspects that affected the feeling of safety in public spaces. These aspects were skimmed through and sorted to attain a coherent set of indicators that can be defined as general indicators of safety in public space. Each indicator was mentioned by several theories, using various terms that reflect the same value. Figure1 shows the different approaches to safety and the pinciples of each approach that has been consolidated into nine general indicators of safety.

In order to identify indicators of safety that specifically relate to female subjectivity, further review has been conducted. The literature review explored a number of reports, articles and empirical studies about street design and women's safety perception. Moreover a number of women's safety audits, conducted in different

countries, was reviewed to extract strategies and policies which aim to reduce violence against women. Principles of such literature have been matched wth general indicators of safety to be short listed to six indicators of safety related specifically to women as seen in Figure 2.
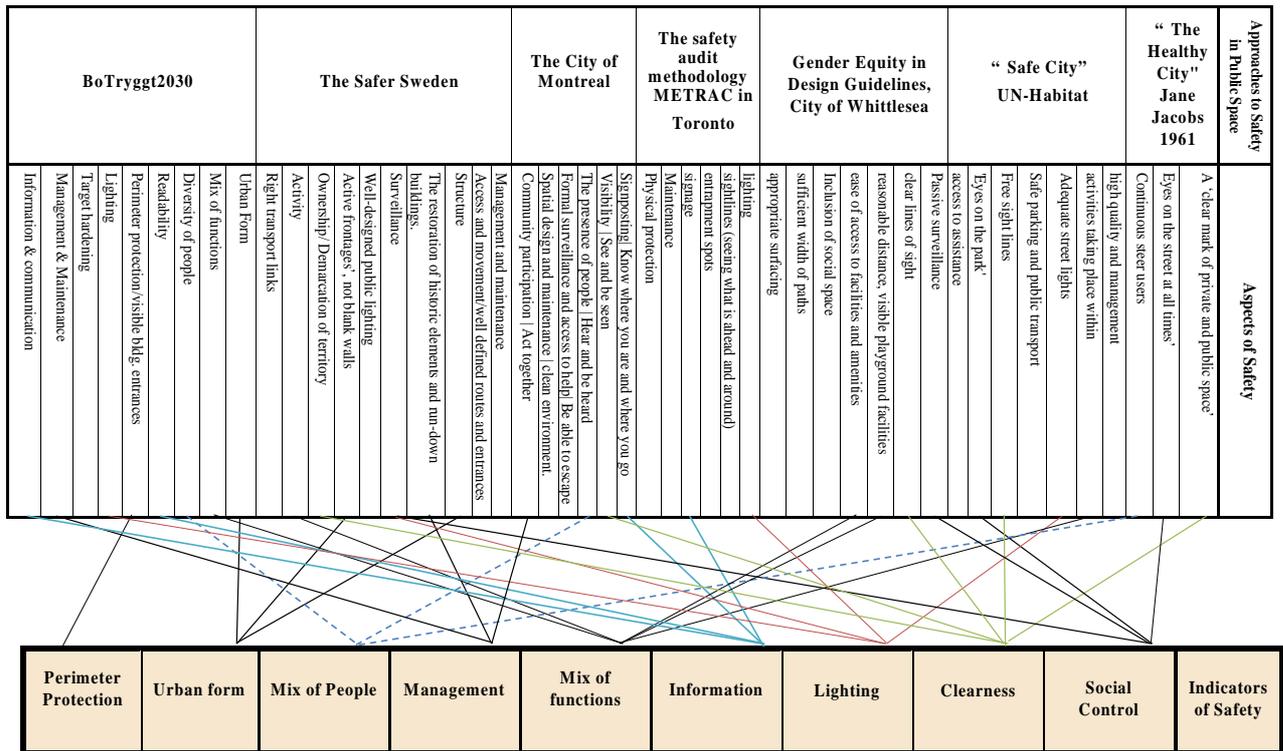
Fig. 1: General Indicators of Safety
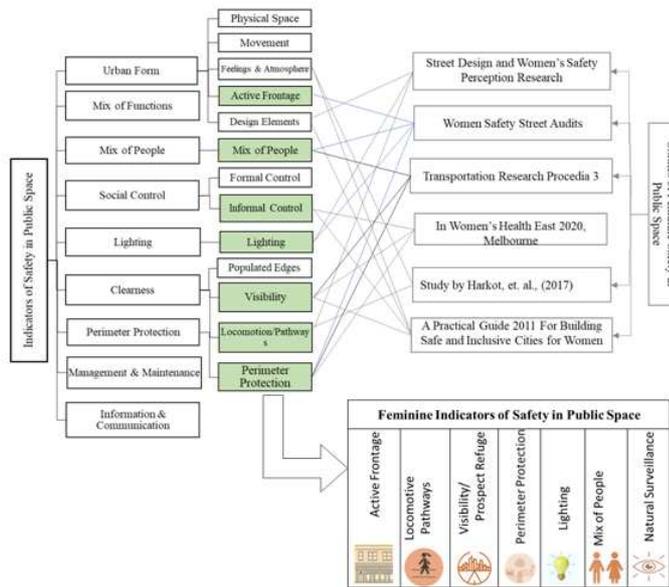
Fig. 2 : Indicators of Safety That Specifically Relate To Female Subjectivity. Source: Researchers, 2023.

4 THE RESEARCH FRAMEWORK AND CONCEPTUAL MODEL

The research perspective on physical and social indicators was predicated upon a combination of the environmental/physical POS theories (i.e., Broken Windows Theory, CPTED, and Defensible Space), which underpin the theoretical knowledge of the study and combination of principles of the most effective approaches of several cities around the globe to urban safety (i.e. The Healthy City-Jane Jacobs, "Safe City" UN-Habitat, Gender Equity in Design Guidelines-City of Whittlesea, The safety audit methodology-METRAC, The City of Montreal for safe cities, The Safer Sweden, BoTryggt2030). In the mentioned literature, some indicators for each factor are emphasised; however, the simultaneity of their effects has not

been investigated yet. The current study hence aimed to bridge the gap by modelling the possible relationships between these factors and their indicators. The research approach to women's POS was not based on unequal gender structure assumptions. However, in order to concentrate on women's POS, the search was for the indicators which affect POS among women with different individual characteristics in public spaces by reviewing a number of reports, articles, women safety audits and empirical studies about street design and women's safety perception (Study by Harkot, et. Al., 2017), Transportation Research Procedia 3 (2018), Women's Health East, Melbourne study (2020), Building safe and inclusive cities for women-2011 (a practical guide), Street Design and Women's Safety Perception Research (Rashid, Suhaila & Wahab, Mohammad Hussaini & Wan Mohd Rani, Wan., 2017) and a number of safety audits (Towards a Gender Inclusive City-Delhi, ActionAid International, 2013; UNHABITAT et al., 2010; Jagori, 2007, 2010; SAKHI, 2011; Women in Cities International, 2010a, 2010b) conducted in both the developed and the developing world. Figure 3 illustrates the conceptual model, including the primary factors of safety and their indicators, and in order to test this model, some demographic characteristics are taken into account.
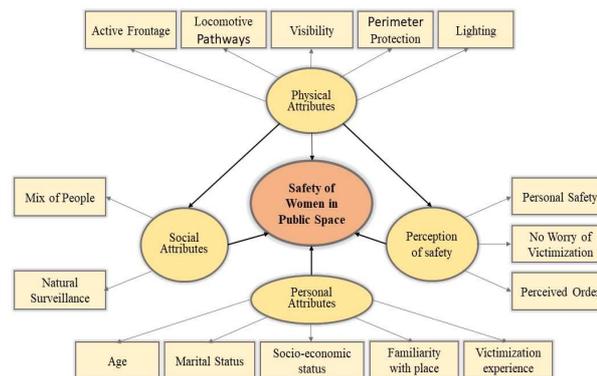
Fig 3: Conceptual Model of Feminist Safety Perception in Public Space (The Researcher, 2023)

5 METHODOLOGY

The aim of this study is to identify the most important indicators of public space that evoke appropriate emotional response (feeling safe) contributing to engagement of women in public space. This will be achieved by adopting a neuroarchitecture approach to validate how the identified indicators affect the neurophysiological correlates of emotion in women.

In order to achieve such aim, this paper uses a mixed method approach for the study, conducted in three phases: The preliminary phase (Site Analysis) where activities were mapped along the entire 630 m stretch on both sides of the street between the months of April–May (2023). Through this mapping all zones of the street, were identified for detailed study. Thereafter, the indicators affecting the perception of safety, as identified in the literature review, were listed and mapped along with the activity mapping in the different zones of the street. This was followed by an in-depth study of the gendered usage of space day and night. The outcome of the site analysis was the availability of most indicators of safety along the street except for a deserted area near the end of it.

Second phase was a questionnaire based survey, where 104 female users were surveyed using a structured questionnaire where they rated the female indicators of safety extracted from literature on a Likert scale, as well as unstructured questionnaire wherein questions were asked about their social background, their experiences of harassment on the street, and there familarity with place.

Third phase was the EEG Measurments, where female participants were asked to wear the non invasive Emotiv mobile electroencephalography (EEG) to understand the impact of the street design on women's brain activity. During navigation experiment participants were asked to move from an origin to a destination, simulating naturally occurring condition in the street while the eeg device recorded their brainwaves.

6 CASE STUDY

6.1 Study Area and Sampling

The study is conducted in Syria street in Alexandria city of Egypt. The street is one of the most famous streets in the city and considered one of the best places to go out. It includes a wide variety of facilities such

as banks, school, shops, and luxury apartments. Best street sights are a Jewelry trade building, Industrial School for Girls, shopping mall and an abandoned Palace. The street was selected as it represents some of the different kinds of urban mixed-use streets common in Alexandria city and include areas differing in visibility, vegetation density, extent of facilities and level of development.

The survey sample consisted of a number of 104 random female subjects who participated in the experiment with different demographic characteristics. An online advertisement was launched on social media apps seeking female volunteers. They were asked to walk through Syria street and observe the indicators of safety before rating them in the questionnaire form on the Likert scale.

The route was the same for all participants, it was selected to include all Syria street classified into two zones. Zone A,C (mixed use,busy commercial containing banks and a girls school, shops, residential buildings and many pedestrians); Zone B (residential use, path through 160 meter blank facade of a palace wall, residential villas, graffati and rubbish, poor lighting, few pedestrians). Photographs of the two zones are shown in Figure 4. The walk was conducted during day and night time to assess how lighting changes at different times of the day affected visibility.

Fig.4 : Photos and Map of Syria street showing two different zones A,B,C

6.2 Questionnaire Survey Method

The questionnaire administrated to the sample of female participants was designed in two main sections. The first section included questions about the respondent's demographic characteristics including age, gender and occupation. In the second section, the respondents were asked to walk through the street and observe the naturally occuring enivironment to rate 28 indicator of safety investigated on a 5-point Likert scale. The street was selected upon the availability of safety indicators presenting sufficient variability in the physical and social attributes investigated. The research hypothesis to be tested is that the female safety perception has a positive relationship with the extracted safety indicators. The two versions of the questionnaire survey were pilot tested prior to data collection to insure clarity of the questions. This led to some improvements in the formatting of the questionnaire. The questionnaire form is illustrated in Table 1 with the coded street features to be rated.

Safety Factors	Code	Indicators	Architectural Features	
Physical attributes	PH1	Active Frontage	PH1.1- Density of buildings /no. of premises	
			PH1.2- Number of entrances	
			PH1.3- Number of windows	
			PH1.4- Transparency of facades	
			PH1.5- Variety of activities	
	PH2	Locomotive Pathways	PH2.1- Adequate width of pathways to walk freely without brushing	
			PH2.2- Good quality of the pavement	
			PH2.3- Absence of obstacles to locomotion	
	PH3	Visibility / Prospect & Refuge	PH3.1- Absence of obstacles that block view	
			PH3.2- Density of trees	
			PH3.3- Clearings between trees	
			PH3.4- Form of tree not blocking visibility	
			PH3.5- Possibility of being seen and seeing around	
			PH3.6- Absence of places for offenders to hide	
	PH4	Perimeter Protection	PH4.1- Availability of possible escape routes	
			PH4.2- Visibility of entrances	
			PH4.3- Permeability of fencing system towards the street	
	PH5	lighting	PH5.1- Amount of lighting	
			PH5.2- No obstacles covering light posts	
			PH5.3- Amount of glare	
Social attributes	S1	Mix of people	S1.1- Presence of people on the street	
			S1.2- Absence of threatening people (homeless, drug takers....)	
			S1.3- day	Presence of women compared to men
			S1.4- night	
	S2	Natural Surveillance	S2.1- day	Degree of observation from inside buildings, (shops or restaurants with large windows, housing with balconies)
			S2.2- night	

Table 1: Coded Items To Be Rated In The Questionnaire Survey Form (The Researcher, 2023)

6.3 Neuroarchitecture Approach Method

Neuroarchitecture is the built environment designed with principles of neuroscience, which establishes spaces that enhances wellbeing, improve cognitive abilities, stimulate brain and eases nerves. Its goal is gaining a better understanding of the relationship between emotions and architectural design by observing people's responses and measuring the relevant regions of the brain. It provides an empirical basis for the design choices made by architects, rather than settling for purely theoretical debates in design.

Feminist Safety Perception	SP1	Personal safety	SP1.1- Feeling of safety while walking alone at night
			SP1.2- The level of presence in the street at night
			SP1.3- Lack of zones you avoid walking through
	SP2	No Worries of Victimization	SP2.1- Absence of sexual harassment (verbal, touching, chasing
			SP2.2- Absence of Violent Physical attack
			SP2.3- Absence of Robbery, murder, …
	SP3	Perceived order and organization	SP3.1- Absence of young hooligans
			SP3.2- Absence of ruined places
			SP3.3- Absence of rubbish or graffiti

Neuroarchtecture relies on philosophical constructs or analysis of behaviour patterns in order to relate human responses to design. Psychological studies using subjective methods, such as surveys or interviews, have also been used to test such relationships; however, these methods rely on the subject's understanding or ability to articulate why they respond to a design element in a particular way. In contrast, neuroscientific investigations offer a higher degree of objectivity, providing a number of additional tools that can measure both conscious and sub-conscious responses without the need to interrupt the subject. Nor do researchers interfere with the results themselves by asking subjects to think about how or why they respond as they do.

This paper builds on research using Emotiv mobile electroencephalography (EEG) to investigate particular indicators of safety extracted from literature, and explore it within the theoretical paradigm of neuroarchitecture to generate specific hypotheses for the design of public spaces that are safe for women.

To achieve such an objective, the literature review incorporated studies investigating design characteristics of the urban environment that included measuring objective neurophysiological response. The neuroimaging based studies have shown that different environments may be associated with distinctive patterns of brain activity (Chang, C.Y.; Hammitt, W.E.; Chen, P.; Machnik, L.; Su, W., 2008) (Ulrich, R.S., 1981). Further research has shown differences in neural activity derived and interpreted via Emotiv electroencephalography (EEG) proprietary software when walking in various urban environments, indicating changing neural activity in response to changing urban environments (Aspinall, P.; Mavros, P.; Coyne, R.; Roe, J., 2013).

Based on psychological and neuroscience research, it has been suggested that the responses along the dimensions of stress assosiated with feeling of fear and relaxation assosiated with feeling of safety are correlated with activity in particular regions of the brain.

6.3.1 The Expirement

For the naturalistic experiment, a pilot sample of female participants, who conducted the questionnaire survey, wearing EMOTIV EPOC headset were asked to walk along the same route in Syria street that took them through the busy commercial area into the deserted area. A custom-software platform to geoannotate emotional states from Emotiv's Affectiv suite was developed in the conduct of the outdoor studies.

6.3.2 EEG Data Acquisition

Brain electrical activity was recorded non-invasively from the scalp using the Emotiv EPOC+ EEG headset with 14 channels corresponding to the international 10–20 position system (AF3, AF4, F3, F4, F7, F8, FC5, FC6, T7, T8, P7, P8, O1, and O2). P3 and P4 acted as reference electrodes. Data was recorded using Emotiv Pro software. Where different recordings of each subject have been exported as CVS files to Emotiv cloud for analysing. The output from Emotive Performance Metrics is deduced emotional reactions from brain activity. The Performance Metrics creates a different profile for each subject then interprets the EEG activity from the available channels into six emotional parameters;"Engagement" En, "Excitement" Ex, "Focus "Fo, "Interest" In, "Relaxation" Re and "Stress" St (Emotiv, 2011).

Moreover, the Emotiv testbench provides Fast Fourier Transform (FFT) Method. This method employs mathematical means or tools to EEG data analysis and transforms a signal from the time domain into the frequency domain. Where the power of the different bands could be extracted in different lobes of the brain.

560

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In this experiment the relaxation and stress parameters were selected for analysis. These parameters were normalised for each individual and scaled as values between 0 and 1, which allowed between subject comparisons, at each sampling point. Due to the intellectual property rights of Emotiv, it is unclear what particular EEG signature underlies each of the Performance Metrics outputs. Based on findings from previous research (Aspinall, P.; Mavros, P.; Coyne, R.; Roe, J, 2013). "Relaxation" is associated with a calm relaxed state and "Stress" has negative valence. The EEG data set was generated by creating three sequential means per walking segment at the individual level and then averaging these means across the whole cohort for each walking route. These means were generated using the time taken for a given participant to complete a particular section of the walk and then dividing this into three time locked sections. It is these means that are used for the analysis of the Performance Metrics data extracted from the Emotiv pro software.

The experiment also builds on the scientific fact that Alpha and Beta frequency power are linked to negative mood, stress and depression. whereby Alpha band has higher activation in the frontal lobe in non-stressful environments (active zones of the street) and Beta band higher activation in the stressful deserted area of the street. This is associated with an increase in the P7 and P8 electrodes which are closest to the amygdala in the brain, which is a fear-related area (Pizzo et al., 2019). Therefore, using the Emotive pro tesbench, the power of Alfa and Beta bands were extracted in the frontal lobe channels F3 and F4, and in the parietal lobe channels P7, P8. The research hypothesis that there will be an increase in Alfa power band in zone A, C and an increase in Beta band in zone B, is associated with the Performance Metrics results hypothesis that there will be an increase in stress along zone B and an increase in relaxation along zone A, C.

7 RESULTS

7.1 Questionnaire Survey Analysis

The analysis of the questionnaire survey method was done using the statistical package for social sciences (SPSS V. 28) for basic descriptive statistics, and (SmartPLS 3.2.9) for SEM-PLS modeling. The first section deals with demographic characteristics. The measurement model was evaluated for the reliability and validity of the instruments with several descriptive statistics and bivariate correlations in the second section. Finaly, the examining structural model for testing hypotheses underlying this paper includes path coefficients, collinearity diagnostics, coefficient of determination (R2), effect size (f²), predictive relevance (Q2), and global goodness of fit criteria.

7.1.1 Measurement Model

Factor loadings, average variance extracted (AVE), composite reliability (CR), and discriminant validity were used to assess construct validity (Hair & Lukas, 2014). (Hair et al., 2017). The values of composite reliability should be greater than 0.6 and AVE above 0.4 (Fornell and Larcker, 1981). These indicate that the study satisfied these requirements for convergent validity and internal consistency of the scales. The values for Skewness between -2 to +2 and kurtosis between -7 and +7 are considered acceptable in order to prove normal distribution (Hair et al. 2014; Byrne 2016). The results of the normality test show that the values of Skewness and kurtosis for the constructs of the model were within the specified range.
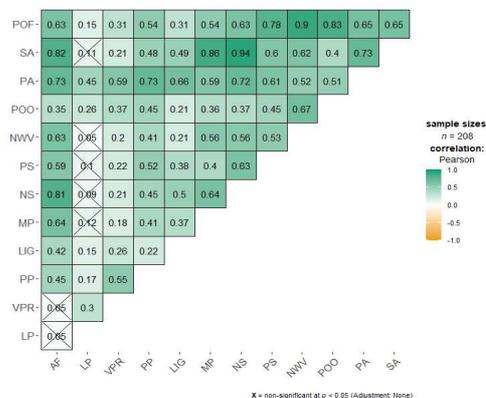

Fig. 5: Visualization of the correlation matrix

The Pearson product-moment correlation coefficient was calculated to determine the strength and the direction of the relationship between the selected constructs. Figure 5 shows the matrix of Pearson

correlation coefficients between all constructs and the dimensions. It was indicated that there is a positive relationship between the independent variables (and its dimensions) with the dependent variable (and its dimensions). It is also observed that there is a significant positive relationship between Physical attributes and Perception of Safety since $(r(208) = .649, P < 0.001)$ and between Social attributes and Perception of Safety since $(r(208) = .651, P < 0.001)$.

7.1.2 Assessing the Structural Model

Examining the structural model includes path coefficients, collinearity diagnostics, coefficient of determination (R³), effect size (f²), predictive relevance (Q²), and global goodness of fit criteria. Prior to analysing the structural model, the collinearity between constructs was examined (table 2) using variance inflation factors (VIF), and found that all values were less than the threshold of 5 (Hair et al., 2017).

Path	B	t-value	P-value	95% Bias-Corrected CI		Remark
				LB	UB	
H1: Physical attributes -> Perception of Safety	0.544	6.269	0	0.377	0.712	Supported
Active Frontage -> Perception of Safety	0.348	3.297	0.001	0.151	0.554	Supported
Locomotive Pathways -> Perception of Safety	0.028	0.539	0.59	-0.081	0.12	Not Supported
Perimeter Protection -> Perception of Safety	0.186	2.413	0.016	0.023	0.33	Supported
Visibility/Prospect & Refuge -> Perception of Safety	0.128	2.196	0.028	0.002	0.231	Supported
lighting -> Perception of Safety	0.033	0.473	0.636	-0.11	0.168	Not Supported
H2: Social attributes -> Perception of Safety	0.223	2.421	0.016	0.028	0.385	Supported
Mix of people -> Perception of Safety	0.122	2.03	0.043	-0.008	0.234	Supported
Natural Surveillance -> Perception of Safety	0.174	1.873	0.061	-0.016	0.349	Not Supported

Table 2: Results of Hypothesis Testing
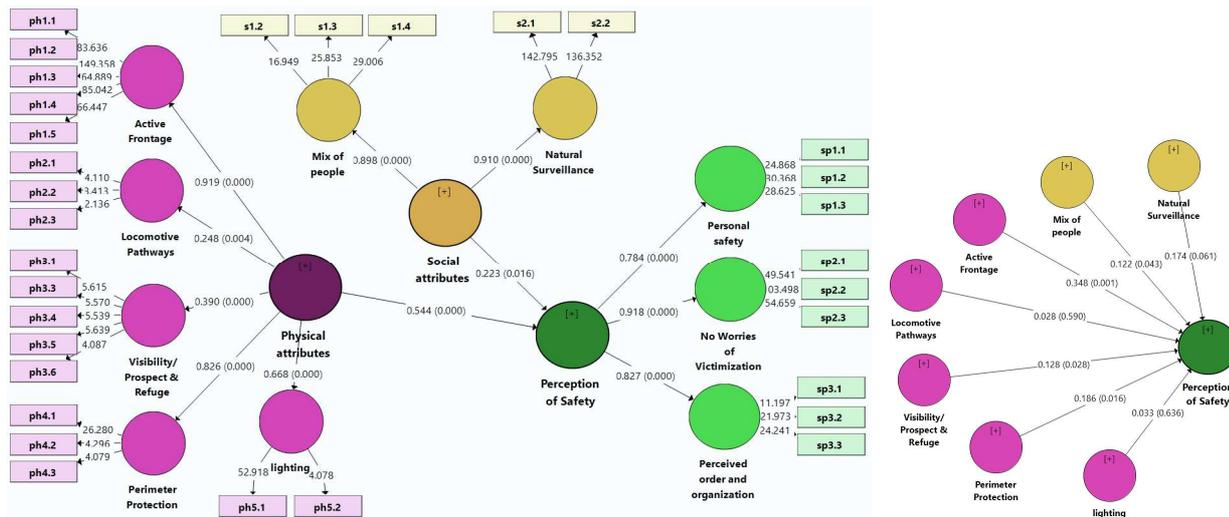
Fig. 6: Structural model assessment. Fig. 7: Sub-hypotheses testing

The results of hypothesis testing in Table 2 and Figure 6 showed that Physical attributes yielded a significant positive effect on Perception of Safety since $(\beta = 0.544, t = 6.269, P < 0.001, 95\% \; CI \; for \; \beta = [0.377, 0.712])$, consequently, the first hypothesis is confirmed. Moreover, Social attributes yielded a significant positive effect on POS since $(\beta = 0.223, t = 2.421, P < 0.001, 95\% \; CI \; for \; \beta = [0.028, 0.385])$, consequently, the second hypothesis is confirmed. The sub-hypotheses were also tested and given in Table 2 and Figure 7.
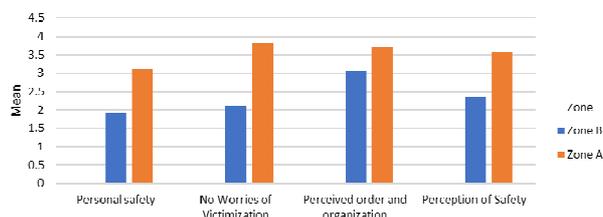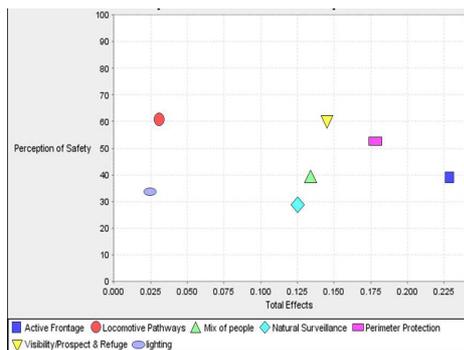
Fig. 8: Importance Performance Map. Source: Researcher, 2023. Fig. 9: Difference in perception of safety across zones.

7.1.3   Importance Performance Map Analysis

Importance performance map analysis (IPMA) was utilised to provide additional insights by combining the importance (I) and performance (P) dimensions analysis (Ringle & Sarstedt, 2016). IPMA enables the identification of places where action is necessary. Figure 8 depict the dimensions of the constructs that influence the dependent variable Perception of Safety. Figure 8 show that Active Frontage was the most important construct, followed by Perimeter Protection, Visibility, Mix of people, Natural Surveillance, Locomotive Pathways, and lighting. Moreover, Locomotive Pathways performed the best, followed by the Visibility, Perimeter Protection, Mix of people, Active Frontage, lighting, and Natural Surveillanc.

7.1.4   Personal Attributes Testing

In this section the analysis of the personal attributes will be investigated upon the respondent's satisfaction. The appropriate tests are the parametric tests, since the data were normally distributed (Table 3). The demographic variables are categorical variables with more than two independent categories, so the suitable parametric test is the analysis of variance (ANOVA) test. Concerning the age; the results show that there is a significant difference in Perception of Safety and its dimensions. Furthermore, the results for marital status show that there is a significant difference in only Perceived order and organization across the levels of marital status. Moreover, the results of Familiarity with Space show that there is a significant difference in only Personal safety.

Variable	Age		Marital Status		Familiarity with Space		Zone	
Test	F	*P-value*	F	*P-value*	F	*P-value*	t	*P-value*
Personal safety	4.438	0.013	0.378	0.686	3.506	0.032	9.968	<.001
No Worries of Victimization	1.092	0.337	0.361	0.697	0.870	0.421	12.378	<.001
Perceived order and organization	3.192	0.043	3.453	0.033	2.159	0.118	5.017	<.001
Perception of Safety	3.594	0.029	1.037	0.356	1.978	0.141	11.755	<.001

Table 3: Personal attributes results

7.1.5   Difference in Female Safety Perception Across the street zones

Since the zones of the streets are categorical variables with two independent categories, so the suitable parametric test is the independent-samples t-test. The results show that there is a significant difference in Perception of Safety and it's all dimensions between zone A and zone B since P-value is less than 0.05 as for Personal safety $(t = 9.968, P < 0.001)$, No Worries of Victimization $(t = 12.378, P < 0.001)$, Perceived order and organization $(t = 5.017, P < 0.001)$, and OS $(t = 11.755, P < 0.001)$. These differences were visually represented in Figure 9.

7.2 Neuroarchitechture Approach: Results

Although based on a small sample, the results of this pilot study was in line with the paper's hypothesis that the extracted female indicators of safety trigger a positive emotion in subjects concerning their safety perception. The results also demonstrated the potential of mobile EEG to tap into the emotional and cognitive states of women who are engaged in naturalistic tasks, like walking in urban environments. The analysis of the extracted EEG data are analysed using two methods elaborated in the following sections.

7.2.1   Performance Metrics Analysis

This anylsis is to test the first hypothesis of the neuroarchitecture approach method. At a descriptive level, a map of the route and a typical EEG record from one participant are shown in Figure 10 . The chart at the top shows the emotional levels from relaxation (1) and stress (2) that have been smoothed by Emotiv's software.

A record of the fluctuations in relaxation and stress is plotted as a map according to their geographical location in figure 11 below. For example, this participant remains relaxed through zones A and C, which are full of active frontages, whereas relaxation falls in zone B which is a deserted blank frontage. Conversely, stress seems to be lowest at the start of the walk and highest towards the end.

An aggregate visualisation of the relaxation levels of three participants (peaks are in red, yellow and blue, respectively) Figure 11, reveals shared patterns of emotional activity, even though the experiment was performed on different days.
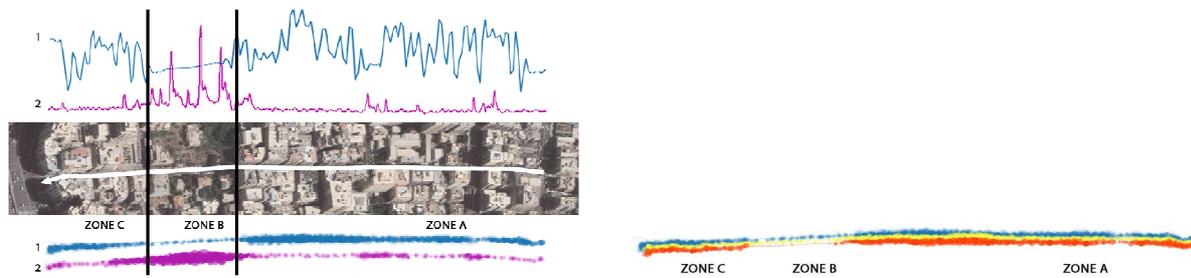
Fig. 10: Map of the route in Syria street. Emotional activity of one participant during the route, in charts (top of the map) and plot in space (bottom of map). Cyan shows relaxation; Magenta shows stress. Source: Researcher, 2023. Fig. 11: Shows aggregate of relaxaion levels from the three participants. Peaks are in red, yellow and blue, respectively, for each participant. Source: Researcher, 2023.

7.2.2 Fast Fourier Transform (FFT) Method

Testing the second hypothesis of the neuroarchitecture approach method, the outcomes were in line with the FFT extracted results. As seen in Figure 12, the readings of one participant shows an increase in Alpha bands associated with relaxation in Zone A,C of the street in the F3 and F4, P6, P7 channels after 5 minutes walk and conversely an increase in the power of Beta band associated with stress in the F3 and F4, P6, P7 channels when the participant walked through zone B after 7 minutes walk shown in Figure 13.
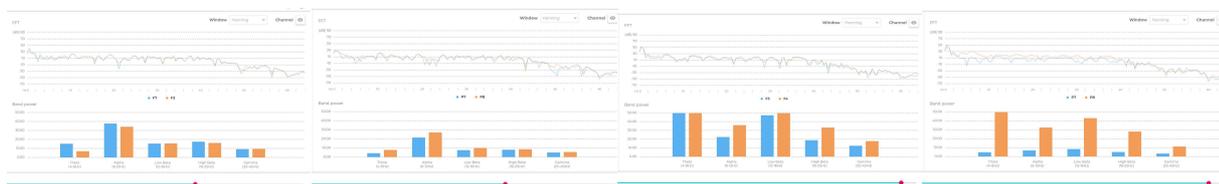

Fig. 12: Increase in Alfa band in F7, F3, P7, P8 in Zones A & C (FFT of Emotiv Pro Software). Fig. 13 : Increase in Beta band in F3, F4, P7, P8 in Zone B (FFT of Emotiv Pro Software)

8 DISCUSSION AND CONCLUSION

This paper piloted and presented a novel mixed methods study focusing on the changing mood of female subjects while walking in an active mixed-use urban street with one deserted area, using interpretations of EEG along with subjective scales. This approach allows for a deeper understanding of mood variation amongst women by identifying the indicators of safety of the physical and social environment, which influences how they feel during a walk in the street at day and night time. A Female Safety Conceptual Model was conducted to identify the different attributes that affect the safety of women in public space, which was a base for validating the indicators of safety through the questionnaire survey method. The analysis of the indicators of safety using the questionnaire survey method was done using the statistical package for social sciences (SPSS V. 28) for basic descriptive statistics, and (SmartPLS 3.2.9) for SEM-PLS modeling. The results showed that physical and social attributes yielded a significant positive effect on women's perception of safety in public space. Consequently the first hypothesis of the paper is confirmed. Only three of the indicators were found to have no effect on perception of safety which are locomotive pathways, lighting, and natural surveillance which contradicted with literature and previous studies.

Importance performance map analysis (IPMA) was used to identify the most important indicator for the perception of safety. Active Frontage was the most important indicator, while lighting was the least important. Moreover, Locomotive Pathways performed the best and Natural Surveillance performed the least. Concerning the personal attributes and the perception of safety, the paper used the analysis of variance (ANOVA) test. The results showed that there is a significant difference in Perception of Safety across the levels of age, marital status and familiarity with space. The levels of POS tend to increase with age, which is contradicting with the reviewed literature. The familiarity with space was found to help increase the POS while the divorced category was found to be the highest in their POS.

The independent-samples t-test was conducted to show that there is a significant difference in Perception of Safety between zone A (active) and zone B (deserted) of the street. Where, the perception of safety was high in the presence of such indicators in the active area of the street and the POS dropped down in the deserted area of the street, which was the base to examine the validation of such hypothesis in the context of neuroarchitecture.

The EEG recordings extracted from the Emotiv pro software has been analysed using two methods; the Performance Metrics Analysis and the FFT analysis method. The Performance Metrics Analysis presented the findings from the female participants that started their walk in the active Zone A of the street and then walked into the the deserted zone B. This pilot found evidence of high relaxation when walking through zone A, and higher stress when moving into zone B—and higher relaxation when moving out of it. The FFT analysis found an increase in the power of the Alpha band associated with relaxation while walking along the street and conversely an increase in the power of Beta band associated with stress in the deserted fearful area of the street. Consequently the second and third hypothesis of the paper are confirmed.

Results of the Neuroarchitecture approach method were found to be consistent with the results of the qustionnaire survey method. Analysis of the Performance metrics and FFT data appeared to show interpretable differences between walking through the two zones of the street, further supported by the questionnaire survey analysis, which suggested that participants experienced a beneficial effect all over Syria street except for the deserted area towards the end of it. Such evidence shows that the availability of the proposed safety indicators along the street has a main role to play in contributing to women's safety perception through mediating the stress induced by the fearful zone of the street.

This paper seeks for improvement of women engagement in public space. It is a search for the scientific evidence which could support the design. The innovative part is that instead of asking subjects about their feelings towards different design features, their brains were "asked" directly by observing which brainwave patterns were active while moving along different areas of a street setting. This new approach highlighted the most important features of public space contributing to safety perception.

This study is one of the first to use a mobile EEG system outdoors and EEG-based emotion recognition software to record emotional changes as female subjects walk through an urban environment, supported by a questionnaire survey method that provided insight into interpretations of the Emotiv testbench. However, there is still difficulty in establishing reliable interpretations of the Affectiv terms for use in this context, suggesting that further research is required using a larger sample.

Nonetheless, the paper findings are consistent with the theories and principles of perception of safety in public space and encourage the use of the technology to extend current research by developing novel and objective cortical correlates of emotion. This would be particularly beneficial in exploring the health improving potential of environments while women are on the move.

9 REFERENCES

ABBOTT, J., McGrath, S. A., & May, D. C. (2020). The efects of police efort on victims' fear of crime. American Journal of Criminal Justice, 45(5), 880–898. https://doi.org/10.1007/s12103-020-09523-7

ALLIK, Mirjam & Kearns, Ade. "There goes the fear": feelings of safety at home and in the neighborhood: The role of personal, social, and service factors: Feeling Safe at Home and in the Neighbourhood. Journal of Community Psychology., 2016 45. 10.1002/jcop.21875.

ASPINALL, P.; Mavros, P.; Coyne, R.; Roe, J. The urban brain: Analysing outdoor physical activity with mobile EEG. Br. J. Sports Med. 2013, 49, 272–276.

BEDIMO-Rung AL, Mowen AJ, Cohen DA. The significance of parks to physical activity and public health: a conceptual model. Am J Prev Med 2005;28:159–68.

BLUMENTHAL, Terry D. The more-or-less interrupting effects of the startle response, 2014, Vol 52.

BRÅ. The Swedish Crime Survey 2014: concerning exposure to crime, insecurity and confidence. Stockholm: The Swedish National Council for Crime Prevention; 2014.

BRUNTON-Smith, I., & Sturgis, P., 2011. Do neighborhoods generate fear of crime? An empirical test using the British Crime Survey. Criminol, 49(2), 331–369.

BURGESS J. Focusing on fear 1996: the use of focus groups in a project for the Community Forest Unit, Countryside Commission. Area;28:130–6.

BYRNE, B. (2016). Structural equation modeling with AMOS. New York, NY: Routledge.

CHUN-Yen Chang, William E. Hammitt, Ping-Kun Chen, Lisa Machnik, Wei-Chia Su, Psychophysiological responses and restorative values of natural environments in Taiwan, Landscape and Urban Planning, Volume 85, Issue 2, 2008, Pages 79-84,

DELONE, G. J., 2008. Public housing and the fear of crime. Journal of Criminal Justice, 36(2), 115–125.

EDELSTEIN, E.A., Macagno, E. Form Follows Function: Bridging Neuroscience and Architecture. In: Rassia., S.T., Pardalos, P.M. (eds) Sustainable Environmental Design in Architecture. Springer Optimization and Its Applications, 2012, Vol 56. Springer, New York, NY.

EMEL Birer, Pınar Çalışır Adem, 2022. Role of public space design on the perception of historical environment: A pilot study in Amasya, Frontiers of Architectural Research, Volume 11, Issue 1,

EMOTIV, 2011. Emotiv software development kit user manual for release 1.0.0.3. Hong Kong: Emotiv Ltd.

FATTAH, E. A., & Sacco, V. F. (1989). Crime and victimization of the elderly. Springer. https://doi.org/10. 1007/978-1-4613-8888

FORNELL, C., & Larcker, D. F. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 1981, 18(1), 39–50.

GLASER M. Security v. park and recreation service delivery: reduced effectiveness of public investment. J Urban Affairs 1994;16(4):359–69.

HAIR, J. F., & Lukas, B. Marketing research, 2014 (vol. 2). McGraw-Hill Education

HAIR, J. F., Hult, G. T., Ringle, C. M., & Sarstedt, M. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) (2nd Ed.). Los Angeles, CA: SAGE, 2017.

HARKOT, M.K., Andrade, M.H., Giannotti, M., Santoro, P. Gender and walking: does the quality of built environment equally promote walking for women and men? In Cidades de Pedestres: a Caminhabilidade no Brasil e no mundo (C. C. Linke, V. Andrade, eds.). Babilonia Cultura Editorial. Rio de Janeiro, Brazil, 2017

HATTACHARYYA, Rituparna. Street Violence against Women in India: Mapping Prevention Strategies. Asian Social Work and Policy Review, 2016. 10. 10.1111/aswp.12099.

JACOBS J. The Death and Life of Great American Cities. New York, NY: Random House; 1961.

JAGORI. Understanding Women's Safety: Toward a Gender Inclusive City; Research Findings, Delhi,2009-10. Delhi, 2010. http://jagori.org/wp-content/uploads/2010/11/gic-delhi-report.pdf

JAGORI. Safe Cities Free of Violence Against Women and Girls Initiative: Report of the Baseline Survey, Delhi, 2011.

JANSSON M, Fors H, Lindgren T, Wiström B. Perceived personal safety in relation to urban woodland vegetation: a review. Urban Urban Greening 2013 ;12:127–33.

JUAN Luis Higuera-Trujillo, Carmen Llinares. The Cognitive-Emotional Design and Study of Architectural Space: A Scoping Review of Neuroarchitecture and Its Precursor Approaches, 2021, Vol 21, Issue 6

KRENICHYN K. Women and physical activity in an urban park: enrichment and support through an ethic of care. J Environ Psychol 2004; 24:117–30

LYNCH, K. The Image of the City. Cambridge, MIT Press, 1960.

MADGE C. Public parks and the geography of fear. Tijdschrift voor Economische en Sociale Geografie; 1997, 88(3):237–50.

MARUTHAVEERAN S, van den bosch CC. A socio-ecological exploration of fear of crime in urban green spaces: a systematic review. Urban Forestry Urban Greening 2014; 13:1–18.

MASLOW A. H. A Theory of Human Motivation, 1943.

MESCH GS. Perceptions of risk, lifestyle activities, and fear of crime. Deviant Behav 2000; 21:47–62

MIETHE T. Fear and withdrawal from urban life. Ann Am Acad Political Soc Sci 1995;539(1):14–27.

OLDER People's Experiences of Mobility and Mood in an Urban Environment: A Mixed Methods Approach Using Electroencephalography (EEG) and Interviews. Int. J. Environ. Res. Public Health 2017, 14(2), 151

PALLASMAA, Juhani.& Mallgrave Harry. and Arbib, Michael. Architecture and Neuroscience. Finland: Tapio Wirkkala-Rut Bryk Foundation, 2015.

PIZZO, F., Roehri, N., Medina Villalon, S., Trébuchon, A., Chen, S., Lagarde, S., Carron, R., Gavaret, M., Giusiano, B., McGonigal, A., Bartolomei, F., Badier, J. M., & Bénar, C. G. 2019. Deep brain activities can be detected with magnetoencephalography. Nature Communications, 10(1).

RANGAJEEWA Ratnayake. Sense of safety in public spaces: university student safety experiences in an Australian regional city, Rural Society, 2017, 26:1, 69-84.

RASHID, Suhaila & Wahab, Mohammad Hussaini & Wan Mohd Rani, Wan. Street design and women's safety perception. Journal of the Malaysian Institute of Planners. 15. 10.21837/pmjournal, 2017, v15.i4.313.

RINGLE, C. M., & Sarstedt, M. Gain more insight from your PLS-SEM results: The importance-performance map analysis. Industrial management & data systems, 2016.

RUITER R, Abraham C, Kok G. Scary warnings and rational precautions: a review of the psychology of fear appeals. Psychol Health 2001;16:613–30.

SEOUL Foundation of Women and Family, Seoul Metropolitan Government. Women-Friendly Seoul Project Facilities Guidelines I. Seoul, 2009.

ULRICH, R.S. Natural Versus Urban Scenes: Some Psychophysiological Effects. Environ. Behav. 1981, 13, 523–556.

UN-HABITAT. Gender Equality for Smarter Cities: Challenges and Progress, 2009. http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2887

UN-HABITAT. Women's Safety Audits: What Works and Where? 2009 . http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2847

VAN DER GIESSEN, M., Brein, E. and Jacobs, G. Community policing: The relevance of social contexts. Community Policing-A European Perspective: Strategies, Best Practices and Guidelines, 2017, pp.35-50.

WOMEN'S Initiatives for Safer Environments. Women's Community Safety Audit Guide. Ottawa, 2005. http://www.femmesetvilles.org/pdf-general/WISE_new%20safety%20 audit%20guide.pdf

WOOLLEY H, Amin N. Pakistani teenagers' use of public open space in Sheffield. Managing Leisure 1999; 4:156–67.

566

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Optimising Sustainable Urban Mobility: Analysis of Non-Motorised Transport along M1 Road in Lilongwe Town, Malawi

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1 ABSTRACT

Rapid urbanization in cities has increased the demand for sustainable mobility options. At the Centre of sustainable urban mobility is Non-Motorized Transport (NMT). Nevertheless, NMT is confronted with lack of sufficient infrastructure despite being at the forefront of sustainable urban mobility initiatives in Lilongwe city. Therefore, this paper explores the barriers faced by implementation of infrastructure supporting NMT and the experiences of pedestrians and cyclists. The study employs a case study research design using mixed methods approach along M1 road in Lilongwe city. An open-ended questionnaire was administered to cyclists and pedestrians along the M1 road. Additionally, interviews with the officials from Malawi police road traffic and physical planning departments were conducted. The findings reveal that inadequate NMT infrastructure is due to lack of institutional capacity failing to enforce bylaws, using outdated urban structure plans and the city's prioritization of Motorized Transport. As a result, both pedestrians and cyclists are excluded from having access to economic activities which sustain their livelihoods. Pursuant to that, the study recommends institutional capacity development by prioritizing investment and development NMT for promotion of sustainable and resilient Lilongwe city.

Keywords: Infrastructure, Non-Motorised Transport, Sustainable urban mobility, Institutional Capacity, Mobility planning

2 INTRODUCTION

Globally rapid population growth has a significant impact on the urban landscape in cities leading to increased motorized transportation while neglecting non-motorized alternatives (Diao et al. 2021). As a result, African cities have made efforts to integrate Sustainable Development Goals (SDGs) in local initiatives which seeks to promote sustainable transportation that is inclusive, safe, and resilient (Bamwesigye and Hlavackova, 2019). Non-motorized transport (NMT) is at the Centre of development goals creating sustainable urban cities with improved social equity, resilience, safety and respect for the environment thereby achieving the SDGs (Risimati and Gumbo 2022). NMT leads to reduction in air pollution, alleviate traffic congestion, create safe conditions for NMT users and improve environmental conditions (Mansoor et al. 2022). However, NMT is faced with numerous challenges that emanate from the lack of integration with Motorized transport (MT) mainly because of ineffective policies deteriorating urban environment and lack of infrastructure for NMT (Lukomona and Nchito, 2022). In Lilongwe city of Malawi, NMT is at the forefront of sustainable urban mobility projects because of the city's initiative to promote sustainable transport modes, particularly NMT. Nonetheless, the existing initiatives have not been successful in addressing existing NMT challenges that are manifested through the lack of adequate infrastructure such as a number of lanes, street width, Zebra crossing, overpass, road markings and separation of pedestrian sidewalks and cycling lanes along M1 road.

The lack of NMT infrastructure has negatively affected economic growth, congestion, longer trips and increased road fatalities in Lilongwe. A sustainable urban transport system is characterized by efficiency, equitability and environmentally sensitive to social, political, environmental, and economic constraints. To ensure that there is an achievement in sustainable transport, Abu-Eisheh (2019) emphasized the need for investigating the complexes of transport infrastructure designs. The holistically approach will bring solutions to transport challenges, thus this paper aims to explores the barriers faced by implementation of infrastructure supporting NMT.

The paper is structured as follows; Section 1 is the abstract while section 2 is the introduction. Section 3 presents the literature review on NMT and its benefits. Section 4 and 5 present the study area and the

methodology respectively. Section 6 presents results and discussions. Lastly, Section 7 discusses policies and legislation guiding NMT while section 8 discusses the policy implications, recommendations, and conclusion.

3 LITERATURE REVIEW

3.1 Sustainable Transport

There are debates around what constitutes sustainable transport. Sustainable transport system is a system that is affordable, accessible, efficient and that meets the needs of society and is environmentally friendly, Ogryzek et al (2020). Conversely, Ndwandwe and Gumbo (2018) defines the sustainable transportation system as the system that allows the basic access of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, with equity within and between generations. It must also be affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy and reduces production of noise. Many urban poor cannot afford motorized transport such as public buses and private cars, so they must cycle or walk to their work and business places (Bruzzone et al, 2021). The transport sector needs to create separate NMT facilities and ensure that motorized and non-motorized transport users do not use the same facilities as well as to ensure safety.

3.2 Non-Motorized Transport (NMT)

Non-motorized transport refers to any mode of transportation that does not include motorized devices or is unduly reliant on engines for motion (Astrid, 2019). Walking and cycling are the dominant NMT modes. There are various benefits of NMT that promote socio-economic development in cities.

3.3 Benefits of NMT

3.3.1 Increased livability

Non-motorized transportation promotes liveable urban environments and neighbourhood communities (Patil, 2021). For example, NMT allows the implementation of public spaces, the presence of pedestrians in the streets, and the creation of structures that incorporate a feeling of place and significance. People can interact with one another as they stroll together across urban surroundings to various destinations such as school, employment, and other opportunities when NMT mobility is effective.

3.3.2 Economic benefits

Non-motorized transportation is a common mode of transportation that is affordable, dependable, and convenient (Mbatha and Gumbo, 2022). NMT is less expensive than motorized transportation in a way that when one is walking or cycling, there are no transport fare, no parking fees, no fuel is needed, as well as lower operation and maintenance costs. It may also lead to shorter travel times in heavily populated cities and towns. Additionally, NMT offers advantages such as serving as a stand-alone mode of public transportation and incorporating affordable, efficient travel for marginalized people, particularly in emerging and transitional nations (Venter et al, 2019).

3.3.3 Environmental benefits

Increased usage of NMT in cities leads to reduced traffic congestion which ultimately results in increased mobility (Amaniyo, 2022). The environmental effects of NMT are favourable. It does not produce local air pollution or greenhouse gases, which are bad for the environment and people's health. As a result, whenever a motorized trip is replaced by a non-powered one, emissions are directly reduced.

4 STUDY AREA

Lilongwe is Malawi's capital city, located in the country's central region as shown in figure 1. The Lilongwe Central Business District is under the administration of Lilongwe City Council. The most recent census in 2018 reported that 989, 318 people live in Lilongwe (Madinga, 2021). The study covers a popular M1 road in the high-density Lilongwe town. M1 road is the backbone, as it interconnects all three cities in Malawi. This indicates that it is the most used and crowded road. M1 forms a significant part of the daily activities of people as they commute to and from public transport stations and places of work, education, and worship. It is about 347 km, but the research focused only 1.59 km which is a distance from Lilongwe town hall to

568

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Simama hotel. 1.59km was selected because of its compactness, constant congestion from both MT and NMT. In addition, there are shops along the selected route and it is the inlet of the popular Tsoka flea Market in town. The disconnect between urban motorized and non-motorized has been exacerbated leading to multiple challenges in the city thus making M1 road (1.59km from Lilongwe town hall to Simama hotel) a suitable research area.
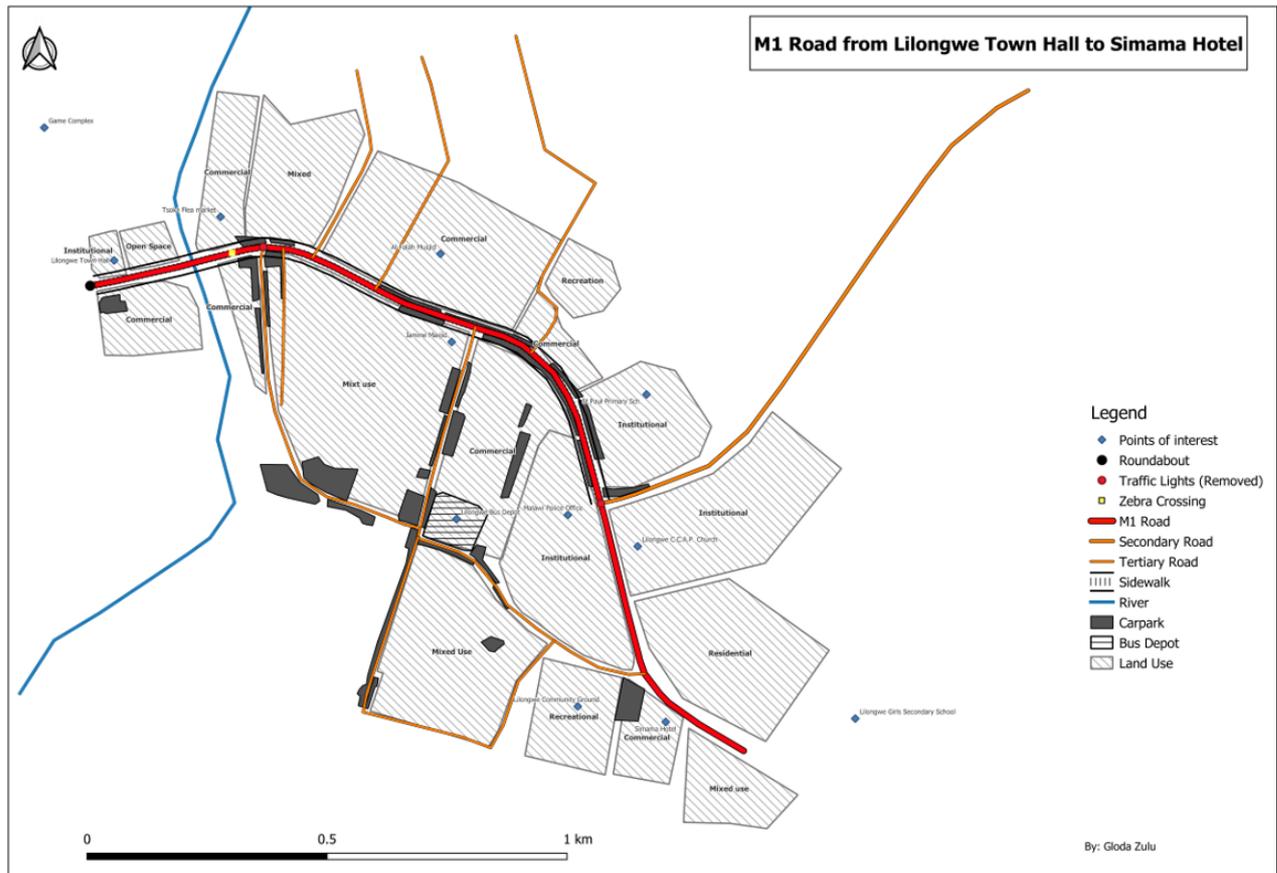
Fig. 1: Study Area M1 Road

5 METHODOLOGY

The study adopted case study research design which aided a comprehensive understanding of the state of NMT in Lilongwe. Using a mixed method approach, interviews and questionnaires were conducted to further analyze the barriers faced by NMT. During data collection process, questionnaires containing open ended questions were administered to NMT users which were cyclists and pedestrians. 64 NMT users were randomly selected along M1 road and given questionnaires to fill in.

Additionally, semi-structured interviews were conducted with 15 different stakeholders responsible for NMT planning. The stakeholders compromised of planning officials, officials from Roads Authority, Civil engineers, traffic police officers and association representatives. Purposive sampling was used to select key informants because they play an important role in the transport system. The data collected from the research was analyzed by two methods of data analysis which are thematic and descriptive. In thematic, the researcher read all the transcripts to identify, analyze, and report repeated patterns. These patterns and trends from data collected were coded in, and general themes were constructed for summarization. On the other hand, Quantitative data including demographic information was analyzed using descriptive data analysis where distribution of the study population, central tendency and dispersion of other quantitative variables was generated. This information is presented in the form of frequencies and percentages using Microsoft Excel.

6 RESULTS

The results presented in this section are conveyed through modal share, population distribution, experiences of pedestrians and cyclist, institutional capacity in investing in NMT infrastructure and the main barriers for NMT.

6.1 Modal Share

The modal split in figure 2 shows the percentage of travelers who use non-motorized and motorized transport along the M1 road in Lilongwe town. A total of 96 respondents filled in questionnaires of which the majority were pedestrians 56% while cyclist recorded 23% and vehicles consisting of minibus and private vehicles recorded 21%. The results indicate a high usage of NMT. This means that people are heavily reliant on this mode of transportation, this can be so because it is cheap and faster when there are traffic jams.
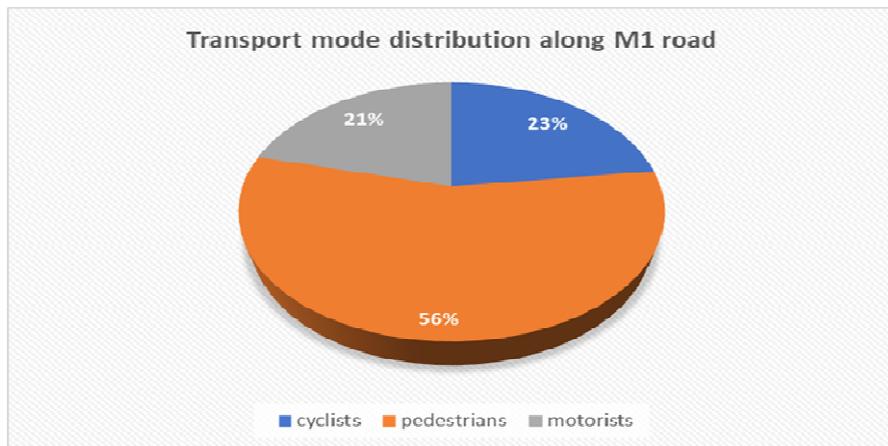
Fig. 2: Modal Share of Transport

6.2 Population distribution

Respondents were probed on their place of residence and from the responses, there was variation in terms of where they reside. The respondents were from Area 14, Area 10, Area 15, Mchesi and many other residential areas as shown in figure 3. This ensured diversity of M1 road users from all over Lilongwe. It also indicates that M1 is a connecting route in all areas in Lilongwe which confirms its frequency of use.
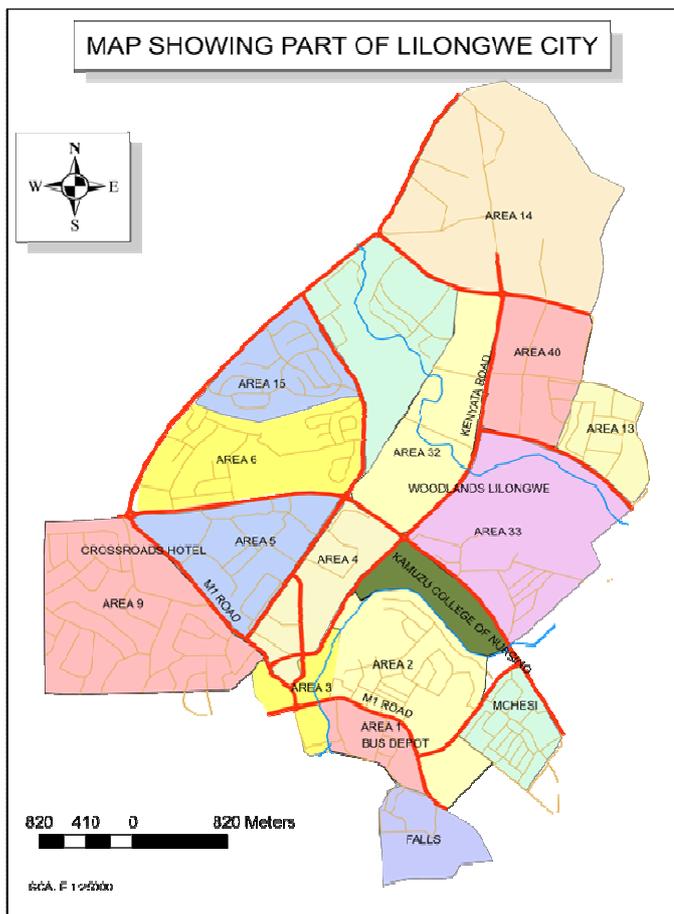
Fig. 3: Lilongwe residential Areas of M1 users

6.3 Experiences of Pedestrians and Cyclist

Findings from the study indicated that the majority of pedestrians and cyclists felt unsafe while using the M1 road and this attributed to the poor state and lack of NMT infrastructure. Figure 4 shows safety levels of pedestrians, cyclist and motorist.
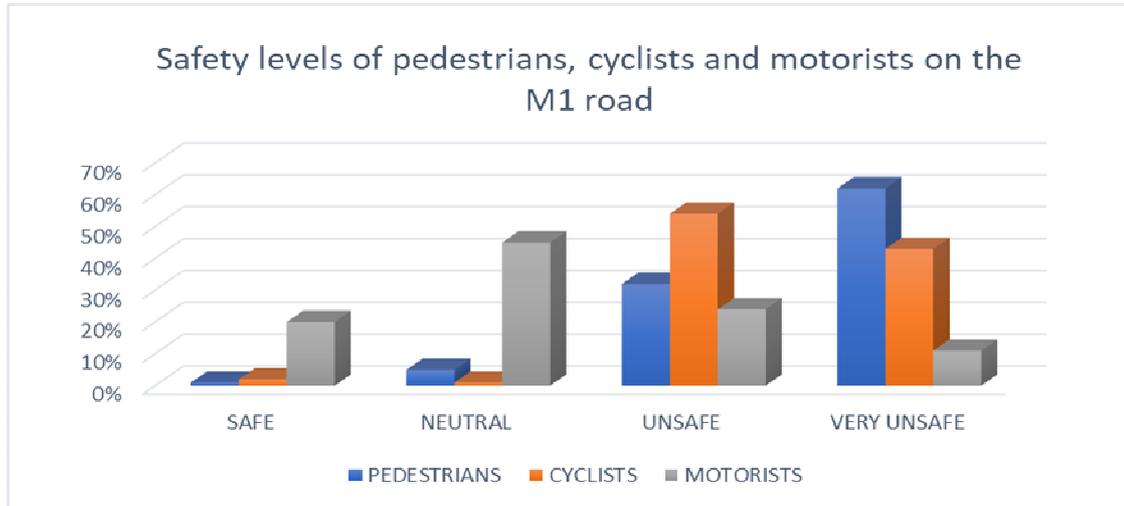
Fig. 4: Safety levels of M1 road users

6.3.1   Pedestrians

The responses from pedestrians mostly focused on the lack of NMT infrastructure, unsafe conditions caused by over speeding of motorists and overtaking unnecessarily in a road that has limited to no pedestrian sidewalks. The absence of pedestrian crossing was also pointed out as one of the challenging experiences that pedestrians face along the M1 road. Lack of zebra crossing, and sidewalks creates unsafe travelling conditions for them. There are no designated crossing zones for pedestrians, and this leads to a lot of jaywalking along the road, which subsequently causes road accidents and inconveniences to motorists.

6.3.2   Cyclists

Cyclists expressed their discomfort when using the M1 road due to lack cycling lanes. The M1 road has no cycling lanes and any visible road marking as shown in Figure 6. This has negatively affected cyclists as they always struggle and compete with other motorists on the M1 road. One cyclist said:

"We are at always at a disadvantage because other road users do not respect us, sometimes we end up cycling in between vehicles which is dangerous for us"- cyclist

Fig. 6: Part of M1 road without road marks and cycling lanes.

6.4 Institutional Capacity in investing in NMT infrastructure.

Malawi Roads Authority initiated the Malawi M1 Road Rehabilitation 1 project under the supervision of Ministry of Transport in October 2019 to integrate NMT to the existing transportation system. The government was given K131 billion financial assistance from European Investment Bank for the M1 road project (Times news, 2022). The primary goal of the rehabilitation project was to increase the reliability and durability of the M1 road's roadway. Despite the existence of strategic plans and approaches responsible for efficiently investing in NMT in the Lilongwe city, the rehabilitation project is a failure. The NMT infrastructure looks to have outlived its economic life and has deteriorated overtime. The lack of infrastructure of NMT poses a plethora of challenges jeopardizing the NMT users and overall sustainable urban mobility of Lilongwe city.

6.5 Main barriers for NMT in Lilongwe

There are many hindrances affecting the NMT from effectively saving its purpose. There are physical and organization barriers that reduce and remove the opportunity of the performance of NMT in Lilongwe city.

6.5.1 Physical barriers

The M1 road is a congested route in terms of traffic and pedestrian flows, yet it lacks readily apparent infrastructure that might enhance walkability and cycling, such as pedestrian walkways and cycle lanes for NMT. There are no facilities on the street to handle Lilongwe's large number of pedestrians. Unmaintained pedestrian pathways are congested by parked cars, forcing some walkers onto the road and raising the possibility of MT-NMT conflict. Road signs and zebra crossings are absent on M1, which heightens the possibility of conflict with MT. To aid NMT users' mobility, there are no pedestrian crossings or lights. There are no facilities for cycling. The biker must take a chance when using the road with MT who disobeys NMT. Overall, M1 Road was created without giving proper thought to NMT as a mode, much like many other streets such as Malangalanga and Gyln Jones in the Lilongwe Municipal area, which explains the absence of pedestrian pathways and cycle tracks among other NMT facilities. Lilongwe generally lacks a sufficient NMT infrastructure.

6.5.2 Organizational barriers

The NMT project is failing to be properly implemented because of lack of institutional capacity, the projects stand halfway through construction due to a lack of oversight, planning and budgeting by the Malawi Roads Authority. On the other hand, The Lilongwe city council lack a framework to make plans and prepare projects, the city is still using outdated urban structure plans. Even when money and financing are available, each of these situations shows how a lack of institutional competence can prevent the implementation of NMT infrastructure growth.

7 POLICIES AND LEGISLATIONS GUIDING NMT

7.1 Road Traffic Act 2014

The Road Traffic Act aims at safe regulation of traffic for both NMT and MT users in Malawi. Subsection (1) of the Road Traffic Act provides instructions for carrying out national-level road traffic law enforcement. To ensure the safety of all road users the Act stipulates that pedestrians are not permitted to walk on a public road except when moving from one side to the other or for other legitimate reasons and are only allowed to use the sidewalk or footpath. Contrary to the regulations of the Act, pedestrians are forced to walk on the road because of lack of infrastructure and street vending. The Act, however, is failing to regulate NMT to ensure safety on the M1 road.

7.2 Malawi National Transport Policy 2017

The policy aims to promote equity among all road users, increase understanding of the social and cultural aspects associated with non-motorized modes of transportation, increase the visibility of NMT modes of transportation in transportation planning and programming, and encourage the integration of amenities for non-motorized road users like women, children, seniors, and people with disabilities (Malawi National Transport Policy, 2015). It also encourages the maintenance of the infrastructure as needed. The government pays a blind eye when it comes to maintenance. One key informant lamented the corruption in the building

572

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sector, which he thinks is one of the causes of the nation's subpar infrastructure. There are many factors at play when it comes to the state of Malawi's roads; many contractors take corners, which lowers the standard of the projects' work.

7.3 Malawi Road Transporters Authority Act, 2014

The Authority's goals and functions are to advance, promote, and protect the welfare of approved transporters and the land transportation industry in Malawi, as well as to establish locations where approved carriers can meet for business like bus terminus, designate pedestrian and cyclists' zones and facilities. The Authority also works with the government and municipal authorities to advocate for the improvement and preservation of roads, overpasses, footpaths, and walkways in a satisfactory condition. The Malawi Road authorities is accountable for protecting limited public financing in the road infrastructure itself to ensure fair allocation of both mechanized and non-mechanized infrastructure facilities finance. To build or maintain roads, the government has hired a variety of contractors through the Roads Authority. However, excessive prices, corruption, and subpar roads are costing the nation billions of Kwachas. Many of these roads have questionable pricing. Instead of just accepting the lowest bid price, the Roads Authority and councils may do Malawians a great favour by awarding contracts to contractors that charge fairly for high-quality services.

8 POLICY IMPLICATIONS, RECOMMENDATIONS AND CONCLUSION

The Malawi Road Authority Act of 2014 advocates on improving overpasses and footpaths conditions, the municipality has never maintained them along M1 road. The flyover was removed in 2020 and the footpaths are damaged, broken and with lots of potholes. It has been over 20 years since its construction, but no maintenance work has been done. It has been learnt that poor to no maintenance of NMT creates accessibility problems for its users.

According to the Malawi National Transport Policy (2017), a road reserve includes a utility strip, footways, on-street parking and lines of trees and space for future widening of the road. However, the reality is that the above-mentioned NMT facilities such as walkways for pedestrians and cyclists, zebra crossings and road signs are still absent and insufficient. People see no use for the NMT infrastructure, and they have turned it to be used as a site for business opportunities whereby street vending is booming along the sidewalks. This has created unsafe conditions for NMT users as they use the same facilities as motorized transport mode.

This study has presented evidence that Lilongwe city of Malawi, lacks infrastructures that support walking and cycling. NMT infrastructure is partially provided specifically along the M1 road used frequently for pedestrians and cyclists, however, those few places do not even have road signs for the other road users to acknowledge and give access to the NMT users. These problems result in congestion, longer commuting hours and accidents are inevitable. The study recommends that, Policy makers, transport planners and engineers will require to make changes in infrastructure maintenance in a way that avoid liability costs and to keep road users safe, they must assure quick reaction to newly discovered road problems, prioritize preventative maintenance, and integrate modern technology into road infrastructure management systems. Another recommendation can be on providing efficient intermodal transportation connectivity points within and between modes, in order for each to function properly and users to connect easily, and where the capacity to switch between modes should be in a timely, cost-effective manner where performance is measured on the capacity to interconnect in order to optimize the end-to-end movement with the most effective system.

9 REFERENCES

Abu-Eisheh, and Ghanim, M.S., 2022. Improving senior-level students' performance in Traffic Systems Management using multimedia contents. Ain Shams Engineering Journal 13.1: 101511.
Aderibigbe, O.-O and Gumbo, T. (2022a) Variations in Mode Choice of Residents Prior and during COVID-19: An Empirical Evidence from Johannesburg, South Africa. Sustainability, 14, 16959. https://doi.org/10.3390/su142416959
Aderibigbe 0.0 & Gumbo T (2022b) Influence of Socioeconomic Attributes on Travel Behaviour in the Rural Areas of Nigeria: Towards a Sustainable Rural Planning and Development, Urban, Planning and Transport Research, 10:1, 181-199, https://doi.org/10.1080/21650020.2022.2072946
Amaniyo, M., 2022. The impact of no-motorised roads on vehicle traffic flow in Kampala City Doctoral dissertation, Makerere University.
Brightnes Risimati and Trynos Gumbo (2018) Exploring the Applicability of Location-Based Services to Delineate the State Public Transport Routes Integratedness within the City of Johannesburg, Infrastructures 2018, 3, 28; 1-14; https://doi.org/10.3390/infrastructures3030028

Dastan, B. and Hlavackova, P., 2019. Analysis of sustainable transport for smart cities. Sustainability 11.7 (2019): 2140.

Diao, M., Kong, H. and Zhao, J., 2021. Impacts of transportation network companies on urban mobility. Nature Sustainability, 4(6), pp.494-500.

Dumba, S; Vassileva LD, and Gumbo T, (2017) Methodological issues in modelling signalised intersection capacity under informal public transport operations: Case study, Harare, Zimbabwe, Transportation Research Procedia, 25, 4895-4919, https://doi.org/10.1016/j.trpro.2017.05.367

Fonseca, F., Conticelli, E., Papageorgiou, G., Ribeiro, P., Jabbari, M., Tondelli, S. and Ramos, R., 2021. Levels and characteristics of utilitarian walking in the central areas of the cities of Bologna and Porto. Sustainability, 13(6), p.3064.

Haas, A.R., 2019. Key considerations for integrated multi-modal transport planning. Cities That Work.

Malawi. Ministry of Transport and Public Works, 2015. Malawi National Transport Policy, Ministry of Transport and Public Works.

Mbatha, S. and Gumbo, T., 2022, November. Possibilities of Integrating Motorized Transportation and Non-Motorized Transportation in the City of Johannesburg. In Mobility, Knowledge and Innovation Hubs in Urban and Regional Development. Proceedings of REAL CORP 2022, 27th International Conference on Urban Development, Regional Planning and Information Society (pp. 603-613). CORP–Competence Center of Urban and Regional Planning.

Madinga, E., 2021. Land use and land cover in Lilongwe, Malawi. University of Johannesburg, South Africa.

Mansoor, Umer, et al., 2022. A review of factors and benefits of non-motorized transport: a way forward for developing countries. Environment, Development and Sustainability 24.2: 1560-1582.

Melchor, O.H., and Lembcke, C.A., 2020. Developing transit-oriented communities for better accessibility and affordability: The case of the Metro Vancouver Region.

Moyo, T.; Mbatha, S.; Aderibigbe, O.; Gumbo, T and Musonda, I (2022). Assessing Spatial Variations of Traffic Congestion Using Traffic Index Data in a Developing City: Lessons from Johannesburg, South Africa. Sustainability, 14, 8809; 1-16. https://doi.org/10.3390/xxxxx

Musakwa, W., and Gumbo, T. (2017). Impact of Urban Policy on Public Transportation in Gauteng, South Africa: Smart or Dumb City Systems Is the Question, pages 339-356. In R. Álvarez Fernández, S. Zubelzu, & R. Martínez (Eds.), Carbon Footprint and the Industrial Life Cycle: From Urban Planning to Recycling, Springer: Cham, https://link.springer.com/chapter/10.1007/978-3-319-54984-2_16

Ndwandwe, B and Gumbo T (2018) Progressive or regressive: efficacy of innovative urban public transport systems on urban mobility in the City of Tshwane; The 37th annual Southern African Transport Conference and Exhibition and The 4th international Conference on Transport Infrastructure; 9 - 12 July 2018; 428 – 438; Pretoria, South Africa

Lukomona, R. and Nchito, W.S., 2022. The Provision of Non-Motorised Transport Infrastructure in the City of Lusaka: An Analysis of Policy, Practice. Transport and Mobility Futures in Urban Africa. Cham: Springer International Publishing, 279-296.

Patil, P., 2021. Sustainable Transportation Planning: Strategies for Reducing Greenhouse Gas Emissions in Urban Areas. Empirical Quests for Management Essences, 1(1), pp.116-129.

Ogryzek, M., Adamska-Kmieć, D. and Klimach, A., 2020. Sustainable transport: an efficient transportation network—case study. Sustainability, 12(19), p.8274.

Oseifuah, J., Gumbo, T. and Chakwizira, J., Exploring Non-Motorized Transport as a Transport System: Lessons from Thohoyandou CBD.

Risimati Brightnes, Gumbo Trynos and Chakwizira James (2021) Spatial Integration of Non-Motorised Transport and Urban Public Transport Infrastructure: A Case of Johannesburg, Sustainability, 13, 11461; 1-17, https://www.mdpi.com/2071-1050/13/20/11461

574

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Optimization of Cities through Green Spaces

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1 ABSTRACT

In general, the trend prevailed in recent years that the effects of civilization's interventions in environmental conditions have not been as prominent in publications as they were before the outbreak of the Corona pandemic. The Corona pandemic has focused attention on the most pressing problems in recent years, such as, in metrological terms, the dispersion of liquid aerosols. Although incidences due to Corona are still extremely high, and the number of days of illness has a massive impact on industrial and societal processes, Corona is no longer considered the No. 1 issue. This is due in particular to the lower mortality that has resulted from the immunization of the population and the attenuation of the dangerousness of the new generations of the pathogen. By pushing the topic of Corona off the front pages of journals, previously discussed priorities are increasingly resurfacing.

Against this backdrop, the long 'dead' discussion about the occurrence and effects of particulate matter is gaining momentum again. This paper revisits a previous Real Corp conference paper (Westphal et al., 2022), in which the authors suggest and explain the contributions of an innovative measurement device (ProxiCube) developed by the City of Mannheim's ecosystem addressing the key success factors for awarded Smart Cities and the various factors of an urban management model. This paper exemplifies the cube's contribution by a specifically designed and conducted research experiment.

In the research setting of the City of Mannheim, a city in the forefront of the Smart City movement in Germany, the empirical part of the paper comprises the parameters of liquid aerosol, dry particulate matter, CO_2, humidity, temperature, pressure and light conditions which were measured by innovative and internationally awarded air quality measurement devices (ProxiCube) (see Westphal et al., 2022) simultaneously at five parallel measurement points of the city at a high data rate. With the measurement constellation, influences can be visualized such as the daily course of all these measured variables at a busy street juxtaposed to the backyard of adjacent buildings or to the building itself implying a crucial impact for the citizens' life quality.

Keywords: carbon dioxide, environment, green spaces, ventilation, air quality

2 INTRODUCTION

The term particulate matter covers airborne particles up to 2.5 µm in diameter and is an important factor in the air quality index. Both, directly emitted particles and particles generated by secondary particles are included in this category. Tucker lists as PM 2.5 particles sources combustion processes and high temperature metallurgy, secondary particles from atmospheric reactions, and fine particles deposited and resuspended by wind or human activities, and adds that it is difficult to identify the main sources of the particles because of the interaction of numerous emission sources (Tucker, 2000). The Federal Environment Agency lists combustion processes in the home, from road traffic and from agriculture as sources of particulate matter 2.5 (Umweltbundesamt, 2023).

The results of the study shed light on the following research questions: does living in a high-rise building at a great height offer environmental advantages or how densely planted and how large must green areas be in order to filter fine dust? This leads to further implications of deep penetration of particulate matter into green strips within urban facilities. The building implications of the findings derived via the data, furthermore, allow conclusions to be drawn about optimal ventilation behavior, hereby assessing how CO_2 and particulate matter accumulate kinetically during the time of the ventilation process of shock ventilation. Summarizing,

the environmental loads of humans exposed to the given measured variables are measured and presented graphically.

3   MATERIAL AND METHODS

The measuring device used as basic hardware, called ProxiCube NX3, is a cube-shaped multi-sensor system with an edge length of approx. 8 cm (Figure 1). It simultaneously measures various environmental data such as CO_2, TVOC, temperature, pressure, humidity, but also fine dust and liquid particles (Westphal et al., 2021). The device categorises the fine dust into different size classes and enables the exact identification of the respirable load. The instrument is capable of producing the same readings as highly complex reference instruments and can enable the correlation between different environmental influences on indoor and outdoor conditions, as confirmed by recent publications (Westphal et al., 2022). Depending on the test set-up, several Proxicube NX3s, with or without additional GPS trackers, are used at specific points or distributed over longer distances. The basic ProxiCube is modified for the shown measurements to increase the measurement frequency rate. All data are transmitted via the mobile network to the cloud storage, where they are retrieved from the database, displayed, compared and further processed.

Figure 1: ProxiCube NX3 multi-sensor system

The measurement data for the fine dust class PM2.5 are presented and compared with the official air measurement values of the two measuring stations (identifier DEBW098 and DEBW005) of the Federal Environment Agency in Mannheim.

4   RESULTS AND DISCUSSION

Six series of measurements were planned and carried out to determine the local particle concentrations in green, rural, industrial and built-up areas in the city of Mannheim and the concentrations to which cyclists, for example, are exposed.

Indoor/outdoor air measurement Institute kitchen

Figure 2 shows the PM2.5 fine dust pollution on 12 May 2023 from 9:00 to 14:00. The PM2.5 measurement values of the measuring stations DEBW098 and DEBW005 in Mannheim as well as the measurement values of three Proxicube measuring devices are plotted. The values of the measuring stations of the Federal Environment Agency are plotted as hourly moving averages. One Proxicube is located outside on the windowsill facing NW, another Proxicube is located in the middle of the kitchen on a table. The third sensor is located in the hallway leading to the kitchen. The outdoor air readings largely correspond to the air measurement of DEBW098 with a slight tendency towards slightly higher particle densities. At the beginning of the experiment, the sensors inside the building show significantly lower particulate matter levels of about 3-4 µg*m-3. In the period from 10:20 a.m. to 10:30 a.m., the window of the room is completely open (shaded grey area in the figure). During this period, a clear increase in the fine dust particle

576

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density in the room can be observed. After closing the window, the concentration drops back to the initial value. In the period from 11:20 to 11:30 a.m. the window is fully opened again, with identical results. From 12 to 14 o'clock the window is tilted (shaded area in grey in the figure). The fine dust concentration rises to the level of the outside air - and remains at this high level. The measurement in the corridor to the kitchen shows an increase in the fine dust concentration at 11:30 and 13:00. This can be attributed to the fact that the door to the kitchen was repeatedly opened and closed from 11:30 to 12:00 and is permanently open from 13:00.
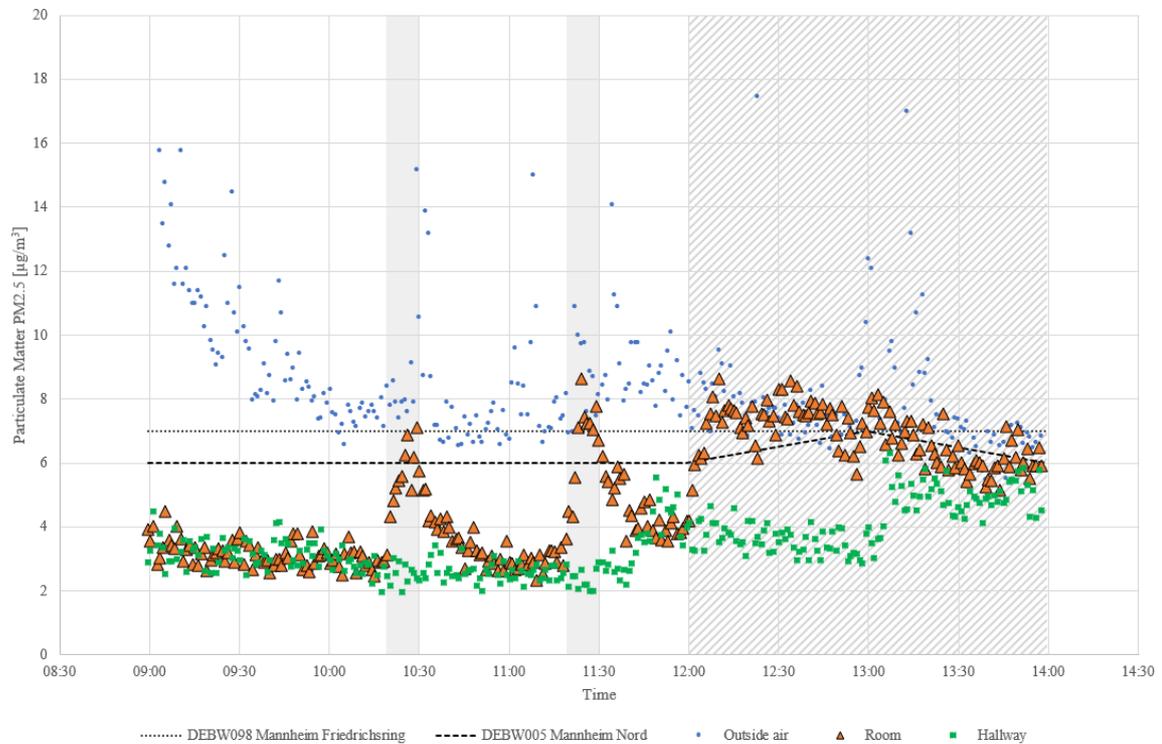

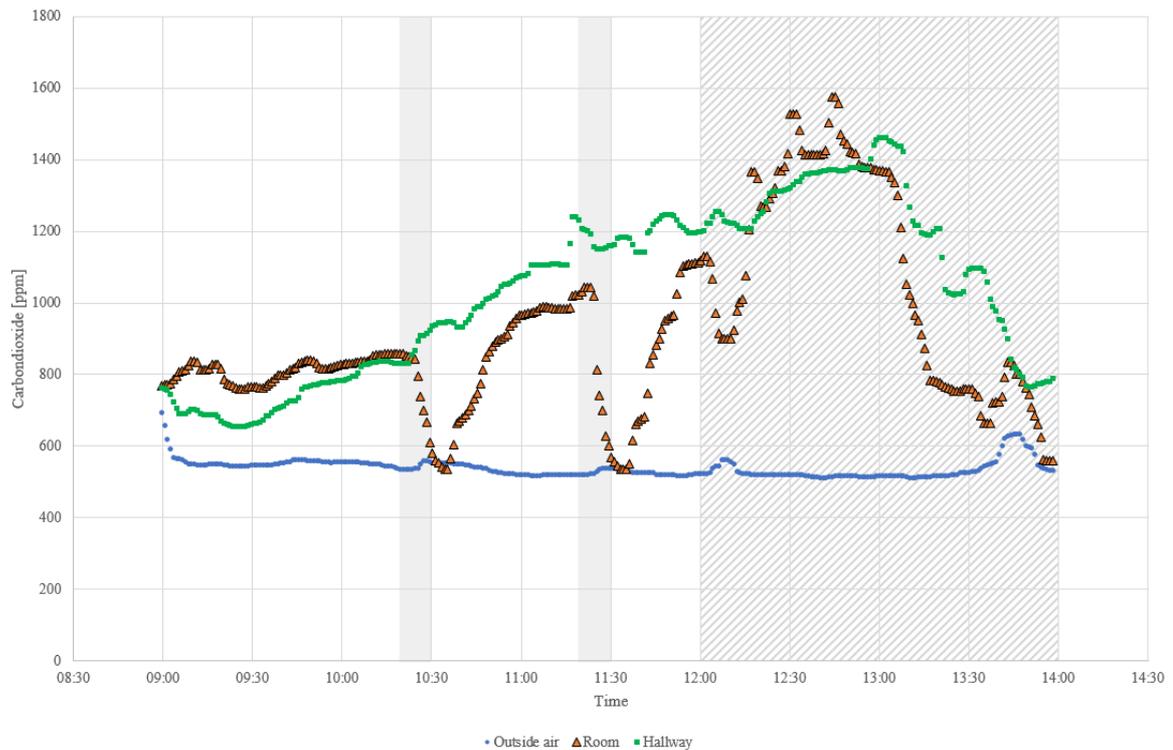Figure 2: Indoor outdoor comparison in office kitchen, PM 2.5

Figure 3: Indoor outdoor comparison in office kitchen; carbon dioxide concentrations

In Figure 3, the carbon dioxide concentrations are plotted for the same period as in Figure 2. With the windows open and tilted (10:20 - 10:30, 11:20 - 11:30 and from 12:00), the carbon dioxide concentration drops significantly, followed by an increase with the windows closed (from 10:30 and 11:30). From 12:00 - 13:00 there are about 5 people in the room. The tilted window is not sufficient to remove the carbon dioxide, so the concentration rises again. At the same time, however, fine dust enters the room, as already shown in Figure 3. The carbon dioxide concentration in the hallway increases continuously throughout the day. The concentration only decreases after the door is permanently opened.

Based on these results, short-time shock ventilation is preferable to permanent tilt ventilation in order to achieve a more efficient air exchange and a temporally lower exposure to fine dust.

Measurement of the outside air at different heights
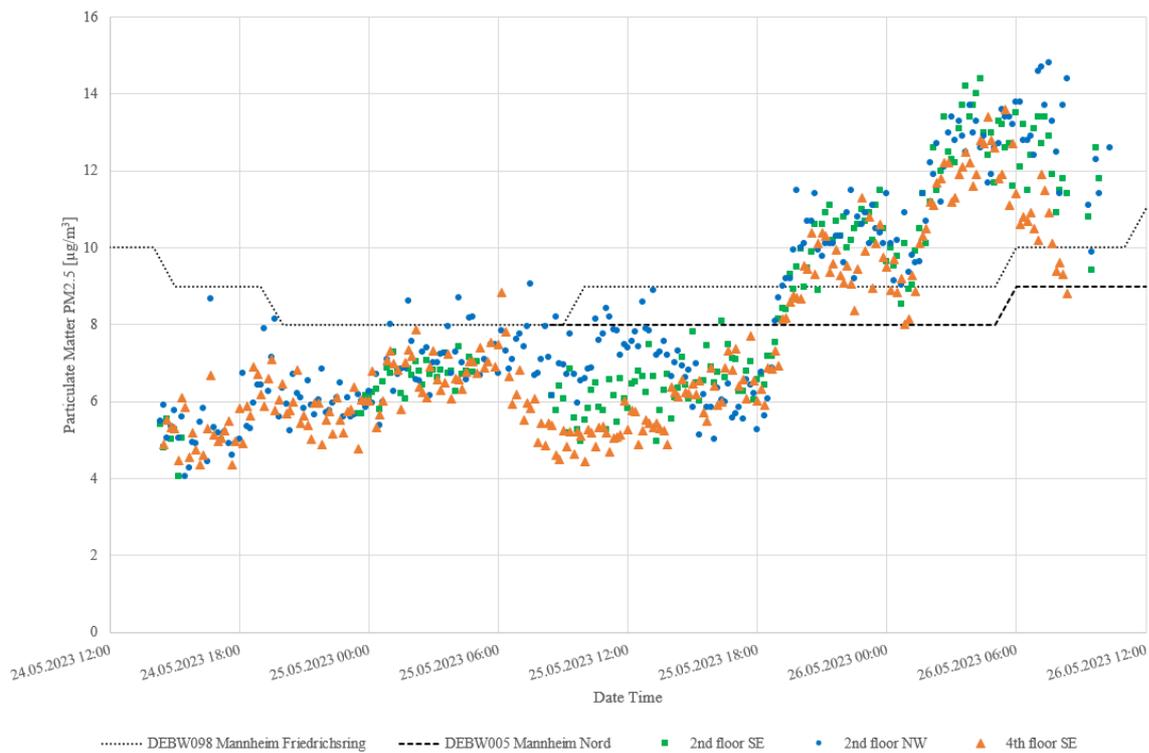
Figure 4: concentration in the outdoor air in different heights

Figure 4 shows the fine dust concentration in the outdoor air from 24.05.2023 to 26.05.2023. In addition to the official air measurement values for PM2.5, the measurement results of three Proxicube air sensors are entered. One sensor unit is located on the second floor facing southeast. Another Proxicube is located on the other side of the building, also on the second floor, facing northwest. The third Proxicube is located on the 4th floor facing south-east. All three sensor units are outside the building on window sills. The readings from the proxicubes are below the official air readings in the first half of the experiment from 24.05.23 14:00 to 25.05.23 18:00, in the second half above them. The official readings show an increasing trend, which is reflected in the readings of the proxicubes. Comparing the measured values of the proxicubes with each other by median formation shows that there is only a slight difference in concentration for PM2.5 between the sensors on the 2ndfloor. If one compares the measured values from the 2nd floor with those from the 4th floor, greater differences become apparent. Thus, the proxicube on the 4th floor has a median fine dust concentration that is 9 - 10 % lower than the proxicubes on the 2nd floor. This indicates that, for example, residents of attic flats are exposed to lower levels of particulate matter than their neighbours on the lower floor.

Air measurements around the coal-fired power plant Mannheim Grosskraftwerk

Figure 5 shows the results of the air measurements from 05.05.2023, 11:00 a.m. - 4:30 p.m., around the coal fired power plant Mannheim (GKM) in comparison with the measured values of the measuring stations DEBW098 and DEBW005. One Proxicube is located east of the GKM at the Stengelhofweiher, opposite the GKM on the banks of the Altrhein and west of the GKM, downstream on the flood embankment. The

measured values of all three sensor units lie between the measured values of the Federal Environment Agency. Conspicuous or increased fine dust concentrations due to e.g. blown coal dust, fly ash or FGD gypsum are not detectable.
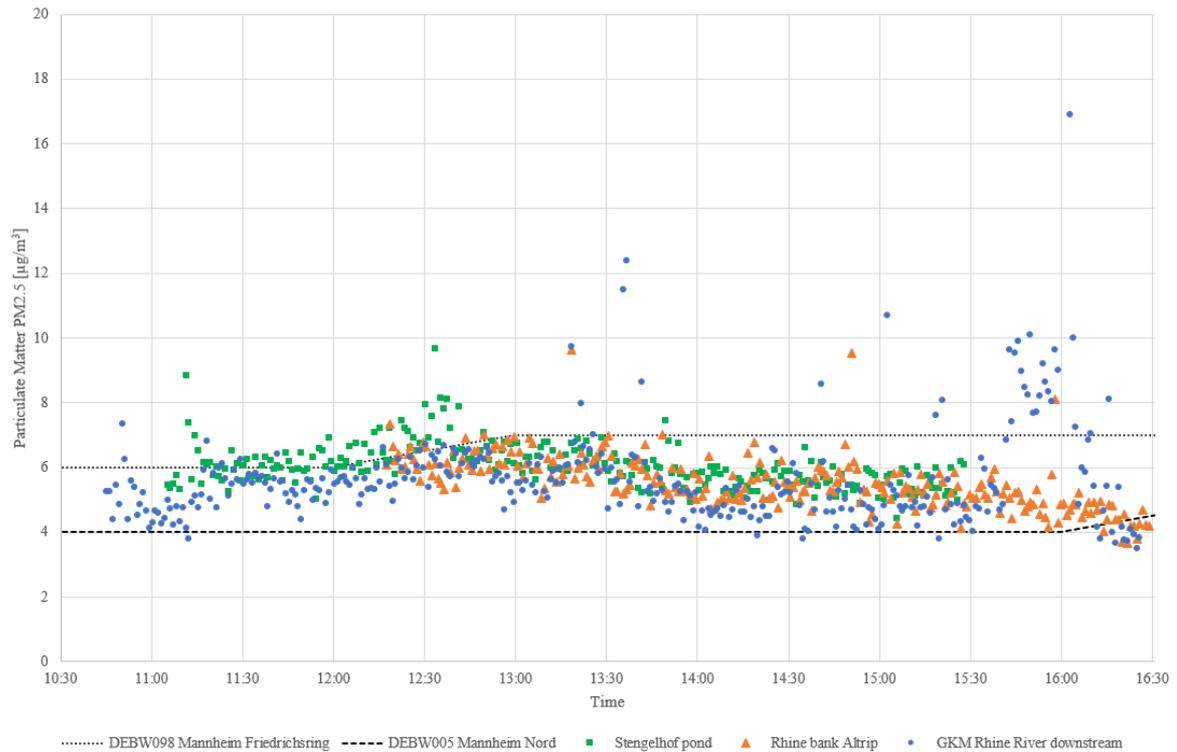
Figure 5: Air measurements around the coal-fired power plant Mannheim Grosskraftwerk

Traffic node
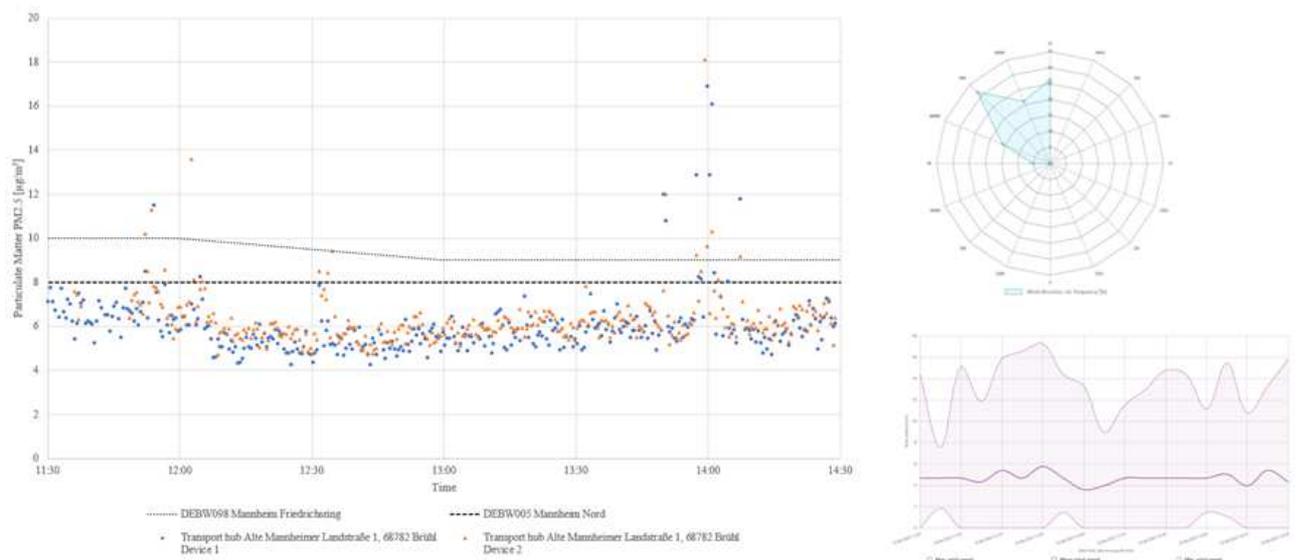
Figure 6: Traffic node and wind data

The two measurements in ABB ran in parallel at a traffic junction point in Mannheim. The measured PM2.5 values are somewhat lower than at the measuring points of the city of Mannheim. The fine dust pollution does not have the same effect at this well-traveled location as in a street surrounded by buildings. The wind speeds indicated by the city of Mannheim for this time period are 5 km/h on average. Here, the assumption can be made that the particle pollution caused by traffic is diluted continuously by the light wind. Locally recorded increased measured values can be attributed to the drive-in station in the vicinity.
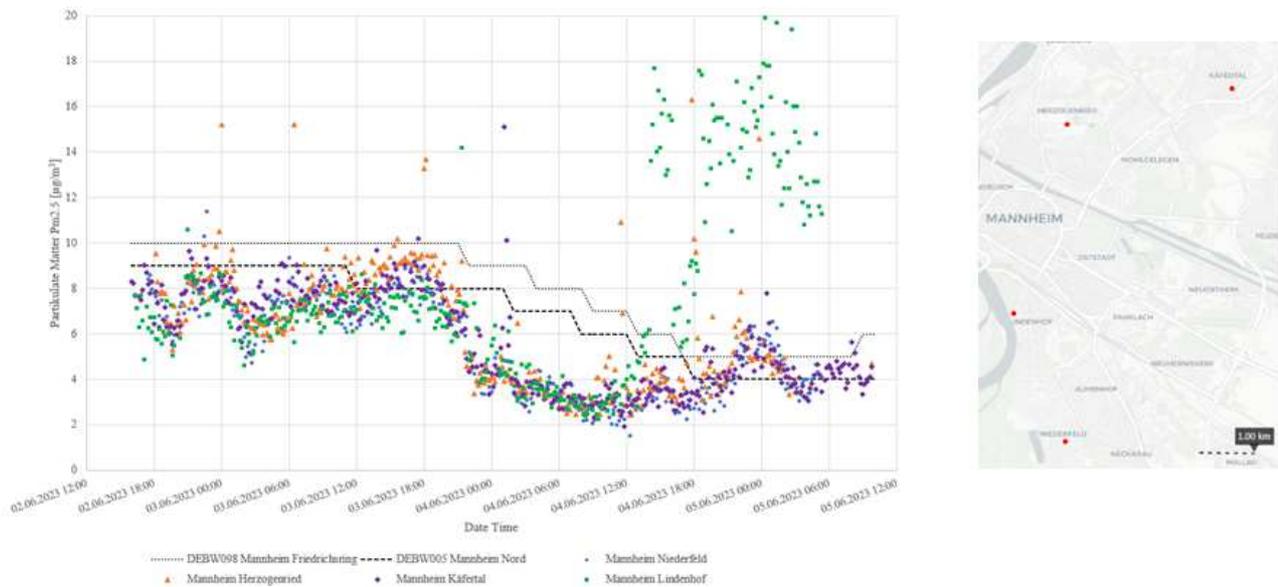
Figure 7: Measurements on four different parts of the city

The measurement cubes were positioned in four districts in Mannheim for three days and the measurement results were presented in Figure 7. At all four locations the basic course is the same and the changes of the particle concentrations are similar to the measured curves. Locally measured higher particle concentrations cannot be justified with certainty, but there are numerous sources in residential areas, such as cigarette smoke, barbecues, a running motor under the balcony, etc., which can lead to these measured values.

Bicycle tours

The measuring boxes are attached to the bicycle basket at a height of approx. 50 cm. Three people set off in the direction of the north-west, north-east and south-east of the city. The aim of the study is to identify zones with comparatively higher particulate matter pollution within the city and in the peripheral areas. Figure 1 shows the entire distance travelled with the measured PM 2.5 values.
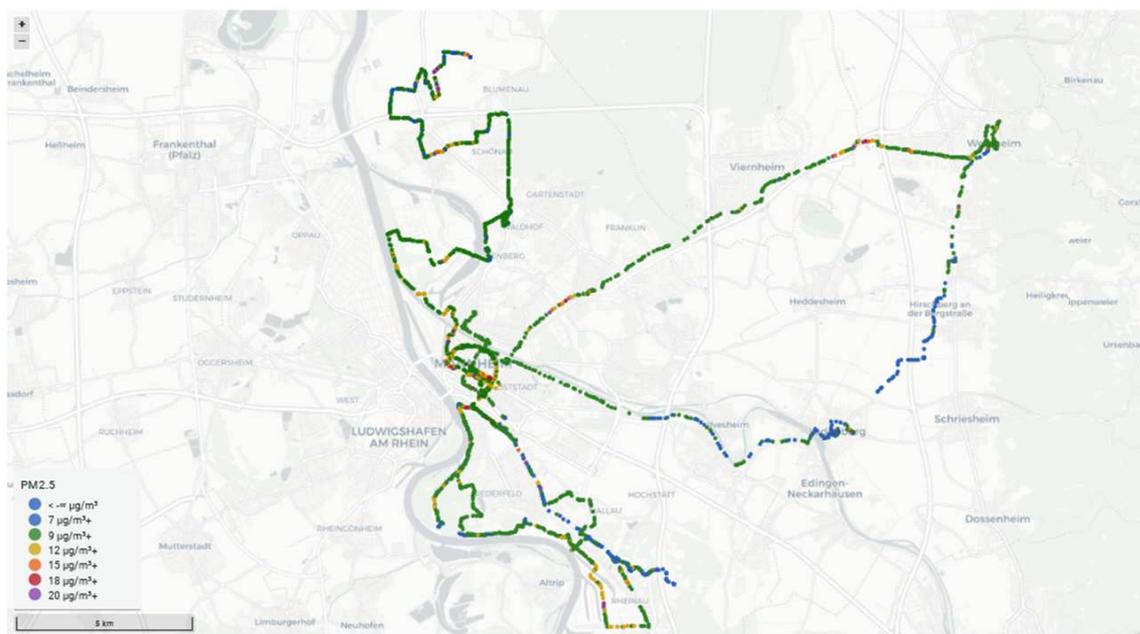
Figure 8: Bike route between 8:30 and 15:30

In the following, sections of the map are enlarged for a better overview and the hotspots are marked individually. The areas with special observations are noted in the legend.
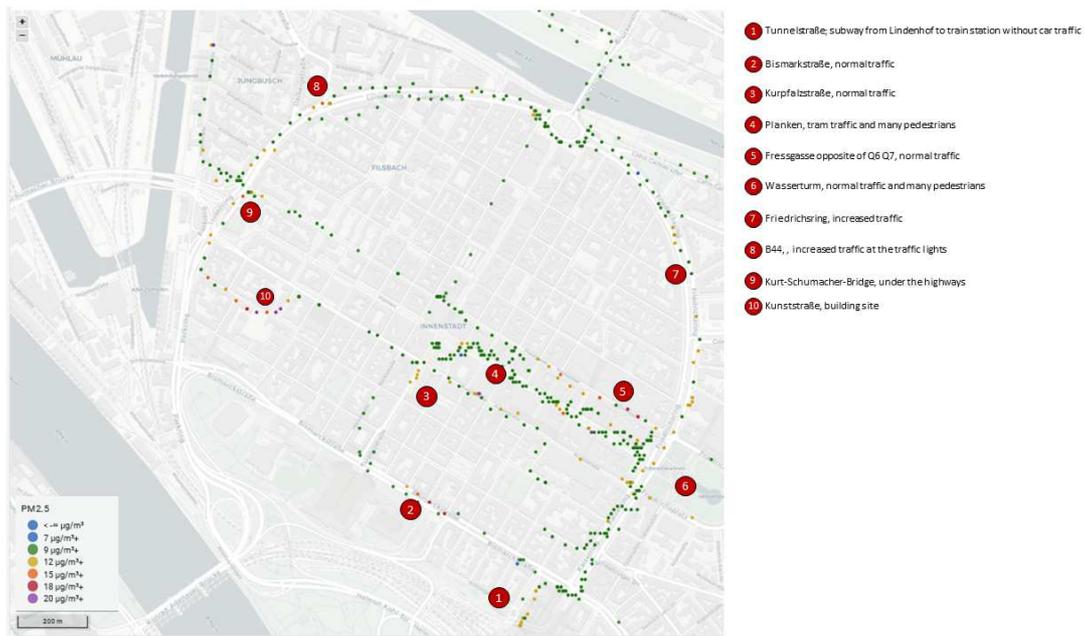
Figure 9: Cycle route between 9:40-10:30 in city centre

In Figure 9, ten zones stand out. Most of the areas with comparatively higher readings have in common that they run along a busy major road or that many pedestrians are on their way. In the case of point 10, the higher readings could be attributed to the adjacent construction site. Here, the air circulation is lower than on an open road, which is probably why the swirled-up particles reach a higher concentration. The section at point 8 is located at a junction with traffic lights with higher traffic volume.
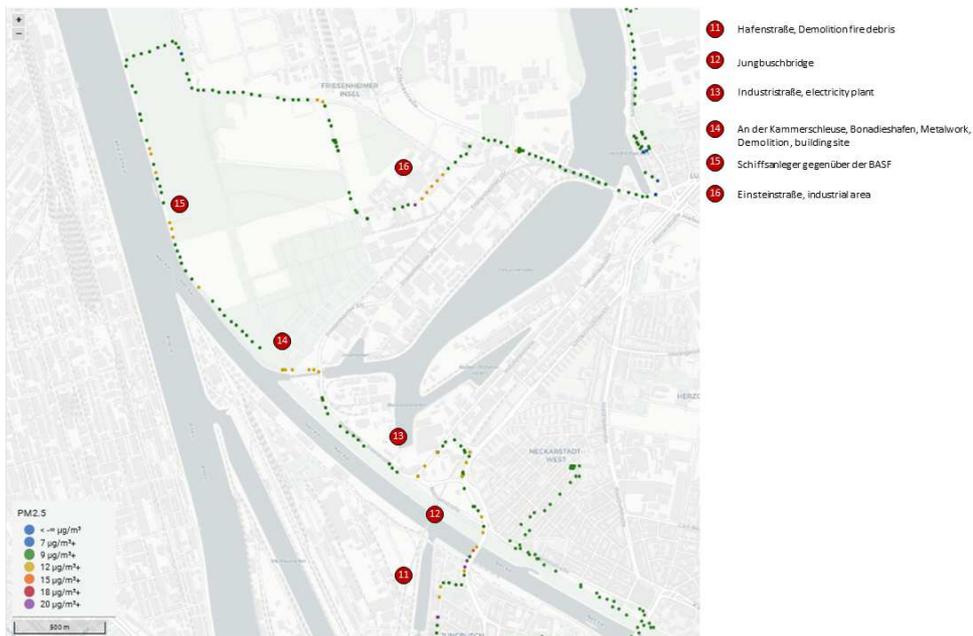
Figure 10: Cycle route between 11:00-12:30, north west route part 1

In Hafenstraße at hotspot 11, there is a burnt building in the route that is currently being dismantled. There is also a work site at 14. The other hotspots marked in Figure 10 are located near industrial facilities.
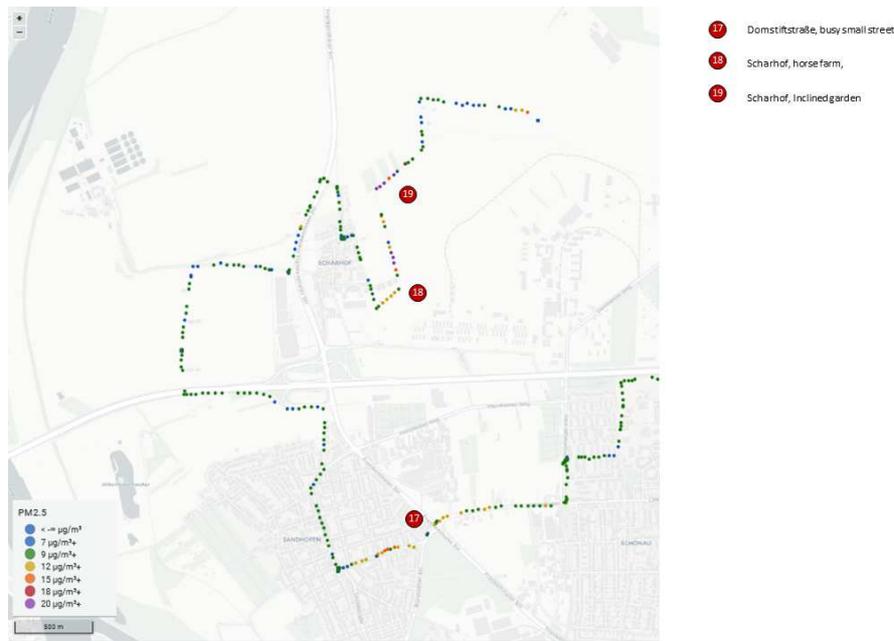
Figure 11: Cycle route between 12:30-13:30, north west route part 2

The track at point 17 is a small but busy road surrounded by buildings. The assumption here is that the particles are not blown away well enough and the concentration is higher than with open roads. The more rural stretches at 18 and 19 also show increased concentrations of particles, which could possibly be caused by the blowing of unpaved road sections, animal feed or similar bulk material.

Figure 12: Cycle route between 10:15-15:30, north east route

Figure 12 also shows that higher values are measured in places close to industrial facilities and with heavy traffic or where cars have to stop and go and drive more slowly.

Increased values measured at points 25 and 26 in Figure 13 could be attributed to the football pitch. Dust stirred up by the wind and people is measurably distributed in the surroundings. The other hotspots are again routes with city traffic and industrial sites.
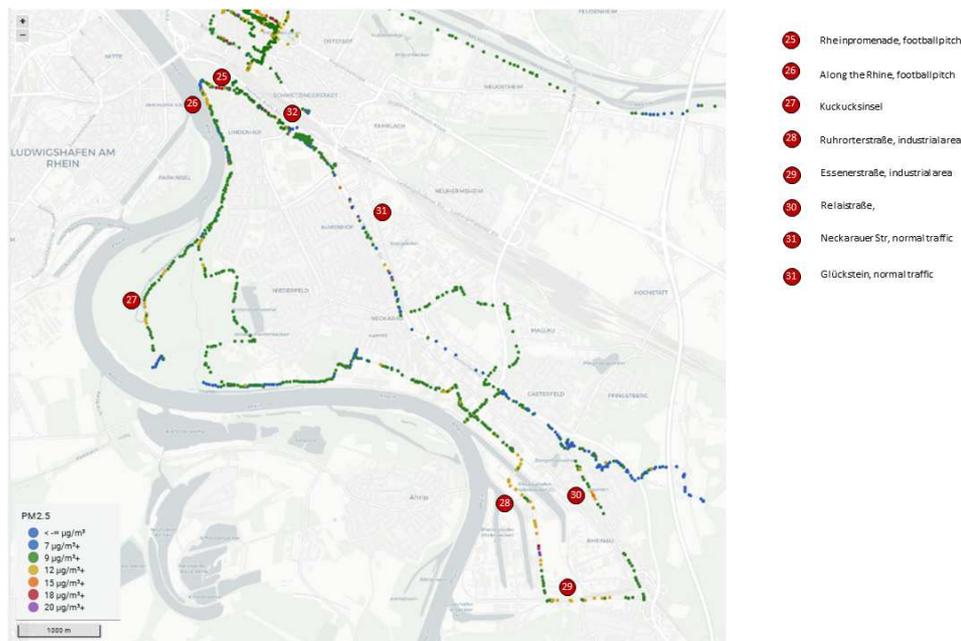
Figure 13: Cycle route between 9:40-16:10, south east route

5 CONCLUSION

The empirical experiment reflects the contribution of a measurement device (ProxiCube) to the key success factors of awarded smart cities highlighting the central importance of its citizens' health. It is an important ingredient of a smart city's technological infrastructure, informs the strategy for digital transformation i.e. in terms of planning the nexus between streets, factories, construction sites and residential areas evtl. via digital twins, providing the necessary skills, i.e. in terms of transversal (research), general or specific IT competences, informs the awareness and health education of citizens, and contributing to the authentic implementation of a Smart City's identity, i.e. in terms of a health orientated or life quality related identity. Furthermore, the experiment illuminates the interplay of the factors of an urban management model relating to competences, implicit SC domain priorities and the necessary collaboration of the SC ecosystem actors to achieve the SC objectives and outcomes (Westphal et al., 2022).

In more detail, the experiment determines the distribution of CO_2 and particulate matter as a function of the height of the measuring point and the cross-influences of the other environmental parameters (temperature, humidity, dew point…). As to specific health orientated citizens' behavior, short-time shock ventilation is preferable to permanent tilt ventilation in order to achieve a more efficient air exchange and a temporally lower exposure to fine dust. Interestingly, residents of attic flats are exposed to lower levels of particulate matter than their neighbours on the lower floor. Numerous sources in residential areas, such as cigarette smoke, barbecues, a running motor under the balcony, etc., need to be taken into account to avoid excessive exposure.

In busy, major roads, the air circulation is lower than on an open road, which is probably why the swirled-up particles reach a higher concentration.

In general, it can be summarised that elevated PM 2.5 levels were measured on routes that run close to urban traffic or industrial facilities. In addition, construction sites with demolition work and unpaved roads or playgrounds could be sources of particulate matter.

6 REFERENCES

Tucker, W. (2000). An overview of PM2.5 sources and control strategies. Fuel Processing Technology 65–66, S. 379-392.
Umweltbundesamt. (2023). www.umweltbundesamt.de. Von https://www.umweltbundesamt.de/daten/umweltindikatoren/indikator-emission-von-luftschadstoffen#welche-bedeutung-hat-der-indikator. abgerufen
Westphal, D., Teumer, T., Schäfer, T., Ahlers, R.-J., & Rädle, M. (October 2021). Detection and Differentiation of Liquid and Solid Particles in Ambient Air. Chemie Ingenieur Technik, Volume 93, Issue 10, S. 1636-1642.
Westphal, D., Ünsal-Peter, G., Rädle, M., Kaufmann, H., & Walch, T. (2022). A Mannheim Best Smart City Case: New Measuring System for the Complex Analysis of Spatially. 27th International Conference on Urban Developement, Regional Planning and Information Society. Mobility, Knowledge and Innovation Hubs in Urban and Regional Development. Proceedings of REAL CORP 2022.

Optimizing the Infrastructure of Electric Vehicles and Developing Business Models for Sustainability

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1 ABSTRACT

Transportation is one of the major sources of economy for any country. But the main problem with the vehicles is the amount of pollution conducted by them. One needs a particular source that creates Net Zero Carbon Emissions. Electric vehicles are becoming a popular source of transportation as they do not produce any carbon emissions. But due to a lack of proper infrastructure and customer awareness, consumers hesitate to decide on an Electric Vehicle to date. The paper also covers the expansion of VANET Technology that can improve the traffic management system and reduce the number of accidents. For this reason, this paper aims to identify the area of improvement in building the infrastructure of electric vehicles with economic policies.

Keywords: management systems, VANET, mobility, sustainability, transportation

2 INTRODUCTION

As the climate is changing rapidly, a growing concern can be seen for the environment. The fuel market is unreliable, and electrification of the transport system entails a major systemic overhaul in a country. Strategies are being discussed by every major country to reduce the overall CO2 emissions and go all-electric by 2030. The paper introduces an overview of the present electric vehicle (EV) market scenario. This market follows certain standards like charging standards, safety standards, and grid integration (Das, 2019). The EV infrastructure covers certain things like power, control, and communication. As different companies are producing these vehicles, each vehicle will impact the power system, which is why grid system optimization is summarized. Lastly, the paper will cover challenges and suggestions for the development and challenges for future vehicles. It refers to major aspects from the perspective of the world being ready to go for EVs and will introduce the idea of bringing smart grid technology to charging stations. Moreover, to build a sustainable infrastructure what policies should be taken for the charging stations, use of renewable energy and connecting it with smart grids, and VANET Technology (Das, 2019).

3 RESEARCH GAP

According to Das and Rahman (2022, p. 24), "future research could be done on implementing in expansion in VANET technology along with a well-developed business model which can be beneficial for EV owners, users as well as utility companies". A further gap is provided by Ahmad and Iqbal (2022, p. 16) stating that "future research and challenges faced are related to include optimal places and sizing of charging stations with renewable energy sources and integrating the load for power management problems". Consequently, this study aims to investigate the factors that lead to a solution for optimizing the infrastructure for electric vehicles and closing these gaps.

Four research questions are derived from the literature to achieve the research objective:

(1) How can renewable energy play a major role in providing clean energy to EV charging stations?

(2) What role does a charging station play in creating a sustainable business model?

(3) How can we provide VANET Technology to improve traffic Management systems?

(4) How can we establish a radio communication channel by reviewing security challenges and testing VANET in a critical case scenario?

4 LITERATURE REVIEW

The chapter deals with previous studies on the elements leading to increasing sales of Electric Vehicles in the past decade. It provides a clear picture of previous research initiatives having identified some major problems related to the infrastructure and availability of charging stations. To find relevant literature for this paper, the research was done in different phases. At first, several articles and journals were looked at by

using keywords like Renewable Energy, Charging Infrastructure and Policies, VANET Technology, and Electric vehicles on open platforms. For the research, data were filtered via journals and articles from Google Scholar, Research Gate, and IEEE Explorer.

4.1 Renewable Energy

Today, global warming has become a major issue that needs to be urgently resolved. With a vision of having a clean environment-friendly energy source, it has become a prime topic of interest to many environmentalists. With a rise in population, it is becoming difficult for governments to fulfill the need for electricity as our society is progressing towards high standards of living. According to Elavarasan et al. (2020, p.1), "the power systems energy production sector contributes nearly 75% of total CO2 emissions in the world which contributed to Greenhouse Gas (GHG) emissions as well as in Global warming".

4.1.1   Role of Renewable Energy

With a dramatic rise in the purchase of EVs, the demand for the use of EVs globally has increased dramatically. The global electric car market has shown a significant jump in sales as people are more concerned about zero carbon emissions. But this upsurge has created a problem with the provision of proper charging infrastructure as people are using the current charging system. The latter is pressuring the load on transformers, especially during the night, as people charge their vehicles overnight. One of the drawbacks of renewable energy is its inconsistency to offer energy all the time. To tackle the problem, it is required to get optimal planning for allocating EV charging stations. The proposed solution could be to use solar energy panels by creating a "Green Roof" that will create a balance in the temperature due to its ecological benefits. At the same time, solar panels can provide a clean source of energy to charge EVs.

4.1.2   Renewable Energy Transition in EU by 2050

The European Union is a key influencer in reducing carbon emissions by 2050 to meet the target of climate change to have a competitive, efficient, and sustainable source of energy supply network. The Paris Agreement is a step towards the transition in energy supply to achieve the goal of a carbon-neutral EU. As we know, dealing with climate change is one of the major challenges in modern society. Therefore, the European Commission proposed a target of net GHG emissions to neutralize climate change by 2050. The Paris Agreement aims to reduce global warming below 2 degrees Celsius, but the preferred number is 1.5 degree Celsius (Sanja, 2021).

Supply of Renewable Energy Networks and Large-scale Biofuel Production

There are some extensive studies in past years relating to the development of renewable technology and optimizing technology on a large scale with a supply chain of networks. This is confirmed in the study conducted by Sanja (2021, p. 14), "This study shows that a significant amount of additional land (about 6%) is needed to achieve a climate-neutral EU. Therefore, further development of technologies should aim at minimizing land use. Offshore wind turbines and PV panels do not require additional land, full electrification of the transport sector and mastering fusion-based nuclear reactors could be examples of such technology". This study was based on criteria including geographical locations, biofuels, and renewable energy, driven by the research objective to achieve biofuel production by 2050.

Critical Analysis of Biofuel and Technology

The author Sanja et al. (2021), p. 14 "To implement the technology, there are several things that need to be considered. At the first stage, some existing technologies are available like dry goring which is a commercialized system that can be installed all over the world. Several other technologies like sugar fermentation could also be considered. The second stage, which is the most challenging stage, is the availability of biomass in abundance. To make biofuel, biomass must be available in large amounts to meet the demand and supply for clean energy. However, the production cost of the energy will be lower". To implement a sustainable energy network there must be the availability of cultivation areas along with machinery through which we can extract the oil and can store it in large facilities to ensure an uninterrupted supply chain of oil so that it can reach the end users.

4.2 Charging infrastructure and policies

In recent years, the world has faced serious climate change problems, leading to the burning of forests, drought, and floods in most of the world. These climate changes occur due to the overuse of fossil energy as most countries are today using this source of energy to power their nation. With the emergence of greenhouse gasses, most of the countries like China, India, USA, and Germany are reducing their dependencies on the use of fossil fuels. The countries have signed a cause to reduce the use of fossil energy and adopt better ways or green sources of energy to power their countries (Jang, 2020).

4.2.1 Characteristics of EV Batteries

Today, EVs are mostly equipped with Lithium-ion batteries which are the leader of the market due to their high energy lifecycle and efficiency. These batteries consist of a large number of single battery cells which are arranged in serial or parallel ways. To monitor the charging, a battery management system must be installed to manage and protect the Li-ion battery while charging. It is considered that the ideal charging with the operating range is 90% within such management.

4.2.2 EV Charging Habits

EV charging habits are one of the major concerns when it comes to sustainability. The use of energy depends on the consumers' habits of charging their vehicles. The frequency of charging a vehicle matters: the more often it is charged, the more electricity will be consumed. As the number of EV users is rising over the period, the use of energy and power is also increasing (Andresen, 2021).

4.3 VANET technology

Vanet (vehicular ad-hoc network) is a modern technology that allows vehicle-to-vehicle communication through the Internet in which various networking and communication channels are transmitted among cars. The technology was first introduced in 2001 and operates on a similar concept of mobile networking which is known as MANET (mobile ad-hoc networks). Vanet is an integral part of the intelligent transportation system as it works with the help of the Internet of Things (Shrestha, 2018).

4.4 Expansion on VANET

VANET being a modern technology could help to better traffic management in cities, especially cosmopolitan ones like New York, Frankfurt, and Mumbai. To do so, it requires further improvement and expansion as its main criteria are road safety and vehicle entertainment. As VANET is working on ad hoc networks, the system will pass the information via the wireless medium of a network (IoT) to the devices which can help to predict the possible circumstances of moving vehicles. This will form a chain of networks (Saleem, 2019) like a node that will transfer the information to other nodes. Once the information is received, it will be transferred to other nodes and this process will go on. These nodes will be an open source of networks that will be free to join or leave due to high vehicle mobility conditions.

4.4.1 Testing VANET in Critical Scenarios

It is important to test this technology to ensure its reliability in different case scenarios. While testing this technology, there must be certain variables such as the number of vehicles in a particular area, weather conditions, road temperature, and wind speed should be considered (Saleem, 2019). As stated by Duarte et al. (2021), "automobile environments are spending new set of requirements on today's wireless communication system".

The scenario explains to us that two emergency vehicles are approaching from different directions towards the intersection. They will reach the intersection almost at the same time and at least one EV may be at the intersection. Now the system should cope with this situation to avoid conflict if more than one EV shows up. To do this, it is considered that the transmitter will communicate with the traffic light controller that can control the state of traffic lights based on intersections. The transmitter will send the controller the relevant information related to EV status like speed, position, and direction. The controller will decide to handle and proceed to coordinate traffic lights to ensure a safe journey (EDUARDO, 2021). Finally, as the EV clears the intersection, Roadside Unit (RSU) will alert with a specific message from the EV or via Basic Safety Message (BSM), and this process will be broadcast continuously.

5   INITIAL CONCEPTUALIZATION MODEL

Derived from the literature review an initial conceptualization has been developed to be validated by the empirical research stage (figure 1).
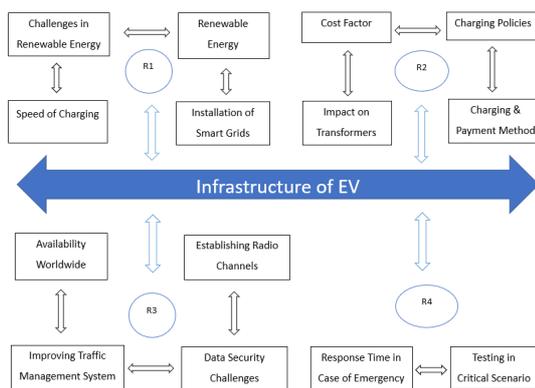
Figure 1: Initial Conceptualization Model, Image Source: Morton2021, Lee 2020, VINEL 2021.

6   RESEARCH METHODOLOGY

6.1 Research design

The objective of this research is to explore factors that reduce carbon emissions and build a sustainable infrastructure that would provide a feasible solution by eliminating different challenges as described in the literature. The research also aims to optimize the infrastructure and improve the existing technology to make it more reliable by providing examples for different scenarios. As this study is exploratory in nature, the qualitative approach is the best fit to narrow the gaps for this study.

6.2 Data collection

For data collection, 7 semi-structured interviews were conducted with open-ended questions to understand and interpret each interviewee's thinking. Purposive and Snowball Sampling were chosen as the sampling method for obtaining data information. The selection was done based on the people who are industry experts in the field of sustainability and the automotive industry. The age group from 25 to 40 years covered mostly EV Charging Experts, Senior Managers, Low Carbon Vehicles & Fuels advisors, and ambassadors for Clean Mobility.

6.3 Data analysis

Interviews that were conducted were manually transcribed and analyzed by MAXQDA. All the information like the respondent's body language, tone of voice, expressions, and gestures was considered during the process which resulted in the richness of data collection. The exchange of information and ideas from both sides was highly appreciated and showed a belief in the research. A qualitative technique was followed for analyzing the content standards, Qualitative techniques are simple, transparent, and highly reliable to master content analysis. The data were evaluated by the content analysis method suggested by Kuckartz (2019). The following categories emerged as a result of the analysis.

Categories	Procedure	Presentation	Anchor Example
Renewable Energy	Deductive	All passages mentioning about renewable energy sources, types, and challenges.	Renewable energies like solar and wind are the most crucial and dynamic solutions to fill the gap and support the charging infrastructure.
Battery Characteristics	Deductive	The passage mentioning about battery type and lifecycle in the market.	EVs are mostly equipped with Lithium-ion batteries which are the leader of the market due to their high energy lifecycle and efficiency.
Location	Inductive	The statement given by the respondent emphasizes the country's location.	"Location plays an important role and of course the climate. For example, if it's a bright sunny day, you can charge your vehicle easily".
Data Centres and Cyber Attacks	Inductive	The statement given by the respondent emphasizes data security.	"Not all the countries have capabilities to build data centers".

Table 1: Categorization Table

6.4 Renewable energy

To recap, the purpose of the study was to connect the infrastructure with renewable sources of energy that can help the environment to reduce carbon emissions and meet sustainability goals. After interviewing seven experts in the domain, it was noticed that many respondents were in favor of using renewable energy like Solar and Wind as they believed it is the cleanest form of energy. Unanimously, R1, R4, R5, and R6 highlighted the importance of renewable energy.

6.4.1 Transition

To begin with, the transition phase is a phase from which we need to switch from 1st Generation fuel to 2nd Generation fuel. Second-generation fuels are much cleaner and produce low carbon emissions. R2 emphasizes this aspect: "More energy transitions and natural development employing current enterprise resources". The respondent also highlighted that the "European Union has advanced on developing lots of policies and with the current situation in EU, they have passed some budgets to go fully on their natural resources". On the other hand, R3 mentioned: "The grids are coping in the world with all these transitions from lower to high consumption".

6.4.2 Policies

Policies are critical to creating since they drive the project in the appropriate path. In this regard, R2 has stated that "environmental regulations from the United States and China are the biggest polluters in the work like didn't like Stein?? The situation is unclear. The European Union is establishing environmental regulations to rely entirely on natural resources such as wind energy."

6.5 Supply chain

6.5.1 Labour

The aspect focuses on the manpower to build the infrastructure. This could include anyone who relates to the project like managers and workers. R1 highlights this factor: "The installation is huge, and the biggest element is the labor aspect of implementing this".

6.5.2 Raw Material

The raw material involves the supply of things that are required in the infrastructure. R1 emphasizes the availability of raw materials: "You've got to install a lot of wires, lot of cables to make it work. You know, we got to think also of the supply of the materials as the material comes from China".

6.5.3 Covid and War

One of the major concerns is to affect the supply chain of raw materials and to build the infrastructure. One of the future concerns that needs to be addressed is to develop a solution. R1 highlights "The supply chains have been affected since COVID and obviously with China being in lockdown for a couple of months as well that says affected". R2 says "Right now like with all like let's say the crisis with Russia and the Ukraine War, all the energy transitions are becoming slower, and the Issue for the EU is to move from Russian Dependency and have multiple suppliers of energy for Temporized from Africa". R3 was not sure if the raw materials were available it stated, "Since the war in Ukraine, I think it must be available". So, we can see a major impact on the supply chain due to these situations and must ensure that in the coming future, we must have different suppliers or supply chains available as a backup and not just be dependent on one variable only.

6.6 Cost

6.6.1 Household Income

An area addressed by another respondent was household income. R2 stated in this context: "Companies are taking new strands and they will be like it is necessary to reduce the consumption of the personal car. But I think it is a long process. Like me, at least in Europe, for middle- and lower-income households, just like it happens. Maybe like once in 10 or 20 years, of course, every household will change and adapt. There is time for implementing electric vehicles and creating an infrastructure around them in Europe".

6.6.2   Budget and Investment

Funds are the most essential part of any infrastructure. R1 stated: "Investments need to happen to build the infrastructure. Any specific region may have specific investment requirements which need to be considered, and there are a lot of opportunities as well". R2 confirmed the view of R1: "There is a cost of infrastructure and there will be a need for funds to make it". Furthermore, R4 supported this view as well: "You need a huge investment capital to build the infrastructure".

6.7 Location

6.7.1   Inner-city

R1 state concerning inner-city travel: "There are a lot of opportunities available and to adapt this technology by looking at the current infrastructure and charging capabilities and existing charging stations, one needs to discover the aspect on how inner-city mobility can relate to the charging. Energy renewable aspects can influence our people who may don't even have an opportunity to charge their vehicle overnight". R2 also highlights the city situation: "I am from Rome, and let's say there is traffic in the city, I believe that there should be traffic management systems linked in a trampoline creating more less energy consumption and strategically since it should be possible to introduce traffic management system so that every time a person is encouraged to reduce the demand for power and energy consumption".

6.7.2   Country and Climate

This section highlights the importance of climate estimates in various countries. R1 mentioned: "I think this matters a lot as some of them are utilizing, depending on where geographically, they are utilizing solar power to generate some power back to the units". R3 states: "In Singapore, there are 100s of 3-wheelers driving with a 5kW hour battery pack and an onboard charge is only 3.2kW. The customer doesn't require any big and fast change. The charging also depends on vehicle type and battery size".

6.8 Charging frequency

6.8.1   Charger Types

As we know, for charging EVs, there are multiple types of chargers available. R3 emphasized: "To make charging simple, there must be a solution with a single segment charger for each EV segment. For me, the perfect charging speed is always 50 kW below as the speed doesn't degrade". R4 expresses it in simple terms: "Slow charging is healthy charging as it generates less heat due to steadiness and has a very steady way of pumping energy inside".

6.8.2   Habits and Patterns

Charging of vehicles is directly connected with people's and cultural habits and it is important to track the patterns of charging the vehicle. R1 highlighted - supported by R5: "Some people like to leave the battery running flat before you charge it and then some suggest you better keep topping it up". R2 states: "People mostly charge their vehicles overnight which is the peak hour, but it also depends on the class like working class, they still charge their vehicle at night".

6.9 VANET

6.9.1   Artificial Intelligence

This category describes the role of Artificial Intelligence. R1 responds: "Reacting to an incident, AI has a big impact". R2 - supported by R3 - responds: "The system based on Artificial Intelligence could help in prioritizing the emergency levels for a vehicle, and I think GM is implementing this technology". R5 - supported by R6 - says: "Artificial Intelligence can help in finding alternative routes during peak hours and measure the response time in case of critical emergency".

6.9.2   Testing VANET

To implement this technology, it is important to test it in a real scenario. R1 specifies: "It will require high-performing computers as the camera will capture billions of photos in a real-time scenario". Similarly, R3 confirms the usefulness of the technology: "This is a very useful technology as GM is already using it as it

beeps and alerts driver before the collision". In the same vein, R5 -supported by R6- said: "It's hard to tell what the situation is. As vehicles are getting smarter, the technology will be programmed in such a way that it could alert the driver or programmed with all the possible situations that could tell the vehicle how to react before the collision".

6.10 Technology

6.10.1 Radio Communication

Radio communication will help VANET in guiding the technology to send signals over radio communication channels. R1 points to the important role of telecommunication companies: "Telecommunication companies can play a major role and they will require huge investment. It will give more chances for new talents to hire network communication experts. We can also use 5G, and 6G technology in the future". R5 relates to an infrastructural component: "We can put a communication tower near each data center to actively communicate with the vehicles".

6.10.2 Data Centers

Data centers are the structures in which all the information will be stored, and they will manage all the operations of the technology that will be available. R1 mentions in this context: "Not all the countries have capabilities to build data centers". R4 stated: "There must be a traffic management system that could logically balance the traffic".

7 DISCUSSION

Renewable energy like solar and wind can fill the gap to support the infrastructure but some areas need to be explored like the use of nuclear-based energy, and sustainable energy from Bio- Fuel. The amount of energy consumption must be calculated as the charging of an Electric Vehicle majorly depends on the Speed of charging and the impact on transformers that are transmitting the energy into the EV. During the interviews, it was found that the speed of charging can be still controlled as there are different types of chargers with specified kW's that can reduce the impact on transformers which I found to be consistent. During the research, it was important to address synergistic as well as adverse mutual effects and the overall micro-climate of the build-up area. This area was left undiscovered as it was not discussed in the interviews and it would be interesting to see how this factor will be considered during future research. Location and Data Centers were both new categories that were discovered during this research. These categories were innovative as they covered very detailed levels of information related to the inner city, country, and a center point where all the collected data will be stored that can further be used to make our EVs smarter by constantly feeding them with different data. This will make our EVs smarter as they would be programmed through blockchain on how they can react in the possible situation which can reduce the number of accidents.

8 CONCLUSION

As climate conditions are changing, it has become important to focus on Sustainability. One of the concerns was the lack of awareness amongst people about renewable energy. As pollution is increasing at an alarming rate, its effects can be seen in different parts of the world. With the Paris Agreement, the European Union along with other countries are taking some serious measures towards the environment. India is one of the major concerned nations and has strengthened its knots with Germany to achieve the goal of Carbon Neutral by 2050.

With the rise in demand for Electric Vehicles, it is important to develop and focus on new technology that is environment friendly and fulfills the need for energy production. So far undiscovered new technologies like VANET can prove very helpful in many ways. With the proper traffic management system, there will be a reduction in air pollution. Solar and Wind energy are the main source of renewable energy. As the population will rise, the energy demand will get higher which could create problems like load-shedding or blackouts in many countries.
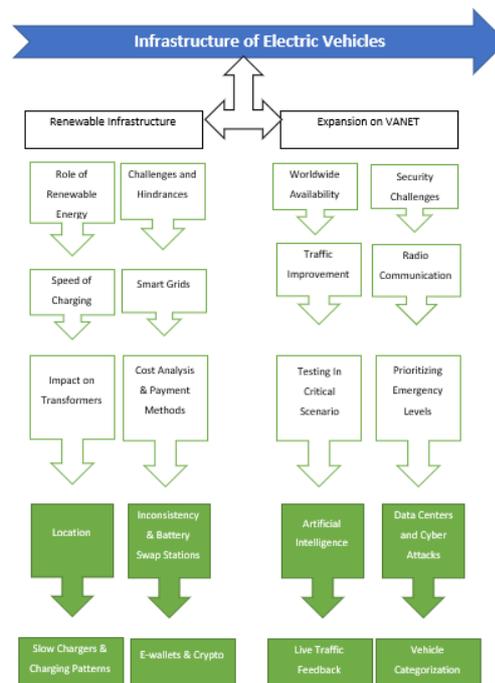
Figure 2: Final Conceptualization Model.

9   LIMITATIONS AND FUTURE RESEARCH

The research was exploratory in nature and the sample size was small based on a global sample lacking national or cultural differentiation. As a result, all interviews had to be performed online rather than in person. Future research could be done on an expansion in VANET technology along with more detailed well-developed business models as it was difficult to cover both aspects due to time limitations. There were some discussions on heat island effects in literature reviews but it also seems necessary to address synergistic as well as adverse mutual effects and the overall micro-climate of the build-up area. Future research is also suggested on how developed countries can help developing nations adapt to technology. Moreover, studies on the use of hydrogen and biomass as 2nd Generation fuel are suggested.

10   BIBLIOGRAPHY

Alireza Khaksar, Georgios Tsaousoglou, Emmanouel Varvarigos (March,2021). Sizing of electric vehicle charging stations with smart charging capabilities and quality of service requirements. Science Direct, Volume 70 Sustainable Cities and Society (2021), 102872.

Å.L. Sørensen. Andresen (August,2020). Analysis of residential EV energy flexibility potential based on real-world charging reports and smart meter data. Science Direct, Volume 241 Energy & Buildings (2021), 110923.

Abbas Dallatu Umar, Ammar Alkahtani (April,2021). Review of Renewable Energy-Based Charging Infrastructure for Electric Vehicles. Research Gate, Wind Energy Research.

Atif Iqbal, Fareed Ahmad, (January,2021). Optimal Location of Electric Vehicle charging station and its Impact on distribution network: A Review. Science Direct, Energy Reports 8 (2022), 2314-2333.

Alexander Thomas Hayes, Abhishek Gaur, Henry Lu (June 2022). Nature-Based Solutions (NBSs)to Mitigate Urban Heat Island (UHI) Effects in Canadian Cities. MDPI.

Can Liu, Yu Li (November,2021). A hybrid approach to trust Node Assessment and Management for VANETs Cooperative Data Communication: Historical Interaction Perspective. IEEE Explore, Transactions on Intelligent Transportation System, (2021).

Chao Hong, Yupeng Wang (July 2022): Cool facades to mitigate urban heat island effects. Sage Pub. Indoor and Built Environment 2022, Vol. 31(10) 2373-2377.

Eduardo Duarate, Luis Antonio (November,2021). Safe Smart: A VANET system for faster responses and increase safety in Time-Critical Scenarios. IEEE Explore, Volume 9, (2021).

Gamal Alkawsi, Yahia Baashar & Ammar Ahmed Alkahtani (March,2021). Review of Renewable Energy -Based Charging Infrastructure for Electric Vehicles. Science Direct, Renewable, and Sustainable Energy Reviews, Volume 153, (2022).

H.S DAS, M.M. Rahman (November,2019). Electric Vehicle standards, Charging Infrastructures, and Impact on Grid Integration: A technology review. Science Direct, Renewable, and Sustainable Energy Reviews, Volume 120, (2020).

L. Sumia, V. Ranga (November,2017). Intelligent Traffic Management System for Prioritizing Emergency Vehicles in a Smart City. Research Gate, International Journal of Engineering, Transactions B: Applications, Sensor Enables Internet of Things for Smart Cities (2018).

Rajdeep Kaur, Tejinder Pal Singh (May,2018). Security Issues in Vehicular Ad-Hoc Network (VANET). IEEE Explore, 2nd International Conference on Trends in Electronics and Informatics (ICOIE), (2018), 18290893.

592

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Shaikh Sharique Ahman, Prof. Hiralal Solunke (July 2018) Simulation and result analysis of VANET-based Self Adaptive Prioritized Traffic Signal Control. Academia Education, International Journal of Scientific Research in Computer Science and Information Technology, Volume 3, Issue 6, (2018).

Sanja Potrc, Lidija Cucek, (August,2021). Sustainable Renewable Energy supply networks optimization- The gradual transition into a renewable energy system within the European Union by 2050. Science Direct, Renewable, and Sustainable Energy Reviews, Volume 146, (2021), 111186.

Subhash Kumar Ram, Sachin Devassy (June 2021). Review on Renewable Energy based EV charging system with grid support functionality. IEEE Explore, 7th International Conference on Advanced Computing and Communication Systems (ICACCS), (2021),20799999.

Katie Emory, Frank Douma (August 2021). Autonomous vehicle policies with equity implications: Patterns and gaps. Science Direct, Transportation Research Interdisciplinary Perspectives 13, (2022), 100521.

Xiaohu Chen, Anjia Yang, (June,2022). A Multi signature-based secure and OBU- Friendly Emergency Reporting Scheme in VANET. IEEE Explore, Internet of Things Journal, (2022).

Zachary J. Lee, Cheng Jin (September 2021). Adaptive Charging Networks: A Framework for Smart Electric Vehicle Charging. IEEE Explore, Transactions on Smart Grid, Volume 12, No.5, (2021).

Overall Layout of Socialist and Post-Socialist Large Housing Estates in Croatia

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1 ABSTRACT

The study compares the overall layout of socialist (old) and post-socialist (new) large housing estates (LHEs) in Croatian large cities that depends on daily basis equipment and public infrastructure. The existence and quality of primary facilities and infrastructure is different in new settlements, where it is more often reduced in comparison to old settlements. The main differences occured during the last three decades of transition and market-led economy adopted by Croatia, when the construction of multi-family buildings became commercial and private, and when the construction of urbanistically planned housing estates as housing units became mostly abandoned. For the analysis, the qualitative method of semi-structured interviews with experts (N=26) was used, which was conducted in Croatia during 2022 as part of a joint and bilateral project between Croatia and Slovenia. The current study analyses attitudes of experts on how socialist and post-socialist LHEs in four major Croatian cities (Osijek, Rijeka, Split, and Zagreb) fulfill residents' daily, primary level needs. Experts show that it is the level of neighborhood in which elementary differences in these estates can be seen, and that basic facilities used daily by the residents (school, kindergarten, health center, public transport, green spaces, public spaces etc.) often lack in new residential construction. Therefore, at the level of estates, socialist estates show that they are often better equipped than post-socialist estates, with more public and green spaces and facilities. Due to a large density of building during the transition period new housing estates experience a reduction in public services, green areas and equipment, and therefore a neglect of residents' needs. New residential construction is shown to be reduced in terms of the multifunctionality of space and estate, which should be urbanistically, sustainably and ecologically desirable, but it is often not the case. Thus, the architectural appearance of the post-socialist estate is inadequately adaptive for the residents, because it is too densely built and inhumane in its overall layout, with inadequate infrastructure and facilities, unlike the socialist estates that are, although older and more derelict, more desirable to the residents for everyday living. It is therefore necessary to regulate the future process of planning and housing construction through the national legal framework.

Keywords: primary neighbourhood equipment, residential satisfaction, old (socialist) and new (post-socialist) large housing estates, quality of housing, comparative analysis

2 INTRODUCTION

The study is related to a research conducted bilaterally between Slovenia and Croatia[1] that aimed to analyse the quality of housing and estate equipment at the level of both states, and to explore the residents' perception on housing in large housing estates of the socialist and post-socialist period. Large housing estates built after the Second World War in the socialist system period (1945-1990) were comparatively selected, along with new or post-socialist estates built in the period of transition, or the post-socialist period, respectively (after 1990). Two types of estates in these neighboring countries have a similar history of development of large housing estates, both in the former system in Yugoslavia, and after the 1990s, since their independence until today. This common tradition is in the context of housing policy interesting for comparison in the research and scientific sense, but also for bringing certain recommendations for possible improvements and renewal of housing estates and multi-family buildings at the level of each particular country. Nevertheless, the aim of the present analysis was only Croatia and its sample of largest cities, because the common methodology did not employ all identical mehods.

The joint project included the use of mix methodology, i.e. the quantitative method of questionnaire survey and the qualitative method of focus groups, conducted at the level of both countries. Nevertheless, for the purpose of this paper there was not enough space to present all the employed methods and obtained results.

Additionally, in Croatia the qualitative method of semi-structured interviews with experts was also carried out, which was not conducted in Slovenia, so that we decided to present only the basic findings of this qualitative method. Therefore, the current study will explore how experts in Croatia see socialist and post-socialist LHEs comparatively between these two types of estates, socialist and post-socialist. The content analysis of experts' attitudes, whose domain of work is related to spatial and urbanistic topics, explored to what extent the differences between these estates are present at the level of neighborhood and everyday life, and of their overall layout. It was especially analysed how much LHEs fulfill residents' daily needs for public and green spaces and facilities, and what suggestions and improvements they offer. These improvements are important in the context of potential renewal and revitalization of old, and improvement of life quality in new estates. As Croatian national housing policy is still in the process of development, and political and legal formulation, it needs to be pointed out that it is still trying to adapt to existing European trends, declared primarily in The New Leipziger Charter, 2020 and the New Urban Agenda 2023. In these documents, basic principles of development of contemporary cities are highligthed, such as sustainable, safe, inclusive, green and resilient cities. Nevertheless, everyday life in Croatian LHEs, especially in the largest cities, demonstrates how much these principles are still deviated from and hard to implement. In that sense, there is a national housing strategy envisioned for 2024 in Croatia, which could additionally strengthen a more sustainable and nature-based developmental direction, which has to this point been minimal.

3 SOCIALIST AND POST-SOCIALIST LHES

For Croatia it could be said that it belongs to Central and Eastern European pathway (Dekker et al., 2005) characterized by a significant percentage of former housing estates in the existing housing stock, and a more positive image of living in estates of this type than is present in the estates of Western cities. The estates of Western and North European cities far more often feature numerous social problems linked with economic poverty and issues of segregation and stigmatization (Dekker et al., 2005; Hess et al., 2018), which are for now rarely present in Croatian estates, and residents mostly feel safe and do not wish to move out from them.

Fig. 1: Socialist estate in Zagreb with more public and green space. Source: authors

Similar to other European countries, especially the ones of the former Eastern bloc, LHEs in Croatia were built primarily to resolve the housing issues within the broader processes of post-war regeneration, state-level industrialization and mass urbanization. Socialist LHEs (Figure 1) were supposed to provide housing mostly for the members of working and middle-class in the cities of the newly industrialized society (Rogić, 1990; Sendi and Kerbler, 2021). Because of that mass and urgent need for housing production in socialist LHEs, often cheap and prefabricated elements and suboptimal architectural and constructional solutions were implemented (Hess et. al., 2018; Pojani and Barr, 2016; Nedučin et al., 2019), but they were also built with solid reinforced concrete construction, which even today gives them a safe and good quality of housing in high-rise buildings. LHEs were often located on the periphery of the cities resulting in more dispersed

housing, spatial isolation, higher costs of commuting, higher infrastructure costs, and higher energy costs (Hegedüs et al., 1996, 106; Hegedüs and Tosics, 1998). High building density, monolithic design and focus on residence were the customary characteristics of socialist LHEs (Seferagić, 1988; Rogić, 1990; Dekker and Van Kempen, 2004; Musterd et al., 2017) and after more than 50 years most of them became neglected and deteriorated. Therefore, with the passage of time, in combination with poor maintenance and management, housing in these estates often led to further decay of external and internal layout of buildings (problem with elevators, dilapidated facades, old windows, bad roofs, poor isolation etc.), and with neglected built environment and public infrastructure in the estates (Seferagić, 1988; Černič-Mali et al., 2003; Svirčić Gotovac et al., 2021).

The new, post-socialist housing estates (Figure 2) are those built after 1990, and they could be independent housing units, but also building complexes interpolated into already existing estates. Most of the new residential construction situated either on city outskirts or in the city zones, is being built "in spots" (Svirčić Gotovac, 2015). These new housing locations were built by private investors and real-estate entrepreneurs looking for extra profit in the housing sector. Almost three decades since, these locations in large cities are overbuilt and lacking basic infrastructure requirements and public facilities for daily urban life. All this puts extra pressure on the old estates, formerly better urbanistically planned as autonomous housing units with basic and additional infrastructure (services, public institutions, public and green spaces, etc.) (Svirčić Gotovac, 2015). In Croatian cities, commercialization and gentrification that has occurred in the newer housing estates, has thus created large contrasts between old buildings and new ones. Destructed and overbuilt public spaces often "become a battleground in the competition between different users" (Madanipur, 2004, 271; Petaccia and Angrilli, 2020; Vasilevska et al., 2014). There is also not only a physical lack of space, but also a lack of the social content necessary for different activities that would meet the sociability needs of all their residents, no matter of their age, socio-economic status and cultural background (Petaccia and Angrilli, 2020), especially of children and the elderly population. Lack of public and green spaces especially in the summer months, threatens, for example, the residents' stay in outdoor spaces and often leads to high temperatures in these city zones that are not pleasant for housing. Thereby, in the context of public health, specific groups of residents are at additional risk, particularly children and the elderly.

Fig. 2: Densely built post-socialist estate in Zagreb. Source: authors

Therefore, it is not surprising that socialist LHEs, because of their better equipment, spatial and urbanistic layout, still maintain their reputation as desirable places to live (Kovacs and Herfert, 2012; Grossmann et al., 2017). It is the urban design of these estates, with an adequate ratio of green spaces (parks, walks, tree alleys) and public services (kindergartens, schools, health center) that brings an additional positive image of residing in them, 50 and more years after their construction. This difference occuring between socialist and post-socialist estates affects the perception both of residents and experts, the latter particularly pointing to it.

4 QUALITY OF HOUSING ENVIRONMENT

The existence and quality of public facilities should improve the quality of housing environment and quality of living in the neighborhood, and could add to its use value (Seferagić, 1988; Svirčić Gotovac, 2015). When a housing estate has well-developed equipment, its use value is high. An ill-equipped housing development does not satisfy the needs of its residents and its use value is low. Furthermore, the perception of these attributes of the estate is important for the residents' overall feeling of satisfaction, and influences the decision on a possible relocation (Sirgy and Cornwell, 2002). Sirgy and Cornwell (2002) also state that the dissatisfaction with the physical attributes of the estate, such as the disrepair of buildings, yards and environments, is important for the residents' overall feeling of satisfaction with housing environment. Outdoor services or elements may contribute to the quality of the housing stock, urban design, physical appearances, cleanliness, quality of public space, safety, etc. (Van Gent, 2009; Diaz-Serrano, 2006). In general, it can be said that the perception of the neighborhood is a result of the interplay between various factors (Pan Ké Shon, 2007). They often depend on specifically and spatially driven urbanistic standards by which everyday resident's needs could be better fulfilled.

Thus, in the post-socialist context of housing in Croatia the notion of the so called spatial standards, which has for decades defined the basic urbanistic parameters of the housing estates' development, is gradually lost. Therefore, analyzing the standards of housing and their equipment by comparing the spatial standards for building and the urbanistic-technical conditions of building set in the Zagreb Master Plans of 1971, 1986, 2000, 2003 and 2007, it can be concluded that for decades they have been gradually reduced, and some disappeared completely (Jukić et al., 2011, 103). The problem is in inconsistent implementation of existing urbanistic regulations, for example by the loss of the role of the General Master Plan. This has led to the problem of commercialization of the urban space and the loss of the housing estate standard, and the so called scattered building that even in the new housing locations often leads to the downfall of the quality and equipment of housing estates, and eventually lowers the residents' satisfaction (Svirčić Gotovac et al., 2021). Therefore, the main differences can be seen in the level of neighborhood basic equipment with utilities/facilities used daily by the residents (school, kindergarten, health center, public transport, green spaces, public spaces etc.), which is in new housing estates reduced and inadequate (Svirčić Gotovac and Đokić, 2023), and also by the experts who emphasize these disadvantages and unbalanced housing development, often not in line with the European sustainable and Nature-based solutions (Bush & Doyon, 2019; Zlatar Gamberožić et al., 2021; Snep, et al., 2023).

5 METHODOLOGY

5.1 Semi-structured interviews with experts

The method of semi-structured interviews with experts was within the project conducted only in Croatia. This paper presents results obtained from semi-structured interviews with experts from Croatia, and the thematic and content analysis of the interviews was related to LHEs and the quality of life in them with regard to the two explored periods. In the analysis of results, the emphasis was put on experts' opinions on the situation in Croatian cities, and the attitude of urban policy towards the built and housing space in the context of everyday life and residents' needs.

The total number of experts interviewed by the researchers was N=26, and the majority were according to their specific scope of work from the architectural and urbanistic profession (18), then the urban-sociological (6), civil engineering (1), and the art historical (1). The interviews were carried out during 2022, from April till September in 4 Croatian cities (Zagreb, Split, Rijeka and Osijek), according to an a priori developed writing protocol. Most interviews with experts were conducted in Zagreb (13), Rijeka (6), Osijek (5) and Split (2). The questions from the protocol were then additionally adjusted to the specific professional working domain of a particular expert. The duration of talk per an interview was 40 minutes. Interviews were recorded by a dictaphone and transcribed, and data was analysed in NVivo-12. Ethical consideration included informing the respondents about the purpose of the research, and guaranteeing them confidentiality.

6 RESULTS

The coding of obtained data was conducted at thematic level, which was building on the specific research questions (Elliot, 2018), and the analysis resulted in the following two thematic codes: a) advantages and disadvanatages in LHEs and b) partial urbanism and planning process today.

In the first thematic unit called advantages and disadvantages in LHEs, statements of experts of various profiles were extracted, in which they mostly pointed out the shortcomings of new estates visible in excessive building and reduced green and public areas, such as squares and streets, while advantages of old estates were underlined.

As of green areas, I think that a big problem is that 'toothless' building. We increase the density, which is not followed by public areas. Nothing of new parks, children's playgrounds, and here is a kind of an imbalance. We increase the number of people, and that's why old estates appear better in that sense. (architect, Osijek).

Further, it is pointed out that "generally, it can be assessed that housing estates lack green areas and public space, primarily the one that is designed and functions as a public area of pedestrian character (square, street) with the central amenities of the estate" (architect, Rijeka), and that it is a fact for most housing estates in Croatia.

Such a situation is present primarily in new estates, which are also called 'parasite', due to their frequent reliance on old infrastructure from the socialist period. This happens because new infrastructure is not built, so most of accompanying public institutions and services are missing.

We have these buildings that I call parasite buildings. So, investor, if he/she has a 5-meter access to a road, nobody checks whether he/she has further access, then whether the capacity of kindergartens is adequate, the capacity of schools, etc. (architect, Zagreb).

Nevertheless, besides disadvantages, they also pointed out certain advantages of new estates, such as better building quality, better solutions for traffic and parking spaces, and their better demographic structure (more families with children) 'preventing' them from further degradation and neglect, present in older estates.

The advantage of "new" estates lies in the better quality of building, solving of stationary traffic (in the greatest number of cases), better demographic structure and a relatively balanced social structure (architect, Rijeka).

In the second thematic unit called partial urbanism and planning process today statements on an inadequate process of planning were pointed out, the one that no longer cares for the quality of housing, but instead for the occupation and consumption of space by new and permanent building. Additionally, certain neglect of public spaces is pointed to in new estates, which are on the other side reduced only to a street, but not to a structure of estate as a whole.

In new estates public spaces are almost non-existent, because what the market, finances, investments do is leads to a situation in which they are willing to sell everything that can be sold. In former times during the social ownership, it was not that important to sell everything, but the quality of housing was what mattered. And this is our problem (architect, Osijek).

The relation towards public space and estate is abandoned or criticized, as something that is not structured, and the concept of street is affirmed. When you look at certain solutions, it is visible that there is a vagueness of public space, which is between semi-neglect and neglect (sociologist, Zagreb).

They also point out the importance of regulations in spatial documentation for instance for green areas, which are omitted, and due to which the neglect of public space happens. Today they are viewed in the urbanistic process as a 'loss', because they do not yield profit and cannot be commercialized. Experts see in it the guilt of both their own profession and the legal framework at the level of state, which has adjusted to the post-socialist transformation of space.

Unlike for some other areas, not the smallest regulations are prescribed for the dimensioning of green areas. In the nowaday situation, when green infrastructure is so much emphasized, there should be at least some binding basics of dimensioning established, because the practice of spatial/urbanistic planning shows the following: public green areas are treated as a "loss" of space (no commercialization oportunity), expense for the state budget (buying of the land and further actions), and the support is lacking even within the architectural profession, which is primarily oriented towards designing (architect, Rijeka).

The expert then emphasizes the difference between urbanisms of these two periods, pointing out their different values and concluding "it could be ascertained that with time the civil engineering quality of building has risen, while the urban and esthetic has declined".

On the other side, it is stated that there is awareness on the importance of adopting the sustainability paradigm and, within it, of strengthening of the participation process of citizens and local community, i.e. neighborhood, who themselves need to work more actively on the raising of life quality in a sustainable and contemporary way.

LHEs in the future – if wishing to ensure the quality of life to their residents, will have to include sustainability paradigms. It means green, but also social sustainability, relying on participation, local community, and eventually, on the readiness to connect together in one sustainable social community (sociologist, Zagreb).

According to the statements of experts, it can be concluded that there is a clear difference between the two examined types of estates in terms of urbanistic standards for providing the neighborhood with infrastructure and equipment. The standards related to public infrastructure were more adequate in the socialist period than during the processes of shifting to market capitalism and privatization, introduced from the 1990s onwards. Nowaday context of urbanism has brought a gradual reduction of standards visible in urbanistic plans, and in the housing construction that was not equipped with complementary infrastructure. An overview of the largest differences in the built primary and public infrastructure is presented in Table 1.

BASIC INDICATORS	Socialist estate	Post-socialist estate
school	often built	rarely built
kindergarten	often built	rarely built
green spaces/parks	often built	reduced on smaller place
children's playground	often built	reduced on smaller place
health center	predominantly exists	does not exist
market place	predominantly exists	does not exist
parking places	inadeguate (for today's car number)	inadequate (the advantage is the occasionally construction of underground garages)

Table 1: Built primary and public infrastructure in socialist and post-socialist estates. Source: authors.

7 CONCLUSION

In the current study, it was explored how experts for spatial themes in Croatia see socialist and post-socialist LHEs in the comparative sense of these two types of estates. The content analysis of experts' attitudes revealed that there are significant differences between these estates at the level of neighborhood and everyday life quality, but also the overall layout of these estates. The thematic analysis of interviews with experts points out that in the previous, socialist, system it was easier to protect and build public spaces because there was no market, which nowadays evaluates space differently, i.e. only to the extent at which it brings profit. Urban design of housing spaces used to be planned as a housing unit, which had certain spatial standards and regulations, which were in the post-socialist period brought into question or even partly lost. Thus, a space for significant commercialization of housing space was left open, and for private investments and thickening of the remaining city space, primarily for housing purposes. Professional remarks especially of the architectural profession emphasize that nowaday practice of spatial and urbanistic planning in Croatia shows that public green areas are treated as a "loss" of space that does not bring additional profit, and that they are often viewed only as an expense for the state budget. This way investing in them is either postponed or minimized, and urbanism is replaced with the process of designing, but not planning, at least not on the long term. In that context, in the last three decades public interests have been continuously threatened and destructed in Croatian cities, especially the largest ones. In addition, it can be emphasized that the basic foundations of development of contemporary cities such as sustainable, safe, inclusive, green and resilient principles are better incorporated in the old, or socialist, than in the new, or post-socialist, estates. At the national level it is therefore important to bring a housing strategy by which further housing construction would be controlled and planned more clearly, and which would be based on the mentioned nature-based principles.

600

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Current lack of urbanism and urbanistic standards is particularly visible in new housing estates, which are mostly overbuilt with housing construction and suffer from reduction of public and green areas and basic services. Thus, the architectural appearance of the post-socialist estate is inadequately adaptive for the residents, because it is too densely built and inhumane in its overall layout, with inadequate primary and public infrastructure and facilities. Therefore, despite the old age and neglect of old estates, their advantages in equipment with accompanying infrastructure are pointed out, which was urbanistically planned in the former system and is more adoptive in the architectural sense. With regard to the differences occuring between these estates, experts conclude that it is necessary to follow and incorporate European sustainable trends on liveable, resilient and green cities so that the quality of life and housing at the level of neighborhood would be raised, especially in new estates. This is possible with nature-based solutions by turning the remaining unused spaces into public and green spaces (urban parks, urban gardens, more bicycle paths and recreational zones, etc.) at a small-scale level. In this process it is necessary to activate also the local community and the residents themselves, so that they could reach concrete improvements more successfully. Finally, although the recommendation for the first phase of changes is aimed at short-term solutions, because long-term are harder to achieve and oblige the city and state authorities to be involved, for the second phase it is recommended that exactly the city and state institutions become more intensively involved in urban development, so that post-socialist cities would come closer to desirable European trends.

8 REFERENCES

BUSH, Judy, and DOYON, Andréanne: Building Urban Resilience With Nature-based Solutions: How Can Urban Planning Contribute? In: Cities, vol. 95, pp. 102483, Elsevier BV, 2019.

ČERNIČ MALI, Barbara et al.: Large Housing Estates in Slovenia. Overview of developments and problems in Ljubljana and Koper, RESTATE report 2g, Faculty of Geosciences, Utrecht University. Utrecht, 2003.

DEKKER, Karien et al.: Restructuring large housing estates in European cities: an introduction. In: R. Van Kempen, K. Dekker, S. Hall and I. Tosics (eds) Restructuring large housing estates in Europe. Pp. 1-17, University of Bristol, Bristol, 2005.

DEKKER, Karien, and VAN KEMPEN, Ronald: Large Housing Estates In Europe: Current Situation And Developments. In: Tijdschrift Voor Economische En Sociale Geografie, vol. 95, no. 5, pp. 570–77, Wiley, 2004.

DIAZ-SERRANO, Luis: Housing satisfaction, homeownership and housing mobility: a panel data analysis for twelve EU countries, IZA Discussion Papers, No. 2318, Institute for the Study of Labor (IZA), Bonn, 2006.

ELLIOT, Victoria: Thinking about the Coding Process in Qualitative Data Analysis. In: The Qualitative Report 23(11), pp. 2850-2861, 2018.

GROSSMANN, Katrin, et al.: Understanding the Social Development of a Post-socialist Large Housing Estate: The Case of Leipzig-Grünau in Eastern Germany in Long-term Perspective. In: European Urban and Regional Studies, vol. 24, no. 2, pp. 142–61, SAGE Publications, 2015.

HEGEDÜS, József, et al.: Transition of the housing sector in the east central European countries. In: Review of Urban & Regional Development Studies, vol. 8, no. 2, pp. 101–36, Wiley, 1996.

HEGEDÜS, József and TOSICS Iván. "Towards New Models of Housing System Social Change and Urban Restructuring in Central Europe", in G Enyedi (ed) Social Changes and Urban Restructuring in Central Europe. pp. 137-168, Akademia Kiado, Budapest, 1998.

HESS, D. Balwin et al.: Lessons learned from a pan-European study of large housing estates: Origin, trajectories of change and future prospects. In: B. D. Hess, T. Tammaru and M. Van Ham (eds) Housing estates in Europe: Poverty, ethnic segregation and policy challenges. Pp. 3-31, Springer, 2018.

JUKIĆ, Tihomir et al.: Zagreb - Stanovanje u gradu i stambena naselja, Zagreb: Sveučilište u Zagrebu, Arhitektonski fakultet, Zavod za urbanizam, prostorno planiranje i pejsažnu arhitekturu, Gradski ured za strategijsko planiranje i razvoj Grada, Zagreb, 2011

KOVÁCS, Zoltán, and HERFERT, Günter: Development Pathways of Large Housing Estates in Post-socialist Cities: An International Comparison. In: Housing Studies, vol. 27, no. 3, pp. 324–42, Informa UK Limited, 2012.

MADANIPOUR, Ali: Marginal Public Spaces in European Cities. In: Journal of Urban Design, vol. 9, no. 3, pp. 267–86. Informa UK Limited, 2004.

MUSTERD, Sako, et al.: Socioeconomic Segregation in European Capital Cities. Increasing Separation between Poor and Rich. In: Urban Geography, vol. 38, no. 7, pp. 1062–83, Informa UK Limited, 2017.

NEDUČIN, Dejana et al.: Post-socialist Development and Rehabilitation of Large Housing Estates in Central and Eastern Europe: A Review. Tehnički vjesnik, 26(6), pp. 1853-1860, 2019.

PAN KÉ SHON, Jean-Louis: Residents' Perceptions of Their Neighbourhood: Disentangling Dissatisfaction, a French Survey. In: Urban Studies, vol. 44, no. 11, pp. 2231–68, SAGE Publications, 2007.

PETACCIA, Nicola and ANGRILLI, Massimo: Regeneration in European Post-socialist Cities. WIT Transactions on the Built Environment, WIT Press, 2020.

POJANI, Dorina and BAAR, Kenneth: Multi-family Housing Management in Post-socialist Countries: The Albanian Experience. In: Journal of Housing and the Built Environment, vol. 31, no. 4, pp. 743–60, Springer Science and Business Media LLC, 2016.

ROGIĆ, Ivan: Stanovati i biti: rasprave iz sociologije stanovanja [Living and Being: Debates in Sociology of Housing]. Sociološko društvo Hrvatske, Zagreb, 1990.

SEFERAGIĆ, Dušica: Kvaliteta života i nova stambena naselja [Quality of living and New Housing Estates]. Sociološko društvo Hrvatske, Zagreb, 1988.

SENDI, Richard, and KERBLER, Boštjan. "The Evolution of Multifamily Housing: Post-Second World War Large Housing Estates versus Post-Socialist Multifamily Housing Types in Slovenia. In: Sustainability, vol. 13, no. 18, pp. 10363, MDPI AG, 2021.

SIRGY, Joseph M. and CORNWELL, Terri: How Neighborhood Features Affect Quality of Life. In: Social Indicators Research, 59, pp. 79-114, 2002.

SNEP, Robbert P. H., et al.: Social Housing as Focus Area for Nature-based Solutions to Strengthen Urban Resilience and Justice: Lessons From Practice in the Netherlands. In: Environmental Science & Policy, vol. 145, pp. 164-174, 2023.

SVIRČIĆ GOTOVAC, Anđelina and ĐOKIĆ, Ratko: Osnovni pregled rezultata o kvaliteti života u stambenim naseljima iz socijalističkog i postsocijalističkog razdoblja u Hrvatskoj i Sloveniji. [Basic overview of quality of life results in housing estates from the socialist and of the post-socialist period in Croatia and Slovenia]. Institut za društvena istraživanja u Zagrebu, Biblioteka Posebna izdanja, Zagreb, 2023.

SVIRČIĆ GOTOVAC, ANĐELINA, et al.: The Quality of Life in Housing Estates in the Context of West-European and Post-Socialist Countries. In: Geoadria, vol. 26, no. 2, pp. 143–66, University of Zadar, 2022.

SVIRČIĆ GOTOVAC, ANĐELINA: New housing estates in the settlement network of Zagreb – community infrastructure. In A. Svirčić Gotovac and J. Zlatar (eds) The quality of living in new housing estates in the settlement network of Zagreb. Institut za društvena istraživanja u Zagrebu, Posebna izdanja, pp. 45-72, Zagreb, 2015.

The New Leipzig Charter: The transformative power of cities for the common good. (2020). https://futurium.ec.europa.eu/sites/default/files/2021-03/new_leipzig_ charter_en.pdf

VAN GENT, Wouter P.C: Estates of Content: Regeneration and Neighbourhood Satisfaction. In: R. Van Kempen, S. Musterd and R. Rowlands (eds) Mass Housing in Europe: Multiple Faces of Development, Change & Response, pp.77-100, Hampshire, 2009.

VASILEVSKA, Ljiljana, et al.: The Effects of Changes to the Post-socialist Urban Planning Framework on Public Open Spaces in Multi-story Housing Areas: A View from Nis, Serbia. In: Cities, vol. 36, pp. 83–92, 2014.

ZLATAR GAMBEROŽIĆ, Jelena, URSIĆ, Sara and VUKIĆ, Jana: Socio-prostorni pristup definiranju i istraživanju otpornosti i održivosti. In: Socijalna ekologija 30, br. 3, pp. 369-393, 2021.

602

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Paratransit, Built Environment, and Urban Mobility – a Responsive Relationship

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1 ABSTRACT

Transit and mobility in developing countries are crucial issues, achieving appropriate mobility in residential neighbourhoods can be a huge challenge; due to the complex urban structure of the built environment and the prevalence of paratransit service that evolved to fill the formal public transportation system gap. This paper tries to answer the dilemma of the chaos and informality in local urban mobility inside residential neighbourhoods in Egypt through a systematic review that analyzes paratransit service in Egypt, discusses its role in supporting local urban mobility, and analyzes its relationship to the built environment in the local urban context regarding land use, accessibility, and socio-economic conditions.

To conduct this study, a comparison is made between paratransit services in Egypt and in some Asian countries that depend on paratransit as an official system that has its laws and guidelines and operates in an integrated manner with public transit. Also, a residential neighbourhood that depends mainly on paratransit in local mobility was selected in Alexandria, Egypt, and several components were assessed through the neighbourhood including service characteristics, pattern of movement, stops, congestion zones, regulations, safety … etc.

The results of the study highlight the deficiencies in Egyptian laws and regulations concerning the planning and design of residential streets and neighbourhoods to accommodate paratransit service. and recommend some regulations to be covered to achieve better local mobility inside residential neighbourhoods.

Keywords: Urban mobility, Built environment, Paratransit, Accessibility, Mobility planning

2 INTRODUCTION

Unlike most developed countries worldwide, which work to develop smart and sustainable mobility plans for people, including all means of transportation (train, metro, light rail, BRT, bus, and bicycle), most developing countries barely have any vision for a better and integrated transportation system. According to the United Nations' Sustainable Development Goals 2030 (SDGs), Goal 11: sustainable cities and communities "make cities and human settlements inclusive, safe, resilient, and sustainable"(United Nations 2015), where mobility is a main target to provide sustainable public transportation system that ensures safety, affordability, and accessibility for all people. However, in developing countries, transportation lacks the primary qualities for adequate urban mobility that are centered on: affordability, availability, accessibility, acceptability, safety, and sustainability (El-Khateeb 2017). Moreover, the prevalence of paratransit service that covers more than 60% of the transportation network is considered a main challenge for these countries (Williams, White et al. 2015, Behrens, McCormick et al. 2016).

Paratransit is an informal and semi-formal network that evolved to fill the gap in the formal public transportation system which does not respond quickly to the population growth and mobility demands in developing cities, and mitigate poor accessibility in low-income communities (Lubis, Buchori et al. 2020, Acheampong, Lucas et al. 2022), it has no specific routes, stops, schedule, or fare, and always develop in response to customers' demand (Cervero 2000, Cervero and Golub 2007, Finn 2012).While some see paratransit as a threat that weakens the transportation system of the city and causes congestion, others find it an opportunity for sustainable mobility. Paratransit network is complex, it is not a sign of informality or rural areas, It appears in most urban regions of cities, reaches the zones where the public transit failed to cover, and provides excellent accessibility. Consequently, it should be recognized as a constituent component of the public transportation system, and there is a need for an integration between the formal and paratransit systems, where the two systems serve each other in a reconciliation (Gota 2018, Talamini and Ferreira 2019).

Service between urban, rural, and peripheral zones is provided by paratransit, which begins at the neighbourhood level and adapts to reach main transit stations, markets, and core parts of the city, and serves as intermodal connections to the formal public transportation system (Gamble and Puga 2017, Talamini and Ferreira 2019). It operates mainly in the zones surrounding the main transit stations and stops, carries

commuters from their place to destination, and ensures accessibility to the zones outside the catchment areas of the mass transit, so its role is important however its spontaneity is an obstacle.

This paper focuses on the informal transit in Egypt as a constituent of paratransit. It reviews and examines the laws and regulations of informal transit in different developing countries, especially in Asia, compares it to the current situation in Egypt, and highlights the main shortcomings and recommendations that should be taken into consideration to achieve an adequate integration between formal and paratransit systems. The paper's structure will continue as follows: section 3reviews the literature on paratransit and previous studies in developing countries and compares it to Egypt, section 4discusses the parameters of the built environment that affect urban mobility, section 5 presents the selected case study, findings and discussion, section 6 the main conclusion is given, and section 7 is concerned about recommendations and intervention scenarios.

3 PARATRANSIT IN DEVELOPING COUNTRIES

Paratransit is mainly concentrated in developing countries, and low and middle-income communities, its modal share represents nearly 50% in Asia, 80% in Africa, and 70% in South America(Salazar Ferro 2015, Behrens, McCormick et al. 2016). However, some countries have succeeded in dealing with, organizing, regulating, legalizing, and converting it into a complete local mobility network that operates in harmony with the official transportation system. While others are struggling to accommodate.

Paratransit mobility depends on affordability, availability, reliability, door-to-door accessibility, comfort, flexibility in schedule, routes, and stops, and speed of the service(Lubis, Buchori et al. 2020). However, many problems are associated with it, including traffic congestion, road accidents, noise and air pollution, and fuel consumption. Many scenarios were set up to overcome these problems including age-based retrofit programs, emission-based regulations, use of electric vehicles, fuel economy standards, and restrictions at sometimes.(Hook and Fabian 2009). WHO (2017)put strategies for paratransit accident reduction to ensure safer vehicles, roads, mobility, and road users' safety, and improve the built environment parameters and road infrastructure to accommodate different mobility options. This includes some interventions including exclusive paratransit lanes, traffic calming, improving road conditions, widening sidewalks, providing cycling facilities, providing vehicles with antilock brake systems and headlights, enforcing drivers to compulsory training, mandatory licensing of vehicles, enforcing speed limits, and enforcing alcohol and medical legislations.

3.1 Paratransit in Asia

The most successful paratransit models can be found in Asian countries like India, Thailand, Bangladesh, the Philippines, and Indonesia. The annual expansion average rate in paratransit system in these countries is 7% and their fleets are expected to double every five years especially the two and three-wheeler vehicles which currently constitute close to 30% of total motorized vehicles worldwide and is expected to reach 1.5 billion vehicles by 2050 (Kumar, Singh et al. 2016, Gota 2018).

3.1.1 Current situation

Paratransit appears in several modes in Asian countries including Auto Rickshaw, Bajaj, Minibus, Tata Magic, Vikram, Mahindra, Angkot, and Becak. It operates either motorized or manually and its capacity varies from 1-2 passengers to 20 passengers. These means vary from one context to another for example in the rural zones it has no license, fare, or route regulations, however, in urban cities, the paratransit is subjected to restricted regulations by the government and transport authorities considering licensing, fare, route, safety standards, and organizational structure(Kumar, Singh et al. 2016, Phun, Kato et al. 2019).

3.1.2 Laws and Regulations

The research reviewed the laws and regulations of paratransit applied in developing countries in India, Thailand, Bangladesh, Malaysia, Singapore, Vietnam, Indonesia, and Cambodia, these laws provide an effective model for regulating paratransit where the government, department of Transport, and regulatory bodies are always present to contribute to safe mobility, create convenient environment for paratransit operation, and work to integrate between paratransit and the formal transportation system. These regulations can be divided into two sections as follows:

(a) Legalizing Framework

- Licensing and permitting: To establish new paratransit services, operators must request a permit from the government's Department of Transport. The government's approval is based on the current service situation and passengers' demand; as the number of permits is limited to control the number of service vehicles.

- Route planning: To ensure traffic flow, avoid conflicts with the main transportation system, and cover the demand pattern, the service routes are designed and indicated through the regulatory bodies, and a fine is applied for not adhering.

- Fare regulation: The regulatory bodies are responsible for setting mechanisms to calculate the appropriate fare and periodical fare revision. In some places, metered fares are applied to calculate fares based on distance.

- Safety standards: Paratransit vehicles are required to meet certain safety standards, such as first aid kit, fire extinguisher, drivers' training, and periodic inspection to ensure compliance with these standards.

- GPS tracking: for real-time monitoring of vehicles; to make sure of their adherence to the designated routes and their adherence to regulations. In some cities, paratransit is organized through dedicated Apps-based systems that are used for booking and payment.

- Electric vehicles: encouraging sustainable mobility through the usage of electric vehicles and providing charging facilities to lessen environmental impacts on transportation

(b) Organizational Structure

- Public and private ownership: Ensure the ownership and operation of paratransit vehicles whether by individuals or components of a bigger organized private fleet

- Operators associations: The role of the associations is to represent paratransit drivers and their interactions with transport authorities.

- Coordination with transport authorities: verify the interaction between paratransit operators and transport authorities in charge of monitoring their activities. This includes data sharing, reporting procedures, and compliance monitoring.

- Road Infrastructure: To accommodate paratransit, the government makes investments in strengthening road infrastructure including widening streets and providing dedicated lanes for paratransit vehicles in which street design includes defined lanes inside residential neighbourhoods; to avoid conflicts with other modes of transportation and pedestrians and ease mobility and traffic flow, particularly in congested areas. These lanes are integrated into the built environment with consideration to lane width and turning radii. These street design considerations are planned to fit the movement and space needed for paratransit vehicles.

- Parking and stations: Create centralized pick-up and drop-off points for paratransit close to transit terminals, markets, and residential areas. This will give passengers a convenient and organized space to wait without being stacked in traffic congestion on main streets or around mass transit stations. and make it easier for people to switch between public transport and paratransit.

- Traffic management: using traffic signals and signages for paratransit vehicles to organize their movement in the built environment without contradiction with pedestrians, cyclists, and traffic.

- Road safety campaigns: The government aims to decrease accidents and increase transportation effectiveness by enhancing road safety. It runs initiatives for paratransit passengers and drivers to promote road safety, these campaigns raise public awareness of the value of safe driving and compliance with traffic regulations.

3.2 Paratransit in Egypt

Paratransit in Egypt is mainly focused on small vans, microbuses, minibuses, and three-wheelers tuk-tuk. On one hand, it is accompanied by many problems like traffic congestion, and lack of the primitive qualities for adequate urban mobility, and sometimes leads to social segregation based on the local urban context, built environment, and socio-economic status of the people. However, on the other hand, the paratransit's

complementary role as an essential mode of mobility that people depend on is non-negotiable; it acts as a feeder for the main public transport, solves the challenges of accessibility and the first and last-mile connection problems in the peripheral urban zones of the city, and provide thousands of employment opportunities for unskilled workers (Cervero 2000, Valenzuela Jr, Schweitzer et al. 2005, Neumann 2014, C. Liu 2018, Acheampong, Lucas et al. 2022).

3.2.1 Current situation

Paratransit modal share in Egypt is nearly 55% of the whole transportation system (Salazar Ferro 2015, Behrens, McCormick et al. 2016), and it represents almost 83% of all motorized trips (Abd Alla, S. 2017). People depend on paratransit in their daily life routine; as it is the most available, flexible, and extended schedule means of transportation that respond to the shortage in the formal transit system.

Paratransit service in Egypt is divided into semi-formal and informal transit. The semi-formal transit is organized and licensed by the city's public transport authorities, it has specific routes and fares but no fixed stops, frequencies, schedules, or times. While, informal transit -which is the focus of this research- is mainly represented in the following classes (small vans, old microbuses, and 3-wheelers tuk-tuk) as shown in (Figure 1), It is not licensed or organized, has no exact information, has no specific routes, stops, frequency, fare, or time, operates on an extended schedule based on customers' demand, and concentrated on the local scale of the neighbourhoods.

A big share of the informal transitis represented in the tuk-tuk; a small size 3-wheeler vehicle that operates almost 24-7, especially in the inner local zones. It started to appear in 2005, according to CAPMAS (2021), Egypt contains 5,600,000 tuk-tuk, of which only 306,917 are licensed which is nearly about 5% of the total number of vehicles and the rest are informal ones. Egypt imports 50,000 tuk-tuk each year, which provide 150,000 job vacancy (Hosny 2013), It is an effective mean of transport; due to its small size and fast service that makes it easy to operate in the small zones, narrow streets, and complicated urban fabrics that public transport cannot reach.

However, the informal transitsector in Egypt is accompanied by several problems which can be grouped under three main categories: traffic congestion, accidents, and personal safety. This is due to the absence of regulations, surveillance, and law force.

3.2.2 Laws and Regulations

Several governmental documents, mobility reports, official plans, and transportation laws and regulations were reviewed, it was found that Egypt has no clear laws to regulate informal transit, there is no specific data or counts regarding their numbers or operators, and no definite legislation to regulate their routes, fare, schedule, operation zones, or safety standards. There is no force to legalize and license them except for some practices from the local authorities of each district, otherwise, they operate either without a license like in the case of tuk-tuks, or they are licensed as private cars like in the case of small vans, however, they operate commercially and pay no taxes.

Many governmental plans noted the importance of stopping importing the tuk-tuk, pan its mobility in the streets, and replacing it with small vans that operate on natural gas; due to its implications as it exceeds the capacity of cities and towns (Arafa 2021). However, all these plans failed to be achieved; due to the rapid and vast spread since 2010 especially in the local urban contexts, which led to the necessity to license and authorize the informal transit and find ways to regulate and integrate it into the whole transportation network of the city as an effective way for sustainable mobility.

Some successful attempts were made to organize tuk-tuk which resulted in organized fleets operated by private companies like Uber and Careem, these fleets have specific fees, facilities, and schedules, ensure personal security and safety standards considering drivers and vehicles, and sometimes they use Apps for booking and GPS tracking. However, these fleets operate on a small scale for local mobility inside private gated communities and residential compounds like El-Gouna City in Hurghada governorate on the Red Sea, and Marassi City on the North Coast of the Mediterranean Sea(Figure 2).

Table 1 represents a comparison of the paratransit service in Asian countries and Egypt; to summarize and highlight the main shortcomings and the promising interventions that were applied in these developing countries and achieved convenient practices and regulations for urban mobility.

606

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Criteria	Developing countries in Asia	Egypt
Licensing	Yes	Partially
Route planning	Yes	No
Fare regulations	Yes	No
Safety standards	Yes	No
GPS tracking	Partially	No
Electric vehicles	Partially	No
Operators' associations	Yes	No
Coordination with transport authorities	Yes	No
Road infrastructure	Yes	No
Parking and stations	Yes	No
Traffic management	Yes	No
Road safety campaigns	Yes	No

Table 1: Comparison between regulations of paratransit in Asian countries and Egypt

4 BUILT ENVIRONMENT FACTORS THAT AFFECT URBAN MOBILITY

In studying the relationship between urban mobility and the built environment inside the neighbourhoods, most studies highlighted that the characteristics of the built environment are the potential that encourages informal transit to evolve, urban structure elements including land use, public transport planning, street pattern, urban fabric, demographic characteristics, social aspects, and economic status all influence travel behavior and mode choice, in addition to different measures of the built environment including the 5Ds variables defined by Cervero (density, diversity, design, distance, and destination accessibility) (Ewing and Cervero 2010, Guerra, Cervero et al. 2012, Gamble and Puga 2017, Tong, Wang et al. 2018, Kumar, Sekhar et al. 2020, Falchetta, Noussan et al. 2021, Acheampong, Lucas et al. 2022, Gupta, Bivina et al. 2022).

4.1 Land use diversity

Many scholars have cited that land-use patterns affect travel behavior and mode choice; this then impacts how paratransit is planned and spread. Studies defined land-use diversity as a combination of eight land-use categories that exist within the neighbourhood context: residential, commercial, industrial, recreational, transportation, government buildings, utility, and vacant land. When all amenities: schools, grocery, hospitals, facilities, and open spaces are in proximity and within walking distance, people depend less on informal transit for mobility.

4.2 Transportation accessibility

Representing the distance and time needed to access public transit and stations from the center of the neighbourhood, this gap determines where informal transit works as an intermodal system to achieve first and last-mile connectivity between homes and destinations.

4.3 Road infrastructure

Streets in terms of (design, width, pavement, and geometry) affect the ability to accommodate public transportation systems to serve the district, which in turn affects the use of informal modes that can reach these zones. sidewalks in terms of(presence, width, and quality), facilities for the physically disabled, presence of pedestrian crossing, traffic signs and signals, traffic speed, and volume. All these factors affect travel behavior and mode choice.

4.4 Walkable and friendly environment

Providing spaces that encourage active modes of travel in which sidewalks are well-designed to attract pedestrians and positively influence them to walk; as they find comfort, safety, cleanliness, continuity, surface quality with no obstacles, a buffer from traffic, greenery, shading, shops to screen, open spaces, and adequate lighting. Also, providing safe cycling lanes that are separated from traffic encourages people to use bicycles safely and reduces depending on the informal travel modes.

4.5 Population density

In densely populated neighbourhoods the demand for transportation service is high, and informal transit often meets this demand and provides flexible transportation options that adjust routes, patterns, and schedules based on the local needs and amenities.

5 CASE STUDYALEXANDRIA, EGYPT

To better understand informal transit in Egypt and how it operates inside neighbourhoods, an analysis of a residential neighbourhood in Alexandria, Egypt was undertaken. The selected study area (Moharam-bek district) is considered a condensed middle-class residential neighbourhood within the urban context of Alexandria. The neighbourhood is served by public transit on the periphery however the inner zones inside the neighbourhood are barely accessible by public transport, a matter that leads to the revealing of informal transit the achieve local mobility inside the neighbourhood.

5.1 Methods

The survey is based on two steps; first, an observational analysis is carried on by taking rides on the existing modes of the informal system operating in the neighbourhood; to analyze the current situation, and second, conducting discussions with users and drivers about the service. The following key components were studied in the survey:

- Types of existing informal transit
- Vehicles' characteristics (safety, design, manufacture, etc.)
- zones of operation, and pattern of movement
- service stops, hotspots, and congestion zones
- Routes and scheduling
- Fare structure
- Operational characteristics
- Role and contributions of the service
- Existing regulations
- Licensing
- Social concerns and personal safety

Figure 3: paratransit vehicles in Moharam-bek, Alexandria – represented in tuk-tuks that operate illegally (researcher, 2023)

5.2 Findings

The study area is featured by the spread of tuk-tuks as shown in figures 3 and 4 in which they operate illegally, move in opposite directions without any regulations, and cause congestion and conflicts with trams

608

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and vehicles. The key components of paratransit that were analyzed in the study area are summarized in table 2.
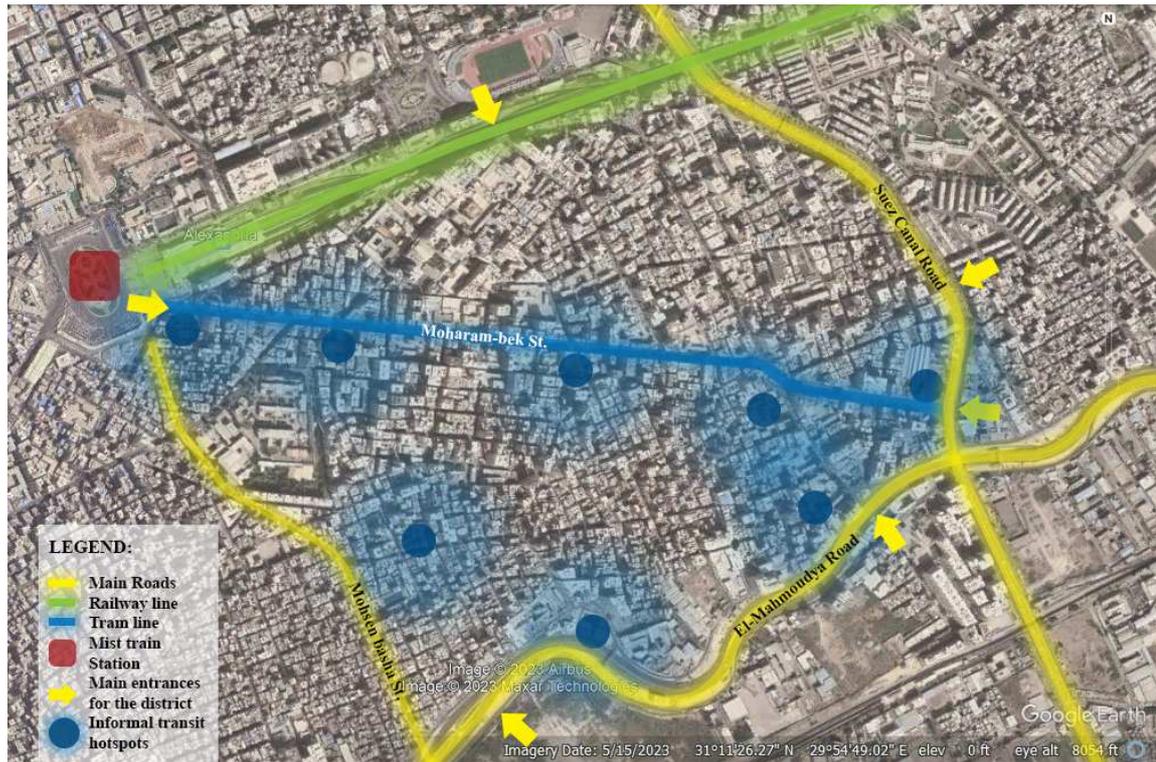

Figure 4: illustrative satellite image indicating context & mobility options in study area (source: Google earth, 2023)

Component	Description
Existing informal transit	Motorized tuk-tuk: a three-wheeled vehicle with a capacity of 2 passengers
Vehicle characteristics and safety standards	Vehicles are of poor quality, sometimes there is an overcapacity of 3-4 passengers, all vehicles run on diesel, and lack any safety standards considering driving techniques, maneuvering, their rush driving cause accidents with vehicles and pedestrians.
zones of operation, and pattern of movement	Tuk-tuks mainly operate in the inner zones and streets. And the main collector street in the neighbourhood (tram street) is their reference, where they start from or end at. The pickup points can be anywhere if the vehicle is empty.
service hotspots and congestion problems	Vehicle pick-up/drop-off stops are near the main railway station and bus stop at (Misr Station)and near the main markets; to carry people to their homes. And the main congestion appears when they move in opposite directions with the tram.
Routes and scheduling	Routes are highly flexible and dynamic based on customer demand, they operate in opposite directions to reach their destination. Scheduling is extended 24-7, and at the main hotspots the vehicles work on a queue system
Fare structure	There are no definite measures to calculate fares based on distance, drivers charge passengers at their discretion or based on negotiation; which leads to over-charging causing problems between drivers and passengers.
Operational characteristics	Tuk-tuks provide door-to-door and ride-hailing services. As soon as the passenger gets down, the drives tend to move back to the main hotspot zones.
Role and contribution	Tuk-tuks play a critical role in addressing local mobility needs inside a neighbourhood, providing connectivity between highly generating and attracting points, and achieving first and last-mile connectivity to public transit.
Existing regulations	There are no regulations applied to tuk-tuks, they operate chaotically.
Licensing	The majority of tuk-tuks are not licensed, a few tuk-tuks were noticed to carry license plates but that doesn't exceed 5% of the total number.
Social concerns and personal security	There are many concerns noticed regarding inappropriate drivers' behavior with users when negotiating fares and with other vehicles' drivers when complaining about their movement out of their lanes and in the opposite direction. Also, there are some accidents regarding kidnapping and harassment using tuk-tuks.

Table 2: Characteristics of the informal transit in the case study area (Moharam-bek district, Alexandria, Egypt)

5.3 Discussion

In the absence of adequate official data, the methods used for the case study formed a significant input, it provided information concerning informal transit operations and characteristics in urban neighbourhoods. The case study area showed that however tuk-tuks are accompanied by a huge amount of problems and have a lot of concerns: safety, personal security, congestion, traffic, fare, routes, and regulations, these modes of informal transit provide the needed local mobility inside the neighbourhood which is not served by public transport; this service is the only way to connect people to their destination whether to the main transportation terminals, markets, and other amenities.

The study revealed that the characteristics of the built environment played a vital role in the spread of paratransit; high population density, condensed urban fabric, poor road infrastructure, irregular geometry of streets, and poor road planning hierarchy, all these factors obstruct public transit accessibility which in turn open the space for paratransit, also the deteriorated conditions of sidewalks and the unfriendly walkable environment prevent people from active transportation.

6 CONCLUSION

This paper has contributed to a better understanding of the role of paratransit service in meeting the needs of local urban mobility in Alexandria, Egypt. It helped to answer several questions considering: What type of local mobility inside neighbourhoods? What contribution does it add? What type of users does it serve? and What problems are accompanied with? On one hand, the paper showed that paratransit service is a problem that causes chaos and congestion inside neighbourhoods. However on the other hand, it highlighted its role in local urban mobility, it showed that this service is indispensable in the areas poorly served by public transit, this service is highly flexible to fit users' needs, although it may not be comfortable and safe, sometimes they represent the only choice for people to move to/from their destinations.

When comparing the situation in Egypt to the successful examples in Asian countries, it was found that Egypt almost has done nothing to solve the chaos and informality of paratransit service, the only consideration is some calls to license these vehicles and this is not the regulatory decision that ensures a better organization to the network. With more than 6millionvehicles that operate informally in the streets of Egypt, more decisions and laws have to be made to regulate and accommodate this service.

Learning from the Asian lessons, Egypt has to focus on the legalizing framework considering: obligatory licensing, route planning for the service, fare regulations based on the distance, GPS tracking for each vehicle, and safety standards including vehicle compliance, driver training, and regular inspections. Also, the organizational structure has to organize this service through specific laws and regulations for this type of transit and paratransit has to be represented by operators associations that are responsible for organizing public and private ownerships of vehicles, coordinating with transport authorities, ensuring continuous inspection and laws implementation, and solving the drivers' problems.

Moreover, one of the main problems of paratransit service is the accompanying congestion and accidents. Specific rules have to be formulated concerning traffic management that regulate the movement inside the built environment, indicate separate lanes especially on the main streets to prevent conflicts with cars, and determine specific parking and stations which have to be well designed and placed based on the analysis of the hotspots and transit terminals for each neighbourhood; to prevent overcrowding and street blocking

7 RECOMMENDATIONS

This paper sets the basic guidelines for the role paratransit plays in the urban environment and its effect on local mobility in Alexandria, Egypt. However, it highlighted the deficiencies and shortcomings in the Egyptian transportation laws that failed to accommodate paratransit service. These laws need to be considered by the government and decision-makers; to ensure adequate and safe mobility for all people.

First: mobility in Egypt has to be planned on two levels (two services) that work in integration with each other. The primary service is dedicated to long-distance mobility including railways, metro, tram, and BRT (known as trunk network), and the complementary service for local mobility, acts as an intermodal network that connects commuters to the primary service including local microbuses, vans, and tuk-tuks (know as the trunk-feeder network).

Second: Governments, transport authorities, and policymakers should acknowledge the presence of paratransit modes in cities and the role they play in urban mobility, analyze their challenges, and develop laws and policies that enhance the quality of services, organize their operation, and achieve safety based on the successful practices applied in Asian countries as discussed before.

Third: urban planners have to pay attention to the planning standards of the built environment and residential neighbourhood that achieve strategically placed hotspots like markets, hospitals, schools, amenities, and transportation hubs, smart planning enables residents to access services without the need to distant move and has enormous promise for reducing the demand for local urban mobility.

Fourth: attention should be paid to the improvements in roads and sidewalks infrastructure, urban design, and landscape, which in turn shall provide a friendly environment that encourages people to active means like walking and cycling, and reduce the need for local mobility.

Future research should consider how to apply these regulatory and organizational frameworks in the field, measure their effectiveness, and ensure law adherence.

8 REFERENCES

Acheampong, R. A., et al. (2022). Transport and Mobility Futures in Urban Africa, Springer Nature.

Arafa, A. (2021). "Tuk-tuk license issue and numbers in Egypt." www.youm7.com.

Behrens, R., et al. (2016). "Paratransit in African cities." Operations, regulation and reform.

C. Liu, R. P., M. Zlatkovic, K. Fayyaz, and J. Taylor (2018). FIRST AND LAST MILE ASSESSMENT FOR TRANSIT SYSTEMS.

CAPMAS, Central Agency for Public Mobilization And Statistics. (2021). Egypt statistical yearbook 2021.

Cervero, R. (2000). Informal transport in the developing world, UN-HABITAT.

Cervero, R. and A. Golub (2007). "Informal transport: A global perspective." Transport policy14(6): 445-457.

El-Khateeb, M. (2017). Urban Mobility in Greater Cairo: A history of patchwork solutions, Taḏāmun.

Ewing, R. and R. Cervero (2010). "Travel and the Built Environment." Journal of the American Planning Association76(3): 265-294.

Falchetta, G., et al. (2021). "Comparing paratransit in seven major African cities: an accessibility and network analysis." Journal of Transport Geography94: 103131.

Finn, B. (2012). "Towards large-scale flexible transport services: A practical perspective from the domain of paratransit." Research in transportation business & management3: 39-49.

Gamble, J. and E. Puga (2017). Is Informal Transit Land-Oriented?: Investigating the Links Between Informal Transit and Land-Use Planning in Quito, Ecuador, Lincoln Institute of Land Policy.

Gota, S. (2018). Two-and-Three-Wheelers: A policy guide to sustainable mobility solutions for motorcycles. Sustainable Urban Transport Project (SUTP), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Transformative Urban Mobility and TUEWAS, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Guerra, E., et al. (2012). "Half-mile circle: Does it best represent transit station catchments?" Transportation research record2276(1): 101-109.

Gupta, A., et al. (2022). "Does neighbourhood design matter for walk access to metro stations? An integrated SEM-Hybrid discrete mode choice approach." Transport policy121: 61-77.

Hook, W. and B. Fabian (2009). Regulation and Design of Motorized and Non-Motorized Two-and-Three-Wheelers in Urban Traffic.

Hosny, k. (2013). "Tuk-tuk overcome government failure and fight unemployement." www.alarabiya.net.

Kumar, M., et al. (2016). "Informal public transport modes in India: A case study of five city regions." IATSS research39(2): 102-109.

Kumar, P. P., et al. (2020). "Identification of neighbourhood typology for potential transit-oriented development." Transportation Research Part D: Transport and Environment78: 102186.

Lubis, E. S., et al. (2020). "The influence of Paratransit on urban land patterns:"Becak Masin" in Padangsidimpuan City, Indonesia."

Neumann, A. (2014). A paratransit-inspired evolutionary process for public transit network design, epubli.

Phun, V. K., et al. (2019). "Paratransit as a connective mode for mass transit systems in Asian developing cities: Case of Bangkok in the era of ride-hailing services." Transport policy75: 27-35.

Salazar Ferro, P. (2015). "Paratransit: a key element in a dual system." CODATU, Agence Française de Développement.

Talamini, G. and D. P. Ferreira (2019). "An informal transportation as a feeder of the rapid transit system. Spatial analysis of the e-bike taxi service in Shenzhen, China." Transportation research interdisciplinary perspectives1: 100002.

Tong, X., et al. (2018). "Correlation between transit-oriented development (TOD), land use catchment areas, and local environmental transformation." Sustainability10(12): 4622.

United Nations (2015). Transforming our world : the 2030 Agenda for Sustainable Development Right to development.

Valenzuela Jr, A., et al. (2005). "Camionetas: Informal travel among immigrants." Transportation Research Part A: Policy and Practice39(10): 895-911.

WHO (2017). "Powered two-and three-wheeler safety: a road safety manual for decision-makers and practitioners."

Williams, S., et al. (2015). "The digital matatu project: Using cell phones to create an open source data for Nairobi's semi-formal bus system." Journal of Transport Geography49: 39-51.

Pathways to Urban Parks Functionality Enhancement: Lessons from Gugu Dlamini Park

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1 ABSTRACT

Urban parks are a crucial component of the city fabric but their intended use is overlooked by informalities and activities that distort the user's positive experience. South Africa has been investing massively in urban parks to improve the fabric of cities. However, the approaches to enhancing the functionality of urban parks have not yet been studied and documented convincingly, particularly in most urban areas. Consequently, this paper highlights the pathways to enhance the effective use of urban parks, specifically focusing on Gugu Dlamini Park, eThekwini Municipality. The study adopted a case study research design and applied a qualitative approach to gather relevant data on the current use of urban parks. Specifically, data was collected using geo-spatial mapping, in-depth interviews, and observation schedules. The paper reveals that the elements such as safety and placement affect park users, mainly due to poor management and enforcement. The paper recommends the incorporation of urban parks within government and municipal strategic goals. There is also a need to integrate informal trading into formal spaces in urban parks. In conclusion, the paper recommends that to achieve effective utilization of urban parks they must be inclusive and vibrant. The enhancement of urban park functionality fits well into the broader phenomena of the current use of parks in urban areas.

Keywords: Urban Parks, Urban Green Spaces, Placement, Public Spaces, Informality

2 INTRODUCTION

Historically, urban parks were intended to offer open spaces inside cities to diminish the harmful impacts of industrialization. Lately, many countries have acknowledged the importance of the multi-functional use of urban parks (2017 Kothencz, G.; Blaschke). Nevertheless, many of these urban open spaces suffer from underutilization due to several reasons that among others include a lack of social activities and sports, inadequate facilities, and poor maintenance and safety (Akpınar, 2020; Babey et al., 2015). This study aims to evaluate the factors desirable to enhance the park's functionality and also analyse the subjects influencing the use of urban parks in South Africa.

Urban parks have always been an element of the city structure; though it is not been an occurrence since the nineteenth century (Abdelhamid, 2019). For example, up to the nineteenth century, Britain's towns were characterized by low-density growth (Gunn, (2013). According to Walker and Duffield (2007), citing Chadwick (1966); Perrin and Cochrane (1970), states urban areas were not developed at densities that were high enough to totally remove open space until the nineteenth century. Walker and Duffield (2007), add that the nineteenth century stood out due to rapid urbanization, and the exceptional speed at which cities were growing, this resulted in the first active promotion of urban open space. They further explain that urban open spaces must be viewed essentially as the consequence of the emerging industrial cities as well as of the social and geographical organization of fast-growing expanding populations.

According to the United Nations (2018), the total urban population of the world is set to intensively grow, it is highly expected that by 2050, three billion more people are projected to reside in cities, bringing the proportion of urban dwellers to two-thirds of the global population. In spite of this, the rapid growth of cities and urban areas and how urban parks are used have led to the clear decline of urban open spaces around the world, resulting in significant social and ecological problems (Faragallah, 2018). Urban park functionality enhancement has become a prime essence of restoring the intended use of green spaces in urban areas.

3 PUBLIC SPACE AND THE ROLE OF URBAN PARKS

Alwah et al. (2020) argue that urban parks are crucial for the social growth of city dwellers, pointing out that social interactions are developed in these settings. Soltanian & Mohammadi (2015) agree to state that more than serving a purely functional purpose, urban public open spaces are essential for fostering social connections or ties among residents. They further state that public spaces in a city are impacted by the social

and economic developments of the era, which result in altered cityscapes. Thus, continuing in their explanations, they state that social problems in cities might result from a lack of an appropriate urban space. It points out that the rapidly changing social conditions have increasingly affected how people use and influence their surroundings. In addition, Abbasian (2016); Balogh & Takacs (2011) state that overall, the urban population has been dramatically growing, and this results in the physical makeup of metropolitan regions constantly changing, typically in negative ways. In another instance Memluk (2013) adds that infrastructure and equipment are more in demand as the population grows, which results in "increased mobility, communication technology, and globalization causing metropolitan areas to grow and change in size, resulting in a shift in lifestyle and use of public places." On the contrary, Abbasian (2016) and Mehmet NCEOLU (2009) place emphasis on the impact of technological advancements on causing worry, which worsens daily to the point that the effects have further isolated and privatized people's lives. As a result, the significance and importance of public spaces in social life decrease resulting in urban open spaces being used inappropriately as designed or intended.

Furthermore, according to Abdelhamid, & Elfakharany (2020), Berg et al (2022), research on the use and significance of urban environments have been carried out in Europe, America, Australia, China, and several East Asian nations. These studies have confirmed the various aspects of using and visiting open spaces. This study fills in a knowledge gap. For instance, a study on urban open spaces in Yemen, an East Asian country, reveals that the majority of the population uses open spaces for walking, playing with their children, relaxing, and amusement. Users also like locations that offer suitable and ample seating places, a variety of contemporary entertainment options, a high standard of hygiene and maintenance, and secure locations free from intruders (Alwah et al., 2020). Such information, they say, helps Yemeni urban planners and developers create new public spaces and help restore deteriorated open spaces (ibid). According to Fan et al. (2017) Faragallah 2018, Niemelä (2014), Wolch et al (2014), public open space is one of the most important components of sustainable urban design and development. They explain that in addition to providing ecosystem services to the populace. These ecological services include changing the climate, managing stormwater, and enhancing air quality as well as regulating leisure, sports, and recreation (Elsheshtawy, 2011).

Conversely, urban parks are essential for fostering individuality and cultural variety, which exemplifies democracy through open-access public places (Thompson, 2002). Instead of seclusion in situations with only one type of culture, intercultural interaction in public places helps to foster tolerance and understanding among people (Salama & Gharib 2012). Additionally, parks are good for people's health and fitness when they engage in exercise activities or simply walk outside to appreciate or enjoy nature. This is crucial given the rise of age-related disorders like heart disease and obesity brought on by new lifestyles (Salama & Azzali, 2015). However, in order to create lively and dynamic urban park environments that improve well-being and quality of life, it is important that the design, planning, and administration of these open spaces consider the needs and expectations of users by being cognizant of their experiences and preferences (Alwah et al., 2020).

4 MATERIALS AND METHODS

The study adopted a phenomenological case study research design as it seeks to investigate pathways to urban park enhancement in Durban, South Africa. The case study assists in conducting a systematic, critical inquiry into a phenomenon of choice and generating understanding to contribute to cumulative public knowledge of the problem (Simons, 2009). A qualitative research approach was used which qualified the collection of qualitative data (Mohajan, 2018). The study was carried out through in-depth interviews with personnel from users of the park, officials from the eThekwini municipality Department of Parks, Recreation and Culture, and an academia from the Department of Town and Regional Planning, University of KwaZulu-Natal.

To reveal the condition of the park and complimentary amenities (street furniture), geo-spatial mapping was applied as a visualization tool for the spatial arrangement of the study setting. The research area was visited for direct observations and photographic assessment purposes. The convenience and purposive sampling methods were employed to recognize all the study respondents, and further adopted a descriptive-analytic strategy but relied more on developing case descriptions. The intention of making a case description was to

614

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postulate the activities observed at Gugu Dlamini Park and put these observations into context (Yin, 2002). The techniques of pattern-matching, explanation-building, and time-series were developed for data analysis

5 RESULTS

This section presents the findings of the study. It highlights the pathways to Urban Parks functionality enhancement. UN-Habitat (2015) has been in the lead in enhancing the improvement and provision of urban open spaces. ''Cities that have a strong impression of the public, demonstrate an obligation to an improved quality of life of their residents by providing suitable green area, street space and recreational facilities'' (UN-Habitat 2015:4). The results from the empirical investigation are based on three thematic areas namely; planning for a variety of activities, enhancing physical attributes of the park and ensuring safety and maintenance.

5.1 Planning for a Variety of Activities

According to observations conducted over three weeks during morning hours, afternoon hours, and evening hours at Gugu Dlamini Park, it was discovered that the space is dominated by myriad activities including vagrancy, illegal trading, cultural dances as well as young adults consuming alcohol on the edges of the park. According to the eThekwini Municipality Parks and Recreational Bylaws (2015), alcohol is prohibited in the urban open space unless it is consumed in designated areas, which unfortunately are not present at Gugu Dlamini Park, and the bylaws further prohibit any form of trading without obtaining a permit from the municipality. Figure 1 shows the different activities that occur in the park and includes users of the space frequently taking pictures next to the HIV/AIDS sculpture.

Figure 1. Various activities. Source: Author; field observations (2019

Patterns in urban park activity and use appear to be associated with characteristics of the surrounding areas as well as the social environmental and physical characteristics of the park (McCormack et al., 2014). The types of visitors and times of use vary. The park is situated next to the Workshop Mall, during the lunch hour, workers from the mall tend to use it often and in the late afternoon is dominated by school children. Table 1 summarizes the prominent activities according to their time of occurrence.

Activity types	Time		
	Morning 06:00-09:00 09:00-11:00	**Afternoon** 01:00-01:00 01:00-03:30	**Evening** 03:30-07:00
1. Seating and relaxing	***		
2. Vagrancy	***		
3. Informal trading	**		
4. Football play		*****************	
5. Performances	**************************		

Table 1 Activities vs. time observed at Gugu Dlamini Park

5.2 Enhancing physical attributes of Parks

Gugu Dlamini Park is positioned in a strategic position, which makes it easily accessible by the surrounding land uses. The nature of the area is associated with human interaction because of the adjacent mall to the park. The trails of the park are well-designed and connect both to the streets and other services (see Figure 2). Timmermans and Cilliers (2016), support the view that the physical attributes of a successful urban park can be quantifiable and tangible with attributes such as accessibility, location, shape, size, and natural features. Caryn et al (2018), further confirm that hardscape, landscape and services designs affect physical activity and influence the degree of urban open space usability.

Regarding supporting amenities, the urban park is furnished, however, it was observed that some of the street furniture has deteriorated. The elementary function of street furniture in urban open spaces is to assist the lives of citizens and provide them with a comfortable space (Tereci and Atmaca, 2020). The work anticipated from the space design is that its street furniture prevents redundancy and complexity. Therefore, the user will receive the best service in an original, harmonious, and comfortable place. About 56 % of the respondents at Gugu Dlamini Park complained about the lack of shelter during rainy and hot days as enormous portions of the park are deprived of shelter. The park further lacked essential facilities such as bathrooms and water fountains. Caryn et al (2018), A National Study of Neighborhood Parks in America approved that number of park users may decrease if the park does not have comfortable public toilets and clean water, even if it has great amenities and is easily accessible.

Although other facilities are not found, the remnant amenities are still crucial for the attraction of people to the space. The park has trees along the perimeters and the trees proffer a sense of boulevard scenery in the space. Users of the park enjoy taking photographs of the natural landscape and flowers.
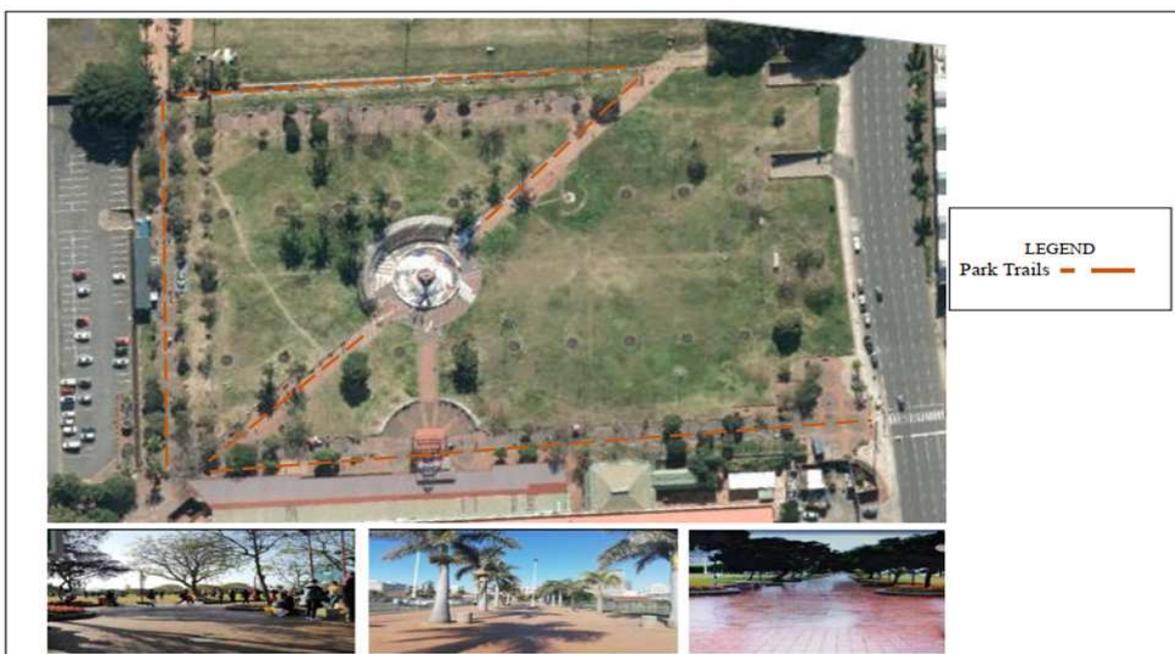
Figure 2: Aerial view and existing park trails

5.3 Ensuring safety and regular maintenance

Urban parks are central to the functioning of cities and strongly impact the quality of life of city dwellers (Camargo et al., 2017; Koramaz & Türkoğlu, 2018). However, if urban parks feel unsafe, users are less likely to visit them. 76% of the respondents perceive Gugu Dlamini Park as an unsafe space because of the high presence of homeless people who pester and ask for money. Table 1 further substantiates and gives a clear insight into the vagrant people who occupy the park during the day. Dogrusoy and Zengel (2017) mentioned that the perceived safety of parks is a vital aspect that may discourage many potential visitors from enjoying and using available urban open spaces.

Observations from the researcher exhibited that users of the park use the green grass as an alternative to the designated pathways and trails. As a result, the presence of bare land in the green zones of the park is causing environmental degradation. Damaged waste receptacles and signage within the park were observed as a hindrance to the user's experience of the urban open space.

6   DISCUSSIONS

Understanding urban park purpose use and evaluating visitor perspectives on physical attributes, accessibility, safety, and maintenance can assist to advance planning, management, and design across a range of city parks. The research study was unique in that it applied a qualitative methods approach with on-site observations to evaluate urban park users' activities, as well as in-depth interviews to differentiate various viewpoints on access, use, improvement, and enhancement preferences.

616

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The results obtained from empirical investigation reveal that enhancing urban park functionality is not a generalized topic. Urban park functionality comprises optimal landscape features such as plants and trees and physical attributes such as linkages that proffer excellent connection with adjacent land uses (PPS, 2015b). It is also argued that urban park functionality is dependent on social interaction environments and it has to be emphasized and addressed from an architectural perspective (Liu T and Liu W, 2016).

From the study observations, there were imperative highlighted park uses and discoveries that relaxation, adult interactions, and solitude were some of the most common park activities. These results are consistent with other studies that demonstrate urban parks as crucial places for encouraging psychological health (Bratman et al., 2019; Frumkin et al., 2017; Schnell et al., 2019). It is also evident that the use patterns of the park are influenced by a variety of socio-spatial factors. These findings were constantly disturbed by the presence of vagrant people who brought a sense of insecurity as submitted by users of the park.

As indicated in Table 1, informal traders and different performances as a form of entertainment are common activities in the park. Such activities received positive feedback from interviewed users of the space even though they are highly prohibited by the eThekwini Municipality Parks and Recreational Bylaws (2015) if they occur without the municipal's approval. Wood (2003), green spaces offer not only active and passive recreation but also include numerous socio-economic activities. In African cities, informal trading rests as a daily reality because it is the source of livelihood in today's extreme poverty and unemployment and it remains a call for urban planners to incorporate such activities in urban parks but also not compromise their functionality.

7   TOWARDS FUNCTIONAL URBAN PARKS
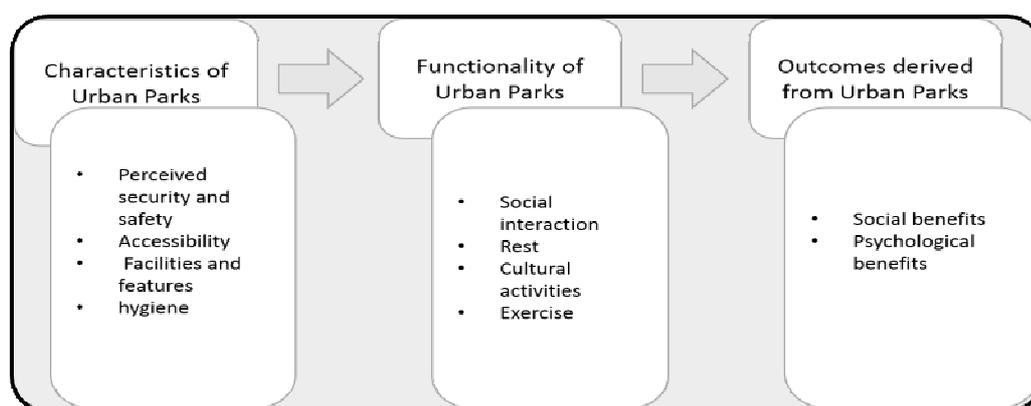
Figure 3: Relationship between urban park characteristics, functionality, and outcomes. Source: M. Mndzebele (2023)

As assumed by the empirical and literature reviewing outcomes, the characteristics of urban parks entail features and facilities, accessibility, hygiene, attractiveness, security, and perceived safety. The potential outcome is having functional urban parks that constantly encourage social integration and tranquillity aswel as cultural activities as seen in Figure 1. The relationship between urban park characteristics, functionality, and outcome is demonstrated in Figure 3.

As part of facilities, to address informal trading in urban parks, it is of high importance for municipalities to provide unique and designated selling points within the spaces. It can be linked to the government policy of permitting informal traders to do business there so that the traders will not have to fear being evicted (Widjajanti et al., 2022). It is also advocated that a place makes sense when it is rich in urban park features such as sculptures, food concessions, benches, and water features. However as observed at Gugu Dlamini Park, these features are not enough to provide an exceptional user experience. Understanding the controls for change is an essential prerequisite for urban planners to be able to address joint concerns of planning as exemplified in urban park challenges.

The concern of vagrancy in urban parks is a sensitive social issue and cannot be dependent on urban planners only to proffer solutions. Institutions such as homeless shelters, rehab facilities, the private sector, and NGOs that deal with social development complications could be brought in as an intermediary to assist vagrants lodging in urban parks to be integrated well within the communities. Our analysis further reveals that cultural and social interactions were not appreciated with low tree cover. Plenty of the respondents found the park inefficient in terms of providing adequate shelter, especially during harsh weather conditions. Shade is

an important feature in urban parks concerning the improvement of social benefits as it allows users to stay longer, protected from over-exposure to unfriendly weather. Improving the attribute of shade can be a positive measure to further better physical activity levels and enhance the comfort of people's use of these types of spaces (Liu et al., (2023).

The approach to curb most urban park challenges and enhance functionality is by fully incorporating parks within the government and municipality's strategic goals. For example, as municipalities plan for security and safety, they must prioritize providing security for adjacent land uses for urban parks. If surrounding land uses for city parks have good surveillance, urban parks are most likely to benefit. This approach is not limited to safety but also accessibility. Gugu Dlamini is easily accessible according to respondents as the park was designed on the notion that supports the principle of ease of movement which presents the park in well-connected streets and adjacent land uses. Spaces that are easily seen from the street by passers-by are most likely to be used than those that are visually obscured, explaining the high patronage of space (Corbett, 2004:82). Access to transport and urban open spaces in particular, is important for human well-being as acknowledged by the UN sustainable development goals (UN, 2015, see 11.2 and 11.7).

7 CONCLUSION

It is clear that urban parks are important for the city of Durban and its users, therefore, not only the eThekwini Municipality and city planners should be responsible for making sure they are usable. Urban parks are an element that brings a refreshed atmosphere to cities, making it essential that they are well-maintained, regulated, and monitored for users. If the responsibility of making them usable is neglected by city residents, we will most likely experience and have similar issues with urban parks.

The findings associated with informal trading, vagrancy, and cultural activities signify that urban parks in the context of Durban are beyond the traditional intended meanings. The discoveries of this paper further confirmed that urban parks are shared by strangers who are generally not associates but peacefully coexist. However, these noble models are threatened by several issues, such as ablution facilities, lack of maintenance, and problems related to security and safety. These are imperative indicators that influence the current use, making it essential to critically find a holistic approach that will assist to encourage safe, friendly, healthy, and welcoming urban parks in Durban and South Africa.

8 REFERENCES

Abbasian, A. (2016). Importance of Urban Squares as Public Space in Social Life A NewDesign of Fisktorget in Karlskrona City. Blekinge Institute of Technology: Karlskrona, Sweden.

Abdelhamid, M. M., & Elfakharany, M. M. (2020). Improving urban park usability indeveloping countries: Case study of Al-Shalalat Park in Alexandria. Alexandria Engineering Journal, 59(1), 311-321.

Aggio, D., Smith, L., Fisher, A., & Hamer, M. (2015). Mothers' perceived proximity to green space is associated with TV viewing time in children: the Growing Up in Scotland study. Preventive medicine, 70, 46-49.

Aksu, V. (2012). Kent mobilyaları tasarımında özgün yaklaşımlar," İnönü Ün. Sanat ve Tasarım, 2(6):373-386.

Akpınar, 2020 A. Investigating the barriers preventing adolescents from physical activities in urban green spaces

Alwah, A. A., Li, W., Al-Fanini, S. M., Alwah, M. A., Saad, G. A., Tran, D. T., ... & Fadeleseed, S. (2020). Relationship between physical elements and density of use of public spaces in Sana'a City. Proceedings of the Institution of Civil Engineers-Urban Design and Planning, 173(4), 125-145.

Alwah, A. A. Q., Li, W., & Al-Attar, A. N. M. (2020, December). Characteristics of visiting urban open spaces in Sana'a city in Yemen. In IOP Conference Series: Earth and Environmental Science (Vol. 608, No. 1, p. 012002). IOP Publishing.

Balogh, P. I., & Takács, D. (2011). The significance of urban open spaces and green areas in urban property developments. In First International Conference "Horticulture and Landscape Architecture in Transylvania" Agriculture and Environment Supplement (Vol. 110, p. 121). Cluj-Napoca, Romania: Sapientia Hungarian University of Transylvania.

Beck, H. (2009). Linking the quality of public spaces to quality of life. Journal of Place Management and Development, 2(3), 240-248. https://doi.org/10.1108/17538330911013933

Camargo, D. M., Ramirez, P. C., & Fermino, R. C. (2017). Individual and environmental correlates to quality of life in park users in Colombia. International Journal of Environmental Research and Public Health, 14, 1250–1260.

Carmona, M. (2019). Principles for public space design, planning to do better. Urban Design International, 24(1), 47-59.

Chen, B., O.A. Adimo, and Z. Bao. (2009). Assessment of aesthetic quality and multiple functions of urban green space from the users' perspective: The case of Hangzhou Flower Garden, China. Landscape and Urban Planning, 93 (1): p. 76-82.

Chen, Y., Liu, T., Xie, X., & Marušić, B. G. (2016). What attracts people to visit community open spaces? A case study of the Overseas Chinese Town community in Shenzhen, China. International journal of environmental research and public health, 13(7), 644.

Chiesura, A. (2004). The role of urban parks for the sustainable city. Landscape and urban planning, 68(1): p. 129-138. Walker, S. E., & Duffield, B. S. (1983). Urban parks and open spaces—an overview. Landscape research, 8(2), 2-12.

Cloete, M., & Yusuf, S. (2018). Conceptual commentary of public spaces in Durban, South Africa. Town and Regional Planning, 73, 35-45.

Cilliers, E., & Timmermans, W. (2015). An Integrative Approach to Value-Added Planning: From Community Needs to Local Authority Revenue. Growth and Change, 46(4), 675-687.

Doğrusoy, İ., & Zengel, R. (2017). Analysis of perceived safety in urban parks: A field study in büyükpark and hasanağa park. METU Journal of the Faculty of Architecture 34(1), 63 - 84.

Elsheshtawy, Y. (2011). Informal Encounters: Mapping Abu Dhabi's Urban Public Spaces. Built environment, 37(1): p. 92-113.

Fan, P., Xu, L., Yue, W., & Chen, J. (2017). Accessibility of public urban green space in an urban periphery: The case of Shanghai. Landscape and Urban Planning, 165, 177-192.

Faragalla, R.N 2018. The impact of productive open spaces on urban sustainability: The case of El Mansheya Square – Alexandria.

Gehl, J. (2011). Life between buildings: using public spaces. 2nd ed. London: Island Press.

Gunn, S. (2013). Beyond Coketown: the industrial city in the twentieth century. Industrial cities. History and future, 29-45.

Kothencz, G.; Blaschke, T. Urban parks: Visitors' perceptions versus spatial indicators. Land Use Policy 2017, 64, 233–244.

Koramaz, E. K., & Türkoğlu, H. (2018). Measuring and understanding urban parks' contribution to quality of life in Istanbul. Social Indicators Research, 138, 335–351.

Liu, M.; Chen, C.; Yan, J. (2023). Identifying Park Spatial Characteristics That Encourage Moderate-to-Vigorous Physical Activity among Park Visitors. Land.

Marafa, L. M., Tsang, F., Watts, G., & Yuan, X. M. (2018). Perceived tranquility in green urban open spaces. World Leisure Journal, 60(3), 221-234.

McGarry, M. S. (2018). From housing to human settlements: the role of public space in integrated housing developments (Master's thesis, University of Cape Town).

Mchunu, K. (2020). Roadside death memorials: transformation of public spaces into private spaces for mourning. African Identities, 18(4), 435-449.

Memluk, M. Z. (2013). Designing urban squares. In Advances in Landscape Architecture. IntechOpen.

Naidoo. C. (2017). Towards a sustainable urban form, the influences of social and physical environment: a case study of Albert Park, eThekwini Municipality. University of KwaZulu-Natal: South Africa.

Nared, P., & Lamovšek, A. (2015). Public Open Space as a Contribution to Urban Development in Small Slovenian Cities. Urbani Izziv, 26, S114-S129.

Nasution, A. D., & Zahrah, W. (2012). Public open space privatization and quality of life, case study Merdeka Square Medan. Procedia-Social and Behavioural Sciences, 36, 466-475.

Niemelä, J. (2014). Ecology of urban green spaces: The way forward in answering major research questions. Landscape and urban planning, 2014. 125: p. 298-303.

Njambi, G. (2014). Sustainable utilization of public parks in urban areas: A case of Christina Wangari Garden in Thika Sub-county (Masters dissertation). University of Nairobi: Kenya

Özgüner, H. (2011). Cultural differences in attitudes towards urban parks and green spaces. Landscape Research, 36(5): p. 599-620.

Perry, E. & Munien, S. (2016). Safety and security concerns in relation to open leisure spaces in residential areas in Durban. African Journal of Hospitality, Tourism and Leisure, 5(3), 1-12

Peters, K., B. Elands, and A. Buijs. (2010). Social interactions in urban parks: stimulating social cohesion? Urban forestry & urban greening, 9(2): p. 93-100.

Pillay, S. & Pahlad, R. (2014). A gendered analysis of community perceptions and attitudes towards green spaces in a Durban metropolitan residential area: implications for climate change mitigation. Agenda, 28(3), 168-178.

Radebe, H., & Irurah, D. (2016). The use of recreational urban parks in Johannesburg: a phenomenological study of place attachment in Thokoza Park in Moroka, Soweto (Vol. 204, pp. 697-707). Proceedings of the 11 International Conference on Urban Regeneration and Sustainability (SC 2016). WIT Press.

Ramlee, M., Omar, D., Yunus, R. M., & Samadi, Z. (2016). Successful attractions of public space through users' perception. Environment-Behaviour Proceedings Journal, 1(2), 188-196.

Riki, J., Rezazade, M., & Miri, G. (2016). Urban Park Use, Quality Evaluation, and Resident Satisfaction Indicators in the City of Zahedan, Iran. International Journal of Geography and Geology, 5(4), 60-72.

Salama, A. and S. Azzali. (2015). Examining attributes of urban open spaces in Doha. Proceedings of the ICE-Urban Design and Planning, 168(2): p. 75-87.

Shurbaji, M. and R. Furlan. (2017). The Sheraton Park and Users' Human Behaviour: Strategies for Implementation of the Public Realm in Doha.

Soltanian, F., & Mohammadi, A. (2015). Study of Characteristics of Urban Public Open Spaces based on Social Interaction (Case study: Salavatabad's 3-kilometer Route). European online journal of natural and social sciences, 4(3), 553.

Sturm, R., & Cohen, D. (2014). Proximity to urban parks and mental health. The Journal of Mental Health Policy and Economics, 17(1), 19-24.

Tereci, A., & Atmaca, M. (2020). Integrating Renewable Energy Systems into Urban Furniture for Recreational Spaces: A Design Proposal for Konya Adalet Park. Gazi University Journal of Science, 33(1), 1-12.

Vasileiou, K., Barnett, J., Thorpe, S., & Young, T. (2018). Characterising and justifying sample size sufficiency in interview-based studies: systematic analysis of qualitative health research over a 15-year period. BMC medical research methodology, 18(1), 1-18.

Villanueva, K., Badland, H., Hooper, P., Koohsari, M., Mavoa, S., Davern, M., Roberts, R., Goldfeld, S. & Giles-Corti, B. (2015). Developing indicators of public open space to promote health and wellbeing in communities. Applied geography, 57, 112-119.

Wood, R. (2003). Improving the indoor environment for health, well-being and productivity. Greening Cities: a new urban ecology, 30 IV 2003. Australian Technology Park, Sydney

Wolch, J.R., J. Byrne, and J.P. Newell. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. Landscape and urban planning, 2014. 125: p. 234-244.

Wood, L. and Martin, K. (2010). What makes a good play area for children? Centre for the Built Environment and Health, The University of Western Australia.

Programmmanagement als Grundlage zur Umsetzung von Stadtentwicklungskonzepten

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1 ABSTRACT

Die aktuellen Herausforderungen der Stadtentwicklung in Deutschland sind komplex und vielseitig: Digitalisierung und Energiewende, Strukturwandel und Zuwanderung, Wohnraumknappheit und demografischer Wandel, um nur einige zu nennen. Mit ihren Verwaltungen haben Kommunen eine Schlüsselfunktion zur Bewältigung dieser Herausforderungen inne. Zu viele Behörden dienen jedoch als reine Abwicklungsapparate und können selten eigenständig Innovationen anstoßen oder größere Wagnisse zur Bewältigung der Herausforderungen eingehen. Aktuell werden unter anderem Ansätze zu nachhaltigen resilienten Smart Cities, ob blau oder grün, diskutiert und erprobt. Die Förderlandschaft fokussiert somit auf vorherrschenden Zeitgeist und verleitet Kommunen dazu, auf gewisse Trends aufzuspringen. Aus dieser Grundkonstellation heraus stellt sich die Frage, wie für Städte langfristig und nachhaltig Handlungsoptionen entwickelt werden können, um die resiliente Stadtentwicklungsplanung agil und innovativ zu bewältigen.

Untersucht wurde der Zusammenhang zwischen erfolgreicher nachhaltiger Stadtentwicklung und der organisatorischen, strukturellen und prozessualen Leistungsfähigkeit von Mittelstädten in Deutschland. Hierzu wurden gemischte Methoden angewendet, die sowohl deduktive als auch induktive Ansätze verfolgen. Wie für gemischte Ansätze üblich, ist die Forschungsarbeit problemorientiert aufgestellt und zieht Rückschlüsse aus verschiedenen Blickwinkeln.

Verknüpfung zu Wissenschaft und Forschung, Kooperationen zwischen Städten, Netzwerke mit der Wirtschaft, Austausch mit der Bevölkerung, sowie interne Kommunikation und Wissenstransfer sind die entscheidenden Faktoren, die untersucht wurden. Festgefahrene und veraltete Strukturen sind daher aufzubrechen und Städte auf diesen Wandel vorzubereiten, um mit innovativen und agilen Impulsen aufzuschlagen und die Stadtentwicklung kontinuierlich voranzutreiben.

Zu einzelnen Herausforderungen der Stadtentwicklung liegt eine Vielzahl an Forschungsarbeiten vor, jedoch fehlen Anknüpfungspunkte zu den Alltagsrealitäten der Verwaltungen. Es gilt also, die interdisziplinäre Lücke zu schließen und eine Methodik zu entwickeln, welche die Anpassungsfähigkeit hinsichtlich Stadtentwicklung nachhaltig und kontinuierlich verbessern kann. Demzufolge darf der Fokus nicht auf die planerische Lösung der Probleme selbst gerichtet werden, sondern muss auf die Erneuerung der Rahmenbedingungen von Stadtentwicklungsmanagement gelenkt werden: strukturell, organisatorisch und prozessual.

Die Studie startet mit dem klassischen Top-Down-Ansatz, also einer deduktiven These. Diese These gründet auf dem Meinungsbild aus nichtwissenschaftlichen Quellen, welche Aufschluss über das Lager der Kritiker geben und die Daseinsberechtigung der Arbeitbegründen.Nach intensiver Literaturrecherche erfasste eine erste Impulsphase die vorherrschenden Bedingungen in teilnehmenden Kommunen der „Zukunftsstadt". Anschließend erfolgte eine Feldforschung in vier Untersuchungsräumen (kommunale Planungsämter), um eine stichhaltige Grundlage zur Beweisführung zu erhalten und die Relevanz von nachhaltigem Stadtentwicklungsmanagment zu unterstreichen.

Der folgende induktive Ansatz erschien zunächst weniger strukturiert als der deduktive, weshalb hier der Standard für Programmmanagement[1] des Project Management Institute (PMI) zur Strukturierung unterstützend verwendet wurde. Durch die angewendete Szenariotechnik wurde den untersuchten Kommunen ein großer Freiraum überlassen, denn die persönlichen Erfahrungsschätze der Gesprächspartnerflossen in die Analyse ein und ergaben eine dichte qualitative Datenerhebung. Hierwaren deshalb widersprüchliche und paradoxe Ergebnisse möglich. Methodisch wurden neben semi-strukturierten Interviews, Dokumentenanalysen, Fallbeispiele und Observationen pandemiebedingt virtuelle Workshops durchgeführt. Mit Beobachtungen zu strukturellen, organisatorischen und prozessualen Rahmenbedingungen in der Stadtentwicklung wurde das Wechselspiel zwischen Ursache und Wirkung weiter herausgearbeitet und mündete in einen resilienten und nachhaltigen Leitfaden für Stadtentwicklungsmanagement.

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[1] Der Standard für Programmmanagement (Vierte Ausgabe Ausg., 2019), Project Management Institute (PMI).

Keywords: Anpassungsfähigkeit, Stadtentwicklungsmanagement, Programmmanagement, Stadtentwicklung, Begleitforschung

2 EINLEITUNG

2.1 Ausgangspunkt

Die Städte in Deutschland gehen mit den einzelnen Herausforderungen sehr unterschiedlich um. Es ist davon auszugehen, dass einzelne Städte konkrete Treiber haben und in den örtlichen Schwerpunkten auf hohem Niveau performen. Flächendenkend kann jedoch nicht von einer gleichmäßig hohen Qualität ausgegangen werden. Aktuelle Forschungsprojekte, beispielsweise die vom Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) durchgeführte „Stadt von Übermorgen" (Petrin, Köhler, Ackermann, Da Costa, & Sibum, 2022)geben konkrete Arbeitshilfen zur Umsetzung von Zukunftsdiskursen, die den Städten helfen können, ihre Stadtentwicklungskonzepte aufzusetzen oder zu überarbeiten.

Bereits nach der ersten Recherchephase ließ sich feststellen, dass die Stadtentwicklung gegenüber den Schwester-Disziplinen Architektur/ Hochbau/ Tiefbau deutlich besser vernetzt ist. Der höhere Vernetzungsgradlässt sich durch das größere politische Interesse und vermeintlich weniger Expertentum erklären. Dennoch war festzustellen, dass trotz guter Strukturen und Vernetzungen, die Ämter der Kommunen dem Rhythmus, der auf Bundesebene angeschlagen wird, nur schwer folgen können. Die Umsetzung der großen Agenden (Charta von Aalborg 1994, Neue Charta von Athen 1998, Leipzig Charta 2007, Marseille Statement 2008, Toledo-Deklaration 2010, Zukunftsstadt 2015, Pakt von Amsterdam 2016 (New Urban Agenda), Smart City Agenda 2017) werden lediglich in Pilotprojekten ausreichend unterstützt. Jedoch werden nicht ausreichend nachhaltige Ansätze zur Verstetigung der Prozesse innovativer Stadtentwicklungsprojekte verankert.

Ohne Einbindung in ein kontinuierliches einfassendes Stadtentwicklungsmanagement bleibt zu befürchten, dass auch nach Durchführung der Zukunftsdiskurse eine Verstetigung der Herangehensweise in den Stadtplanungsämtern ausbleibt. Ein übergeordnetes Umdenken zur Einordnung und Verknüpfung von Stadtentwicklung im Gesamtkontext zwischen Portfolio einer Stadt und den einzelnen stadtplanerischen Projekten ist dringend erforderlich.
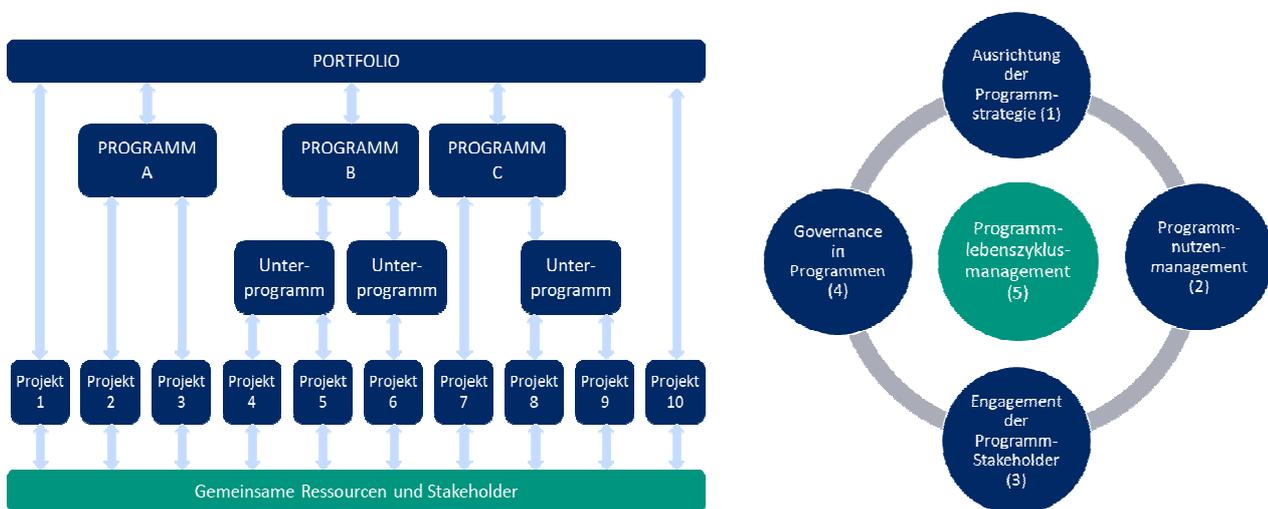
Fig. 1, li.: Zusammenhänge von Portfolio, Programmen und Projekten, gemäß dem Standard für Programmmanagement, PMI. Fig. 2, re.: Leistungsbereiche im Programmmanagements, gemäß dem Standard für Programmmanagement, PMI.

Ohne auf die städtebaulichen Inhalte konkret einzugehen, stellt sich die Frage, ob die allgemeinen Rahmenbedingungen in den Verwaltungen die gleichen sind. Ist es erstrebenswert, eine Vergleichbarkeit herzustellen? Ist es überhaupt möglich, eine Vergleichbarkeit herzustellen? Strukturell, finanzstrategisch, organisatorisch und prozessual lassen sich durchaus Maßstäbe ansetzen und vergleichen, da in anderen Branchen bereits mehrere Reifgradmodelle entwickelt worden sind. Zu vergleichen wären für den Fall der Stadtentwicklung neben Kompetenzen und Kapazitäten auch der Grad der Vernetzung zu Wissenschaft und Forschung, Kooperationen mit anderen Städten, Verknüpfungen zur Wirtschaft, der Austausch mit der Bevölkerung, die interne Kommunikation, sowie der Umgang mit Risiken undWissensaustausch.

Somit ist klar, dass die Herausforderungen in den Stadtplanungsämtern sich stark gewandelt haben und auch weiter stark verändern werden. Meistens haben Mitarbeiter und Führungskräfte in Stadtplanungsämtern einen planerischen Hochschulabschluss und selten weitere Zusatzqualifikationen, die eigentlich erforderlich wären, um den gewandelten Anforderungen gerecht zu werden. Auch herkömmliche Ansätze für Projektmanagementsind dabei nicht mehr ausreichend, da es um weit mehr geht als Termine-Kosten-Qualitäten.

2.2 Aktuelle Beobachtungen und Tendenzen (akademisch)

Bisherige Ansätze, wie die städtischen Gesellschaften die Aufgaben der Zukunft lösen sollen, werden durch Agenden undExperten teilweise zwar aufgezeigt, aber in der Umsetzung nur bedingt weiterverfolgt (Schubert, 2015). Die Erfahrung und das generierte Mehrwissen aus Untersuchungsräumen wird nicht nachhaltig dokumentiert und transferiert. Folgende Probleme sind festzustellen

- Verschärfung der aktuellen Probleme: Zu den bekannten Herausforderungen ist mittelfristig eine weitere Verschärfung zu prognostizieren. Dies lässt sich an den Beispielen Zuwanderung, Digitalisierung, Klimawandel oder Verkehr und Mobilität deutlich vor Augen führen: Es ist zu erwarten, dass wir in allen drei Bespielen momentan nur mit der Spitze des Eisbergs konfrontiert sind. Es ist kaum vorstellbar, wie unsere Städte eine wirkliche Mobilitätsrevolution oder eine größere Flüchtlingswelle als 2015 oder aktuell aus der Ukraine stemmen sollen. (BBSR, Aktuelle städtische Herausforderungen, 2017).

- Faktor Unbekanntes - neue Herausforderungen: Die Plattform „Zukunftsstadt" formuliert, dass „die grundlegenden Bedingungen für die Entwicklung der Städte (…) sich in den kommenden Jahrzehnten deutlich verändern" werden. (BMBF, 2015) Hierzu werden integrierte und kontinuierlich geführte Vulnerabilitäts- und Risikoanalysen erforderlich werden, die eine vernetzte Strukturder Städte voraussetzt.

- Verschärfung der Geschwindigkeit: Zu beobachten ist ein immer schneller werdender Wandel und verstärkte Gleichzeitigkeit von Trends und neuen Herausforderungen. Dies führt bei gleicher Personalstärke zu Verwässerung von Themen oder Nichtabschließen von Maßnahmen und Aktivitäten.

- Kluft zwischen Theorie und Praxis: Der Kluft zwischen politischer Willensbekundung und der Umsetzung der theoretischen Agenden in den einzelnen Städten ist enorm groß. Es könnte auch heißen: Kluft zwischen Politik und Verwaltung oder zwischen Strategie und Operative oder zwischen Vision und Mission.

- Vernachlässigte Konsultative: Gemäß Leggewie und Nanz in „Die Konsultative" (2016), könnten sogenannte Zukunftsräte aus Bürgerinnen und Bürgern beratend, konfliktbearbeitend undzukunftsorientiert wirken. Sie könnten Werte, Prinzipien und Visionen vieler Menschgruppen repräsentieren und damit klassische demokratische Strukturen um eine Vierte Gewalt ergänzen.

- Dokumentenschwemme: Die Förderlandschaft bei Stadtplanung und Stadtentwicklung generiert bei Kommunen eine unkoordinierte Produktion an Dokumenten, welche nicht zusammengeführt und rückverankert werden.

- Forschungsdilemma: Die wissenschaftliche Forschung zu Stadtentwicklung erfolgt selten über die Kommunen selbst. In den meisten Fällen werden sie in laufenden Förderprogrammen von außen evaluiert. Hierbei wollen sich die Städte aus nachvollziehbaren Gründen im guten Licht präsentieren. Der Erkenntnisgewinn und die Selbstreflektion werden vernachlässigt.

2.3 Ansatzpunkt

2.3.1 Absicht und Ziele

Die Absicht der Arbeit ist es, Wege für Städte und Gemeinden herauszuarbeiten, um die neuen Herausforderungen der Stadtentwicklung agil und innovativ zu bewältigen. Das Promotionsvorhaben soll die Notwendigkeit wissenschaftlicher Arbeit mit, durch und über öffentliche Vertreter unterstreichen. Wenn Städte und Gemeinden an der Verbesserung ihrer Leistungsfähigkeit in der Stadtentwicklung wirklich

aufrichtig interessiert sind, dann sind neue Impulse durch die politischen Entscheider zu setzen, um für die anstehenden Aufgabengewappnet zu sein.

„Darüber hinaus benötigen einige Forschungsziele, wie beispielsweise die Einführung von Wissensmanagement oder die Förderung der Innovationsfähigkeit, ein kontinuierliches Prozessmanagement als Basis. Da für den nachhaltigen Erfolg von Projekten im Bereich der prozessorientierten Verwaltung das Prozessmanagement langfristig aufgestellt sein muss, besteht hier ein dringender Bedarf, die Strategieentwicklung im Bereich des Prozessmanagements sowie das vor allem sehr wichtige Verstetigen des Prozessmanagements zu vertiefen." (Becker, et al., 2012)

Veränderungsbereitschaft und das Vertrauen in Forschung und Innovation sind der Schlüssel für eine erfolgreiche Zukunft. Die nationalen PlattformZukunftsstadt unterstreicht diesen Missstand:

„Rechtliche, finanzielle, organisatorische und prozessuale Rahmenbedingungen müssten entsprechend gestaltet und Erfahrungsaustausche organisiert werden." (BMBF, 2015) und weiter:

„Für die langfristige Planung und Begleitung der Umsetzungsprozesse müssen neue Grundlagen geschaffen werden. Mit der Einbeziehung des Wissens aller relevanten Akteure wird eine neue Basis geschaffen." (BMBF, 2015).

Ziel ist es, Grundlagen zu schaffen, um die vorliegenden Stadtentwicklungskonzepte (Dokumente) in ein Stadtentwicklungsmanagement (Instrument) zu überführen. Hierbei werden die Grundsätze des Programmmanagements herangezogen.

2.3.2 Forschungslücke

Die Forschungsarbeit platziert sich im Spannungsfeld zwischen Planungs-, Verwaltungs-, Politik- und Wirtschaftswissenschaft. Die aktuellen Themen der Stadtentwicklung sind allseits erkannt und Herausforderungen identifiziert. Zu den Planungsthemen liegen eine Vielzahl an Forschungsarbeiten und Untersuchungen vor, jedoch fehlen nachhaltige Ansätze zur Verstetigung der Prozesse innovativer Stadtentwicklungsprojekte für die Verwaltungen. Die Forschungsaufgabe besteht darin, die interdisziplinäre Lücke zwischen Management, Verwaltung und Planung zu schließen und nach Möglichkeit eine Methodik zu entwickeln, welche die Leistungsfähigkeit aller deutschen Mittelstädte nachhaltig verbessern kann.

Zentrale Fragen

Wie können Kommunen dem immer schneller werdenden Wandel und dem immer schnelllebigeren Erscheinen neuer Trends und Herausforderungen gerecht werden? Wie können Städte und Gemeinden ihren Wirkungsgrad und ihre Schlagkräftigkeit in der Stadtentwicklung verbessern? Wie kann dabei Innovation und Agilität flächendeckend sichergestellt werden? Wie können Städte ermutigt, ermächtigt und befähigt werden, um vom Reagieren zum Agieren, vom Passiv zum Aktiv und vom Verwalten zum nachhaltigen Erschaffen zu kommen?

2.3.3 Fokus

Die Forschungsarbeit fokussiert sich demzufolge nicht auf die inhaltliche Lösung der Probleme selbst, sondern auf die Analyse und Erneuerung der Rahmenbedingungen: strukturell, organisatorisch und prozessual. Neben planerischem Verständnis sind Projekt- und Programmmanagementfähigkeiten in den Ämtern grundlegende Voraussetzung zur Umsetzung von neuen Ansätzen. Die Literatur zeigt, dass seit 2000 Projektmanagementexperten die Standards des PMI oder APM hinterfragen und neu überdenken. Vor allem Wissensmanagement, „Organisational Learning" und Programm- und Portfoliomanagement sind neue Herausforderungen für eine sogenannte Rethinking Generation (Andersen, 2008). Limitiert ist die Arbeit auf Städte und Gemeinden mittlerer Größe in Deutschland.

3 ABLAUF UND ERGEBNISSE DER DATENERHEBUNGSPHASE

3.1 Auswahl der Untersuchungsräume

Die Forschungsarbeit beschränkt sich bewusst auf die Mittelstädte Deutschlands, da in Großstädten bereits von den Stadtplanungsämtern losgelöste Einheiten zur Stadtentwicklung gebildet wurden und dadurch die Verwaltungen in puncto Governance abweichend aufgestellt sind. Eine Vergleichbarkeit ist bei Mittelstädten wesentlich höher und dadurch der Verallgemeinerungsgrad der Arbeit deutlich besser.

Der Radius auf Baden-Württemberg beschränkt. Es wurden acht Städte angeschrieben, die bezüglich Stadtentwicklung unterschiedliche Ausprägungen erwarten lassen. Vier Laborräume konnten zur Untersuchung ausgewählt und zur Kooperation überzeugt werden. Die Laborräume werden in der Arbeit anonym behandelt und werden im Folgenden als Stadt B, E, G, und T benannt. Je Laborraum wurde die Datenerhebung mit verschiedenen Akteuren innerhalb der Verwaltung über einen längeren Zeitraum hinweg angesetzt.

3.2 Ablauf der Datenerhebung

Die Datenerhebung erfolgte in drei Phasen von September 2019 bis Juli 2021. Die Vertiefung erfolgte schrittweise über semi-strukturierte Interviews, problemzentrierte Expertengespräche und abschließenden konfrontationsorientierten Workshops, die pandemiebedingt virtuell erfolgten.
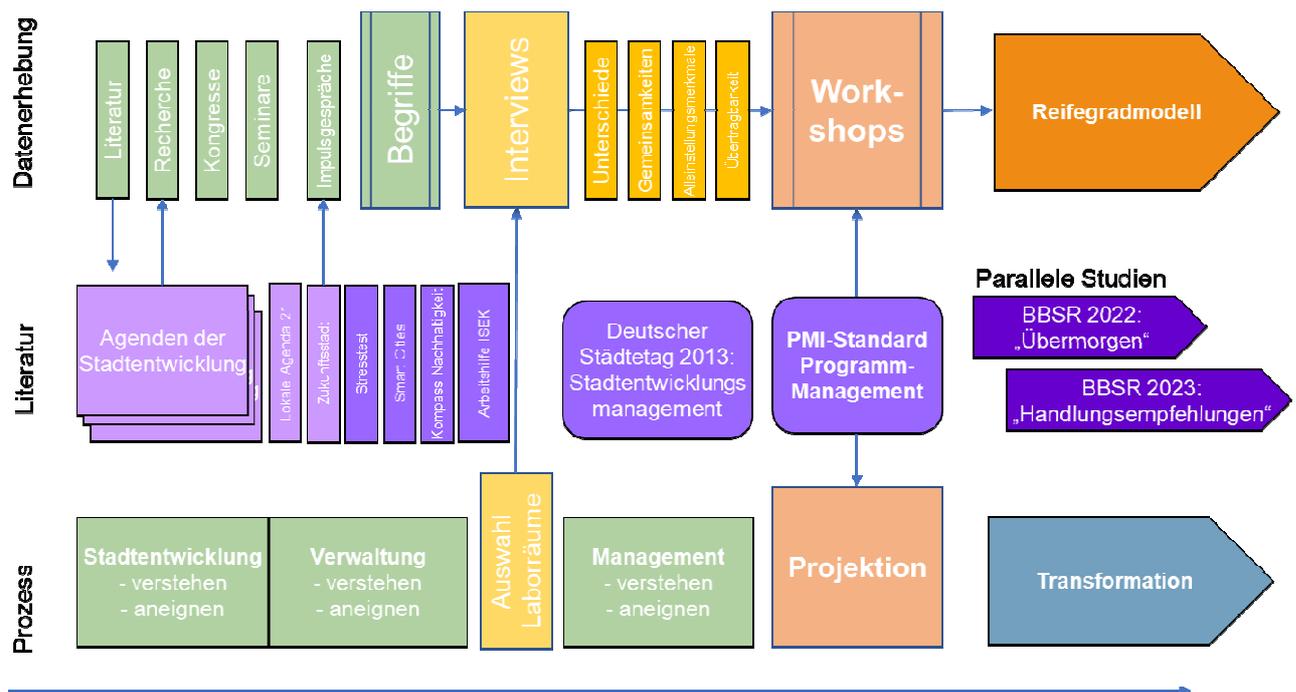
Fig. 3: Schema zu Methodik und Prozess der Datenerhebung, eigene Darstellung.

Bereits in den ersten beiden Phasen konnten einige Missstände detektiert werden: Dokumentenschwemme, Kapazitätsengpässe/ Überlastung, Kampf um gute Köpfe, Arbeitsmarktsituation, Frustration durch Haushaltskürzungen, Austragung von Konflikten auf Projektebene, Frustration, sich als Einzelkämpfer zu fühlen, Hinterherlaufen bei Zukunftsthemen, resultierender Aktionismus, Mehraufwand aus mangelnder Transparenz gegenüber Dritten, fehlende Verlinkung der Projekte, fehlende Wissensgenerierung, Gefühl des Ausgeliefertseins aufgrund von Willkür und Zufall, Partizipation als Stressfaktor, Feigenblatt oder Alibiveranstaltung, fehlende Werkzeugkiste Partizipation.

Die folgenden Workshops erfolgten nach dem Prinzip der Szenariotechnik, d.h. die Experten wurden aufgefordert, sich in die Lage einer vergleichbaren fiktiven Mittelstadt in Deutschland zu versetzen, in der noch kein(e) Stadtentwicklungskonzept(e) aufgestellt wurde(n) und noch keine kanalisierten Strukturen zur Stadtentwicklung in der Verwaltung hinterlegt wären. Die Aufgabenstellungen der Workshops bezogen sich somit auf den fiktiven Idealfall, wie Stadtentwicklung platziert und aufgezogen werden sollte. Dadurch sollten auf neutralem Terrain die Erfahrungswerte der Experten einfließen und eine kritische Auseinandersetzung mit dem eigenen Umfeld erfolgen. Im Diskurs wurde die vorausgegangene akademische Analyse zum eigentlichen Untersuchungsraum herangezogen und in Vergleich gesetzt. Zusätzlich konnten auch die Erkenntnisse des Forschers aus den anderen Untersuchungsräumen in den Diskurs mit einfließen.

Zur Anleitung des Diskurses dienten dem Forscher die Erkenntnisse aus der Arbeitshilfe des BBSR, die Positionspapiere des Deutschen Städtetags, sowie die Workshopberichte der städtebaulichen Begleitforschung der Städtebauförderung.

Die Untersuchungsräume sollten im Szenario das gewohnte Umfeld verlassen und sich außerhalb der Komfortzone auf die gezielten Konfrontationen des Forschers Lösungen für einen Idealfall entwickeln. Sie wurden somit zu einer Reflektion und zum Schulterblick geleitet. Durch die Durchführung der Szenario-Technik in allen vier Untersuchungsräumen wurden aus den unterschiedlichen lokalen Situationen heraus die Erfahrungswerte abgeschöpft, ohne einen Untersuchungsraum für Misserfolge oder Fehlentwicklungen bloß zu stellen. Das Übereinanderlegen und Vergleichen der unterschiedlichen Erkenntnisse aus den vier Workshopsituationen erzeugte eine Bündelung der relevantesten Sichtweisen und Perspektiven undgenerierte ein verdichtetes Bild zur idealen Entwicklung von Stadtentwicklungsmanagement.

Zur Überprüfung der theoretischen Ansätze des Programmmanagements des PMI wurden weitere Dokumente aus dem Bereich der Stadtentwicklung analysiert und in Kontext gesetzt:

- Arbeitshilfe zur Erstellung von Stadtentwicklungskonzepten
- Positionspapiere des Deutschen Städtetags
- Evaluations- und Monitoringberichte der Städtebauförderung

3.3 Ergebnisse aus der Interviewphase

3.3.1 Diversität der sogenannten Stadtentwicklungskonzepte

Die Stadtentwicklungskonzepte der untersuchten Städte sind sehr unterschiedlich einzustufen. Stadt G überzeugt durch ein Stadtentwicklungskonzept, dass sowohl im Prozess als auch im formalen Ergebnis und den hinterlegten Handlungsperspektiven den Anforderungen gerecht wird. Es ist ein publiziertes Heft, welches auch der Öffentlichkeit zugänglich ist. Untersuchungsraum E hingegen hat das sogenannte Stadtentwicklungskonzept selbst verwaltungsintern erarbeitet, genügt aber nicht den Ansprüchen gemäß Leitfaden des BBSR (BBSR, 2016). Es ist der Öffentlichkeit nicht zugänglich und dient eher dem verwaltungsinternen Überblick zwischen der Vielzahl an Portfolio-Dokumenten, Unterprogrammen und Einzelprojekten. In den Kommunen B und T liegen keine Stadtentwicklungskonzepte vor. Im Stadtraum T überzeugt die vorbildliche integrierte Umsetzung auf der Ebene der Unterprogramme, die Leitfäden auf Portfolioebene sind hingegen veraltet und überholungsbedürftig. Der Laborraum B wird versuchen über den aufgesetzten IBA-Prozess eine Verstetigung zu entwickeln und perspektivisch Grundlagen für ein Stadtentwicklungskonzept zu erzeugen.

3.3.2 Dominanz von spezifischen Unterprogrammen

In allen Untersuchungsräumen ist zu konstatieren, dass Unterprogramme die Gesamtkonzepte überstrahlen, sei es durch dominante Stadtteilkonzepte, durch starke Einzelunterprogramme (Mobilität, Klima, Hochwasser, Einzelhandel etc.) oder durch einzelne Stadtplanungsprojekte (Leuchtturmprojekte).

3.3.3 Unverknüpfte Dokumente aus Unterprogrammen und Projekten

Die Vielzahl der vorliegenden Dokumente ist in allen Kommunen gleichermaßen erschlagend und in Gänze kaum erfassbar. Ein Großteil der erarbeiteten Dokumente ist älter als 10 Jahre und überarbeitungswürdig. In den seltensten Fällen sind die angestoßenen Prozesse rückverankert in das Gesamtkonzept. Selbst wenn die Dokumente in Prozesse oder Projekte überführt wurden, sind die Erfahrungen unzureichend dokumentiert und können deshalb nicht in die Fortschrittsmessung oder in ein Wissensmanagement für Stadtentwicklung übertragen werden. Die Mehrwertgenerierung und Rückverankerung ist also stark vernachlässigt.

3.3.4 Risikomanagement und Änderungsmanagement

In keinem der vier Untersuchungsräume ist ein Risikomanagement oder Änderungsmanagement für Stadtentwicklung systemisch aufgesetzt.

3.3.5 Wissensmanagement

In keiner der vier untersuchten Kommunen ist eine Wissensgenerierung systemisch aufgesetzt. Die Verwaltungen verlassen sich auf den internen Flurfunk. In einzelnen Fällen wurde zwar in Projekten Lessons-Learnt-Protokolle erstellt, jedoch beziehen sich diese auf planerische Schwerpunkte und weniger auf Struktur, Organisation oder Prozess.

3.3.6 Stakeholdermanagement

Ein pro-aktives Akteursmanagement für sämtliche Beteiligte ist systemisch/ konzeptionell in keinem Untersuchungsraum aufgesetzt. In einzelnen Untersuchungsräumen (Städte E/T) erfolgen partizipative Prozesse ausschließlich über eigens geschaffene Stabfunktionen.

Beteiligungsprozesse mit der Bürgerschaftsind in allen vier Untersuchungsräumen angekommen. Die Ausprägung und Umsetzung von Beteiligungen erstreckt sich von Information über Mitwirken bis hin zur Mitentscheidung. Beteiligung von weiteren Akteuren erfolgt in deutlich geringerem Umfang.

Auch wenn die Vielzahl an möglichen Formen der Beteiligung hinlänglich bekannt sind, werden in den untersuchten Kommunen bei Weitem nicht alle Werkzeuge verwendet. Weder konzeptionell flächendeckend, noch mit einem Wissenspool rückverankerte Mehrwertgenerierung ist hinsichtlich Stadtentwicklung zu erkennen.

Peer-Kooperationen mit vergleichbaren Städten und Vernetzung mit Wissenschafts- und Forschungseinrichtungen konnten nicht identifiziert werden.

3.4 Projektion von Programmmanagement auf Stadtentwicklung

Zur Klärung von Tätigkeiten und Aktivitäten von Stadtentwicklungsmanagement wurde als grundlegender Ansatz das Prinzip des Programmmanagements gemäß PMI zugrunde gelegt.
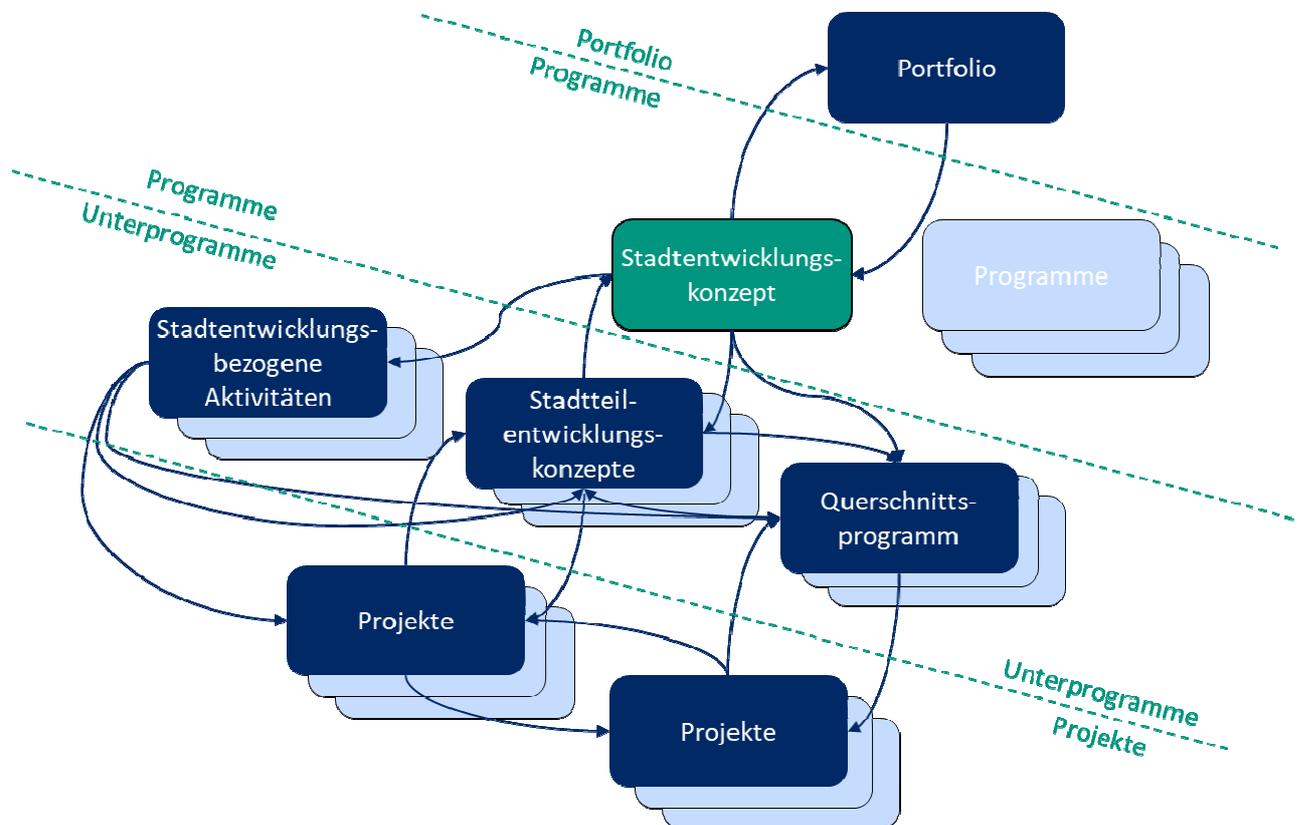
Fig. 4: Projektion von Portfolio, Programm, Projekte auf Stadtentwicklung, analog dem Standard für Programmmanagement, PMI.

Die Verknüpfung des Stadtentwicklungsprogramms mit den Leitlinien und Leitbildern der Stadt ist ein grundlegendes Merkmal um übergeordnete Ziele stadtplanerisch einzufangen. Entscheidend ist eine klare Definition, was über die Stadtentwicklung im Bereich der Stadtplanung umgesetzt werden kann.

3.5 Ergebnisse aus der Workshopphase

3.5.1 Definitions- und Schnittstellenklärung

Das Verständnis für Projekt, Programm und Portfolio ist dringend in allen Untersuchungsräumen zu schärfen, denn in allen Untersuchungsräumen lässt sich feststellen, dass das Verständnis für diese Aufteilung sehr unklar ist. Das hat zur Folge, dass auch die Schnittstellen zwischen Portfolio, Programm und Projekt nicht geklärt sein können. Logischerweise folgt ein Zuständigkeitsproblem zwischen Politik und Verwaltung

und auch zwischen den einzelnen Ämtern. Dementsprechend ist die Aufgabenteilung und die Aufgabenverteilung sehr schwammig. Tendenzen zu Konkurrenzkampf und Aktionismus in den einzelnen Ämtern sind die Folge.

Aus Sicht des Beobachters lässt sich feststellen, dass ein gewisser Handlungsdruck auf den Amtsleitern wirkt, in regelmäßigen Abständen mit neuen Überschriften und Dokumenten aufzuschlagen, um zu zeigen: wir haben da was Neues aufgesetzt, wir arbeiten da dran. Wenn allerdings die einzelnen Dokumente (meist Querschnittsprogramme) nicht rückverankert und integriert werden durch ein Stadtentwicklungsmanagement, werden sie nicht in ein Instrument überführt. Die festgestellte Dokumentenschwemme in allen Untersuchungsräumen ist also eine Ursache dafür, dass die meisten Produkte nicht über den Status eines Dokuments hinauskommen. Gestärkt wird dieses Beobachtung durch die vielschichtige Förderlandschaft, welche viele Einzeldokumente provoziert.

Am meisten überrascht die Unklarheit der Schnittstellen ausgerechnet in dem Untersuchungsraum, wo rein formal die Stadtentwicklung am stärksten im Organigramm abgebildet ist. Dieser Untersuchungsraum E hat das Dilemma, dass das eigene sogenannte Stadtentwicklungskonzept, trotz angeschlossener Überarbeitungsphase nach drei Jahren, keinen Beschluss und damit keinen ordentlichen Auftrag erhalten hat.

Der Prozess ist mit Erstellung des Stadtentwicklungskonzepts nicht abgeschlossen. Das Programmmanagement kann erst ab Auftragserteilung durch den Gemeinderat starten. Die Erstellung des Dokuments namens Stadtentwicklungskonzept ist ohne ein hinterlegtes Stadtentwicklungsmanagement von geringem Wert. Meist ungeklärt bleibt die Frage, was ein Stadtentwicklungskonzept leisten kann und was nicht. Die resultierende Anschlussfragen daher:

Was leistet Stadtentwicklungsmanagement? Und was leistet Stadtentwicklungsmanagement nicht?

Zu Umfang und Schnittstellen von Stadtentwicklungskonzept und Stadtentwicklungsmanagement ist grundlegend mit allen Beteiligten das gleiche Verständnis zu erzeugen.

Die Analyse der Laborräume zeigt auf, dass aufgrund der fehlenden Rückverankerung in ein zentrales Instrument oft nicht möglich ist, da entweder a) ein aktueller Treiber alle Nebenschauplätze in den Schatten stellt oder b) es schlicht zu viele Dokumente aus Unterprogrammen vorliegen, welche eine Verknüpfung nahezu unmöglich erscheinen lassen.

3.5.2 Fortschrittsmessung

Im Untersuchungsraum T wird die Programmebene vollständig vermisst. Der Sprung erfolgt direkt von Portfolioebene (Leitbild) auf Unterprogramme (Quartiere). Im Verständnis des Untersuchungsraums T könnte die Programmebene/ Stadtentwicklungsmanagement die fehlende Fortschrittsmessung ausfüllen. Über das Portfolio wurden keine Indikatoren festgelegt und somit sei keine Erfolgsgeschichte kommunizierbar. „... das ist übrigens, was dem Leitbildprozess von 2003 gefehlt hat: Es waren keine Indikatoren erkennbar, es war alles schön, aber man konnte es nie messen." (Untersuchungsraum T, 26.05.2021) Man würde sich selber gerne an den gesteckten Leitplanken orientieren: „Haben wir es nun erreicht oder nicht? Oder befinden wir uns auf dem richtigen Weg oder driften wir ab?".

Das eigentliche Ziel von Stadtentwicklungsmanagement sei nach Aussage der Teilnehmer aus Untersuchungsraum G die Entwicklung der Ziele unter Einbindung der verschiedenen Akteure. Kommune G machte sich stark für ein Stadtmonitoring, das gekoppelt sein müsste mit gewissen Indikatoren, die statistisch erfassbar sein sollten. Man könne sich vorstellen, dass ein Teil des Stadtentwicklungsmanagements das Nachhalten dieser Kennzahlen beinhaltet. „Das heißt, wenn man das Wort Ziele in den Mund nehmen möchte, (…) dann braucht es sogar auch die Entwicklung eines Zielsystems."(Untersuchungsraum G, 08.06.2021) Gleichzeitig gibt man auch zu bedenken, dass eine zu starke Ausrichtung an Statistik in anderen Städten einen Graben zwischen Stadtentwicklung und Stadtplanung aufgeworfen hat.

3.5.3 Finanzierung/ Fördergelder

Seitens zweier Untersuchungsräume (G und B), wurde die Verknüpfung des Stadtentwicklungsmanagements mit Finanz- und Kostenmanagement als zentrales Argument für die Daseinsberechtigung von Programmmanagement, denn die Förderlandschaft sei sehr divers.

Untersuchungsraum B zielt speziell auf die Verknüpfung der Förderlandschaft und die enge Zusammenarbeit mit der Kämmerei ab. Die klare Forderung alles der Städtebauförderung unterzustellen und alle restlichen

Förderoptionen nur dann zu beantragen, wenn diese zeitlich und kapazitiv mit dem Prozess der Städtebauförderung in Einklang gebracht werden können.

Im Kontext der Fördergelder noch strategischer zu denken und quasi ein koordiniertes Fördergeldmanagement zu optimieren könnte ein wesentlicher Mehrwert des Stadtentwicklungsmanagements darstellen. Es ist vielleicht die einzige Möglichkeit, den chronischen Ressourcenmangel in den Stadtplanungsämtern zu entgegnen.

Untersuchungsraum G hingegen setzt darauf, dass ein Stadtentwicklungsmanagement die Einsparpotenziale monetär aufzeigen müsste. Zum einen könnte die Daseinsberechtigung sich darüber bestätigen, dass man alle unnötigen Tätigkeiten entferne (1). Dies bedeutet, der Mehrwert von Stadtentwicklungsmanagement müsste sich abbilden, indem man aufzeigt, welche Tätigkeiten im Alltag der Mitarbeiter im Stadtplanungsamt dadurch effizienter gestaltet werden könnten. Die Prinzipien des Lean Managements könnten hier ihre Anwendung finden. Zum anderen sollte man sich die Einsparungen durch Priorisierung und agiles Umschichten von Haushaltsgeldern herausarbeiten und den Mehrwert und damit die Daseinsberechtigung von Stadtentwicklungsmanagement ersichtlich machen (2).

3.5.4 Begleitforschung

Die in allen Untersuchungsräumen geäußerte Ressourcenknappheit lässt kaum Spielraum, sich mit der eigenen Performance auseinanderzusetzen. Es stehen weder ausreichend finanzielle Mittel noch personelle Kapazitäten zur Verfügung, um analytisch an der eigenen Organisation, an den Strukturen und Prozessen zu arbeiten.

Ein Gedankengang des Forschers ist es, diesem Dilemma durch Einbindung von externen Forschungseinrichtungen entgegenzuwirken. Das Thema Begleitforschung ist jedoch in allen Untersuchungsräumen die große Unbekannte. Die bisherigen Kooperationen mit externen Fachleuten erfolgte in Untersuchungsraum G bei der Erstellung des Stadtentwicklungskonzepts. In den Untersuchungsräumen T und E wurden die Portfolioprozesse durch externe Berater, Moderatoren und Mediatoren unterstützt. In Untersuchungsraum B erfolgt aktuell eine intensive Betreuung im IBA-Prozess. Alle Untersuchungsräume lassen sich also bei Beteiligungsprozessen beraten, entweder durch installierte Stabstellen innerhalb der Verwaltung oder durch externe Konsulenten. Die Begleitung erfolgt mit dem Ziel, Neutralität zu wahren und Vorbehalte gegen die Verwaltung abzubauen. Das Produkt, welches die Beratenden meistens vertraglich schulden, ist die Dokumentation und Kommunikation des Prozesses gegenüber allen Beteiligten. Der Adressat ist dementsprechend die Öffentlichkeit.

Die Einbindung von Hochschulen und Universitäten bezog sich bislang auf a) entwerferische Arbeiten, welche b) durch Studierende erarbeitet wurden und c) sich über eine maximale Laufzeit von einem Semester erstreckten. Der Mehrwert für das Stadtplanungsamt ist dabei sehr überschaubar. Erforderlich jedoch sind

a) analytische Untersuchungen durch b) wissenschaftliche Mitarbeiter über c) einen längeren Untersuchungszeitraum von einem bis zu fünf Jahren. Die Adressierung der Erkenntnisse richtet sich ausschließlich intern an das Stadtplanungsamt. Sollten Erkenntnisse aus mehreren Städten in die Forschung einfließen, könnte anonymisiert gearbeitet werden.

In den Werkstätten wurden die Teilnehmer mit dieser Option konfrontiert und es konnte ein gemeinsames Verständnis dafür entwickelt werden, dass eine langfristige Beobachtung und Betreuung durchaus sinnvoll wäre, um eine Verstetigung in der Stadtentwicklung herbeizuführen.

Die funktionierende Verwaltung könnte durch folgende Ziele der Begleitforschung erreicht werden: Best-Practice und Lessons-Learnt institutionalisieren, am Puls der Zeit sein, Werkzeugkiste ertüchtigen, Kommunikation verbessern, Bandbreite der Kanäle erweitern, Transparenz schaffen, Netzwerk ausbauen und pflegen, Arbeitsatmosphäre verbessern, Effektivität und Effizienz steigern, Sicherheit im eigenen Tun steigern, dabei mehr zu steuern weniger zu planen.

4 FAZIT UND AUSBLICK

Die Daseinsberechtigung von Stadtentwicklungsmanagement wird über die dystopische Inversion verdeutlicht: Was wären die Folgen eines Weiterarbeitens ohne Stadtentwicklungsmanagement?

- Weiter Überlastung

- Weiter Dokumentenschwemme

- Weiter Austragung von Konflikten auf Projektebene

- Weiter den Zukunftsthemen hinterher laufen/ weiter Aktionismus

- Weiter Konsequenzen aus mangelnder Transparenz gegenüber Dritten nachlaufen

- Weiter Frustration durch Haushaltskürzungen

- Weiter Frustration, sich als Einzelkämpfer zu fühlen

- Weiter unkoordiniert Projekt für Projekt bearbeiten ohne Wissensgenerierung

- Weiter Willkür und Zufall ausgeliefert zu sein

- Weiter Partizipation als Feigenblatt/ Alibiveranstaltung

Die Leistung von Programmen ist die Verknüpfung von Portfolio-Ebene und Projekt-Ebene mit der Funktion als Bindeglied zur Überwachung, Steuerung und Evaluierung (Reflektion) zu wirken. Es geht darum Arbeitspakete zu schaffen, die zeitlichen und räumlichen Bezug haben, um Inhalte aus der Portfolio-Ebene in die Projekt-Ebene einzusteuern. Programmmanagement überwacht und evaluiert fortlaufend strukturelle, organisatorische und prozessuale Vorgehensweisen.

Als Grundlage zur Ermittlung der Robustheit des Stadtentwicklungskonzepts und der Managementfähigkeit der Stadtplanungsämter sollte eine Bestandsaufnahme über ein Reifegradmodell entwickelt werden, welches die Prinzipien des Programmmanagements (Wissens- und Leistungsbereiche)zugrunde legt.
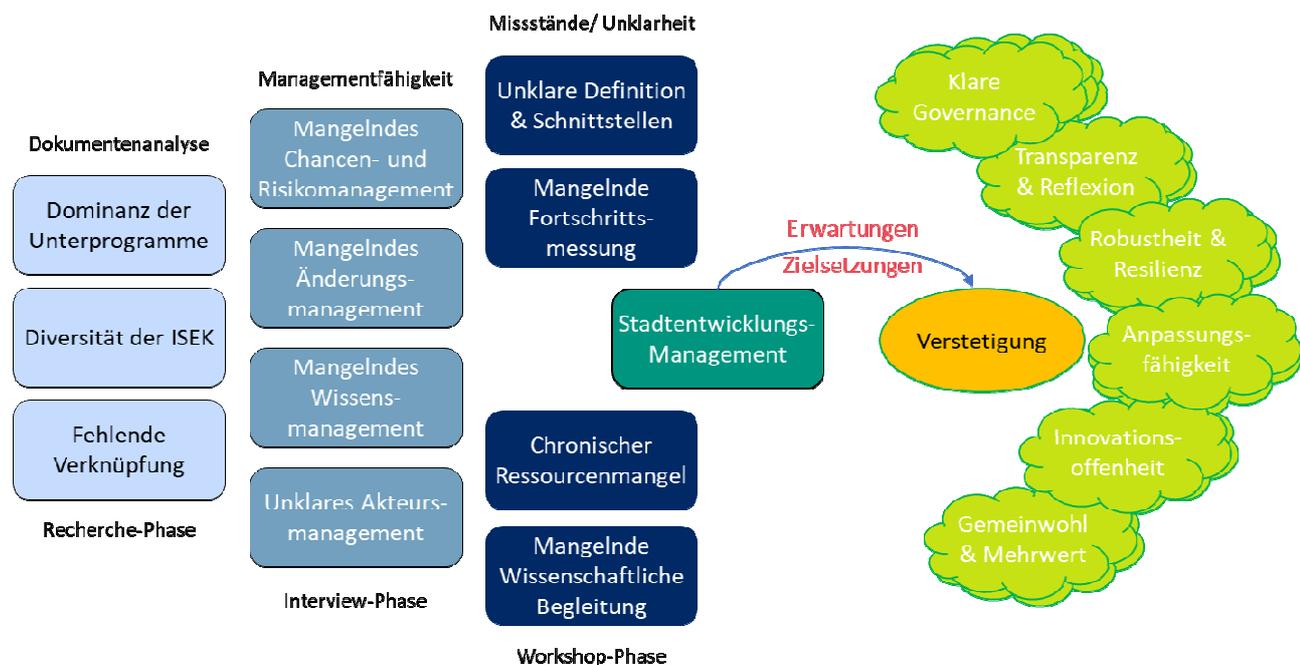
Fig. 5: Erwartungen und Zielsetzungen für die Implementierung von Stadtentwicklungsmanagement, eigene Darstellung.

5 REFERENCES

Altrock, U., & Bertram, G. (2019). Wer entwickelt die Sadt? Geschichte und Gegenwart lokaler Governance. Akteure - Strategien - Strukturen. Bielefeld: transcript.

Altrock, U., Huning, S., Kuder, T., & Nuissl, H. (2014). Editorial. In Die Anpassungsfähigkeit von Städten: Zwischen Resilienz, Krisenreaktion und Zukunftsorientierung (S. 7-21). Berlin.

Andersen, E. (2008). Rethinking Project Management - An Organisational Perspective. Harlow: Pearson Education.

BBSR. (2000). Stadtentwicklung und Städtebau in Deutschland - Ein Überblick. Bonn: Bundesamt für Bauwesen und Raumordnung.

BBSR. (2014). Evaluierung und Selbstevaluierung - Dokumentation des Werkstattgesprächs am 13. Oktober 2014 in Berlin. Berlin: BMUB.

BBSR. (2016). Integrierte städtebauliche Entwicklungskonzepte in der Städtebauförderung. Berlin: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB).

BBSR. (2017). Aktuelle städtische Herausforderungen. In Zehn Jahre Leipzig Charta - Die Bedeutung integrierter Stadtentwicklung in Europa (S. 13-15). Bonn: Bundesinstitut für Bau, Stadt- und Raumforschung.

BBSR. (Februar 2018). Stresstest Stadt – wie resilient sind unsere Städte? Unsicherheiten der Stadtentwicklung identifizieren, analysieren und bewerten. Bonn: Bundesinstitut für Bau-, Stadt und Raumforschung.

630

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Becker, J., Hofmann, S., Jurisch, M., Knackstedt, R., Krcmar, H., Räckers, M., . . . Wolf, P. (2012). Prozessorientierte Verwaltung - Status quo und Forschungslücken. Abgerufen am 3.. 1. 2018 von Prozessorientierte Verwaltung - Status quo und Forschungslücken: https://wi.uni-muenster.de/research/publications/74829

BMBF. (2015). Zukunftsstadt - Strategische Forschungs- und Innovationsagenda. Berlin: Bundesministerium für Bildung und Forschung.

BMI. (2020). Fortschreibung von Integrierten Stadtentwicklungskonzepten (INSEK). Städtebauliche Begleitforschung, Wissenstransfer Städtebauförderung 2019, Dokumentation des Werkstattgesprächs vom 14.11.2019 (S. 16). Berlin: die STEG Stadtentwicklung GmbH.

BMI. (2021). Stadtentwicklungsbericht der Bundesregierung 2020. Berlin: Bunderministerium des Innern, für Bau und Heimat.

BSSR. (2017). Smart City Charta - Digitale Transformation in den Kommunene nachhaltig gestalten. Bonn: Bundesinstitut für Bau-, Stadt- und Raumforschung.

DST. (2004). Zukunftssicherung durch integrierte Stadtentwicklungsplanung und kooperatives Stadtentwicklungsmanagement. Positionspapier des Deutschen Städtetages zum II. Nationalen Städtebaukongress. Deutscher Städtetag.

DST. (2013). Integrierte Stadtentwicklungsplanung und Stadtentwicklungsmanagement – Strategien und Instrumente nachhaltiger Stadtentwicklung. Berlin: Deutscher Städtetag.

DST. (2015). Integrierte Stadtentwicklungsplanung und Stadtentwicklungsmanagement - Positionspapier des Deutschen Städtetags. Hamburg: Deutscher Städtetag.

European Union. (2016). Urban Agenda for the EU - Pact of Amsterdam. Amsterdam: European Union.

Franke, T., & Strauss, W.-C. (4. 2010). Integrierte Stadtentwicklung in deutschen Kommunen - eine Standortbestimmung. Informationen zur Raumentwicklung, S. 253-262.

Hendricks, B. (November 2014). Vorwort - Forschung und Lehre für die Stadtentwicklung. (N. B. BMUB - Bundesministerium für Umwelt, Hrsg.) stadt:pilot spezial.

Ibert, O. (2004). Zu Arbeitsweise und Reichweite innovationsgenerierender Planungsverfahren. In U. Altrock (Hrsg.), Planung und Innovation. Cottbus: BTU.

Ibert, O. (Mai 2008). Zur Komplementarität der Diskurse um Wandel und Alltag der Planung. Alltag der Stadtplanung. Ein Werkstattgespräch über den kommunalen Beitrag zur Entwicklung der Siedlungsflächen, S. 67-71.

Jessen, J., & Reiß-Schmidt, S. (2020). Stadtentwicklungsplanung zwischen Kontinuität und Innovation. In I. Breckner, A. Göschel, & U. Matthiesen, Stadtsoziologie und Stadtentwicklung, Handbuch für Wissenschaft und Praxis (S. 681 - 696). Baden-Baden: Nomos.

Kurth, D. (2015). Renaissance der Stadtentwicklungsplanung. In D. Kurth, R. Bohne, M. Frinken, & J. Kalepky, Leitbilder - Beiträge zu Stadtentwicklung und Städtebau (S. 35-44). Berlin: SRL - Vereinigung für Stadt-, Regional- und Landesplanung e.V.

Leggewie, C. (2015). Wie tot ist die Charta von Athen? Zur Unöffentlichkeit unserer Städte. Informationen zur Raumentwicklung (Heft 4), S. 361-368.

Leggewie, C., & Nanz, P. (2016). Die Konsultative - Mehr Demokratie durch Bürgerbeteiligung. Bonn: Wagenbach Verlag.

Petrin, J., Köhler, B., Ackermann, C., Da Costa, P., & Sibum, D. (2022). Die Stadt von Übermorgen - Zukunftsdiskurse und Arbeitsmaterialien. Bonn: Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR).

PMI. (2019). Der Standard für Programmmanagement(Vierte Ausgabe Ausg.). Project Management Institute.

Rauterberg, H. (2013). Wir sind die Stadt - Urbanes Leben in der Digitalmoderne. Suhrkamp.

Reiß-Schmidt, S., Heinz, W., Kröger, M., Morschheuser, P., Oediger, H.-L., Thielen , H., & Wölpert, R. (2013). Integrierte Stadtentwicklungsplanung und Stadtentwicklungsmanagement – Strategien und Instrumente nachhaltiger Stadtentwicklung. Berlin: Deutscher Städtetag.

Ringler, H. (2015). Stadtentwicklungsplanung: Instrumentarien seit 150 Jahren. Die Sehnsucht nach dem "großen Plan". In D. Kurth, R. Bohne, M. Frinken, & J. Kalepky, Leitbilder - Beiträge zu Stadtentwicklung und Städtebau (S. 21-34). Berlin: SRL - Vereinigung für Stadt-, Regional- und Landesplanung e.V.

Schauber, U. (2003). Bedeutung informeller Planungsinstrumente und Umsetzungsstrategien für eine zukunftsfähige Stadtentwicklung und Risikovorsorge. Hannover: Wissenschaftlicher Wettbewerbsbeitrag, Werner-Ernst-Preis 2003.

Schubert, D. (2015). Stadtplanung – Wandlungen einer Disziplin und zukünftige Herausforderungen. In A. Flade (Hrsg.), Stadt und Gesellschaft im Fokus aktueller Stadtforschung: Konzepte-Herausforderungen-Perspektiven (S. 121-175). Springer.

Selle, K. (2004). Innovationen: Fragezeichen. Klärungsbedarf beider Diskussion um und der Erzeugung von Neuerungen in der Planung. In U. Altrock (Hrsg.), Planung und Innovation. Cottbus: BTU .

Willinger, S. (Heft 2 2014). Governance des Informellen – Planungstheoretische Überlegungen. Informationen zur Raumentwicklung (IzR), S. 147-156.

Refurbished Green Buildings and Net Carbon Emissions Nexus: Towards Safer and Intelligent Futures in South African Cities

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1 ABSTRACT

The study explores the potential of converting existing buildings into green buildings in South African cities for environmental sustainability and economic efficiency. It compares the costs, carbon footprint, and use of recycled materials between refurbishment and new construction. Refurbishment offers advantages in these aspects but presents technological challenges. The study uses Zero Emission Neighbourhood (ZEN) and Zero Energy Building (ZEB) frameworks to evaluate sustainability in refurbishment projects. It concludes that while refurbishment is a promising strategy, standardized evaluation methods, comprehensive databases of projects, and enhanced regulations are needed to support the green building industry in South Africa.

Keywords: Zero emissions, Refurbished Green Buildings, Spatial Planning, Construction, Net carbon

2 INTRODUCTION

2.1 Introduction

As energy demands increase and environmental concerns arise, innovative solutions for sustainable infrastructure are needed. Conventional energy sources, such as coal, pose risks due to high carbon emissions and contribute to global warming, affecting over 90% of South African energy production(Stefanakis, 2019:6981, Lützkendorf and Balouktsi, 2022:964-973).The energy-mix graph below indicates that over 90% of South African energy is produced from fossil fuels (coal) to date.
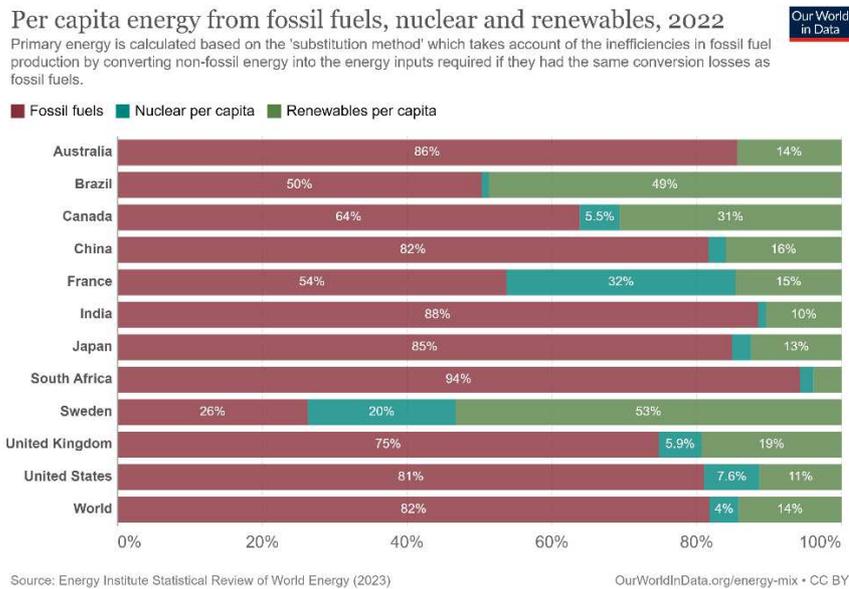
South Africa's economy has grown annually due to international crises, including global warming. The Paris Agreement, initiated by the United Nations in 2015, aims to combat climate change by reducing greenhouse gas emissions from human activities. Countries like South Africa have embraced the agreement and international businesses are supporting it. The South African government has developed a national coordination mechanism to strengthen development policies and improve sustainability.Architects are transforming primitive structures into smart living spaces to combat climate issues and carbon emissions. Modern refurbishment aims to increase sustainable value by integrating technological advancements and renewable energy sources. Green buildings, incorporating advanced technology, reduce dependence on

electricity and increase safety. South Africa's green building industry has moderate development, but financing is limited. The Green Building Council South Africa (GBCSA) has certified over 7.7 million square meters of green buildings since 2007, demonstrating the importance of sustainability in the South African building sector.

The National Department of Public Works has established a green building policy to construct sustainable buildings, leading to substantial savings in finance, time, and space. Cape Town is recognized as the greenest city in South Africa, providing clean energy solutions across various sectors. Recognizing opportunities for refurbished green buildings is crucial for a safer future.

2.2 Role of Refurbishment in Meeting Climate Goals

Refurbishment is a key strategy for achieving climate goals by reducing greenhouse gas emissions and promoting sustainability in the built environment. It involves upgrading systems, improving insulation, and implementing energy-efficient technology to reduce reliance on fossil fuels. Refurbishment projects often incorporate renewable energy sources, such as solar panels, wind turbines, or geothermal systems, to reduce carbon emissions. Water conservation is also a key aspect, with water-efficient fixtures, rainwater harvesting systems, and greywater recycling mechanisms reducing water consumption. Using environmentally friendly materials and practices minimizes the embodied carbon footprint, while enhancing indoor environmental quality through improved ventilation systems and natural daylight. Refurbishment projects offer immense potential for transforming existing buildings into greener, more sustainable structures(van Noorloos and Kloosterboer, 2018:1223-1241).

2.3 Lack of Comprehensive Evaluations for Building Refurbishment

Building refurbishment faces challenges due to the lack of comprehensive evaluations. Robust assessment frameworks are needed to address the complexities of refurbishment projects. Comprehensive evaluations provide a holistic perspective on environmental performance, including energy efficiency, resource utilization, and sustainability. They also identify potential risks and challenges, quantify environmental and economic benefits, and support knowledge sharing and best practices. Life cycle assessment in energy refurbishment is crucial for a holistic understanding of a building's environmental performance. These evaluations help stakeholders make informed decisions and promote sustainable practices in building refurbishment.

Time Period	Evolution in Building Refurbishment	Evolution in Climate Change Understanding
Pre-Industrial (up to mid-18 Century)	Focus on maintaining structural safety and functionality using available materials and techniques.	Natural factors primarily drive climate fluctuations.
Industrial Revolution (mid 18th Century to late 19th Century)	The advent of modern architecture and engineering led to more systematic approaches to building refurbishment.	Increased burning of fossil fuels due to the Industrial Revolution contributed to CO_2 emissions.
Early 20th Century (1900-1950)	Preservation of historic and cultural buildings became a key consideration. Energy efficiency started to be considered.	Spread of industrialisation led to increased emissions. Svante Arrhenius proposed that fossil fuel combustion could lead to global warming.
Mid 20th Century (1950-1970)	Sustainability and energy efficiency became more central to building refurbishment.	Massive increase in industrial activity and greenhouse gas emissions. Introduction of the Keeling Curve.
Late 20th Century (1970-2000)	Emergence of certifications like LEED to guide sustainability in building refurbishments.	Establishment of the IPCC, signing of the UNFCCC at the Earth Summit in Rio.
Early 21st Century (2000-2010)	Revolution of the evaluation process for building refurbishment using Building Information Modeling (BIM). Shift towards holistic evaluations began.	Kyoto Protocol came into effect in 2005.
Early 21st Century (2010-2023)	Evaluations started considering factors like potential for renewable energy use, carbon footprint, and resilience to climate change impacts.	Signing of the Paris Agreement in 2015.

Table 1: Evolution of comprehensive evaluation for building assessments and climate change

In conclusion, the current absence of comprehensive evaluations of building refurbishment poses a challenge to effectively addressing the complexities and maximising the potential benefits of such projects.Robust assessment frameworks are necessary for assessing environmental performance, identifying risks, quantifying benefits, and promoting knowledge sharing in building refurbishment.The development and implementation of comprehensive evaluations will contribute to advancing sustainable building practices and achieving climate change goals.

634

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Outstanding Aspects	Description
Life Cycle Assessment	Comprehensive life cycle assessment, which considers the full environmental impact from extraction of raw materials to end-of-life disposal or recycling, is not universally applied in building refurbishment evaluations.
Embodied Carbon	Embodied carbon, i.e., carbon emissions associated with construction and material production processes, are often overlooked in evaluations. Consideration of embodied carbon could reduce the overall carbon footprint of buildings.
Resilience	Building refurbishment evaluations do not yet standardly include assessments of a building's resilience to predicted climate changes, such as rising temperatures and extreme weather events.
Socio-economic Factors	Evaluations tend to focus on technical and environmental factors, often neglecting socio-economic impacts. Future evaluations should consider effects on local communities, affordability, and improvements in users' quality of life.
Regulatory Compliance	There is a need for better integration of evaluation results into regulatory compliance checks. Compliance checks may not be stringent enough or fully consider comprehensive evaluation results.
Data Accuracy	Evaluation data, especially for older buildings, can be inaccurate or incomplete. Improved data collection methods are necessary for more accurate evaluations.
Technological Developments	Given the rapid pace of technological advancements, evaluation standards must be constantly updated to incorporate new possibilities, especially in areas like renewable energy, energy storage, and digital technology.

Table 2: Outstanding aspects of comprehensive evaluation for building assessments

2.4 Building Refurbishment Evaluation through the ZEN and ZEB Concepts

Building refurbishment is crucial for achieving sustainability goals and reducing environmental impact. Zero-emission neighbourhood (ZEN) and zero-energy building (ZEB) concepts offer a holistic approach to evaluating refurbishment projects. ZEN evaluates energy efficiency, renewable energy use, waste management, transportation systems, green infrastructure, and environmental performance. ZEB focuses on achieving net-zero energy consumption in refurbished buildings, quantifying energy savings, carbon emissions reduction, and economic viability. Standardized data collection methods and a comprehensive database of refurbishment projects are essential for effective evaluation. Integrating these concepts allows for a more informed understanding of environmental, economic, and social effects, enabling stakeholders to make evidence-based decisions and accelerate the transition towards more sustainable built environments(Dong, et al. , 2021:111313).

2.5 The dilapidation and tipping point in structural integrity

The rapid growth of the population and urbanization in South Africa has led to increased construction and maintenance of buildings, which may deteriorate over time due to aging and environmental factors. The Government Immovable Asset Management Act (GIAMA) was introduced in 2007 to guide the management of government-owned assets, including building maintenance. Regular condition assessments must be conducted every five years, but the implementation adds complexity and legal obligations.

Preserving the safety and durability of buildings or infrastructure relies on monitoring deterioration and reaching stability thresholds. Dilapidation refers to the decline or degradation of structures over time, compromising structural integrity. Regular assessment and monitoring are essential to identify signs of deterioration or imminent failure. Engineers and experts can evaluate a building's reliability and take measures to maintain its structural soundness. Managing building maintenance involves establishing thresholds for dilapidation detection and identifying tipping points. Integrated sensors embedded within structures and infrastructures play a crucial role in gathering data on building integrity and environmental conditions. Structural health monitoring (SHM) can help detect and evaluate performance degradation and damage in civil infrastructure as stated below.

Stage 1: Initial Wear (Minor Dilapidation)

Characteristics: Cosmetic damage, minor cracks, paint peeling, early signs of wear in non-structural components.

Recovery Strategy: Regular inspection and monitoring, cosmetic repairs and preventive maintenance, application of weatherproofing where necessary.

Stage 2: Moderate Degradation

Characteristics: Noticeable deterioration in structural components, leaks, rusting, functional impairment of non-essential systems.

Recovery Strategy: Detailed structural assessment to identify affected areas, targeted repairs and replacement of compromised components, Implementation of routine maintenance schedules as per SANS standards.

Stage 3: Advanced Decay (Major Dilapidation)

Characteristics: Serious structural issues, extensive corrosion, compromised safety, and functionality of essential systems.

Recovery Strategy: Comprehensive structural evaluation by certified engineers, major renovations and overhauls, following local regulations such as OHSA, collaboration with local authorities to ensure compliance and safety.

Stage 4: Critical State (Tipping Point)

Characteristics: Imminent failure or collapse, extensive damage that affects the building's overall integrity, immediate threat to safety.

Recovery Strategy: Immediate evacuation and securing of the site, engaging specialized emergency response teams.

Building maintenance in South Africa is crucial due to climate conditions, usage demands, and socio-economic issues. To ensure long-term durability and efficient resource utilization, it's essential to establish phases of deterioration and effective restoration methods. Recommendations include using technology like Building Information Modelling, collaboration among engineers, local authorities, and stakeholders, and implementing training initiatives. Sustainability should be integrated into maintenance practices, and emergency protocols should be in place. This framework addresses South Africa's circumstances while incorporating global best practices.

3 PROBLEM STATEMENT

South Africa's urbanization leads to increased demand for built environments, resulting in increased carbon emissions. Older structures, often inefficient, hinder green practices. Renovating these into green buildings could reduce emissions, but their impact on net carbon emissions in cities is not well understood. This research is crucial for understanding the transition and developing strategies for a sustainable urban future.

4 AIMS AND OBJECTIVES

This study aims to understand whether refurbished buildings help reduce net carbon emissions. This study examines the current state of green building refurbishment in South Africa, comparing it with global standards. It evaluates its contribution to reducing carbon emissions and aligns it with climate change mitigation strategies. It also identifies barriers and enablers to green refurbishment, assesses its social, economic, and environmental impacts, and explores public-private partnerships in fostering it. The study also proposes policy recommendations to enhance green building refurbishment practices and align with South Africa's sustainability goals.

5 RESEARCH METHODOLOGY

This study explores the intersection of refurbished green buildings and net carbon emissions in South African cities, thereby delineating the implications of eco-friendly renovations for sustainable urban development and carbon neutrality.The study employed a robust and integrative mixed-methods approach, coupled with quantitative data analysis and qualitative insights, to comprehensively understand the challenges, opportunities, and impacts of green building refurbishments(ISO 14040, 2006:).

5.1 Materials and Methods

5.1.1 Methodology of building refurbishment to achieve net-zero carbon

Achieving net zero carbon emissions from building refurbishment involves a comprehensive approach that considers the entire life cycle of a building. This includes conducting life-cycle analysis (LCA) to assess the carbon footprint of a building, including embodied carbon emissions from construction materials, transportation, and manufacturing processes. Energy efficiency measures, renewable energy generation, and electrification are implemented to minimize operational carbon emissions. During the refurbishment process, low-carbon and sustainable materials are selected to reduce embodied carbon. Monitoring and control are implemented to optimize energy performance, identifying areas for improvement. Education and occupant engagement are also crucial for promoting sustainable behavior and reducing energy consumption. Integrating ISO 14040 and NZED principles can lead to a more sustainable built environment, optimizing energy performance and achieving net-zero carbon emissions.

5.2 Data Collection

The study used SPSS to collect and analyze data from a 200-participant sample. The process involved selecting variables, designing instruments, sampling participants, collecting data, entering and cleaning the data, conducting descriptive analysis, formulating hypotheses, testing hypotheses with one-way ANOVA, interpreting results, and reporting findings. The online survey included participants from various age groups, financial backgrounds, and working experience levels. The analysis included a one-way ANOVA test to test the hypothesis and ensure accuracy in results(Evon Abu-Taieh, Abdelkrim El Mouatasim, Issam H. Al Hadid, 2020:).

6 RESULTS

The results section of a research report or study provides a detailed presentation and interpretation of the findings obtained from the data analysis. This is a critical component of the research report, allowing readers to understand the study's outcomes and evaluate the validity of the research objectives and hypotheses.

6.1 Profile of respondents

The total number of participants selected for this survey was 200, belonging to different South African construction industry departments. Participants selected for this survey ranged in age from 20 to 60 years, with work experience ranging from 1 year to more than ten years.

	Categories	Frequency	Percentage
Sex (Gender)	Male	45	45
	Female	55	55
Age	20 – 30 yrs	54	27.0
	30 – 40 yrs	45	22.5
	40 – 50 yrs	55	27.5
	50 yrs& above	46	23.0
Income	0 - 1,00,000 ZAR	46	23.0
	1,00,000 - 2,00,000 ZAR	48	24.0
	2,00,000 - 5,00,000 ZAR	54	27.0
	Above 5 000 000 ZAR	52	26.0
Work Experience	None	51	25.5
	1 – 5 yrs	44	22.0
	5 – 10 yrs	57	28.5
	Above 10 yrs	48	24.0
Role in the construction industry	Newly joined	73	36.5
	Junior level	73	36.5
	Senior level	54	27.0

Table 3: Profile of the Respondents

The above table shows that the total number of males in the survey was 45%, whereas the total percentage of female respondents was 55%. The table also shows that the study included participants from multiple age groups. Participants aged 20-30 and 40-50 share the same percentage (27%). In contrast, the percentage of people aged > 50 years in the study was 23%. Evaluating the results obtained from the descriptive analysis, 27% of the participants had an income range of 2,00,000 -5,00,000 ZAR.

In comparison, only 26% of the participants had an income range above five million. Similarly,, around 24% of the participants had an income range of 0-1,00,000 ZAR. It also mentioned that more than 28% of participants have work experience of 5-10 years. Similarly,, the graph confirms that more than 25% of the participants had no work experience. It also mentions that the survey comprises 24% of respondents with more than ten years of working experience. The above table confirms that 36.5% of respondents were newly joined, level, and junior-level employees. Conversely, 27% of participants were senior employees.

6.2 Overall assessment of the refurbished buildings helps reduce net carbon emissions

The study compares refurbished buildings with newly constructed ones to assess the suitability of recycled content. Results show that recycled content is more suitable for refurbished buildings, and prefabricated materials can reduce carbon footprints. Refurbished buildings are less expensive than new construction, and refurbishment is a more effective strategy based on life cycle assessments. However, factors like structural feasibility should be considered before implementing refurbishment strategies. The study concludes that refurbishment outperforms new construction in terms of life cycle assessments, but requires careful consideration of all relevant factors(Corrado and Ballarini, 2016:91-106, Aghasizadeh, et al. , 2022:106897, Palacios-Munoz, et al. , 2019:106203, Sundayi, et al. , 2015:77-82, Loli and Bertolin, 2018:22).

6.3 Assessing the Impact of Refurbishment on the Environment of Energy

Refurbished office buildings, often aligned with the zero-energy building (ZEB) model, can significantly reduce carbon emissions. By modifying structures with recycled and modular components, these buildings can optimize energy efficiency and meet residual energy needs through renewable technologies. The ZEB model exemplifies building refurbishment. A 20% increase in green buildings in South Africa could lead to a 16% reduction in carbon emissions. Prefabricated buildings could also contribute to carbon emission reductions, but their impact on environmental impact is not well understood.

6.4 Alternatives for managing resource policies and building-specific characteristics.

The study compares refurbished buildings with newly constructed ones to assess the suitability of recycled content. Results show that recycled content is more suitable for refurbished buildings, and prefabricated materials can reduce carbon footprints. Refurbished buildings are less expensive than new construction, and refurbishment is a more effective strategy based on life cycle assessments. However, factors like structural feasibility should be considered before implementing refurbishment strategies. The study concludes that refurbishment outperforms new construction in terms of life cycle assessments, but requires careful consideration of all relevant factors(Pons-Valladares and Nikolic, 2020:9741).

6.5 Assessing the Impact of Refurbishment on the Environment of Energy

Understanding the defining attributes of such structures is crucial for understanding the environmental influence of refurbished office buildings. (Rahman, et al. , 2017:112-126) defined a refurbished office building as a structure modified according to specific needs, utilising recycled and modular components. This refurbishment process often aligns with the principles of the zero-energy building (ZEB) model.

A residential or commercial ZEB optimises energy efficiency so that any residual energy need can be met via renewable technologies. This model can function within both off-grid and on-grid frameworks. However, the precise definition of ZEB can vary across enterprises, organisations, and nations. Fundamentally, the ZEB model exemplifies the essence of building refurbishments.

During the implementation of refurbishment processes, it is vital to consider all factors influencing the modification of the structure. A noteworthy observation made by(Lützkendorf and Balouktsi, 2022:964-973)was that a 20% increase in the number of green buildings in South Africa could lead to a 16% reduction in carbon emissions. These data suggest that refurbishment, in line with green building principles, can have a positive environmental impact.

An ancillary hypothesis was examined, which proposed that prefabricated buildings could contribute to carbon emission reductions. However, the one-way ANOVA quantitative analysis technique yielded a p-value of 0.67, exceeding the statistical significance threshold. This result parallels a study by(Ma, et al. , 2021:39-44) in China, which explored factors impacting environmental carbon emissions at prefabricated building construction sites.

6.6 Alternatives for managing resource policies and building-specific characteristics

South African cities often have small buildings with concrete walls and clay brick, leading to increased carbon emissions from new construction projects. Renovating buildings with low-carbon materials can mitigate environmental degradation. A study using a one-way ANOVA test found that recycled content, due to its lower carbon content, is more suitable for refurbished buildings and has general applicability.

Variables	Sum of square	df	Mean square	Sig.
Life cycle assessment of buildings for refurbishment is difficult as there are no regular protocols	2.49	4	0.623	0.019
The use of prefabricated building elements could help in reducing the carbon emission in refurbishment	0.43	2	0.218	0.69
Low-carbon materials are better for refurbishment	2.62	2	1.310	0.13
The use of prefabricated building elements could help in reducing the carbon emission in refurbishment	34.15	4	8.53	0.00
Cost is an essential factor to be considered for refurbishment	2.88	2	1.43	0.39

Table 4: Summary of measures

7 DISCUSSION

The concept of refurbished buildings supports energy and environmental conservation, with South African citizens and the government supporting refurbishment over construction. Recycled content is the most suitable refurbished building material, as approved by the Green Building Council of South Africa. Prefabrication during refurbishment is easy, and the presence of a modular element during prefabrication provides a more satisfactory result.

The primary results show that refurbishment costs are lower and environmentally friendly compared to the construction of new buildings. The current scenario of the South African construction industry supports the primary result, with the refurbishment rate of green buildings being 3500 Rand per m². However, proper

planning and design are required to increase success rates. Refurbishment of a structure is diverse and requires more attention and monitoring.

Using low-carbon materials in refurbished buildings is better because it reduces the cost of construction and supports environmental construction. The life cycle assessment of a building with low-carbon materials is better than that of conventional construction materials. The possible adverse ecological effects of refurbished buildings following each of the three possible government initiatives can be significantly less compared to refurbished buildings operating in the baseline scenario.

Generalised Additive Models (GAM) and Life-Cycle Assessment (LCA) are two distinct approaches used in separate situations. LCA is used to assess the environmental effects of a good or service over the course of its life cycle, while GAM is used to model interactions between variables. Both have various non-exclusive financial benefits, such as flexibility, interpretability, management of missing data, and predictive power.

In the Business-As-Usual (BAU) scenario, external building material, thermal impedance of the ceiling, window-to-wall proportion, number of heating systems placed, annual power consumption, and affect capacity all significantly impact the effect of huge refurbished building structures. Concrete structures require the most energy to produce, accompanied by bricks and concrete structures.

In conclusion, refurbishing green buildings is an effective way to achieve a safer environment in South African cities, with the benefits of refurbishment being lower and more environmentally friendly compared to the construction of new buildings..

8 CONCLUSION

Refurbished green buildings in South African cities like Cape Town and Johannesburg are beneficial economically and environmentally. Recycling content and modular prefabrication reduce carbon content in the construction industry. Enforcing regulations, implementing low-carbon innovation, and limiting energy usage are methods for reducing CO2 emissions. The construction industry must be given due consideration to reduce CO2 emissions and develop a holistic structure to combat climate change. A thorough evaluation is needed to achieve sustainable development goals.

9 REFERENCES

Aghasizadeh, S., Tabadkani, A., Hajirasouli, A. &Banihashemi, S. (2022). Environmental and economic performance of prefabricated construction: A review. Environmental impact assessment review, 97106897.
Corrado, V. & Ballarini, I. (2016). Refurbishment trends of the residential building stock: Analysis of a regional pilot case in italy. Energy and buildings, 13291-106.
Dong, Y., Peng, F., Qiao, Y., Zhang, J. & Wu, X. (2021). Measuring the monetary value of environmental externalities derived from urban underground facilities: Towards a better understanding of sustainable underground spaces. Energy and buildings, 250111313.
Evon Abu-Taieh, Abdelkrim El Mouatasim, Issam H. Al Hadid (2020). Cyberspace.
ISO 14040 (2006). ISO14040: Environmental management -Life cycle assessment -Principles and Framework Management .
Loli, A. &Bertolin, C. (2018). Towards zero-emission refurbishment of historic buildings: A literature review. Buildings (basel), 8(2):22.
Lützkendorf, T. & Balouktsi, M. (2022). Embodied carbon emissions in buildings: Explanations, interpretations, recommendations. Buildings & cities, 3(1):964-973.
Ma, W., Sun, D., Deng, Y., Meng, X. & Li, M. (2021). Analysis of carbon emissions of prefabricated buildings from the views of energy conservation and emission reduction. Nature environment and pollution technology, 20(1):39-44.
Palacios-Munoz, B., Peuportier, B., Gracia-Villa, L. & López-Mesa, B. (2019). Sustainability assessment of refurbishment vs. new constructions by means of LCA and durability-based estimations of buildings lifespans: A new approach. Building and environment, 160106203.
Pons-Valladares, O. & Nikolic, J. (2020). Sustainable design, construction, refurbishment and restoration of architecture: A review. Sustainability (basel, switzerland), 12(22):9741.
Rahman, F.A., Aziz, M.M.A., Saidur, R., Bakar, W.A.W.A., Hainin, M.R., Putrajaya, R. & Hassan, N.A. (2017). Pollution to solution: Capture and sequestration of carbon dioxide (CO2) and its utilization as a renewable energy source for a sustainable future. Renewable & sustainable energy reviews, 71112-126.
Stefanakis, A. (2019). The role of constructed wetlands as green infrastructure for sustainable urban water management. Sustainability, 11(24):6981.
Sundayi, S., Tramontin, V. & Loggia, C. (2015). An investigation into the costs and benefits of green building in south africa. 2015 world congress on sustainable technologies (WCST), 77-82.
van Noorloos, F. &Kloosterboer, M. (2018). Africa's new cities. Urban studies (edinburgh, scotland), 55(6):1223-1241.

Requirements for a Dashboard Application to Facilitate Climate-Smart Planning for Sustainable Resilient Green and Blue Cities

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1 ABSTRACT

To ensure a liveable, resilient and sustainable city in the future, climate change adaptation and mitigation measures must be integrated into urban development projects. This is necessary to counteract the negative effects of climate change, as Austria is already experiencing a noticeable increase in the number of hot days and an increase in extreme weather events (ÖKS 15). Adaptation to climate change requires that the impact of an urban development project on the local microclimate be assessed as early as possible in order to minimise the effects and optimise the project. Microclimate analyses can be used to assess the impact of a development project or to compare different variants of a project and show the effects on local temperature, perceived temperature, wind field or humidity (Oswald et al. 2020). At the same time, urban planning processes are increasingly influenced by digitalisation in the form of Building Information Modelling (BIM).

Linking microclimate simulation and BIM is therefore an important step for the future of sustainable cities. So far, however, no tool exists that combines the various requirements and enables microclimatic assessment or optimisation of urban development projects. Some planning or assessment tools, such as microclimate models or green area indicators, allow for sectoral assessments. What is missing is a comprehensive tool that makes it easy to present the various impacts of a project to spatial planning and development decision-makers, investors and planners and, last but not least, to the general public, such as (future) residents.

This contribution analyses and describes the requirements for such a tool in the form of a web-based dashboard that uses BIM models, links them to microclimatic simulations, and additionally presents key performance indicators (KPI), such as green area indicators, in a structured way. The design of the dashboard is data and task dependent (Conrow et al. 2023); in light of the challenges and opportunities associated with optimising urban development projects from a microclimatic point of view, we set out to address issues related to (i) the requirements for the user interface, i.e. the dashboard, (ii) the requirements for the models (BIM model and microclimatic numerical simulation model), (iii) the possible applications in different planning phases, and (iv) the necessary requirements for data and data preparation.

The aim of the contribution is to analyse and describe the requirements, implementation perspectives and application possibilities of a web-based dashboard, which enables climate impact assessments, macro-ecological data for properties and neighbourhoods in an early planning phase ("climate check") on the basis of three-dimensional building models.

Keywords: Simulation of microclimatic effects, Building Information Modelling, Dashboard, Climate change adaption, Blue and green infrastructure

2 INTRODUCTION

Climate change puts pressure on the sustainable development of cities. To ensure a liveable, resilient and sustainable city in the future, climate change adaptation and mitigation measures must be integrated in urban development projects. This is necessary to counteract the negative developments of climate change, as a noticeable increase in hot days and in extreme weather events is already present in Austria (ÖKS 15). Cities suffer from heat islands also known as the Urban Heat Island effect (Oke 1967). This is the warming of cities compared to the surrounding countryside. The main reason for the stronger heating in fine weather periods is above all the overbuilding and sealing of natural, water-permeable surfaces and thus the related loss of green

and blue infrastructures. This leads to the fact that hardly any precipitation can be absorbed within urban spaces, and thus the subsequent local cooling of the ambient air by evaporation and transpiration cannot take place. Urban heating is intensified by heat-absorbing building materials such as asphalt, concrete or glass. This effect is exacerbated by inappropriate building (block) layouts that prevent ventilation (MA22 2015).

2.1 Climate change adaption in urban development projects

The consideration of these microclimatic effects in planning processes of urban development projects is crucial for the successful adaptation of cities to climate change. Assessing these effects as early as possible in the planning process is necessary to minimise the negative climatic impacts of urban development projects by optimising the project. Optimisation of urban development projects in terms of microclimate and outdoor comfort can address the modification of the urban form, the building orientation and position, the architectural design, façade configurations, the building materials, but also urban green and blue infrastructure etc. There are four areas of action for adapting to climate change and anchoring in urban planning: i) precautionary reservation of land or forward-looking consideration of its use regarding climate change adaption measures, ii) unsealing or avoiding further sealing and increasing the infiltration capacity of the soil, iii) increased use of green and blue infrastructure and nature-based measures and iv) technical measures and protection of property (Jiricka-Pürrer et al. 2021). Adaptation measures of urban development projects can range from minimising sealed surfaces, to appropriate shading and ventilation considerations, and, of course, integration of blue and green infrastructure on both, plot and buildings. The effects of these adaptation measures are well known and have been proven by numerous research projects (e.g. Choi et al. 2021, Dennis et al. 2020, Elmqvist et al. 2015, Demuzere et al. 2014, Peng and Jim 2013). Nevertheless, a concrete assessment of the (inter-)effects of such measures is a complex task. Many variables need to be considered and aligned in order to successfully implement climate change adaptation for urban development projects.

2.2 Building Information Modelling

Meanwhile, planning processes are increasingly influenced by digitalisation in the form of Building Information Modelling (BIM). BIM is a digital and integrated approach to managing projects in the construction industry. In this process a three-dimensional model stores all architectural, technical, (structural-) physical and functional building data in a structured way to create a digital twin of the planned object(s). The "Open BIM" approach (exchange of data via an open, universally readable format) was established for the mutual exchange of this data. Central to this approach is the IFC format (anchored in ISO 16739 and readable for at least 60 years), which provides a standard for structuring the data and is constantly evolving. Compatibility of data formats is a major challenge. Object-related planning is currently largely decoupled from the prevailing microclimatic conditions of the site. Although (landscape) architecture has always responded to its built environment, building design usually follows only spatial-infrastructural parameters or influences such as the course of the sun. However, planning for adaptation to climate change requires the consideration of a number of other conditions. Current planning software (e.g. ArchiCAD, Revit, ...) is only able to consider parameters such as precipitation, temperature gradients, wind situation or shading performance of greenery on building optimisation to a very limited extent. The simulation of ecological and microclimatic effects – if carried out at all – is only done in a decoupled manner and thus causes additional costs (double modelling).

2.3 Microclimate analyses

In parallel, specialists deal with the simulation of the microclimatic effects of buildings and neighbourhoods. These microclimate analyses allow for an impact analysis of a project or the comparison of different variants and show the effects on local temperature, perceived temperature, wind field or humidity (Oswald et al. 2020). Meteorological large-scale and meso-scale models used for weather forecasts do not resolve surface features in the built environment to the extent that allows small-scale microclimate assessment. There are only a small number of different simulation software packages available that are capable of this and consider the conjugate heat transfer, radiation and evaporation effects, which is needed to accurately simulate urban microclimate conditions. Almost all models use regular computational grids with a fixed, spatial resolution, so that there are computational limits for resolving small/thin structures like shading structures.

All of these mathematical models for simulating microclimate in the urban/built environment at neighbourhood level require technical experts to run them and most of them also require high-performance computing. The technical complexity and large amount of data, that these simulations generate means, that the results are not readily available to the layperson or even to urban planning experts.

2.4 Urban planning indicators and certification schemes for assessment

The use of various urban planning indicators is another approach to analyse the qualities of a project in relation to climate change adaptation. In the field of climate change adaptation, there is a wide set of possible indicators. These range from "classical" urban indicators of density and land use (e.g. floor area, built-up area, building mass) to climate indicators (e.g. perceived temperature, wind comfort) to so-called green space indicators. These green and blue area indicators make the extent of blue and green infrastructure measurable and comparable (Ring et al. 2021). In addition, indicators such as the percentage of imperviousness or the degree of sealing are used, which document soil consumption and are an indicator of local water cycle disturbances as well as water drainage.

Another approach used, which usually includes or evaluates several indicators, is certification schemes at building or neighbourhood level, such as klimaaktiv, ÖGNI (Austrian Sustainable Building Council), TQB and LEED (Leadership in Energy and Environmental Design). They play a crucial role as urban planning indicators for evaluation. They consider factors such as energy efficiency, water management, indoor air quality, materials used and the overall environmental impact of the building (klimaaktiv 2023, ÖGNI 2023). By incorporating these certifications into urban planning processes, city authorities can ensure that new developments meet sustainable standards that can be documented and contribute to the creation of more sustainable and resilient cities.

2.5 Tools and instruments for a "climate check"

The link between microclimatic simulations, BIM and climate change adaptation indicators is an important step for the future: A "climate check" for urban development or redevelopment projects is included in or required by numerous national and international climate adaptation strategies or spatial development concepts (e.g. Stadt Wien 2022, Greater London Activity 2023). Within the framework of these development procedures, fundamental decisions are made at a very early stage on urban design and building typologies, which have a major influence on later (climate) resilience, energy requirements or greening options. The assessment of the impact of a project is usually carried out on a sectoral basis and through expert assessments.

So far to the best of our knowledge no instrument or tool is available that unites the multiple requirements and enables an assessment or optimisation. Some planning or assessment tools, such as microclimatic models or green area indicators enable sectoral assessments. What is missing is a comprehensive tool that makes it easy to present the different impacts of a project for decision-makers in spatial planning and development, to investors and planners and, last but not least, to the general public such as (future) residents.

This contribution analyses and describes the requirements for a tool in the form of a web-based dashboard that uses BIM models, links them to microclimate simulations and additionally presents KPIs such as green area indicators in a structured way. Starting with (i) the requirements for the user interface, i.e. the dashboard, (ii) the requirements for the models (BIM model and microclimatic numerical simulation model), (iii) the possible applications in different planning phases as well as (iv) the necessary requirements for data and data preparation are presented.

The aim of the contribution is to analyse and describe the requirements, implementation perspectives and application possibilities of a web-based dashboard that enables climate-impact assessments, macro-ecological data for properties and neighbourhoods in an early planning phase ("climate check") on the basis of three-dimensional building models.

3   MATERIAL AND METHOD

This contribution presents a simulation and visualisation framework representing an interdisciplinary approach to urban microclimatic assessment. This contribution is based on the collaboration of the following fields of expertise: architecture, microclimatic simulation, building information modelling, planning sciences, compliance with quality assurance aspects, e.g. the standard L1136 and L1131 (Austrian Standards,

2010, 2021) and planning practice. In order to provide a microclimatic simulation and visualisation framework, desktop research was carried out on (geospatial) dashboards as well as on the requirements of dashboard design in order to analyse existing methods and steps to conceptualise the dashboard architecture. The development of a dashboard for visualisation of microclimatic data of urban development projects relies on a cyclical process that involves various data, model and user interfaces (Oates 2005).

3.1 Digital Models and Simulators operation

In order to find a convenient workflow for the integration of microclimatic analysis into the planning process of urban development projects, the interdisciplinary project team works at the interface of digital models and tools from different disciplines (architecture, landscape architecture, microclimatic analysis/modelling) to qualify a transdisciplinary workflow for the exchange of data and digital geometry as well as the display of the microclimatic model and information. In particular, a 3D visualisation of an exemplary development project embedded in the existing urban environment is created and the analysis of its microclimatic impact on the urban development project are interactively presented to the user. The simulation model has two main interfaces with the BIM model:

(1) Geometric and spatial information, like terrain, building envelopes, vegetation are inputs for the simulation model. Also, physical properties that influence the microclimate simulation, like heat capacity, heat conductivity, albedo, opacity (for glass surfaces) etc. which are defined in the building information model, are inputs for the simulation.

(2) Simulation results (temperatures, fluid velocities,…) are imported into the BIM Model and displayed in the dashboard alongside the 3D model as supplementary information.

The microclimatic simulation model "UHISolver" was developed by Rheologic on basis of the widely used OpenFOAM library (Jasak 1996, Weller et.al. 1998, Jasak et.al. 2007). The simulation are run transiently (time dependent) over typical time periods of 24h and even longer with coupling of the various heat transfer effects. The spatial resolution is flexible: surface areas are usually resolved around several tens of centimetres, so that the BIM geometry can be represented with high accuracy in the simulation.

4 RESULTS – REQUIREMENTS FOR A CLIMATE CHECK DASHBOARD

The basic idea of implementing a climate check instrument is that of a "dashboard". A dashboard is generally referred to as a graphical user interface that is used to visualise data. The name comes from the English term for a dashboard in a car that displays information from various sources at a glance. Originally, the term referred to the board or leather apron at the front of a vehicle that prevented horse hooves and wheels from spraying mud into the passenger compartment (Mattern 2015).

So-called geospatial dashboards have been used in research and practice since the 1990s (Jing et al. 2019). In the beginning, there was the development of dashboards that were located at the level of the entire city. Only later were object and building-related dashboards developed.

A dashboard usually comprises a user interface that is coupled with models or analysis methods, which in turn process and evaluate certain data bases in order to display (key performance) indicators (Jing et al. 2019, Stehle and Kitchin 2020).

In order to develop a dashboard for the assessment of climatic impacts, an interplay of these elements is necessary. In the following, the requirements for the individual elements are described to enable both experts and laypersons to evaluate and compare projects.

4.1 Requirements for the user interface

To provide planners and other users with valuable insights, the output of simulations and models needs to be effectively presented in the dashboard interface. Planners typically develop different design variants through integrative processes or through competition procedures in the early development stages of urban development processes. A key requirement for the use of a dashboard in these early development stages is therefore to evaluate different variants in order to assess their potentially divergent qualities and compare their microclimatic impacts. This evaluation requires the selection and display of KPIs representing microclimatic information, urban design features and information about green and blue indicators in the

interface of the Dashboard. The interface should be designed with clarity and simplicity, presenting the data in a concise and visually appealing manner.

4.1.1 Requirements for the display of data and indicators in the Dashboard

A successful dashboard must be adapted to the characteristics of its users, so one of the initial steps is to define the target users of the climate check dashboard (see chapter 4.4.). Following Fernandes (2017) the following rules will furthermore help design and implement a successful dashboard:

- "Enable drill-down or drill-through to underlying data sources or reports and filters for flexibility and customisation;
- Provide explanation and context prior to information;
- Require minimal training and easy to use by anyone;
- Stay within single screen boundaries without displaying excessive detail;
- Use modularity to compact information and visual cues to direct attention" (Fernandes 2017, 18f).

4.1.2 Three-dimensional and interactive representation of the urban/architectural model

To present the three-dimensional BIM model in the dashboard interface, a web application with a 3D/BIM viewer can be used. This web application serves as a user-friendly platform for interactive exploration and visualisation of the urban development project and its various information layers. The 3D/BIM viewer provides a realistic and immersive representation of the urban environment, including the architectural elements and spatial layout of the buildings. This viewer acts as a visual medium to convey information and facilitate understanding of the project design. As the design process progresses, urban development projects are further optimised based on an initial assessment. It is therefore necessary to present and evaluate development variants – which may differ in terms of building structure, urban layout, height or density – and design variants – which may differ in terms of different surface textures and colours, or the proportions and locations of green and blue infrastructure. As mentioned above, a central requirement for the use of the Dashboard in the early stages of development (see also chapter 4.3) is the ability of the 3D/BIM viewer to evaluate and compare these different project variants in order to assess their different (microclimatic) impacts and qualities. In Summary, the BIM model must be represented as an interactive 3D model in the projected 3D space with users being able to freely move, zoom, rotate and interact with the model.

4.1.3 Representation of climate indicators

The user interface will present climate indicators such as the typical summer- or hot-day that is used for the simulation – for example according to the DEED-Standard.[1] The external "forcing" conditions for the project domain are for example the air temperature or velocity of incoming wind. Climate KPIs such as the apparent temperature (e.g. UTCI[2]), or wind comfort are derived from these basic indicators (see chapter 4.1.5.) to analyse the projects microclimatic performance and evaluate different development and design variants of the project.

The 3D model of the Dashboard will show spatially resolved KPIs for the local microclimate in the form of color-coded 3D surfaces that can be overlaid optionally. To further enrich the information, it will be possible to select points within the geometry to display time-series of variables at that point, for example the 24h air temperature or surface temperature over time. This gives users deeper insights into the dynamics of the microclimate.

4.1.4 Representation of urban design and planning indicators

The use of different urban planning indicators is a further approach to analysing the qualities of a project in relation to climate change adaptation. Typical urban indicators can either address the building or the plot and usually describe the density and land use intensity (e.g. floor area, built-up area, building mass).

These indicators (see Table 1), such as gross floor area, number/size of flats, and the area of (semi-)private open spaces, offer a quantitative representation of the built environment. Gross floor area serves as a

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[1] https://rheologic.net/articles/definition-DEEDS/
[2] Universal Thermal Climate Index

measure of the overall size and scale of a building or development project, indicating its spatial footprint. It helps assessing the intensity of land use and the potential population density in a given area.

By representing these urban design indicators, planners can assess the spatial layout, functionality, and amenity provision within neighbourhoods and developments. They can use this information to inform decision-making processes, such as zoning regulations, building codes, and urban design guidelines.

Additionally, the area of balconies, loggias, and gardens provides insights into the availability of open spaces within the urban fabric. These private open spaces contribute to enhancing the quality of life, promoting well-being, and improving the overall liveability of urban areas (Giannico 2022).

4.1.5 Representation of green and blue area indicators

Green and blue infrastructure and nature-based solutions make a significant contribution to the adaptation of urban areas to climate change. Only by identifying the benefits that nature provides, and by understanding the value of these benefits can planners, managers and decision-makers move towards creating a sustainable city. The four most important functions of green infrastructures are: (i) shading of surfaces and spaces, (ii) low reflection of incoming solar radiation, (iii) cooling of themselves and the surrounding environment due to evapotranspiration, and (iv) storage of CO_2 in biomass and substrate. These so-called ecosystem services include the Provisioning services, Regulating services, Habitat or Supporting services, and Cultural services (Millennium Ecosystem assessment 2005; TEEB Foundations 2010). The Provisioning services describe the material and energy outputs from ecosystems (like food, water, medicinal resources, etc.); the Regulating services are the services ecosystems provide by regulating the quality of air and soil as well as providing flood and disease control; the Habitat or Support services means that ecosystems provide and maintain living spaces for a diversity of plants or animals; and the Cultural services include the non-material benefits like aesthetic, spiritual and psychological benefits that people obtain from contact with ecosystems (TEEB 2011).

In order to integrate nature-based solutions into urban development projects, the share of green and blue areas is required as a basic indicator (see Table 1). Other factors, such as the green area factor or rainwater management indicators, are based on the area share of green and blue infrastructure. Thus, to convey the importance and microclimatic impact of nature-based solutions, the area share of green and blue infrastructure must be displayed as key information.

Climatic indicators/parameters		Urban indicators/parameters		Green and blue infrastructure indicators/parameters	
Urban heat	Wind	Quarter/Parcel	Building	Green infrastructure	Blue infrastructure
Air temperature	Wind velocity	Sealed surfaces	Building height	Extensive green roof area	Area of waterbodies
Air humidity	Wind direction	Partly sealed surfaces	Façade area	Intensive green roof area	Stream lines
Solar Radiation	…	Unsealed surfaces	Roof area	Façade greening area	Retention areas
Calendarday/solar angles		…	Built area	Green surfaces with/ without floor connection	Infiltration areas (through/ infiltration ditch)
Diurnal air temperature			Underbuilt area (incl. spill height)	Existing vegetation	…
…			Gross/ Net floor area	Number of trees	
			Private available free space	Canopysizeoftrees	
			…	…	
Derived KPIs	**Derived KPIs**	**Derived KPIs**	**Derived KPIs**	**Derived KPIs**	**Derived KPIs**
Apparent temperature – AT	Wind comfort	Degree of sealing	Floor area number	Green area factor	Blue area indicator (BAI)
Universal Thermal Climate Index – UTCI	Wind danger	Degree of building density	Building mass number	Extended Degree of sealing	Rain water management (RWM)
Surface temperature	Air quality(optional)	…	…	Biodiversity indicators	Discharge coefficient/water circle
…	…			Carbon capturing	…

Table 1: Overview and examples of indicators/KPIs that should be presented to assess the performance of a project

4.1.6 KPIs for the assessment

From the many variables and indicators that can be used to qualitatively and quantitatively describe and evaluate urban development projects, it is crucial to select those indicators most relevant for climate change adaptation. The selection of appropriate KPIs for the dashboard is critical to the effectiveness of the evaluation of different design and development options (De Marco et al. 2015). The KPIs should be

646

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

comprehensive, comparable and independent to avoid overlap. The indicators and further calculations should be easy to understand and should be able to provide information to address upcoming design or development issues. Current and historical data should be presented and available, e.g. wind statistics at specific times (Fernandes 2017).

In Table 1 the chosen indicators are listed, representing climate (temperature, wind), urban indicants (quarter, parcel, building) and green/ blue infrastructure. From these basic indicatorsand parameters further KPIs can be derived which enable a simple evaluation or comparison of different variants. The statistics on wind velocity and direction contribute to wind comfort and wind danger. The sealed surfaces add to the degree of sealing and degree of building density. The building height, façade area, roof area, built area and gross/net floor area conduce to the floor area number and building mass number. The green area factor (GAF), biodiversity indicators and the extended degree of sealing derive from the number of trees, façade greening, roof greening and green surfaces with or without floor connection. In the column of the blue infrastructure the natural waterbodies, retention areas and infiltration areas contribute to the blue area indicator, discharge coefficient and rain water management.

4.2 Requirements for the models

This chapter focuses on the necessary conditions and constraints for the models, with the aim of providing flexibility and ease of implementation. By keeping requirements to a minimum, it is easier to adapt and modify the model in the early stages of development. This flexibility allows better exploration of design alternatives and consideration of various factors that contribute to sustainable design.

4.2.1 BIM Model

In the early stages of an urban development project, not all information, both geometric (e.g. details of faced) and alphanumeric(e.g. data on the materials used), may be readily available. In addition, different development and design variants of the project are typically developed. Therefore, the BIM model is required to accommodate the different variants as well as a gap of detailed information. As the development process progresses and more dependencies are established, the complexity of implementing changes increases significantly. Therefore, by reducing the constraints on the model from the outset, it is possible to capitalise on the opportunity for sustainable and impactful changes in the early stages, when they are most feasible and affordable.

A key requirement is that the IFC model, which stores the architectural, technical and functional building data, has a closed surface. The closed surface requirement for the IFC model ensures that the model accurately represents the physical boundaries of the building. This information is critical for microclimate simulations and other analyses related to climate impact assessments. The ability to easily modify and adapt the model allows designers to iterate on different design options and evaluate their impact on sustainability. The second requirement is to assign accurate properties to the surfaces in the model to ensure that the microclimatic analysis properly accounts for the characteristics and attributes of the surfaces (see the next chapter for more information).

4.2.2 UHISolver – Microclimatic Simulation Model

The microclimate simulation model – OpenFOAM based UHISolver in this case – draws on mesoscale weather data usually but not necessarily for summer/hot-weather conditions. Input factors for the simulation domain are air temperature, direction and speed of wind, humidity and solar radiation, all of which need to be available in reasonably resolved time series over the 24 hours of a usual simulation. Typically, hourly values are used, but two-hourly values are also acceptable and even quicker simulations over just 1h are possible with some compromise on quality (for example, surface temperatures will not necessarily be accurate for simulations that only span a short time).

Buildings are included in the simulation with their albedo, thermal conductivity, thermal capacity and of course their geometry. At a minimum, building envelopes, including roofs, are resolved; depending on the requirements of the project, smaller details such as balconies, alcoves, passageways and shading structures may also be represented. The project also requires a geo-location and date so that solar angles can be accurately represented. For example, the DEEDS definition for heat wave days provides not only the daily and hourly input factors for the simulation, but also the annual day on which a heat wave day typically

occurs. If this information is not available, the summer solstice is often used (Xu et al. 2019; City of London 2022; Rheologic 2022).

Blue (water) and green (vegetation) infrastructure in the simulation domain can also evaporate water, converting sensible heat into latent heat trapped in moisture. Evaporation rates are set according to literature data.

4.2.3 Interaction of the models and representation in the interface/dashboard

By integrating data from the microclimate simulations into the 3D/BIM viewer, the web application enhances the viewer's capabilities by overlaying additional layers of information. By visualising these KPIs on the 3D model, users can easily understand the spatial distribution and variation of microclimatic conditions within the urban environment.

The interface should be designed with clarity and simplicity, presenting the data in a concise and visually appealing manner. Users should also be able to toggle information on and off – for example, to display certain variables (such as wind speed or air temperature) in the model. These variables are typically colour-coded on top of 3D surfaces. 2D representations fall short due to many of the variables not being projected onto simple z-normal planar surfaces, but onto more complex surfaces, that follow the elevation changes of the terrain, overlap (for example under bridges, on rooftops, in underpasses and thoroughfares) or are even completely vertical (for example wind speed over height). Without the ability to rotate, zoom and toggle, this information cannot be easily conveyed.

In addition to the spatial information users should ideally be able to see the temporal information too: for example, a colour-coded surface can show the air temperature at certain points in the geometry at one point in time (often 15:00 local time is shown, as this is often the hottest time). Ideally, a user should be able to select a point in the geometry and have the time information for that point – in this example, the temperature over 24 hours – displayed as a time series graph in a side panel.

4.3 Requirements for data preparation of input data

Data is the basis for the creation of the BIM model, the microclimate simulation and the calculation of the various indicators. In addition, a dashboard provides the ability to integrate and display existing data and indicators, for example about the location and mesoclimate.

4.3.1 Necessary input data for the BIM-model and the microclimatic simulation model

The basis for both models is terrain data and building cubature of the existing neighbourhood, as well as for the actual development project. In addition, microclimatic simulations need the implementation of (existing) green spaces and trees. In terms of buildings structure, the surrounding is used/necessary to show the "visual fit" of the new project to the neighbourhood. Concerning the microclimatic simulation, it is mainly necessary to evaluate the wind conditions for higher buildings.

As mentioned above, mesoscale weather data are necessary to set the correct input factors for the simulation. The time resolution should be at least 2 hours or better. A good data source for this data are the ERA5 or ERA5-LAND dataset published by the ECMWF. These data sets are available in hourly resolution globally. The spatial resolution is 0.25° respectively 0.1° (about 30km respectively 9km).

It is also possible to use data from meteorological weather stations, however due to the low height of these stations wind directions and velocities are often not representative. Using the high-quality data from the abovementioned re-analysis, high quality datasets that are error-corrected according to highest standards avoids that problem. It should be noted however that this synoptic wind is not influenced by small scale terrain, so the simulation model has to be tuned carefully to include enough terrain and surface features (buildings, forests, etc.) so that the simulated wind conditions at pedestrian height are accurate.

4.4 Application in different planning phases and for different stakeholder

The development of urban planning projects usually comprises several steps, which include both the area of development planning – i.e. open procedures as well as regulatory planning – i.e. legally binding planning instruments. A dashboard for assessing performance can be used in different phases and for different target groups. These are: (i) (landscape) planners and (landscape) architects, (ii) city executives and expert juries for urban development competition processes and possibly also (iii) laypersons like local or future residents.

The first step is usually the development of a basic urban planning model that serves as the basis for zoning and development planning, or builds on these existing planning instruments. Based on these, often master plans with detailed specifications and detailed qualities for the individual construction sites and public spaces are developed. The next steps usually include the preliminary draft, the design and the submission planning for the authorities before it comes to a detailed implementation planning for both the buildings and the open spaces (Reinwald et al. 2021a).

The use of the dashboard is particularly beneficial in the early phases of development, when there is still a great deal of design freedom and all the relevant parameters – building volume, building position, green space distribution, etc. – can still be modified to improve the project's (microclimatic) performance. Of course, it is also suitable for further planning steps and, above all, for quality assurance in the ongoing process, as there are often decisive changes in the project. Remastering the models according to nature-based solutions (blue/green infrastructure) is a great advantage of assessing the microclimatic effects of a project in early development stages. With regard to the different target groups mentioned above, it can be used as part of public relations work to inform local residents in general about the project. On the other hand, in the competition phase, it can be used by the expert jury to compare the submitted projects in terms of ecological parameters and thus select the submission with the most beneficial impact on the local microclimate and the best climate resilience. Depending on the target group, different modes are recommended/practical (basic vs. expert mode).

5 CONCLUSION – THE "GREENPLANOUT" DASHBOARD

This contribution aimed to describe the requirements, implementation perspectives and application possibilities of a web-based dashboard, which enables climate impact assessments ("climate check") on the basis of three-dimensional building models. The result is a conceptual architecture for the GREENplanout Dashboard (see Figure 1).
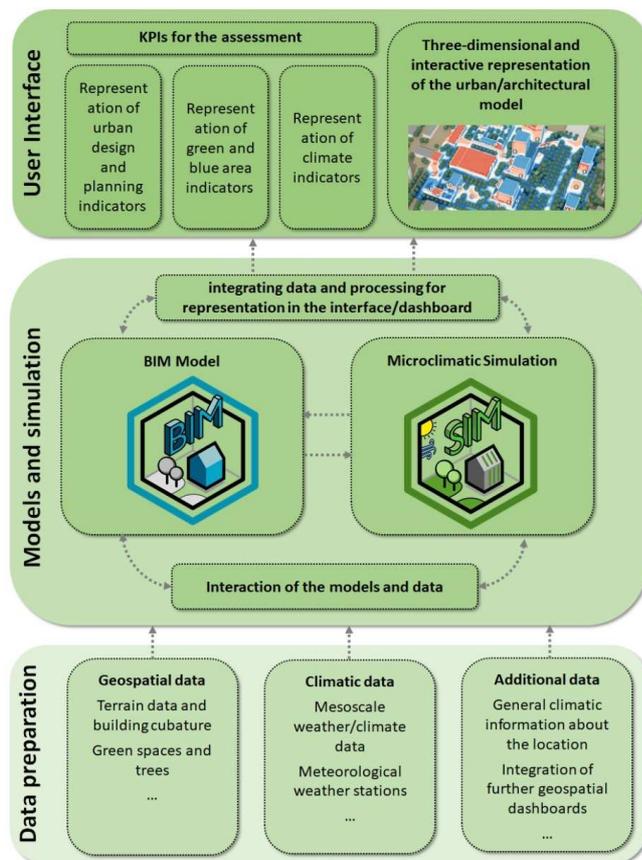

Figure 1: Conceptual architecture for the GREENplanout Dashboard

Requirements were analysed and collected for three areas: (i) Requirements for the user interface (ii) Requirements for the models and (iii) Requirements for data preparation of input data. The user interface should be accessibility for all users via a web portal that is easily readable/navigable by the user, since this

dashboard is aimed for various users from different professional backgrounds. To display information interactive display should be integrated. The user can click on a point in the geometry and an information window pops up with information, parameters and KPIs (see Figure 2). The displayed three-dimensional model is based on the interaction of two models used (BIM and UHIsolver) and the underlying data. These include geospatial and climatic data and can be enriched by additional data (e.g. general climatic information about the location).
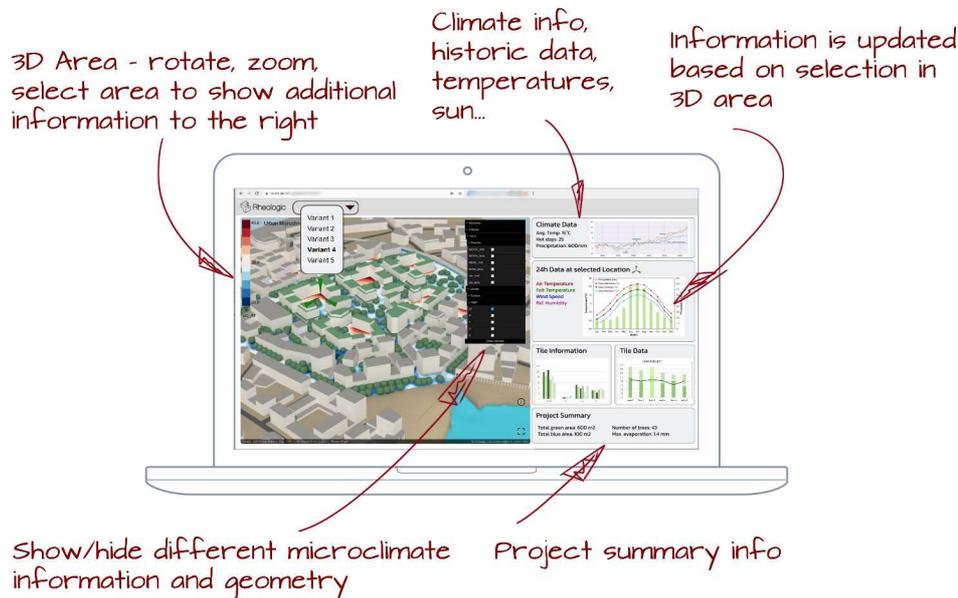

Figure 2: Mock-up of the planned dashboard. Based on the selected design variant the corresponding indicators like thermal load, wind speed etc. can be accessed via a selection menu (left side). Various KPIs allow an assessment of different variants and their performance in relation to the climate resilience of the building or neighbourhood (right side).

The interactive model and dashboard will provide much greater insight into the climatic "ground"-conditions than currently available synoptic weather and climate indicators can. From statistical weather data and meteorological models, it is only possible to indicate air temperature, radiation and humidity without the resolved influence of the built environment: on a shadeless, slightly rough plane without any obstacles. However, the built environment, that is often not resolved in meteorological models, has far-reaching and complex influence on the microclimate with large deviations in radiation (from trees and shading), wind velocity and direction (buildings), air temperature (conjugate heat transfer) and humidity (urban vegetation and water bodies). Insights into how, when and where these factors change allows urban planners to make much better-informed decisions throughout the planning process, ultimately resulting in a healthier, more resilient environment using best available tools. For the general public, it is an accessible way to become engaged in the design of public spaces already during planning, with the potential to foster increasing responsibility and a sense of stewardship for how we design urban space that is fit to the climatic challenges to come.

Especially for the greening building community (Enzi et al. 2021, Formanek et al 2020) this dashboard is very attractive, because the influence of green roofs and facades on the microclimate and the further effects of greening buildings (Mann and Mollenhauser 2021, Pfoser et al. 2013) such as biodiversity promotion, improvement of the albedo, production of evaporative cooling and stationary processes can be analysed and optimized. Greening thrives on visualization, and virtual models provide initial information about the possibilities, as well as a holistic view of radiative exchange in a neighbourhood network. In this way, the understanding of how to improve our future microclimates at specific locations and measures to improve climate protection can be promoted.

It should be noted that the dashboard primarily focuses on architectural or neighbourhood developments. How the object or the neighbourhood affects the surrounding neighbourhoods or the city as a whole can be analysed with other simulation tools that assess these larger-scale effects. A linkage of these levels is necessary to represent the interactions on a larger scale (Reinwald et. al. 2021b).

650

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6 ACKNOWLEDGEMENT

7 REFERENCES

Austrian Standards: ÖNORM L1131 for Green Roofs. Austrian Standards, 2010.

Austrian Standards: ÖNORM L1136 for Green Facades. Austrian Standards, 2021.

Choi, C., Berry, P. & Smith, A.: The climate benefits, co-benefits, and trade-offs of green infrastructure: A systematic literature review. Journal of Environmental Management 291, 112583, 2021.

City of London: Microclimate guidelines. Thermal Comfort Guidelines, 2022. Accessed 15 June 2023: https://www.cityoflondon.gov.uk/services/planning/microclimate-guidelines

Conrow, L.; Fu, C.; Huang, H.; Andrienko, N.; Andrienko, G.; Weibel, R..A conceptual framework for developing dashboards for big mobility data, Cartography and Geographic Information Science, 2023. DOI: 10.1080/15230406.2023.2190164

De Marco, A., Mangano, G., &Zenezini, G.: Digital Dashboards for Smart City Governance: A Case Project to Develop an Urban Safety Indicator Model. Journal of Computer and Communications, 3, 144–152, 2015. https://doi.org/10.4236/jcc.2015.35018

Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A.G., Mittal, N., Feliu, E. &Faehnle, M.: Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. Journal of Environmental Management 146, 107e115, 2014.

Dennis, M., Cook, P.A., James, P., Wheater, C.P. & Lindley, S.J.: Relationships between health outcomes in older populations and urban green infrastructure size, quality and proximity. BMC Public Health 20, 626, 2020.

Elmqvist, T., Setälä, H., Handel, S.N., van der Ploeg, S., Aronson, J., Blignaut, J.N., Gómez-Baggethun, E., Nowak, D.J., Kronenberg, J. & de Groot, R.: Benefits of restoring ecosystem services in urban areas. Current Opinion in Environmental Sustainability 14, 101–108, 2015.

Enzi V., FormanekS., Peritsch M: Green Market Report. Bauwerksbegrünung in Österreich. GRÜNSTATTGRAU, Vienna, 2021.

Fernandes, G.C.D.M.D.A: A Framework for Dashboarding City Performance an Application to Cascais

Smart City. Ph.D. Thesis, NOVA Information Management School Instituto, Lisbon, Portugal, 2017.

Formanek, S., Enzi, V., Peritsch, M., Steinbauer G/ Oberbbichler, C., Erker, G., Ramharter, M., Fritthum, R., Eipeldauer, H., Haas, M., Aspernig, D., Seitl, W., Sellinger, W., Fricke, J., Brunnauer, S., Kocher, M.: Positionspapier Bauwerksbegrünung , „Beitrag der Bauwerksbegrünung zur Konjunkturbelebung und ökologischen Transformation der österreichischen Wirtschaft in der Post-Corona Zeit", Vienna, 2020.

Giannico V. et al.: Green spaces, quality of life, and citizen perception in European cities. Environmental Research, Volume 196, 2021.

Greater London Activity: Environment and Climate Change, Making London greener, cleaner and ready for the future. Greater London Activity, 2023.

Jasak, H.: Error Analysis and Estimation for the Finite Volume Method with Applications to Fluid Flows, PhD thesis, Imperial College London, 1996.

Jasak, H., Jemcoy, A., Tukovic, Z.: OpenFOAM: A C++ Library for Complex Physics Simulations, International Workshop on Coupled Methods in Numerical Dynamics IUC, Dubrovnik, Croatia, September 19th-21st, 2007.

Jiricka-Pürrer, A.; Reinwald, F.; Weichselbaumer, R.; Juschten, M.: Endbericht zur Studie CLIP-OST Climate Proofing – Ostregion Check der Planungssysteme im Burgenland, in Niederösterreich und in Wien zur besseren Bewältigung der Klimawandelfolgen. PGO - Planungsgemeinschaft Ost, Land Burgenland, Land Niederösterreich, Vienna, 2021.

Jing, C., Du, M., Li, S., Liu, S.: Geospatial Dashboards for Monitoring Smart City Performance. Sustainability, 11, 5648, 2019. https://doi.org/10.3390/su11205648

Klimaaktiv: Die Kriterienkataloge im Überblick, 2023. Accessed 10 May 2023: https://www.klimaaktiv.at/bauen-sanieren/gebaeudedeklaration/kriterienkatalog.html

MA 22 – Naturschutz: Urban Heat Island – Strategieplan Wien, 2015.

Mann G., Mollenhauser F.: GRÜNSTATTGRAU-Fachinformation. Positive Wirkungen von Gebäudebegrünungen. GRÜNSTATTGRAU, 2021.

Mattern, S. "Mission Control: A History of the Urban Dashboard," Places Journal, March 2015. Accessed 10 May 2023: https://doi.org/10.22269/150309

Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC. 2005. Accessed 10 May 2023: www.maweb.org/documents/document.354.aspx.pdf

Oates, B. J.: Design and Creation. In Researching Information Systems and Computing (pp. 108–124). Sage Publications, 2005.

Oswald, S. M., Hollosi, B. Žuvela-Aloise, M., See, L., Guggenberger, S., Hafner, W. et al.: Using urban climate modelling and improved land use classifications to support climate change adaptation in urban environments: A case study for the city of Klagenfurt, Austria. In: Urban Climate, 31 (4), no. 100582, 2020.

Oke, T.R.: City size and the urban heat island, Atmospheric Environment, Volume 7, Issue 8,1973, 1967.

ÖGNI - Austrian sustainable building council: Gebäudezertifizierung, 2023.

ÖKS 15: Klimaszenarien für Österreich, Zusammenfassung für Entscheidungsträger, Vienna, 2015.

Peng L. L. H., Jim C. Y.: Green-Roof Effects on Neighborhood Microclimate and Human Thermal Sensation. Energies, 6(2):598-618. 2013. Accessed 10 May 2023: https://doi.org/10.3390/en6020598

Pfoser, N., Jenner, N., Henrich, J., Heusinger, J., Weber, S., Schreiner, J.: Gebäude Begrünung Energie–Potenziale und Wechselwirkungen. Interdisziplinärer Leitfaden als Planungshilfe zur Nutzung energetischer, klimatischer und gestalterischer Potentiale sowie zu den Wechselwirkungen von Gebäude, Bauwerksbegrünungund Gebäudeumfeld, 2013.

Reinwald, F; Auböck, M; Berger, A; Damyanovic, D; Fassbinder, H; Graßmugg, A; Gruber, E; Gutmann, R; Hafner, S; Huber, M., Kraus, F; Lainer, R; Ring, Z; Romm, T; Scharf, B; Unterberger, B; Wolf, T.: Biotope City – Bauanleitung für die grüne Stadt der Zukunft. Abschlussbercht, BMK, Vienna, 2021a.

Reinwald, F., Brandenburg, C., Gabor, A., Hinterkoerner, P., Kainz, A., Kraus, F., Ring, ZT., Scharf, B., Toetzer, T., Damyanovic, D.: Multi-Level Toolset for Steering Urban Green Infrastructure to Support the Development of Climate-Proofed Cities. SUSTAINABILITY-BASEL. 13(21), 12111. 2021b.

Rheologic: Know-How, News & Information, Vienna, 2022, Accessed 10 May 2023: https://rheologic.net/articles/

Stehle, S., Kitchin, R.: Real-time and archival data visualisation techniques in city dashboards. 2020. International Journal of Geographical Information Science, 34(2), 344–366. Accessed 10 May 2023: https://doi.org/10.1080/13658816.2019.1594823

Ring, Z., Damyanovic, D., Reinwald, F.: Green and open space factor Vienna: A steering and evaluation tool for urban green infrastructure. URBAN FOR URBAN GREE. 62, 127131. 2021.

Stadt Wien – MA18 – Magistratsabteilung Stadtentwicklung und Stadtplanung: Smart Klima City Wien. Der WegzurKlimamusterstadt. Wien: Stadt Wien, 2022.

TEEB – The Economics of Ecosystems and Biodiversity: The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations'. Kumar P (ed), Earthscan, London, 2010.

TEEB – The Economics of Ecosystems and Biodiversity: TEEB Manual for Cities: Ecosystem Services in Urban Management, 2011. Accessed 10 May 2023: www.teebweb.org

Weller, H. G., Tabor, G., Jasak, H., Fureby, C.: A tensorial approach to computational continuum mechanics using object-oriented techniques, Computers in Physics, Vol. 12, No. 6, 1998.

Xu, T., Tong, Z., Xu S.: Integration of Microclimate into the Multi-Agent System Simulation in Urban Public Space. Smart Cities. 2(3):421-432, 2019. Accessed 10 May 2023: https://doi.org/10.3390/smartcities2030026

652

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Research on Construction Method of Genetic Map for Rural Settlement Heritage of Ethnic Minorities in Guangxi, China

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1 ABSTRACT

As the multicultural fusion area, Guangxi, China has twelve nationalities who live here for generations, including Han, Zhuang, Dong and Miao, etc. The cultural fusion among various ethnic groups is prominent, and has representative characteristics on multiculturalism and research value on rural heritage. As one of the carriers of culture, rural settlement heritage maintains the genetic characteristics of cultural "gene" in the process of inheritance. The laws are presented based on different expressions of material and non-material elements, and reflect the logic and order of the evolution of rural settlement heritage. Through the investigation of ethnic minority rural settlements in Liuzhou, Guangxi, this paper clarifies the construction logic of genetic map for rural settlement heritage. In addition, the excavation, identification, extraction of genetic elements and the construction of genetic map are carried out for representative rural heritage. Finally, this paper summarizes the research methods of rural settlement heritage genes in multicultural fusion areas of ethnic minorities. At the same time, it provides direction for the protection and sustainable development of rural settlement heritage, and guides the development of rural planning in some degree.

Keywords: map construction, multiculturalism, gene, rural heritage, rural settlement

2 INTRODUCTION

Based on the promotion of rural revitalization in the 14th Five Year Plan in China and the construction of beautiful village, many experts and scholars have carried out the research work on village, especially in some villages which are needed to be constructed because of serious problems. However, a complete system construction has not been formed in the research of rural settlement for ethnic minorities, especially that an in-depth study is lacking for multicultural fusion area of multiple ethnic minorities. The historical process of conflict, communication, integration and regeneration for ethnic culture is world-scale and generalized, and its influences are reflected on multiple domains, levels and perspectives. This has created cultural development opportunities for numerous nations, countries and regions, and brought unknown challenges.

Guangxi Zhuang Autonomous Region has diversified ethnic composition and cultural ecology, and Han, Zhuang, Dong, Miao, Yao, Mulao, Maonan, Hui, Jing, Yi, Shui and Gelao live here indigenously. Twelve nationalities form the multicultural fusion in Guangxi, including Baiyue culture, Miao-Yao culture, Central Plain culture and marine culture, etc. Liuzhou is in the north central region of Guangxi, and plenty of ethnic minorities live in mountainous and hilly areas, especially Han, Zhuang, Miao, Dong and Yao. The cultural fusion among different nationalities has representative characteristics and research value.

"Gene" as a biological concept, was proposed by Gregor Johnann Mendal, an Austrian scholar. This concept refers to a basic unit of biological heredity, as well as the carrier of genetic information, and genetic information can be passed on to the next generation through replication, causing the offsprings to show the same shape as their parents. As one of the carriers of culture, rural settlement heritage maintains the inheritance characteristics of their cultural "gene" in the process of inheritance. On account of the change in time and space, the genes of rural settlement heritage vary slightly in the process of inheritance. Thus, the variation of genes is a result of adaptation to the environment, which is not only the basic law of biological inheritance and propagation, but also the internal logic of the evolution and development of rural settlement heritage culture. Although "gene" and rural settlement heritage have different properties, they have similar inheritance principles [1]. The laws presented in genes reflect the logic and order of the evolution of the rural settlement heritage according to different expression patterns. Meanwhile, the exploration and integration of genes' internal logic and external expression is the process of constructing the genetic map [2].

In the investigation of 27 representative villages of ethnic minority rural settlements in Liuzhou, Guangxi, we also found that the heritage of these rural settlements has certain research value. Especially in these ethnic minority settlements, the cultural fusion and mutual influence are significant among different nationalities in the same region, or among different regions within the same nationality. At the same time,

cultural fusion has certain "gene" characteristics which can be excavated and identified both from the level of material culture and non-material culture. In the process of excavating, identifying, extracting and constructing these characteristics, we can find the direction of conservation and sustainable development of rural settlement heritage. In this way, the establishment of such a systematic framework can guide the future development of rural planning [3].

3 RESEARCH STATUS OF GENE FOR RURAL SETTLEMENT HERITAGE IN ETHNIC MINORITY

There have been many levels of research on rural settlements at home and abroad, these researches mainly focus on the evolution and development of rural settlements [4-7], the distribution characteristics and influencing factors of rural settlements [8-15], the reconstruction and optimization of rural settlement layout [16-17], as well as rural heritage protection [18-23], etc. These studies not only analyzed the spatial distribution and natural geographical causes of rural settlements, but also deeply analyzed the relationship between villages and natural and humanistic elements. In addition, the research work put forward the development direction and strategy for the revitalization and optimization of rural settlements.

Rural heritage is one of the important resources for rural development, and it is also the irreplaceable and irreproducible cultural heritage created by local people over thousands of years. In terms of rural heritage protection and inheritance, Zhou et al. [3] mentioned that villagers are less aware of the history and culture of their own villages, and villagers' senses of belonging to their own villages are gradually weakened. At the same time, the proportion of newly built dwellings in villages is increasing, while the new dwellings have no connection with the characteristics of traditional dwellings and even destroy the traditional features of villages. This phenomenon is widespread in many rural settlements, which brings numerous problems to the protection and inheritance of rural heritage.

The distribution of ethnic minorities in China is characterized by "Large communities, small areas", which means that China's ethnic minorities live together over vast areas while some live in individual concentrated communities in small areas. But the phenomenon of multiple nationalities living together is common in some ethnic minority settlements. Under the fusion of the multi-ethnic culture, rural settlements present the features of "material culture and non-material culture" and form a unique natural and humanistic landscape, among which rural heritage with research value is not lacking. For instance, the rural heritage includes layout features, traditional dwellings and architectural features of rural settlements, as well as the relationship between customs, beliefs, languages and totems. In addition, the symbiotic culture formed by mutual influence among different ethnic groups is also a type of rural heritage. Therefore, it is significant to study the rural settlement heritage in ethnic minority settlements which have the characteristics of cultural fusion.

In this research context, many scholars also suggested to take "gene" as the inheritance carrier of important information to study the landscape gene of a specific region. In addition, scholars regarded "gene" as a basic genetic unit to summarize the characteristics of regional cultural landscape. In 1979, Lewis proposed that the most essential difference between landscape interpretation and research is gene [24]. American scholar Taylor once proposed to apply gene analysis to find the rules of settlement space layout, or to find the most core common factor by comparing the spatial structures of settlements within a certain area, that is, to find genes [25]. In recent years, Liu [26] has carried out systematic and complete research on the landscape genes of traditional villages, using the "landscape gene method" to study the internal characteristics, external expression and inheritance features of traditional settlement landscapes. In the field of landscape genes of cultural heritage in traditional villages, Xiang et al. [27] analyzed the genetic map of cultural heritage landscape in the aspects of spatial sequence, distribution and pattern. Li et al. [28] summarized 13 villages of Dong in Hunan Province and studied the spatial genetic map of settlements, as well as the genes with cultural concepts. Qi et al. [29] identified and analyzed the landscape genes of Miao traditional settlements from the perspective of geography.

The minority areas studied in this paper are in Liuzhou, Guangxi, and many of them belong to multicultural fusion zones. At present, the studies of typical cultural regions are relatively mature, while those of multicultural fusion areas are still insufficient. In response to this situation, Meng reflected on the theoretical research (traditional dwellings and villages) and practical research (development of traditional dwellings) to provide ideas for the research on the development and evolution mechanism of traditional residential buildings in fusion areas [30]. In conclusion, some scholars have carried out researches on the genes of

ethnic minority settlements, but the research framework has not been established for multicultural fusion areas, as well as the inheritance and variation of cultural genes among ethnic minorities.

In this paper, typical rural settlements in Liuzhou, Guangxi are taken as examples to propose method to construct genetic maps of rural settlement heritage in ethnic minorities. In addition, relevant methods to extract and identify genetic elements in multicultural fusion areas are also proposed in this paper. This paper provides a framework for further research on the rural heritage of ethnic minority settlements in multicultural fusion areas, as well as the external representation and internal motivation of genetic inheritance and variation generated by the cultural fusion.

4 THE CONSTRUCTION LOGIC OF GENETIC MAP FOR RURAL SETTLEMENT HERITAGE

As an important part of rural genes, heritage elements of rural settlements would show different laws in different ways of expression, and this is also the expression of inherent laws for cultural heritage of rural settlements. In a word, the logical and ordered expressions of these genes are the processes of genetic map construction. Guangxi is the fusion zone of multiple ethnic groups, and genetic map can be excavated and constructed from three levels to study the fusion of multi-ethnic culture: diachrony, regionalism and confluence.

Guangxi is the confluence zone of multiculturalism. Firstly, the formation and development of multiculturalism can be explored from the perspective of synchronicity and diachrony. Synchronicity can present the symbiosis of different nationalities at the same time, while diachrony is the interpretation of the development of different nationalities in time and space. As a result, it is significant to discuss the cultural characteristics of each nationality in different historical stages from this perspective. Therefore, the relationship between synchronicity and diachrony is closely related to the research of multiculturalism in Guangxi, and is also the dynamic study of regional culture. Table 1 presents the process of demographic change and colony formation of various ethnic minorities in Guangxi from the Shang and Zhou Dynasties to the late Ming and early Qing Dynasties. Furthermore, Table 1 shows that the multicultural fusion among different nationalities was formed due to the regional change of indigenous nationalities and immigration of

Dynasty	Nationality
Shang and Zhou Dynasty (1766BC-255BC)	The three tribes of "Luoyue" in the Zuojiang River Basin, "Xiou" and "Cangwu" in the Guijiang River Basin coexist
Qin and Han Dynasty (211BC-AD220)	Part of the Han Chinese from the Central Plains moved to Guangxi,China,living together with ethnic minorities
Tang and Song Dynasty (618-1279)	After the differentiation and integration of the indigenous minorities, the Zhuang, Dong, Mulao, and Maonan nationalities were formed. At the same time, foreign minorities such as the Miao and Yao entered Guangxi.
Song to Ming Dynasty (1279-1368)	The Hui, Yi, Jing, Gelao, Shui and other ethnic minorities have gradually moved to Guangxi,China
Ming and Qing Dynasty (1368-1911)	A large number of Han people moved in during the Qing Dynasty, and some of the ethnic minorities moved to West Guangxi. The population of Han nationality in eastern Guangxi is larger than that of ethnic minorities, while the population of Han nationality in central Guangxi is increasing

Table 1: The vicissitude process of various ethnic groups in Guangxi

From the view of region, twelve nationalities who live in Guangxi for generations are composed of aboriginal and adventive nationalities, forming a multicultural pattern of "Large communities, small areas" with multiple nationalities living together. At the same time, multiculturism formed under the fusion of Baiyue culture, Central Plain culture and marine culture. Figure 1 shows the regional distribution of numerous nationalities and the pattern of ethnic communities in Guangxi [31].

Overall, the cultural tradition and lifestyles of aboriginal nationalities were generated by transition, differentiation and fusion, and diverse lifestyles and cultural symbiosis formed after the immigration of adventive nationalities. Figure 2 shows that the distribution of Han is wide, and the composition and origin of the population are complex, including three major factions of Guangfu, Hunan-Jiangxi and Hakka. The long struggle between Han and aboriginal nationalities caused the migration and reform of nationalities. Meanwhile, Miao, Yao and other ethnic minorities moved into Guangxi, and numerous characteristics of these ethnic minorities constitute the multiculturalism of Guangxi. In the process of influence and struggle, ethnic culture is affected by each other and crisscross and overlap are generated due to the continuous migration of various nationalities. As a result, the distribution pattern of various nationalities is also changing

constantly. In Table 2, the distribution of various ethnic groups has certain characteristics of fusion. The interaction effects of material culture and non-material culture contribute to the fusion of multiculturalism in Guangxi.

From the perspective of multicultural fusion in Guangxi, from the Paleolithic Age, aboriginal nationalities such as Xiou and Luoyue gradually turned into Zhuang, Dong, Mulao and Maonan with the development of history. These nationalities inherited Baiyue culture in some degree, including farming culture, production and life, Fengshui culture (Fengshui is a kind of traditional Chinese practice of determining the location of a house, tomb, or other items which are believed to have a vital effect on the fortunes of a family, owner, or user) and other aspects [32]. On the other hand, on account of political and economic factors, the Han gradually moved into Guangxi from Central Plains and Guangdong in different historical periods. In this way, multicultural characteristics of Lingnan (south of the five ridges, in south of China) Han were formed in the long-term life and fusion [33]. In addition, some ethnic minorities such as Miao and Yao, gradually moved to Guangxi later. Due to the weak economic status of these ethnic minorities, most of their settlements were in mountainous areas and mountaintops. Since these nationalities lived in the same geographical environment, the latter nationalities also kept the fusion with aboriginal culture and Han culture in Guangxi to ensure the continuation of the nationalities. Therefore, these latter nationalities have the cultural characteristics of "near Zhuang is Zhuang, near Han is Han". Therefore, multicultural fusion characteristics are presented in the dimension of time and space among multiple ethnic groups in Guangxi, which also provides the possibility for our future research.
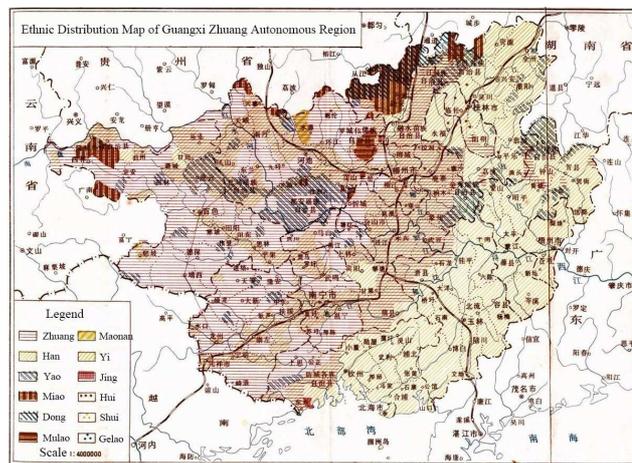
Fig. 1: The regional distribution of nationalities in Guangxi [31].
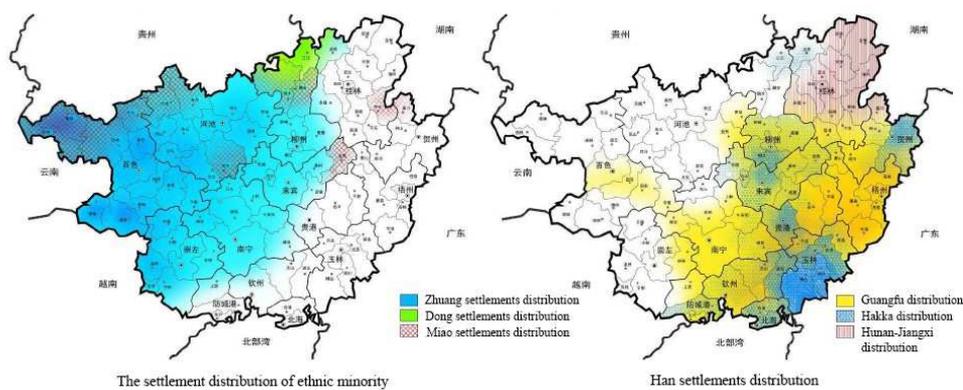
Fig. 2: The distribution of ethnic minorities and Han in Guangxi [31].

5 MATERIALS AND METHODS: CONSTRUCTION METHOD OF GENETIC MAP FOR RURAL SETTLEMENT HERITAGE

The rural settlements of ethnic minorities are characterized by clustering, centrality, defensiveness and respect of the environment. This paper focuses on the genetic identification of the rural heritage in ethnic minority settlements, and landscape genes of settlements have been studied already in the existing literature. However, there are both similarities and differences between this paper and the existing studies. Heritage

elements in rural settlements are significant in the inheritance of rural settlement heritage. They not only are the basic units to identify the "heritage" characteristics in rural settlements, but also reflect the external representation and internal development law of rural settlements.

Nationality	Main settlements
Zhuang	Zhuang residents mainly live in the six cities of Nanning, Chongzuo, Baise, Hechi, Liuzhou, and Laibin in Guangxi. The rest are scattered in 66 counties in the region.
Han	The residents of the Han are widely distributed, and they mainly live in the southeastern part of Guangxi.
Yao	Yao residents are mainly distributed in Duan, Bama, Jinxiu and Dahua in northwest Guangxi, Fuchuan and Gongcheng in northeast Guangxi, and autonomous counties of various ethnic groups in Longsheng.
Miao	Rongshui, Longlin, Sanjiang, Longsheng and other counties
Dong	Sanjiang, Longsheng, Rongan, Rongshui and other counties
Mulao	Luocheng, Yizhou, Liucheng and other counties
Maonan	Huanjiang, Nandan, Duan and other counties (autonomous counties) and Jinchengjiang District of Hechi City,China
Jing	Liwei, Wutou, Shanxin and other coastal areas in Jiangping Town, Dongxing City
Shui	Nandan, Rongshui, Yizhou and other counties
Yi	Longlin Autonomous County and Napo County
Hui	Guiling, Liuzhou, Nanning
Gelao	Longlin Autonomous County

Table 2: Main areas inhabited by various ethnic groups in Guangxi, China [31].

From the perspective of research classification, the studies of rural heritage genes discussed in this paper focus on material and non-material cultural elements with heritage value. Besides, the excavation and identification of rural heritage genes are carried out in multicultural fusion areas. Through the establishment of the genetic map, we can find out the generalities and individualities among different ethnic groups, to analyze the internal motivation of the long-term preservation of the "gene". Meanwhile, in the process of constructing the genetic map, the "genes" of rural settlements are compared longitudinally at different time periods and horizontally among different ethnic groups. Therefore, the cultural fusion areas can be found in the case of multiple nationalities living together, and some variant genes which are generated by long-term cultural fusion can be extracted.

5.1 Excavation and identification of genetic elements

The excavation and identification of genes for rural settlement heritage is a systematic and comprehensive process. Firstly, gene types can be classified according to the grade and importance of rural settlement heritage. In the identification of landscape genes in settlements, Liu classified gene types into main, attachment, mixed and variant gene to distinguish the settlement landscape types [1]. On this basis, the genes of rural settlement heritage studied in this paper focus on other aspects, and the importance of inheritance is combined with the classification of gene types. At the same time, the studies of mixed and variant genes concentrate on the composition and contrast of genetic elements in multicultural fusion areas (Table 3).

Classification standard	Category	Category explanation
Gene Type	Main gene	The core gene elements that occupy a dominant position in the heritage of rural settlements
	Attachment gene	Attachment genes are dependent on the main genes, but they are different from other rural heritage element genes with regional characteristics
	Mixed gene	A genetic element formed under the fusion of various factors in a specific rural settlement
	Variant gene	Due to special factors, genetic elements that have changed some genetic elements but are related to the original genes
Form of Expression	Dominant gene	Genetic elements with material form
	Recessive gene	Non-physical genetic elements
Identification Scale	Macro scale	Rural settlement heritage with regional spatial characteristics and block morphology
	Meso scale	Recognition of residential buildings, main public buildings and other architectural levels
	Micro scale	Material cultural elements such as detailed components and totem signs, as well as influential non-material cultural elements
Construction Method	Extraction element	Important identifiable elements of rural settlements
	Pattern extraction	Extract representative and special decorative patterns or meaningful patterns
	Structure extraction	Elements extraction of structural features such as buildings
	Meaning extraction	Regional expression and construction of non-material cultural elements
	Deduction extraction	Extraction of elements of logical deduction between material culture and non-material culture
Cultural Connotation	Monocultural gene	A rural heritage element that exists in a specific cultural background and has a specific cultural characteristic attribute
	Multicultural Compound Gene	The genetic elements formed by the fusion of diverse cultures and mutual influence

Table 3: Excavating and identifying methods of rural heritage genes in ethnic minority settlement.

Based on the genetic excavation of rural settlement heritage for ethnic minorities, we need to identify corresponding genetic elements. Material cultural genes in main identification methods include environmental factor, layout factor, main public building and residential building, etc. While non-material cultural genes include folk customs, clan culture, Fengshui culture, faith culture and so on. With the establishment of the connection between material cultural and non-material cultural genes, we can find out the logical relationship at different gene levels and deduce the external representation and intrinsic cause of rural heritage gene. So that this method can provide ideas for the construction of genetic map, as shown in Figure 3.

At the same time, gene identification will be carried out from the macro, meso and micro levels according to the scale range. The genetic information corridor was established for the elements with heritage value, and the rural settlement heritage elements were compared horizontally among different ethnic groups. So that we can analyze the genetic variation and genetic influence generated by cultural fusion among multicultural fusion areas, and this is the method of genetic excavation and identification of rural settlement heritage for ethnic minorities, especially the multicultural fusion areas, as shown in Figure 4.
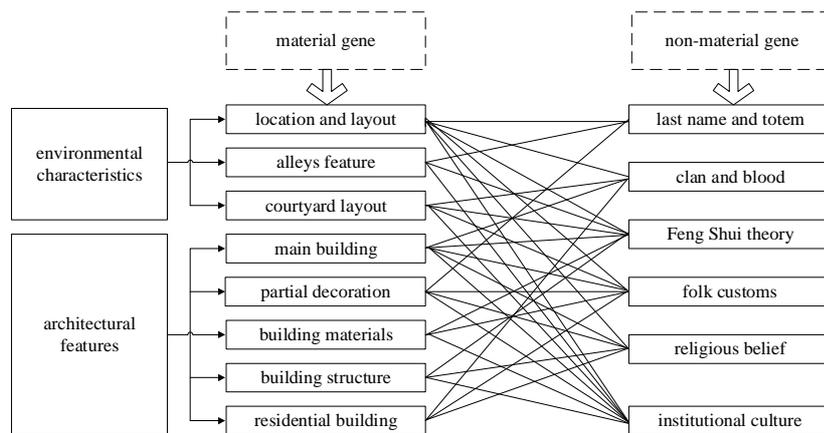
Fig. 3: Logical relationship diagram of material and non-material cultural genes.
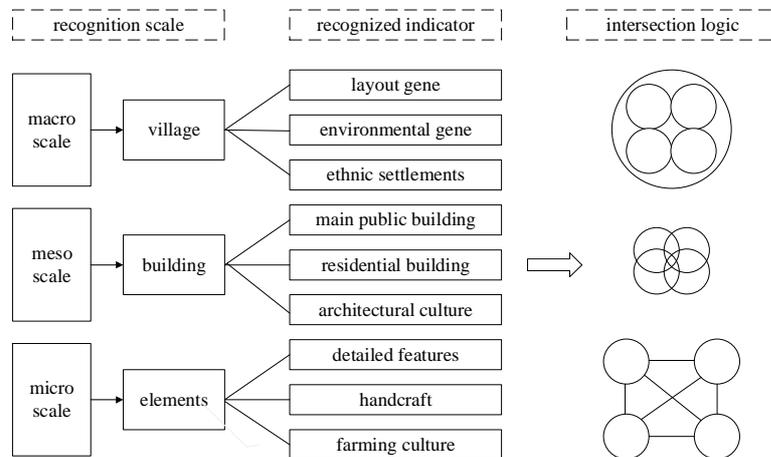
Fig. 4: The relationship between multicultural fusion areas reflected by gene identification at different scales.

In the investigation of rural settlements in Guangxi, we found that the rural population of Han, Zhuang, Miao and Dong is large, and the fusion characteristics among ethnic minorities are distinct, besides, the distribution of rural heritage with research value is wide in these nationalities. In the following sections, four representative villages of Han, Zhuang, Miao and Dong are taken as examples to analyze the important types of material and non-material cultural genetic elements (Table 4). After the analysis and comparison of these four different types of villages, ethnic minority rural settlements have the characteristics of strong centrality, living together in ethnic groups, and paying attention to the environment. At the same time, rural heritage genes retain some representative cultural characteristics, such as the courtyard-style buildings of Han, the phacelloid column square and hanging house (hanging house is a typical stilt style building and usually built on a steep hillside, with the main house on the ground and the other three sides hanging in the air) of Miao, the drum-tower and wind and rain bridge of Dong, and the stilt style buildings of Zhuang. In a word, all these

buildings have certain national characteristics. As various ethnic groups live in the same regional environment, cultural fusion and mutual influence also occur. For instance, Miao settlements occupy the major proportion of settlements in Rongshui Miao Autonomous County, but phacelloid column squares can also be found in some Dong villages due to the influence of Miao culture. In Zhuang villages of Rongan County, people gradually changed the traditional stilt buildings, and tended to build one-floor or two-floor courtyard buildings with cob walls.

Name of the village			Yajiao Village, Dongqi Township, Rong'an County, Guangxi, China	Dali Village, Liangzhai Township, Rongshui Miao Autonomous County, Guangxi, China	Pingmao Village, Gongdong Township, Rongshui Miao Autonomous County, Guangxi, China	Zhangkou Village, Rong'an County, Guangxi, China
ethnic classification			Hang	Miao	Dong	Zhuang
material cultural elements	village environment	location and layout	surrounded by mountains	harmony with site	living by the water	close to the water
		terrain	mountain topography	mountain topography	mountain topography	flat terrain
		landscape	ancient trees	ancient trees and wells	ancient trees	ancient trees
	layout characteristics	form	along the axis	branched form	centripetal form	ring form
		courtyard layout	courtyard style	corridor form	corridor form	corridor form
	architectural features and place	public space	ancient trees	phacelloid column square	phacelloid column square,drum-tower	agritainment
		other landmark buildings and places	watchtower	theatrical stage	Wind and rain bridge,watchtower	bamboo forest
	residential buildings	roof style	flush gable roof	gable and hip roof	gable and hip roof	flush gable roof
		gable shape	herringbone	herringbone	herringbone	herringbone
		decoration	stone carving	woodcarving	woodcarving	stone carving and woodcarving
		material	stone foundation and rammed earth wall	The main body of the building uses wood, but the bottom of the wall is gravel and blue bricks	wood,gravel	soil wall
		structure	courtyard style	Stilt style	Stilt style	courtyard style
		layout form	courtyard style and two floors	bottom overhead	bottom overhead	courtyard style and multi-storey
non-material cultural elements	language		Chinese	Chinese and Dong language	Chinese and Miao language	Chinese
	totem		dragon and phoenix	Miao embroidery	drum-tower	bronze drum
	handcraft		mason	fabric	spinning	brocade
	mode of production		forest fruit industry	agriculture and farming	agriculture	planting rice

Table 4: The identification of genetic elements in representative ethnic villages in Guangxi.

5.2 Extraction of genetic elements

In the extraction methods of genetic elements for rural settlement heritage, the existing studies classified gene extraction into element extraction, structure extraction, pattern extraction, meaning extraction and deduction extraction according to the principles of inherent-uniqueness, external-uniqueness, local-uniqueness, the overall advantages. Among the existing identification and extraction methods of genetic elements, some of the methods can be applied to the research of this paper on heritage elements of ethnic minority rural settlements, but some of them can still be improved. Taking the residential buildings of ethnic minorities as the example, many traditional residential buildings of Zhuang and Miao are mainly in the form of stilt, while hanging houses are more common in Miao settlements. The difference between two types of buildings lies in the extraction of building structure. If the above structure extraction method is used, the difference between two sides cannot be intuitively reflected. If the features of buildings are divided in detail,

local characteristics can be extracted more accurately. As shown in Figure 5 and Table 5, The extraction of genetic elements in residential buildings can be further carried out from the aspects of foot materials, the forms of doors and windows, partial decoration, building materials, roof style, plane structure and so on. In this way, the relationship of genetic elements in the dwellings of different nationalities can be distinguished.

For another example, in the extraction of elements, the unique landmark buildings and characteristic elements of some ethnic settlements will undergo the variation and interaction after cultural fusion, from this point, they cannot be regarded as the unique element features of the nationality. In our interview and research, Anning Village is a Miao village in Chang'an Town, Rongan County, but there is a wind and rain bridge at the entrance of the village. As the main landmark of Dong, the wind and rain bridge cannot be regarded as a sole national feature in such a region. Therefore, in gene extraction method, deconstruction of features can be carried out more meticulously, as a result, architectural, cultural and environmental features can be combined and analyzed in this element extraction method.

Fig. 5: Deconstruction of residential building features.

Serial number	Gene Type	Genetic characteristics
1	foot materials	blue bricks, red bricks, mud bricks, etc.
2	the form of doors and windows	brick carving, stone carving, wood carving, etc.
3	partial decorations	various patterns, decorations and symbols, etc.
4	building materials	crushed stone, wood, soil wall, blue brick, etc.
5	roof styling	Sloping roof, flat roof, gable and hip roof and flush gable roof, etc.
6	plane structure	Courtyard style, single row style, etc.

Table 5: The genetic elements and characteristics of residential buildings after deconstruction

5.3 Construction of genetic map

In terms of the construction of genetic map, it can be divided into plane and facade map, time and space map, entirety and segment map and other expression forms according to different gene types. The establishment of map can reflect the characteristics and laws of genetic elements in rural settlements more intuitively, and can be studied from macro, meso and micro levels. For example, genetic map can be established and studied at the level of rural settlements, villages' cultural heritage and residential buildings. The essence of this method lies in the map expression of genetic elements for representative characteristics after excavating, identifying and extracting the genes in rural settlements. So that we can further distinguish the differences and connections between rural settlements. In our investigation of minority villages in Liuzhou, Guangxi, the plane map was constructed for the representative residential layout among different ethnic groups (Table 6).

6 CONCLUSION AND DISCUSSION

The genetic research and genetic map construction of rural settlement heritage are important research methods for rural settlements in multicultural fusion areas such as Guangxi. This paper studies the logic of cultural fusion and construction method of genetic map for ethnic minority rural settlements in Liuzhou,

Guangxi, and interprets the research methods of rural settlement heritage. As for the actual investigation cases, we selected the representative rural settlements of Han, Zhuang, Miao and Dong to conduct the excavation, identification and extraction of genetic elements, as well as the construction of genetic map, in order to explore the research methods of rural settlement heritage in multicultural fusion areas.

Form	Map	Legend	Characteristic
semi-ring form	hall	hall	The bedroom surrounds the north and east sides of the hall, and the plan layout has a central axis symmetry.
side by side form	hall	hall	The bedrooms are located on the east and west sides of the hall.
open hall form	hall	hall	The open hall at the entrance is combined with the corridor and gatehouse. This is a flat layout formed in order to adapt to the terrain in the residential buildings of ethnic minorities.
Centered form	hall	hall	The main living and functional spaces in the plan are arranged in the center, and the surrounding areas are used as public activity space.

Table 6: The map of representative dwellings for ethnic minorities in Guangxi.

In the ethnic minority settlements of Guangxi, multiculturalism forms the cultural fusion among different nationalities, and forms cultural symbiosis in the same region or in different rural settlements. Thus, "gene" characteristics can be excavated and identified both from the level of material culture and non-material culture. This paper conducts a horizontal and longitudinal comparison of rural settlements. Through the logical and systematic construction of genetic map, this paper provides the direction for the protection of rural heritage and sustainable development of rural settlements, and guides the development of future rural planning in some degree.

This study deals with multicultural fusion areas and marginal rural areas influenced by culture, as well as the material cultural and non-material cultural heritage, and the system construction of the theoretical research involved in this paper still needs to be improved in the future. In practice, the extraction and organization of rural heritage genes contain plenty of contents and elements, and there are great differences among various types of villages. Therefore, the research scope of this paper is limited to a specific regional environment, and the study is conducted on villages that were formed under the multicultural fusion in Guangxi. Meanwhile, there are twelve ethnic groups living in Guangxi for generations. In this paper, four ethnic groups with large population and prominent fusion characteristics are selected as the examples, and the genetic map construction of rural settlement heritage in multicultural fusion areas for other ethnic minorities can be improved in the future.

7 REFERENCES

[1] Liu, P.L. On construction and utilization of Chinese traditional settlements landscape's genetic map. Doctor, Peking University, Beijing, 2011.
[2] Xiao, L.; Wei, C.Y. Knowledge map on the study of Chinese rural settlement form based on CSSCI. In: Economic Geography, Vol. 41, pp. 148-157. 2021.
[3] Zhou, J.; Zhong, X.H. Rural heritage preservation from the perspective of development: Case study of Dong ethnic vallages. In: Urban Planning Forum, Vol. 1, pp. 54-60. 2015.
[4] Sun, Y.K.; Zhai, B.Q. Evolution and pathology of traditional villages in Southern Xinjiang based on human settlement theory. In: Architectural Journal, Vol. S1, pp. 47-52. 2019.
[5] Zhou, G.H.; He, Y.H.; Tang, C.L.; Yu, T.; Xiao, G.Z. Dynamic mechanism and present situation of rural settlements evolution in China. In: Acta Geographica Sinica, Vol. 66, pp. 515-524. 2011.
[6] Naveh, Z. Interactions of landscapes and cultures. In: Landscape and Urban Planning, Vol. 32, pp. 43-54. 1995.
[7] Smailes, P.; Griffin, T.; Argent, N. Demographic change, differential ageing, and public policy in rural and regional Australia: A three-state case study. In: Geographical Research, Vol. 52, pp. 229-249. 2014.
[8] Li, J.S.; Wang, X.R.; Li, X.J. Spatial distribution characteristics and influencing factors of Chinese traditional villages. In: Economic Geography, Vol. 40, pp. 143-153. 2020.

[9] Li, B.H.; Yin, S.; Liu, P.L.; Dou, Y.D. Spatial distribution of traditional Villages and the influencing factors in Hunan Province. In: Economic Geography, Vol. 35, pp. 189-194. 2015.

[10] Feng, Y.F.; Yu, W.Y.; Lei, R.L. Spatial distribution features and controlling factors of traditional villages in Guangdong Province. In: Scientia Geographica Sinica, Vol. 37, pp. 236-243. 2017.

[11] Wulandari, L.D. Typology and morphology of spatial settlement in the traditional village of Penglipuran, Bali. In: International Journal of Academic Research, Vol. 2, pp. 321-325. 2010.

[12] Yang, R.; Liu, Y.S.; Long, H.L.; Qiao, L.Y. Spatio-temporal characteristics of rural settlements and land use in the Bohai Rim of China. In: Journal of Geographical Sciences, Vol. 25, pp. 559-572. 2015.

[13] Qu, Y.B.; Jiang, G.H.; Zhao, Q.L.; Ma, W.Q.; Zhang, R.J.; Yang, Y.T. Geographic identification, spatial differentiation, and formation mechanism of multifunction of rural settlements: A case study of 804 typical villages in Shandong Province, China. In: Journal of Cleaner Production, Vol. 166, pp. 1202-1215. 2017.

[14] Lu, S.; Zhang, X.J.; Zhang, Y.C. Spatial-temporal distribution and controlling factors of traditional villages in Huizhou region. In: Scientia Geographica Sinica,Vol. 38, pp. 1690-1698. 2018.

[15] Zheng, X.Y.; Wu, J.H.; Deng, H.B. Spatial distribution and land use of traditional villages in southwest China. In: Sustainability, Vol. 13, pp. 6326. 2021.

[16] Cao, R.; Yang, C.X.; Liu, Y.; Li, Y.T.; Yang, H.P. Restructuring strategy of rural settlement space in hilly and mountainous areas based on ecological protection pattern. In: Journal of Ecology and Rural Environment, Vol. 35, pp. 689-697. 2019.

[17] Gao, J.; Wu, B.H. Revitalizing traditional villages through rural tourism: A case study of Yuanjia Village, Shaanxi Province, China. In: Tourism Management, Vol. 63, pp. 223-233. 2017.

[18] Yu, Y.F. Landscape transition of historic villages in Southwest China. In: Frontiers of Architectural Research, Vol. 2, pp. 234–242. 2013.

[19] Marschalek, I. The concept of participatory local sustainability projects in seven Chinese villages. In: Journal of Environmental Management, Vol. 87, pp. 226–235. 2008.

[20] Liu, T.Z.; Liu, P.L.; Wang, L.J. The protection and tourism development path of ancient villages and old towns under the background of new-type urbanization: A case study of old town of Xuanzhou in Hunan province. In: Geographical Research, Vol. 38, pp. 133-145. 2019.

[21] Shi, D.; Zhao, D.H. Application research of landscape character assessment method in rural heritage conservation-Taking the survey in Loushang Village in Shiqian County, Guizhou Province as an example. In: Research on Heritages and Preservation, Vol. 3, pp. 125-129. 2018.

[22] Qin, R.J.; Leung, H.H. Becoming a traditional village: heritage protection and livelihood transformation of a Chinese village. In: Sustainability, Vol. 13, pp. 2331. 2021.

[23] Yang, H.; Qiu, L.; Fu, X. Toward cultural heritage sustainability through participatory planning based on investigation of the value perceptions and preservation attitudes: Qing Mu Chuan, China. In: Sustainability, Vol. 13, pp. 1171. 2021.

[24] Conzen, M.R.G. Morphogenesis, morphological regions and secular human agency in the historic townscape, as exemplified by Ludlow. In: Urban Historical Geography, pp. 253-272. 1988.

[25] Hu, Z.; Liu, P.L.; Deng, Y.Y.; Zheng, W.W. A novel method for identifying and separating landscape genes from traditional settlements. In: Scientia Geographica Sinica, Vol. 35, pp. 1518-1524. 2015.

[26] Liu, P.L. The gene expression and the sight identification of the ancient villages' cultural landscape. In: Journal of Hengyang Normal University (Social Science), Vol. 24, pp. 72-80. 2003.

[27] Xiang, Y.L.; Cao, M.M.; Zhai, Z.Y.; Yi, C. The landscape genome maps construction and characteristics analysis of Shanxi traditional rural cave dwelling settlements. In: Human Geography, Vol. 34, pp. 82-90. 2019.

[28] Li, X.; Yi, L.J. Spatial gene mapping of the Dong settlement in Tongdao, Hunan. In: South Architecture, Vol. 2, pp. 89-96. 2020.

[29] Qi, J.Q.; Deng, Y.Y.; He, J.D. A study of the gene identification of landscape in traditional settlements of Miao nationality and its analysis from the perspective of geography. In: Journal of Hengyang Normal University, Vol. 39, pp. 13-17. 2018.

[30] Meng, X.W.; Wang, J.; Ye, M.H.; Jin, Y.B. A speculative study on traditional dwellings in multicultural crisscross area. In: Architectural Journal, Vol. 2, pp. 70-73. 2016.

[31] Huang, X.F.; Huang, Z.Q.; Zhang, Y.M. General History of the Zhuang; Guangxi Nationalities Publishing House: Nanning, China, 1988.

[32] Wei, Y.C. The research of public space among minority ethnic groups in Guangxi, China. Doctor, South China University of Technology, Guangzhou, 2017.

[33] Meng, X.W.; Zhang, L.; Wang, J.; Jin, Y.B. Research on traditional residential architecture zoning in multicultural interlaced area. In: Architectural Journal, Vol. S2, pp. 1-7. 2020.

662

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Rethinking the Urban Green Spaces by the Lens of GIScience: the Experience of the Project Living Urban Parks

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1 ABSTRACT

In Italy, soil sealing is a major threats in terms of soil degradation and the loss of urban ecosystem services. The increase in new artificial surfaces or settlement areas at the expense of green and rural areas is intensifying the effects of climate change, in particular extreme weather events, such as the increase in intense precipitation and heatwaves. In this context, the Municipality of Padua is a paradigmatic case study. According to the Italian Institute for Environmental Protection and Research (2022), almost 50% of the municipal territory is completely sealed, making it the Italian city with the fifth highest values of soil sealing. To contrast the phenomenon, the EU soil strategy for 2030 suggested, among other strategies, the implementation of Nature-Based Solutions, strengthened with the participation and involvement of non-expert actors to be more efficient and effective.

This study was developed within the Living Urban Parks (LUP) project (Key Action 3, Erasmus + Programme EU) during two years of research and participatory activities (2020–2022) within the Municipality of Padua. It aims to involve youths aged 18–30 in a public process to reconceive of the urban green spaces of the city and to develop ideas and proposals for more sustainable urban planning, promoting participatory methodologies by using geographical tools (digital and traditional cartography).

More than 400 participants were directly involved in the project. All the ideas and proposals mapped during the seminars and workshops have been uploaded to the geoplatform Geocitizen. This geotool is usable on smartphones and tablets and, thanks to its interactive features and a geodatabase, allows the collection of georeferenced ideas, good practices and urban issues regarding green areas and parks. By the end of the project, 118 points had been collected on Geocitizen. Beyond the Geocitizen platform, the participants had the opportunity to test other geotools, such as Geopaparazzi and Google Earth Pro. In addition, the participants were able to present their ideas collected on the platform and directly interact with the local decision-makers who were involved to discuss and promote effective and efficient actions for the enhancement of the green areas and urban parks of the city. The use of different geographic technologies combined with participatory mapping approaches allowed an increase in the knowledge of the urban territory by making people more aware of the issue of soil sealing and urban regeneration opportunities. Finally, LUP allowed to reconception and design of green spaces to promote the restoration of degraded and abandoned areas and to propose the implementation of Nature-Based Solutions.

Keywords: geographical tools, green areas, participatory approach, Nature-based Solution, Soil sealing

2 INTRODUCTION

2.1 Nature-based solutions in the urban context: Strategiesto mitigate soil sealing

At present, soil sealing is one of the major threats in terms of soil degradation and the loss of ecosystem services in urban and rural contexts. It is considered one of the main forms of land take by the increase of new artificial surfaces at the expense of green and agricultural areas. This phenomenon is intensified by local

effects of climate change, in particular extreme weather events, such as intense rainfall and heatwaves. The scarcity or lack of permeable and vegetated surfaces can drastically affect the urban drainage systems and can exacerbate the urban heat island effects during heatwaves (Todeschi et al., 2022; Pappalardo et al., 2023). In addition, it decreases other soil functions and ecosystem services, for example, carbon sequestration, microclimate regulation, groundwater reserves, biodiversity and food production (Peroni et al., 2020).

According to the EU soil strategy for 2030, a hierarchy to contrast land take is identified in the pathway of four key actions: i) avoiding new soil sealing, ii) reusing surfaces and soil that are already sealed, such as abandoned or underused buildings and areas, iii) minimizing by using infertile agricultural areas and iv) adopting compensation or mitigation measures and strategies to reduce the loss of soil functions and its ecosystem services (European Commission, 2021). In addition to the four actions of the EU soil strategy for 2030, the adoption of mitigation measures to restore ecosystem services through the implementation of Nature-Based Solutions (NBS) is also encouraged. The strategy promotes cooperation with nature to address societal challenges and provides benefits for both human well-being and biodiversity by using, for example, green roofs, green facades, green buildings, urban forests and community gardens. Moreover, NBS could be utilised as a tool to restore urban brownfield sites by renaturalising or 'greening' these areas. Finally, the design and the process of the implementation of the NBS could be improved with the participation and involvement of citizens to be more efficient and effective. As reported by the European Environment Agency Report on NBS (EEA, 2021), some case studies present the co-creation of NBS by involving local communities and stakeholders, as, for example, the creation the green roofs in France and Germany. Thanks to citizen participation, the quality in urban NBS has fostered a higher degree of multifunctionality in the solutions than the NBS built by urban planners or architects.

2.2 Objectives

The study aims to test the participatory methodologies and technologies to involve youths and non-expert actors in re-thinking urban green spaces to identify abandoned buildings, brownfields and urban parks and to develop ideas and suggestions to restore these spaces by proposing NBS or other strategies. The participatory methodologies are based on the use of geographical tools combining digital and traditional cartography and mapping tasks on paper and in the field with Geoapp.

The specific objectives are as follows: i) to involve non-expert actors, in particular young people, in urban sustainability issues, such as soil sealing and in mitigation measures, ii) to spread the use of geotools for an increase in geographical knowledge of the urban territory and iii) to increase the empowerment of participants regarding their awareness of urban regeneration and planning.

2.3 The Living Urban Parks Project

This study was supported by the Living Urban Parks (LUP) project (Key Action 3, Erasmus + Programme EU). LUP was developed during two years of research and participatory activities between January 2020 and January 2022 within the Municipality of Padua. The project was implemented by the Italian NGO L'Osteria Volante in collaboration with the Municipal Administration of Padua and the research group Climate Change, Territory, Diversity, Department of Civil, Environmental and Architectural Engineering (ICEA) of the University of Padua. A participatory mapping approach was adopted to create a formative pathway and raise awareness among the participants regarding different issues (soil sealing, soil policy, climate change, NBS etc…). The results of the participatory mapping were shared with the different actors (NGOs and researchers) that are developing bottom-up designs and proposals to promote the implementation of NBS and sustainable planning in the green areas and urban parks. Moreover, LUP allowed the participants to have a greater knowledge of the importance of urban parks and green spaces in Padua through the use of geotools and urban walks and events within the parks and green areas. This paper is organised in six sections. The third section is an overview of the general aspects related to the participatory methodologies through the use of information and communications technology (ICT) and geotools, presenting their possible purposes in the context of sutainable urban planning and urban regeneration with the involvement of youths aged 18–30. The fourth section presents the geographical context and the methods and technologies employed during the project. The fifth section shows the results of the project and a critical reflection on the participatory process. Finally, the sixth section highlights some observations that can be takenfrom this study.

664

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3 PARTICIPATORY METHODOLOGIES FOR THE IMPLEMENTATION OF NATURE-BASED SOLUTIONS (NBS)

Until recently, the main sources and producers of spatial data were governmental agencies, cartographic centers, private companies and local policymakers; indeed, high fees and copyright restrictions were a barrier to more widespread access to geodata (Arsanjani et al., 2015). However, in previous decades, the development of ICT and geomedia completely changed the methods of mapping and collecting spatial data, shifting them from a completely professional activity to one involving the engagement of non-experts (See et al., 2016). In particular, the emergence of open-source software and the lowered cost of the equipment played a key role in democratising the access to ICT (Gatti and Zanoli, 2022).

Hence, different terms have been created to refer to the involvement of citizens in the activities related to data collection and community participation, such as 'citizen science', 'neogeography' and 'crowdsourcing'. These terms are usually classified by considering the active or passive contributions from the citizens and the type of collected data, for example, spatial or no spatial data (See et al., 2016). In this context, citizen science is an umbrella term that refers to the involvement of non-expert audiences that contribute to research activities. In most cases, citizen science improves the research by increasing the amount of data collected or granting access to situated knowledge (Pristeri et al., 2019). Simultaneously, participants can increase their knowledge of specific research topics, learning the use of new tools, acquiring new skills, adding new value to the research and better understanding the scientific work in an appealing way. Hence, citizen science represents a unique opportunity to connect citizens to contribute to sustainable urban planning issues by collecting and analysing new data. For example, some studies have demonstrated how citizen science could contribute to the introduction, implementation, management and monitoring of NBS (Restemeyer and Boogaard, 2021).

Finally, if the collection of spatially explicit data is oriented for public purposes, the scientific community refers more specifically to the term Public Participation GIS (PPGIS), defined as the field within geographic information science that focuses on ways the public uses various forms of geospatial technologies to participate in public processes, such as mapping and decision making (Tulloch, 2014).

4 METHODOLOGY

4.1 Geographical Framework

The city of Padua is located in the Veneto region in the northeastern sector of Italy (see Figure 1). The municipal territory spans 93 km² with almost 210,000 inhabitants. Since the last decades of the 20th century, due to demographic growth and new needs linked to economic and industrial development, many low-density residential buildings sprawled throughout the urban core at the expense of green or cultivated fields, as in many other European cities (Peroni et al., 2020). This caused the spread of mixed rural-urban neighborhoods driven by the presence of industrial or commercial complexes and infrastructures. As a result, the Municipality of Padua reflects 49,6% of its territory covered by impervious surfaces (ISPRA, 2022). Among the various impacts of soil sealing, urban heat islands are becoming a serious risk for the local population, particularly the elderly (Todeschi et al., 2022). Moreover, there is also a scarce presence and unequal distribution of green and vegetated spaces. Indeed, only 10% of green areas are municipal and open and accessible to the public. In addition, studies report a low quality of the urban green spaces, with some neighborhoods with only 2.5 m² per capita (Pristeri et al., 2021).

4.2 The Participatory Mapping Process

The involvement of young people was achieved by adopting different participatory methodologies with the contribution of some specific geotools: i) urban walks and in-site laboratories to know the territory of the city and to better understand specific urban management issues and ii) the geo-app Geopaparazzi and the geo-platform Geocitizen to map, collect spatial data and create ideas and proposals to implement and restore the degraded or underused urban green areas of the city.
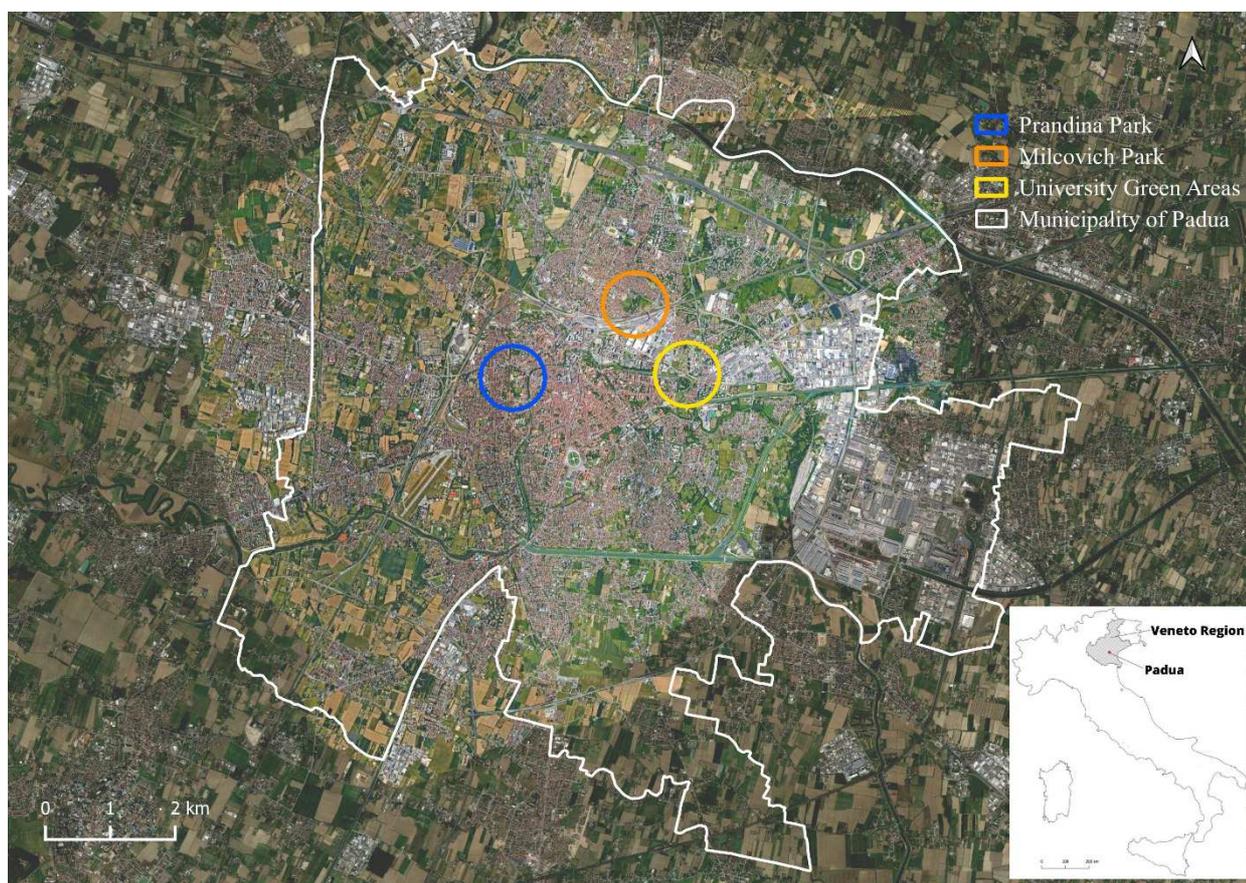
Fig. 1: The Padua municipality with the three study cases thatadopted the participatory mapping process

The participatory mapping activities led by the researchers from the University of Padua were developed during nine events that were open to the public. Each event started with an in-site workshop focused on the LUP project, its importance in promoting urban sustainability and the design of possible NBS. The workshop also included a contextualisation of the area in which the activity would take place (usually an urban park) and, in some cases, an historical excursion. Each time, the participants received an introduction to the geographical tools needed. In addition, a test trial was carried out to ensure the capacity of the participants to use the geotools efficiently. Each workshop focused on one topic related to sustainable urban planning, such as soil sealing, climate change, the importance of the ecosystem services provided by the green areas and the possible restoration and implementation with NBS.

Six events dedicated their second part to the presentation of the Geocitizen platform and to the collection of data. The remaining three events had their second part dedicated to an urban walk with the participants through three different areas of the city: i) the university green areas in the Portello neighborhood, which is a key area for university students, ii) the Milcovich Municipal Park, located in the north sector of the city and closed to the train station and iii) the Prandina Park, in the city center (See Figure 2).

The first area was selected on the basis of the presence of a large number of young people, mainly students. They mainly live in this neighboorhood and are familiar with the area, its advantages and problems. This aspect is crucial to implement the effective and successful collection of proposals and ideas. The Milcovich Municipal Park was selected as a best practice location supported by the municipality. Indeed, years ago, good management and a dialogue with the public administration enabled the restoration of the area that was completely underused and now it is one of the most popular parks in the city and hosts various socio-cultural initiatives. The last area, the Prandina Park, an ex-military zone, at present hosts one of the few urban forests within the city walls. It was chosen as a location due to the intense public debate within the city regarding its future uses.

4.3 Geotools and methodologies for the participatory process

Urban walks are a well tested method in geographical research to support the sharing of people's perspectives regarding different aspects of the cities they live in (Husar et al., 2020). Walking through places

666

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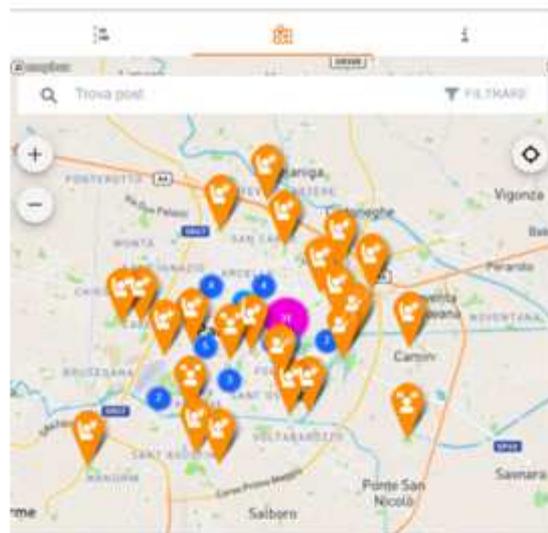
allows discussion on the basis of a direct contact with spaces, integrating the stimuli of all the human senses. During the participatory process, urban walks succeeded as a way to collect data from the ground and as a method for the participants to elaborate and share their ideas. Notably, the two processes became intertwined, resulting in data collection that evolved and changed according to the proposals of the participants while they took part in the construction of the same proposal.

Fig. 2: Identification and geographical details of the three study cases selected for the PPGIS process

During the urban walks, the open-source and open-access mobile app Geopaparazzi was used. The app was developed in 2010 from HydroloGIS to facilitate GIS data collection (HydroloGIS, 2023). GIS data collection allows the user to access and edit spatial data during fieldwork with the support of smartphone GPS functionalities. Geopaparazzi was used to elaborate proposals on how to reconceive of the green spaces within the case studies by suggesting possible NBS. Finally, Google Earth Pro was used to visualise the collected data allowing a better understanding of the points' locations and assessment of their quality.

Geocitizen is a geotool that allows the implementation of participatory processing in which users can propose spatially referenced ideas and comment on the suggestions of the others participants. It is available both as an online platform and a mobile app and it was built in collaboration with the Fundación Centro de Competencia Educativa para Espacios Comunitarios (Ecuador). In the participatory process of the LUP project the Geocitizen platform (https://app.geocitizen.org/lup_padova) worked both as an informative tool that allowed interactive access to various cartographies of the Padua municipality as the main container of the mapped points and as a place to debate the suggestions among the participants through the comment function. The mapped points pertained to four different categories (or tasks) corresponding to: i) ideas to improve the urban spaces (idea task), ii) good practices carried out by the local population (good practices task), iii) existing problems within the spaces (problem task) and iv) questions for the local policy-makers (question task) (see Figure 3). As an online platform, Geocitizen collected data both from the youths who participated in the in-site laboratories and the urban walks and from a larger audience of users not directly involved in the activities but still interested in sharing their perspectives.

Fig.3:a) Screenshots of Geocitizen with examples of different tasks (idea, problems and best practices);b) a possible good practice to be implemented along the embankment of the San Benedetto Riviera for recreational and sports activities; c) a problem mapped near the station of a disused green area; d) and e)two ideas for using abandoned green areas, respectively the activationand promotion ofsocio-cultural activities, and the safeguarding of the riverbank biodiversity that presents several species of birds.

5 RESULTS

This study featureed a high participation of young people. More than 400 participants were involved and were able to approach and understand geographical concepts and issues related to sustainable urban planning. In general, the LUP project achieved two main results: the first concerns the use of geographical instruments and geotools by non-experts and young people to collect spatial data related to urban territory

668

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and its green areas. From a practical point of views, the second outcome is related to the direct involvement in the participatory mapping process (PPGIS) of young people to address issues such as soil sealing, climate change and the possible measure and actions for more sustainable and inclusive urban planning focused on the improvment of green areas, including discussions with decision-makers of the municipality. Furthermore, the approach to the use of ICT and new geographic technologies allows participants to develop new skills and to explore the importance of geographical data in the perception of the territory and the creation of possible proposals to enhance its local context.

5.1 The Geocitizen Platform

The Geocitizen platform represents a useful and powerful tool for spatial data acquisition, providing to local decision-makers opinions and ideas from young people. In total, 118 points were collected and 97 were georeferenced. The majority of them are related to proposed ideas (83%), suggesting a desire to rethink the mapped urban spaces, for example, green areas, urban parks, empty or abandoned spaces and buildings, stream buffers or ecological pathways. The ideas and practices proposed by the youths in this task aimed to achieve a more sustainable city and developing NBS by introducing community gardens, food forests or bug hotels.

All the proposals are related to the improvement of the quality of life through the increase of different ecosystem services. The cultural and social services were the most cited, as well as the regulating and supporting ecosystem services. For example, one idea was proposed to deseal an empty space to create a green area and to implement different ecosystem services by introducing NBS. In addition, other ideas were related to the restoration of green spaces that are abandoned, badly managed or lacking basic equipment, such as benches, tables and drinking fountains. Moreover, the participants highlighted that these lacks often lead citizens to not frequent these areas and thus waste the green areas that could be used for both recreational and sporting purposes.

Many of the collected points concerned river banks or ecological corridors along the water network of Padua. These ideas emphasised the need to create health trails to improve and facilitate outdoor sports activities. Other ideas concerned the preservation of biodiversity, especially related to the avifauna that can be observed along the ecological corridors and canals of the city. The young people suggested restoring some buildings near these areas that could be transformed into birdwatching stations. This idea has a twofold function: the first is to bring citizens closer to the local fauna, which is often unknown, and to understand in a different way the importance of green areas in the city. The second is linked more to tourism as a natural attraction for visitors.

The category related to good practices, reporting virtuous experiences throughout the city, and represented 13% of all the mapped points. These examples allowed the effective and efficient valorisation of specific green areas of Padua with the help of civil society organisations, strengthening different ecosystem services. An example of good practices reported by the participants could be the presence of different agroecological farms in Padua or the requalification of green spaces promoted by different stakeholders and NGOs.

The points mapped as issues to be managed by public authorities (14% of the total) were mainly focused on proposals regarding the restoration of the urban parks and green areas that are totally abandoned, as well as agricultural fields. Another issue was related to the scant valorisation of the ancient city wall system of Padua that are an important cultural heritage and tourist attraction; the walls system includes green areas that are underused at present.

Finally, the last category concerns question tasks that were mainly directed toward knowing whether or not there are any projects to restore or rehabilitate various green areas or infrastructures located within the parks.

5.2 Urban walks with Geopaparazzi

During the urban walk activities, the collection of spatial data and the process of re-thinking urban green spaces were conceived through different geographical tools, from the use of cartography to the geo-technologies such as Geopaparazzi and Google Earth Pro. These geotools increased the engagement during the urban walks and stimulated the participants to use the 'eye-thinking approach' by adopting a double view of the study areas – from below through their own eyes and from the top through the use of cartography and aerial images (see Figure 4).

Fig.4: The photos show some examples of data collection usingGeopaparazzi and Google Earth Pro for the visualisation and the PPGIS activities

The first urban walk was performed in the Portello neighborhood within the university green areas. During the urban walk, the two parks closed to the university green spaces, the Parco Europa and Parco Venturini-Natali, were also crossed and surveyed. The proposals mapped by the young people during this activity mainly concerned the regeneration of the infrastructures and abandoned areas along the urban walk. In addition, a restoration of the Piovego canal banks was proposed with naturalistic dissemination paths presenting the flora and fauna. In addition, the possibility was proposed of transforming the area during the spring and summer seasons into a study area with the installation of temporary structures such as geodesic domes to encourage outdoor teaching activities.

Prandina Park is at the center of an important decision-making process, since the southern area of the park is now used as a car park; currently, the administration seems to be planning to increase the number of parking spaces in the next few years at the expense of the present green area. In this area, the participants proposed a series of very promising interventions for the management of urban greenery and ecosystem services. Among these, one of the most interesting included a redevelopment of the car park area with temporary architectural structures, such as exhibitions, art shows and local markets, in order to turn it into a place of

670

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Edoardo Crescini, ,Francesca Peroni, Francesco Facchinelli, Giuseppe Della Fera, Daniele Codato, Salvatore Pappalardo, Massimo De Marchi

aggregation for the city and to create new local economies. Moreover, the participants proposed to better equip the green area with benches, fountains and a dog area in order to transform it into a multifunctional space. Some ideas proposed to restore and safeguard the urban forest, with the involvement of the NGOs that are already active in the park, into a hotspot area with high biodiversity.

During the last urban walk, performed in the Milcovich Park, the participants developed proposals aimed at increasing the services and activities offered by the area. For example, an open-air cinema was proposed for the centre of the park, which is often not utilised. The creation of a bridge in the eastern sector would connect the park with the surrounding neighborhoods, allowing for greater attendance. Finally, the expansion of the area designated for urban gardens was also proposed with the possibility of creating an educational farm with the introduction of beehives.

5.3 Geographical Approach and Geotools in Sustainable Urban Planning

The use of different technologies allowed the understanding that geotools could be suitable according to the activity planned and the context in which it is used. For example, Geopaparazzi works very well for urban walks and less so as a point collection hub to support a dialogue with the public administration. The Geocitizen platform in that case is more effective, allowing social network interactions with reactions and comments and allowing the discussion of the different proposals directly online.

Furthermore, thanks to geotools, it is possible to strengthen the spatial skills and geographical awareness of the participants. In addition, this type of activity brought them closer to relevant topics, such as soil sealing and the importance of safeguarding and increasing the size and number of the urban green areas, while also presenting the guidelines that have been published and promoted by the EU as the EU soil strategy for 2030 and, thus, an acquisition of the geographical and notional knowledge that allows higher quality data collection.

Finally, this study emphasised the importance of developing and supporting such methodologies in the urban environment, not only to produce open-access spatial data and collect geographical information, but also to make the decision-making processes more inclusive and to turn non-expert actors into active participants who create data and participate in the rethinking of urban spaces. These practices also enable the development of more effective and efficient sustainable urban planning and the design of NBS with a variety of environmental and social benefits.

6 CONCLUSIONS

This study highlights the importance of the production of geodata through the implementation of citizen science and the PPGIS approach in an urban context to design and implement adaptation, compensation or mitigation measures in reducing the loss of ecosystem services mainly caused by the soil sealing phenomenon, and improve sustainability and well-being in the cities. The activities promoted in LUP through the testing of different geotools allowed the reconceptualization of some of the green spaces of Padua, promoting the implementation of NBS. Moreover, other ideas were proposed to realise the multifunctional green spaces directly by youths and non-experts actors. The LUP project is an attempt to enhance bottom-up participatory processes for the promotion of more inclusive decision-making processes that aim to involve local communities, their perceptions and visions in order to operate more effectively within the areas in which mitigation and adaptation actions are taken.

7 REFERENCES

Arsanjani, J.J., Zipf, A., Mooney, P., Helbich, M. An Introduction to OpenStreetMap in Geographic Information Science: Experiences, Research, and Applications. In: Springer, OpenStreetMap in GIScience. Lecture Notes in Geoinformation and Cartography, pp.1-15. Berlino, 2015

European Commission, EU Soil Strategy for 2030. Reaping the benefits of healthy soils for people, food, nature and climate. Brussels, 2021

European Environmental Agency (EEA), Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction. Brussels, 2021

Gatti, A., and Zanoli, A. Revolution in Precision of Positioning Systems: Diffusing Practice in Agroecology and Organic Farming. Drones and Geographical Information Technologies.In: De Marchi, M., Diantini, A., Pappalardo, S.E. (Eds.). Agroecology and Organic Farming Contributions to Technological Sovereignty, 75–98. Boca Raton, 2022.

HydroloGIS, Geopaparazzi Reference Manual. 2023. Retrieved from: https://www.geopaparazzi.org/geopaparazzi/index.html

Husar, M., Ondrejicka, V., Scacchi, M. Involving Citizens through Walking: Urban Walks as a Tool for Awareness Raising in Historic Built Areas. In: IOP Conf. Ser. Mater. Sci. Eng. 960, 022087. Bristol, 2020

Pappalrdo. S.E., Todeschi, V., Zanetti, C. Mapping urban heat islands and heat-related risk during heat waves from a climate justice perspective: a case study in the municipality of Padua (Italy) for inclusive adaptation policies. In: Landscape and Urban Planning. 238, 104831. Amsterdam, 2023

Peroni, F., Pristeri, G., Codato, D., Pappalardo, S.E., De Marchi, M. Biotope Area Factor: An Ecological Urban Index to Geovisualize Soil Sealing in Padua, Italy. In: Sustainability, 12(1), 150. Switzerland, 2020.

Pristeri, G., Peroni, F., Codato, D., Pappalardo, S.E., Crescini, E., De Marchi, M. Urban geography and participation in the digital era: three studies in Padova between GIScience and VGI. In: Bollettino dell'Associazione Italiana di Cartografia, (166), 62-76. Trieste, 2019.

Restemeyer, B. and Boogaard, F.C. Potentials and Pitfalls of Mapping Nature-Based Solutions with the Online Citizen Science Platform ClimateScan. In: Land, 10(1), 5. Switzerland, 2021

See, L., Mooney, P., Foddy, G., Bastin, L., Comber, A., Estima, J., Fritz, S., Kerle, N., Jiang, B., Laakso, M., Liu, H., Milčinski, G., Nikšič, M., Painho, M., Pődör, A., Olteanu-Raimond, A., Rutzinger, M. Crowdsourcing, Citizen Science or Volunteered Geographic Information? The Current State of Crowdsourced Geographic Information. In: ISPRS Int. J. Geo-Inf., 5(5), 55. Switzerland, 2016

Todeschi, V., Pappalardo, S.E., Zanetti, C., Peroni, F., De Marchi, M. Climate Justice in the City: Mapping Heat-Related Risk for Climate Change Mitigation of the Urban and Peri-Urban Area of Padua (Italy). In: ISPRS Int. J. Geo-Inf., 11(9), 490. Switzerland, 2022

Tulloch, D. Public Participation GIS (PPGIS). In: K. K. Kemp, editor. Encyclopedia of Geographic Information Science. SAGE Publications, Inc., 352–355. Thousand Oaks, 2014

The Community Gardens and Kitchens, and their Contribution to the Social Development of the Marginalised Areas in Berlin: the Case Study of Beettinchen Community Garden

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1 ABSTRACT

Over history, food was an essential element in the cities' establishment, and it has had a huge effect on their location, urban context, culture, economy and social network. Urbanization facilitates and improves the physical access to food due to the efficient infrastructure, however the residents of the marginalized areas have vulnerable relationships with food, in addition to other socio-economic problems. That all increases the need for alternative food systems to reduce the distance between the producer and the consumer, and contribute to food security in those marginalized areas. These community food security projects, such as the community gardens and the community kitchens, have become a growing international movement, especially in the developed countries. They have been established, involved and managed by the community members, which followed the bottom up approach. They have been used by the state and civil society as activities to develop the marginalized areas. This paper aims to understand how community kitchens and gardens can be integrated as a vital element of urban development of the marginalized areas in Berlin, through analyzing the empirical aspects including the organization and the governance of these projects, the ownership of the used land, the motivation of the people who participate in these projects and to what extent they benefit from these projects, from the social aspects. The paper presents the case study; "Beettinchen" community garden in Märkischen Viertel in Berlin. The analysis is based on literature research, interviews, study visits and observations. This paper is a part of the author's ongoing PhD research about the community kitchens and gardens in Egypt and Germany, and how they can contribute to the urban development of the marginalized and vulnerable areas.

Keywords: marginalised areas, kitchen, garden, community, Berlin

2 INTRODUCTION

Food plays an important role in our life, not only through nutrition, but it contribute to the cities' development, including their urban context, culture, economy and social network, in addition to defining the urban layouts such as the internal land uses, roads, public spaces and buildings (Bricas and Conaré 2019; Salvador 2019). For example, the markets and slaughterhouses were located in the city centres (Bricas and Conaré 2019). However, this distance between cities and food increased over time because of globalization, and modern trade (Nuetzenadel and Trentmann 2008; Haysom 2015). Community gardens and kitchens are examples of the projects that follow the alternative food system, attempting to decrease the distance between the producers and consumers. Moreover, they are community based projects that focus more on community engagement, and participation. The paper aims to explore and understand the social contributions and effects of the community garden and kitchen projects in the marginalized areas, through analyzing the case study of Beettinchen community garden in Märkisches Viertel in Berlin, which is a neighborhood with large refugees' accommodation. As this paper is a part of the author' s PhD thesis "The community gardens and kitchens , and their contribution to developing the marginalized and vulnerable areas, in Germany and Egypt", it is exploratory research, and there will be a more structured follow-up research.

3 METHODOLOGY

This research is a part of the author's ongoing PhD research about the community gardens and kitchens and their contribution to the urban development of the marginalized and vulnerable areas in Egypt and Germany, under supervision of Prof. Uwe Altrock, from Kassel University, the Urban Development Department. This paper is based on a qualitative approach, aiming to understand the community garden and kitchen projects, and explore their impact on social patterns through analyzing case studies in Berlin. To identify the development patterns that include a local social perspective, a mixed-methods approach was applied.

First, reviews of secondary literature were used to understand the concepts of community gardens and kitchens, in addition to the food system in Berlin. Furthermore, Data collected from fieldwork, observation, interviews, and photography were utilized to analyze the chosen case study. The Beettinchen community

garden is chosen as an interesting case study due to many reasons, it includes different types of community gardens on the same land, as some people rent their own plot while BENN has two plots for the community to plant them together. In addition, it is a good example of a garden with a kitchen so it could help to understand the relationship between community garden and kitchen. Moreover, it is located in Märkisches Viertel, one of the 16 neighbourhoods with large refugee accommodations that includes BENN, Berlin Entwickelt Neue Nachbarschaften (Berlin Develops New Neighborhoods) program offices. BENN is a program of the Berlin Senate Department for Urban Development, Building and Housing to strengthen integration, neighbourly cooperation, social cohesion and participation (Senatsverwaltung für Stadtentwicklung, Bauen und Wohnen 2023).

Fieldwork included 5 site visits to the Beettinchen community garden in May and June 2023. Additionally, 12 semi-structured interviews were conducted to uncover the garden's governance system and organizations, the motivations of the users, and its impacts on their social life. The interviewees included the garden's tenants, visitors, and representatives from the involved organizations in the garden's management. The interviews focused on the garden's system, the users' motivation including the tenants and the users, their activities in the garden, and the governance system. Because the interviews consisted of open-ended questions, the duration was different from one interviewee to another but it was between 10 to 30 minutes.

One of this research's limitations is the time, as most of the community gardens and kitchens in Berlin are active only in summer starting in May due to the weather, and most of them only organize one event per month, which made it difficult to analyze a community kitchen example. Moreover, one of the case studies mentioned before in the submitted abstract has been excluded from this paper because through the analysis, the author discovered that the case study of the project "Make the neighborhood greener" in Beussel- and Huttenkiez in Moabit, Berlin, is about urban agriculture activities more than about systematic community gardens and kitchens which is the focus of this paper. Even with those limitations, the modified project framework produced relevant findings which are presented below.

4 LITERATURE REVIEW

4.1 Alternative Food Systems

Food System is a concept that illustrated all procedures involved in providing food for a population, including 5 stages : production - processing - distribution - consumption / food culture - disposal, beside the input-/output procedures and resource flows (Giseke et al. 2015; Kasper et al. 2017; Jennings et al. 2015). The alternative food system aims to improve the traditional food system through reducing the distance between the producers and the consumers (Campbell 2004). The alternative food systems include different aspects such as sustainable urban agriculture, local and regional food, and farmers' markets.

4.2 Community gardens

Community gardens are a type of urban agriculture's practices or activities. Urban agriculture is defined as "the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, processing and marketing of products." (Mougeot, 2005). Furthermore, the community garden is a plot of land in an urban area that is either communally or privately farmed by a group of residents from the nearby neighbourhood (Veen 2015), so food and plants will be grown on a shared setting. This concept of community garden first appeared in the United States of America in the 1890s due to an economic crisis. (McKelvey 2015; Grace 2022; Kurtz 2007), and it represents an important resource for food security during World War I and II (Grace 2022). Moreover, Europe has a long history of allotment gardens, which people rent as small plots for the purposes of food growing and recreation (Brown 2008), and they are considered a type of community gardens (Veen 2015). They started in the United Kingdom in the 18th century and in Germany in the 19th century (Keshavarz and Bell 2016; Drilling et al. 2016). In addition to allotment gardens, the modern community garden (CG) movement began to gain momentum in Europe in the mid- to late 1980s. In the 1990s, it also became widespread in Germany (Meyer-Rebentisch 2013).

Community gardens have a lot of social benefits as they are mainly built on engagement, and participation. (McKelvey (2015) and Firth, Maye, and Pearson (2011) stated that community gardens enhance the feeling of identity, ownership, and stewardship, since they provide a venue for people of all backgrounds to interact

674

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and share cultural traditions. Moreover, they increase the sense of belonging, especially for newcomers and immigrants (Agustina and Beilin 2012).

4.3 Community Kitchens

Community kitchens are defined as "community-based cooking activities in which small groups of people meet regularly to prepare one or more meals together" (Tarasuk and Reynolds 1999). The community kitchens could be commercial or non-profit initiatives (Conservation Law Foundation, Dewey, and Fink 2018), and food there is usually produced in huge quantities by combining labour and resources (Tarasuk and Reynolds 1999). The community kitchens are different from food aid programmes because of their participatory structure and capacity to enhance mutual support (V. Tarasuk 2001). The concept of community kitchen was first initiated in Latin America (Kalina, Sheryl, and FoodShare 1993; Andreas 1989; Ripat 1998).

5   BERLIN'S COMMUNITY GARDENS AND KITCHENS

Berlin is a city with a lot of food activities, including community gardens and kitchens. Berlin has a long history of community gardens that spans more than 30 years, with a major grassroots movement that had its roots in the early 2000s (Beck 2021). There are 99 community gardens, mapped in Berlin in 2013 (Berliner GartenKarte 2023), as shown in figure 1, and they increased over the years as according to Beck (2021), the number of community gardens in Berlin reached more than 200 gardens in 2021.

Figure 1: the community gardens in Berlin in 2013 (source: Gartenkarte, 2023)

They have various scales, purposes, and organization systems. Regarding the scale, they vary from the large agricultural plots in the outskirts of Berlin such as the Bauerngarten in Pankow (Bauerngarten 2023), to the normal scale of neighbourhood community gardens such as the BrunnenGärten community garden (gruppe F 2023), and even to smaller scale community gardens that focus on the building or the block as GIDAK which is located in the courtyard of a former brewery site "GIDAK-Hof"in the middle of the cooperative at Saarbrückerstrasse as shown in figure 2 (Cityplot 2023). Moreover, the community gardens in Berlin have various purposes and aims. Some gardens focus on the environmental aspect and the ecological diversity,

while others focus on the educational aspect and how to share and transform knowledge and experience about agriculture, such as Maxim Climate-Garden for youth education in Pankow (Urban Abroad 2022). In addition, other community gardens are created because of social purposes, in order to create meeting points for the residents and to provide open space for newcomers and refugees such as Garden of Hope (Bustan El Amal) which is even named in the Arabic language (Grünanteil 2017).

Furthermore, in Berlin, there are a lot of initiatives related to community kitchens, which could be divided into collectives and projects (AWC SYLLABUS 2021). An example of the collectives is LebensMittelpunkte, which is a network that gathers 27 initiatives all over Berlin. These initiatives are locations with three categories of self-organized neighbourhoods' activities (LebensMittelPunkte 2023a):

- the "Depot" which focuses on storing and distributing food,
- the "Küfa" kitchen, which focuses on cooking together, and
- the "Kiez" neighbourhood, which focuses on empowering the people in every neighbourhood.

Four initiatives are regular "ready-to-use" food centre points in Mitte (LebensMittelPunkte 2023b). They are: "Baumhouse" in Wedding, "Offenes Wohnzimmer" in Moabit, Haus der Statistik", which is an old historical building complex, and "Culture Laboratory Trial & Error", and all of them offer community kitchen regularly once a month (LebensMittelPunkte 2023b). Moreover, Open Kitchen is shown as a great example of the community kitchen projects, as the Open Kitchen has been offering social cooking sessions on a regular, weekly basis in the form of a meet-up at Refugio in Neukölln since the summer of 2017 (Open Kitchen 2023). The Open Kitchen project focuses on cooking with refugees (Open Kitchen 2023), similar to other community kitchen projects in Berlin such as the "Refugees' Kitchen" which is a mobile kitchen, created through a partnership between artists and refugees (Refugees' Kitchen 2023). Furthermore, over the last few years, the connection between the community gardens and kitchens has increased, and there are many old projects of community gardens which have added the concept of the community kitchen to their structure. For example, the Prinzessinnengarten Café & Restaurant depends on the harvest of the community garden in addition to small local organic farms in Berlin. It is an example of the commercial community kitchen which stipulates that all its sales of food and drinks will go to the non-profit community garden project ('Garden Cafe | Princess Garden Collective Berlin' 2023)
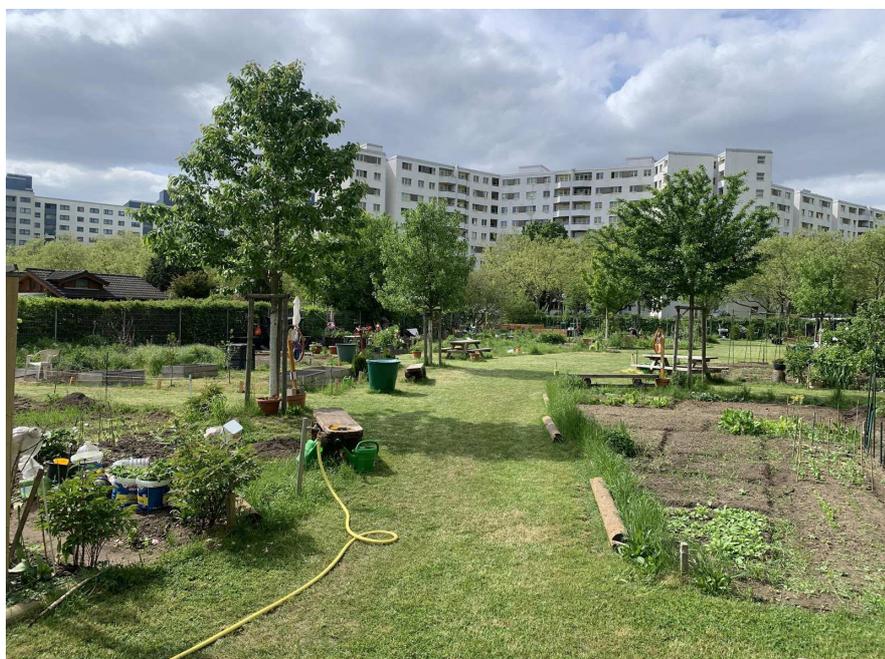
Figure 2 : the plots of the garden and a path between them (source: author)

6 THE CASE STUDY: BEETTINCHEN COMMUNITY GARDEN

The Beettinchen community garden is an intercultural neighbourhood garden in the Märkisches Viertel in Berlin-Reinickendorf. It was founded in 2013 in the old location at Bettina von Arnim School. It relocated in 2021 to its current location at Treuenbrietzener Straße 32, next to the allotment gardens (Monzer 2023). The

garden is easily accessible to the public because there is a bus stop just in front of it. The garden has two entrances, one from the parking spaces in the main street and another from the allotment gardens in the back. The garden has a total area of around 300 m2 (Skowronek 2023) and is divided into 35 plots, each of which is 39 m2 (Spremberg 2023), as shown in figure 2 and figure 3. The plots are rented out to tenants and there is a path between the plots. Based on the author's observations, there is a small kitchen facility which is usually opened for the tenants to use. Moreover it is used by the whole community in the grilling event organized by Albatros or in the summer harvest event in September by BENN. Furthermore, there are other facilities such as toilets, a small children's playground, and a seating area with 5 to 6 benches and tables next to the garden plots, as shown in figure 3 and figure 4.
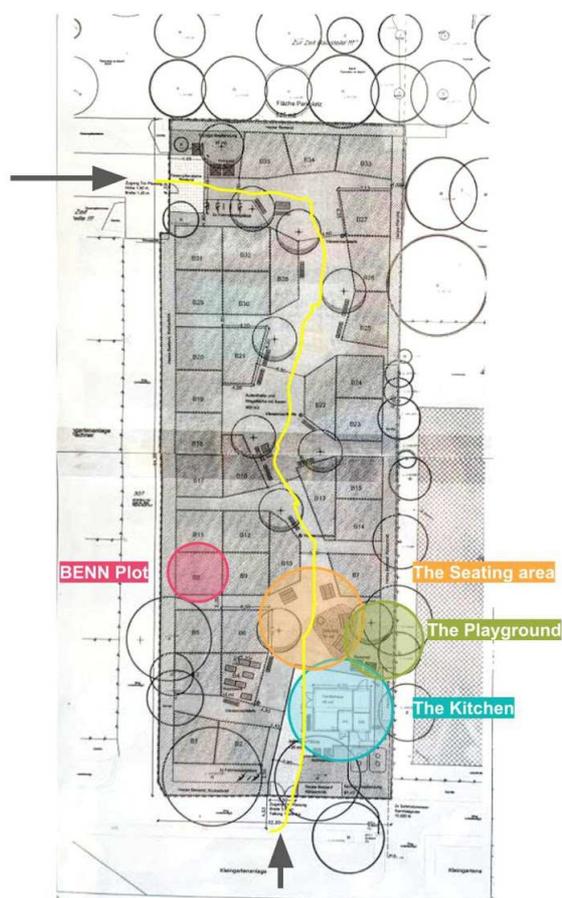
Figure 3: the plan of the garden, illustrated the entrances, the path, the kitchen, the seating area and the playground (source: GESOBAU, 2018, edited by the author)

Figure 4: the seating area and the playground (source: author)

6.1 The Stakeholders Analysis

To understand the governance system of this community garden, the involved stakeholders are mapped and analyzed. The garden land is owned by GESOBAU AG, while MV. Albatros gGmbH is the operator of this

project (Monzer 2023; Sharaf 2023), which rents the whole land from GESOBAU.AG with a subsidized cheap rent, with an agreement until 2027/ After that, the garden could be forced to relocate to another place, according to GESOBAU's future plan for this land (Skowronek 2023). MV. Albatros gGmbH leases the 35 plots to tenants from the neighbourhood (Skowronek 2023). MV. Albatros gGmbH is a company that is interested in social work, especially in the districts of Reinickendorf and Pankow, within the context of district and neighbourhood work (Albatros gGmbH 2023). Since 2009, they have operated a multi-generational home in Reinickendorf and a community floor "Nachbarschaftsetage"in the Märkisches Viertel (Albatros gGmbH 2023). Their team has a weekly meeting in the community floor "Nachbarschaftsetage" to follow up and organize their projects including the garden, and the social manager from GESOBAU joins them once per month to check on how they work (Skowronek 2023).

Moreover, BENN, Berlin Entwickelt Neue Nachbarschaften, - which means Berlin Develops New Neighbourhoods - in Märkisches Viertel supports this garden; financially or through buying the needed materials, besides managing one plot in the garden (Sharaf 2023). BENN is a programme of the Berlin Senate Department for Urban Development, Building and Housing, which started in 2017, aiming to strengthen integration, neighbourly cooperation, social cohesion and participation in neighbourhoods with large refugee accommodations in 16 districts (Senatsverwaltung für Stadtentwicklung, Bauen und Wohnen 2023). The BENN team consists of 3 members, and they have their on-site office in Märkisches Viertel centre (Sharaf 2023). Moreover, BENN rents two plots from Albatros and they run it as a small community garden where all the neighboirs can come and join the gardening process (Sharaf 2023). One of the BENN team is responsible for this project, Mr. Khalil Sharaf, who has a Syrian background (BENN im MV 2023a), In addition atwo on-site workers are present in the garden, one Syrian, the other Kurdis who are responsible for the gardening, People from the neighborhood are allowed to participate in the gardening, and there are specific spots that are left for these people to grow their own plants, while other spots are specified for childrens to learn how to plant (Sharaf 2023). In the summer, starting from May, BENN organizes a garden cafe every Tuesday from 3 to 6 pm in the garden for all the neighbourhood. In addition to general gardening activities include sowing, planting, watering and harvesting (BENN im MV 2023b). Around 15 to 20 persons usually participate and attend this garden cafe (Sharaf 2023) shown in figure 5.

Figure 5: the garden cafe organized by BENN (source: author)

Regarding the tenants of the other plots, half of them are German and the other half are of different nationalities such as Arabic, Cambodian, Vietnamese, Turkish, Portuguese, according to the interview conducted with Volkmar (Spremberg 2023), who is one of the three on-site responsible workers for the garden on behalf of Albatros. One plot is rented by two women who share it and pay the rent together (Spremberg 2023). The tenants have a legal contract with Albatros and GESOUBAU with a cheap price of 240 Euro per year and they can pay by year or by month (Spremberg 2023; Skowronek 2023). This contract is automatically renewed every year and the termination of the contract is subject to a three months notice (Skowronek 2023). Moreover, Skowronek (2023) mentioned that there is a long waiting list of people who want to have their own plot in the garden, who are usually choose in a way that protect the garden's diversity and intercultural spirit, thus involving different nationalities and age groups. There is a house rule that states all the regulations and restrictions of using the gardens (Skowronek 2023) such as saving water and resources. For example, the tenants are not allowed to grill at any time for safety reasons and to avoid the noise and crowds in the garden. In addition, playing football is not allowed in the garden (Dubler, 2023).

Beside the regular tenants and BENN, there are other activities and projects that rent and use plots from the garden. For example, one plot is rented for free by Albatros by "Mobile Stadtteilarbeit" to establish raised beds for plants to be used by the wheelchair users, as shown in figure 6. They are getting plants for the raised beds for free, and they only pay insurance to get the keys of the garden and once they return it, they are getting the insurance back. In addition, they got funds from GESOBAU social organization to buy materials and build the structure of the raised beds for plants (Skowronek 2023). Another activity, which happened in one plot of the garden, is about ecological education. It is run by a person hired by Albatros, financed by BENN and it targets the youth and students (Fred 2023; Skowronek 2023; Spremberg 2023). Moreover, Skowronek (2023) mentioned that there is a plot of the garden rented to the Salam.ev. Initiative.

Figure 6: the raised beds for growing plants by the wheelchair users (source: author)

Figure 7 illustrates the mapping of the stakeholders and the actors involved in the garden and its activities, and their relations.
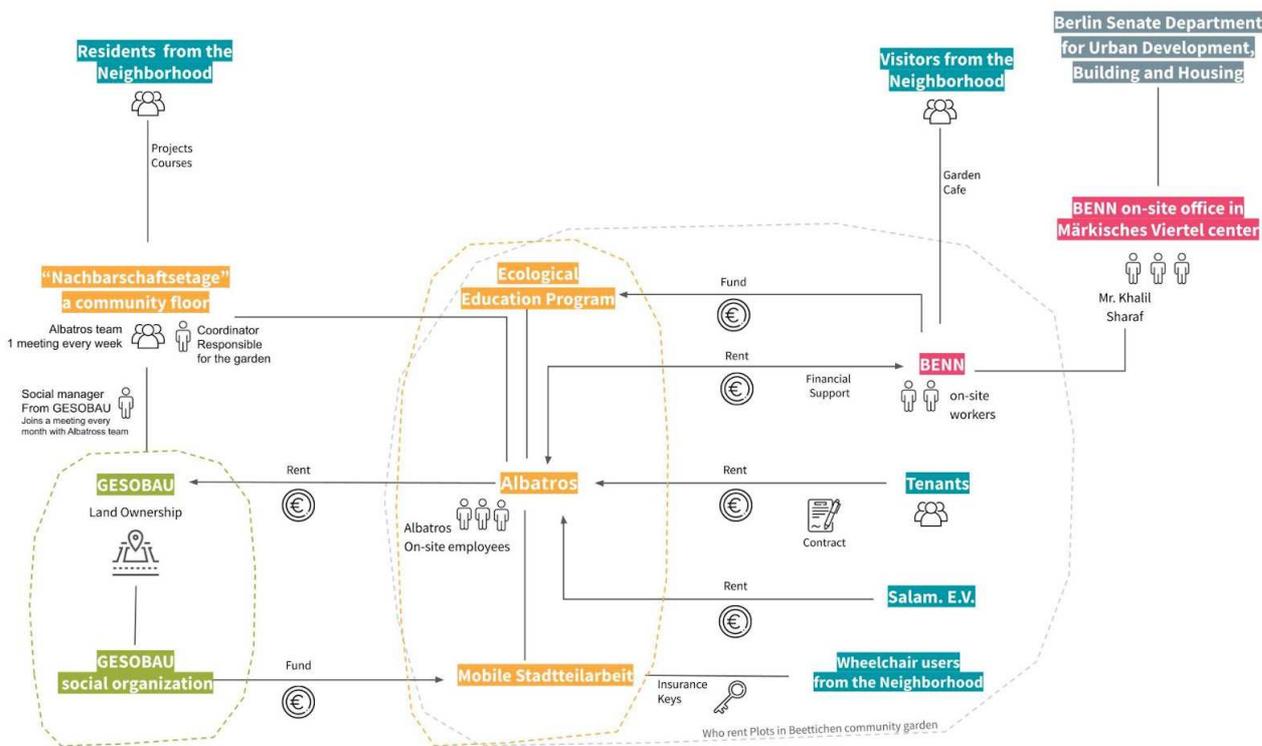

Figure 7: the stakeholders mapping (source: author)

6.2 The Garden's Activities

Regarding the garden's activities, the tenants are allowed to use the garden every day from 6am to 10 pm with their keys. while people from the neighbourhood can also come and many are sitting in the garden during this time (Skowronek 2023). BENN organizes a garden cafe every Tuesday in summer from 3 to 6 pm, and they offer drinks and snacks, in addition to helping in the gardening process (Sharaf 2023). The garden café's activities start with an event at the beginning of summer in May, when the neighbours participate in the decision making process. In addition, another event occurs in September at the end of the summer, and it is mainly about harvesting, then they cook together with fresh fruits and vegetables from the garden by using the kitchen in the garden (Sharaf 2023; Skowronek 2023). Beside the garden cafe, there are other activities organized by Albatros gGmbH, such as the grilling events, in which only the tenants can participate and grill their own food; and the clothes exchange event, a 'market' where people come to buy and sell old clothes (Spremberg 2023). Skowronek (2023) stated that they tried to organize a regular meeting for the tenants but it was not possible because it is difficult to find a day and time that is suitable for all of them. However, when there are events such as clothes exchanges, or fireplaces in winter, Albatros invites all the tenants and most of them usually join (Skowronek 2023). Moreover, there is an attempt from Albatros to move the activities that are used to be in the community floor "Nachbarschaftsetage" to the garden, especially in summer, such as the Turkish women cafe, (women gather every Wednesday at 2pm), Oma gegen Rechts (a programme about anti-racism), Energieschuldenberatung (a consultation on energy consumption and complaints), and a handcrafts course (Skowronek 2023).

6.3 The Interviews and The Social Relations

According to some open-questions interviews undertaken with anonymous tenants to discover the social life in the garden, a German retired man, stated that he knows a lot of people due to the garden, but he considers them as "bekannt" which means familiar not friends. In addition, he mentioned that sometimes they exchange products and food, and sometimes when he was sick, they used to water his plants for him. He comes twice per day to the garden to water the plants and enjoy the fresh air. Moreover, another German retired tenant woman stated that all the tenants mainly know each other as most of them come daily to the garden so they meet, say hi. This woman has one plot and her daughter has another plot and she mentioned that she comes everyday to water the plants of both plots. However her daughter, who lives in Friedrichshain (another district far away), comes on the weekend and during vacation with the grandchildren, and they play with the children of the Cambodian tenants who rent the adjacent plot. On the other hand, the woman mentioned that she cannot communicate with the visitors of the BENN garden cafe, as most of them cannot speak good German language. Furthermore, according to the interview done with Kristina Dubler, the manager of the community floor and the garden, there are problems and conflicts, sometimes happening between the tenants because of their different purposes and motives of using the garden, in addition to their different cultural background. For example, some of them have big families that cause some noise, while the others prefer the calm and rent their plot searching for relaxation. According to observation, it is noticeable that a lot of tenants come to sit in their plots to relax, read books and enjoy the sun. Despite the existence of a House Rule document, it is always difficult to deal with 35 tenants and their families in one piece of land, even though every tenant has a its separate plot, as there are no fences between them (Dubler, 2023).

The visitors of the BENN garden cafe are from various nationalities, such as German, Syrian, Egyptian, Kurdish. According to some open-question interviews done with the visitors of BENN garden cafe and the observations during the fieldwork, most of them know each other as they have a whatsapp group and they invite each other to this garden cafe. One German man who usually joins the garden cafe, mentioned that his motive is to help the immigrants who join the garden cafe through practicing German with him or asking him about any German procedures, for example, health insurance and searching for a job or apartment. Arab women mainly come to socialise and enjoy the sun and the good weather in the fresh air of the garden. Moreover, two women, one Lebanese the other Kurdish, mentioned that they used to celebrate their birthday and their kids' birthday in this garden by organising a party and inviting the people. The Arab women usually bring cooked food or snacks with them and enjoy chatting in the garden, and they use the planted mint and herbs in their teas. However, not all the people who come to the garden cafe participate the gardening, in particular, only a few men and kids participate in the gardening in the BENN plot, as shown in

680

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figure 8. In addition, the garden cafe allows the kids from different nationalities; Syrian, Kurdish and German, to play together in the garden as shown in figure 9 and figure 10.

Figure 8: few men participate in the gardening activities (source: author)

Figure 9: the children from different nationalities play together (source: author)

Figure 10: the children from different nationalities play with the dog of the German retired tenant (source: author)

On 13 June 2023, during the author's visit to the garden cafe in the community garden, a group of 8 women from the sewing course by Albatros, most of them Iranian, Afghan and Kurdish, visited the garden with their instructor Eva. Although 6 of them mentioned that this is their first time to visit the garden as they did not

know about it before, they were interested in knowing all the activities happening in the garden and how to be involved in the future and 3 of them asked about the procedures to rent a plot.

7 DISCUSSION

The previous sections detailed the social patterns and the different activities of the Beettinchen community gardens. Through this analysis, it is noticeable that the Beettinchen community garden has a lot of opportunities to contribute in the social development of Märkisches Viertel, besides challenges.

Based on the interviews, the Beettinchen community garden is opening an opportunity for the locals to socialise, build their network through the garden cafe or other activities. For example, because of the garden cafe, they have a whatsapp group, where they get to know each other and invite each other to the garden cafe and the other events. The garden could be considered as their public space where they can gather and celebrate their birthdays. Moreover, the Beettinchen community garden offers a public space for people from different age groups. By providing a small playground children can play with each other; the retired tenants come to their plots daily to water their plants and to relax; other men and women join the garden cafe to socialise; the ecological education project which rents a plot in the garden targets youth; and the wheelchair users are also engaged in a plot which provides raised beds. As Märkisches Viertel is one of the neighbourhoods in marginalized areas, assigned to the BENN programme as a neighbourhood with large refugee accommodations, the Beettinchen community garden offers a great opportunity for cultural exchange smf for the refugees and the immigrants to integrate. It gathers different nationalities among the tenants and the visitors of the garden cafe or even through the visitors from the sewing course from the Nachbarschaftsetage. Although there are many stakeholders involved in the garden, having daily on-site employees by Albatros in the garden helps to organise the garden system and encourage this network. Having one of the BENN team responsible for the garden cafe from a Syrian background could help to engage more people from different backgrounds. Another potential opportunity for encounters is the kitchen which, despite being small is a good facility with needed equipment. It can be used in different ways that enable people to cook together and create more cultural exchange through organising more events regularly.

On the other hand, there are many challenges that face this model of community garden. As Kristina Dubler, the manager of the community floor and the garden mentioned there are a lot of problems and conflicts between the tenants due to their different motives and their different cultural backgrounds. In addition, language is another barrier. As the German retired tenant woman mentioned it is difficult to deal with the garden cafe visitors as not all of them can speak good German. Finally, the garden is threatened to be relocated, as the GESOBAU rents the land to Albatros only until 2027, and after that, no one knows what GESOBAU's plans will be for the future of the land.

8 CONCLUSION

Berlin is a big city with a lot of food activities that target the alternative food systems, as ways to reduce the distance between the producers and the consumers. These activities include many examples and models of community gardens and kitchens. This paper attempts to understand how community kitchens and gardens can be integrated as a vital element of urban development of the marginalised areas in Berlin, through analysing the case study of Bettinchen community garden in Märkisches Viertel, a marginalised area in Berlin, assigned to the BENN programme, as a neighbourhood with large refugee accommodations and requiring more social work to help the integration of the immigrants and refugees. While at this point the findings of this paper remain exploratory and a comprehensive study in the author's PhD will be necessary for conclusive findings, it is still obvious that the case study of the Beettinchen community garden offers a good opportunity for the people to socialise, integrate and exchange, in addition to considering it a public space for all age groups. However, it faces many challenges such as conflicts and problems between the tenants due to their different cultural background and diverse motives. Nevertheless, this paper argues the importance of the community garden and kitchen in the social development of the marginalised areas in Berlin.

9 REFERENCES

AGUSTINA, Imas, and Ruth Beilin: 'Community Gardens: Space for Interactions and Adaptations'. Procedia - Social and
　　　　Behavioral Sciences 36: 439–48. 2012, available online at https://doi.org/10.1016/j.sbspro.2012.03.048.

ALBATROS gGmbH: 'Albatros gGmbH - District Work and Neighborhood'. Albatros Gemeinnützige Gesselschaft Für Soziale Und Gesundheitloche Dienstleistung MbH. May 2023. https://www.albatrosggmbh.de/stadtteilarbeit-und-nachbarschaft.html.

ANDREAS, Carol: 'People's Kitchens and Radical Organizing in Lima, Peru'. Monthly Review, November, 12–21. 1989, available online at https://doi.org/10.14452/MR-041-06-1989-10_2.

AWC SYLLABUS: '#1 COMMUNITY KITCHEN FOR COLLECTIVE TASTE BUDS'. Arts Of The Working Class Logo. 5 August 2021. https://artsoftheworkingclass.org/text/1-community-kitchen-for-collective-taste-buds.

BAUERNGARTEN: 'bauerngarten'. 2023. https://www.bauerngarten.net.

BECK, Lorenz.. 'Community Urban Gardens'. ArcGIS StoryMaps. 14 July 2021. 2021. Available online at https://storymaps.arcgis.com/stories/ff24e980f44c47c8a856620fab13c3e1

BENN im MV. 'Das Team von BENN Im MV'. BENN Im MV. 2023a. https://www.bennimmv.de/kontakt/team/das-sind-wir-das-team-von-benn-im-mv/.

BENN im MV 'Gartencafé Im Beettinchen'. BENN Im MV. 2023b. https://www.bennimmv.de/gartencafe-im-beettinchen-dienstags-1600-bis-1900-uhr/

.BERG, Agnes E. van den, Marijke van Winsum-Westra, Sjerp de Vries, and Sonja ME van Dillen. 'Allotment Gardening and Health: A Comparative Survey among Allotment Gardeners and Their Neighbors without an Allotment'. Environmental Health 9 (1): 74. 2010, available online at https://doi.org/10.1186/1476-069X-9-74.

BERLINER GARTENKARTE.. 'Berliner Gartenkarte'. 2023. https://gartenkarte.de/#!index.md.

BRICAS, Nicolas; CONARÉ, Damien:. 'Historical Perspectives on the Ties between Cities and Food'. Field Actions Science Reports, no. 20. , 2019, available online at https://journals.openedition.org/factsreports/5594.

BROWN, Stuart.. 'Urban Agriculture, IS THERE NOW AN OPPORTUNITY FOR A VIABLE SMALLSCALE SUSTAINABLE AGRICULTURE TO EMERGE IN BRISBANE, AUSTRALIA?' Master thesis, Charles Sturt University. 2008

CAMPBELL, Marcia: 'Building a Common Table: The Role for Planning in Community Food Systems'. Journal of Planning Education and Research - J PLAN EDUC RES 23 (June): 341–55. 2004, available online at https://doi.org/10.1177/0739456X04264916.,

CITYPLOT.. 'Cityplot Gardens'. Cityplot. 2023. https://www.cityplot.org/cityplot-gardens-berlin.CONSERVATION LAW FOUNDATION, Sara Dewey, and Brian Fink: 'Community Kitchens Legal Guide'. 2018, available online at https://www.legalfoodhub.org/resource/legal-guide-for-community-kitchens/.

DRILLING, Matthias, Renata Giedych, Lidia Poniży, Mary Benson, Maria Bihunova, Duarte Mata, Sophia Meeres, et al.. 'The Idea of Allotment Gardens and the Role of Spatial and Urban Planning'. In Urban Allotment Gardens in Europe, 35–61. 2016, available online at https://doi.org/10.4324/9781315686608-3

Dubler, Kristina, the manager of Albatros community floor and the garden, interview conducted by the author on 13 june 2023.

FIRTH, Chris, Damian Maye, and David Pearson.. 'Developing "Community" in Community Gardens'. Local Environment 16 (July): 555–68. 2011, available online at https://doi.org/10.1080/13549839.2011.586025.

FRED.. the person responsible for the ecological educational project in Beettichen garden, he is hired by Albatros and funded by BENN. Interview conducted by the author, on 1 June 2023

GARDEN CAFE | Princess Garden Collective Berlin'. 2023. Prinzessinnengarten Kollektiv Berlin. 2023. Available online at https://prinzessinnengarten-kollektiv.net/gartencafe/

GISEKE, Undine, Maria Gerster-Bentaya, F. Helten, Matthias Kraume, Dieter Scherer, Guido Spars, A. Adidi, et al.: 'E3 Urban Agricultures Contribution to the Urban Food System'. In Urban Agriculture for Growing City Regions: Connecting Urban-Rural Sphères in Casabanca, pp.396-407. Routledge, 2015.

GRACE.'Community Gardens: Their History, Structure, and Benefits'. 20 January 2022. 2022, available online at https://www.gardening4joy.com/community-gardens-their-history-structure-and-benefits/.

GRUPPE F. 'BrunnenGärten Community Gardening'. Gruppe F. 2023. https://gruppef.com/en/project/brunnengaerten-community-gardening/.

GRÜNANTEIL.. 'Project - Garden of Hope _bustan-Ul-Amal'. Grünanteil. 2017. https://gruenanteil.net/projects/de/garten-der-hoffnung-bustan-ul-amal.

HAYSOM, Gareth: 'Food and the City: Urban Scale Food System Governance'. Urban Forum 26 (3): 263–81. 2015 available online at https://doi.org/10.1007/s12132-015-9255-7

KALINA, Laura, Giudici Sheryl, and Kamloops FoodShare.. Building Food Security in Canada: A Community Guide for Action on Hunger. Kamloops Foodshare South Central Health Unit. 1993

KESHAVARZ, Nazila, and Simon Bell. 'A History of Urban Gardens in Europe'. In Urban Allotment Gardens in Europe, edited by Simon Bell, Runrid Fox-Kämper, Nazila Keshavarz, Mary Benson, Silvio Caputo, Susan Noori, and Annette Voigt, 406. London, UK: Routledge. 2016, available online at https://www.routledge.com/Urban-Allotment-Gardens-in-Europe/Bell-Fox-Kamper-Keshavarz-Benson-Caputo-Noori-Voigt/p/book/9781138588967.

KURTZ, Hilda.. 'City Bountiful: A Century of Community Gardening in America by Laura J. Lawson'. Geographical Review 97 (January): 428–30. 2007, available online at https://doi.org/10.2307/30034184.

LEBENSMITTELPUNKTE 'About Us – Nahrungsmittelpunkte-Berlin.De'. 2023a. https://lebensmittelpunkte-berlin.de/ueber-uns/.

LEBENSMITTELPUNKTE. 'Initiatives & Places – Lebensmittelpunkte-Berlin.De'. 2023b. https://lebensmittelpunkte-berlin.de/initiativen-orte/.

MCKELVEY, Bill.. 'Community Gardening Toolkit, a Resource for Planning, Enhancing and Sustaining Your Community Gardening Project'. University of Missouri Extension. 2015, available online at https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/51823/mp0906-2015.pdf?sequence=1.

MEYER-REBENTISCH, Karen.. „Das ist Urban Gardening! Munich, Germany": BLV Buchverlag GmbH & CO. KG,. 2013, available online at https://www.terrashop.de/Buch/Das-ist-Urban-Gardening-Karen-Meyer-Rebentisch-ISBN-3835410776/art/83541077M/.

MONZER, Frieder.. 'Https://Beettinchen.De/'. Beettinchen.De. 12 May 2023. https://beettinchen.de/.

MOUGEOT, Luc J. A., ed.:. "Agropolis: The Social, Political, and Environmental Dimensions of Urban Agriculture". Ottawa, Canada : London ; Sterling, VA: International Development Research Centre ; Earthscan. 2005

NUETZENADEL, Alexander; TRENTMANN Frank: "Food and Globalization: Consumption, Markets and Politics in the Modern World". Berg. 2008

OPEN KITCHEN. 'Open Kitchen'. Gsbtb. 2023. https://gsbtb.org/projects/open-kitchen/

REFUGEES' KITCHEN. 'About - Refugees' Kitchen'. Refugees' Kitchen. 2023. http://refugeeskitchen.de/about

RIPAT, Geoff.. 'Community Kitchens in Winnipeg, People Cooking Together, Building Community Together'. MASTER OF SOCIdX. WOBg, Canada: the Facuity of Graduate Studies of The University of Manitoba. 1998, available online at https://mspace.lib.umanitoba.ca/xmlui/handle/1993/1452.

SALVADOR, Mariana Sanchez.: 'Shaping the City through Food: The Historic Foodscape of Lisbon as Case Study'. URBAN DESIGN International 24 (2): 80–93, 2019, available online at https://doi.org/10.1057/s41289-019-00084-8.

SENATSVERWALTUNG FÜR STADTENTWICKLUNG, BAUEN UND WOHNEN: 'Berlin Entwickelt Neue Nachbarschaften (BENN)'. 2023. Available online at https://www.berlin.de/sen/stadtentwicklung/quartiersentwicklung/programme/berlin-entwickelt-neue-nachbarschaften-benn/.

SHARAF, Khalil.. Coordinator in BENN Markisches Viertel,. An interview conducted in person by the author, 16 May 2023

SKOWRONEK, Joana. Teamleitung Integrationslots:innen Berlin-Reinickendorf im Landesrahmenprogramm Integrationslotsinnen und Integrationslotsen, Albatros e.V./ Albatros gemeinnützige Gesellschaft für soziale und gesundheitliche Dienstleistungen mbH., Interview conducted in person by the author, 1 June 2023

SPREMBERG, Volkmar. The responsible worker in the garden from Albatros gGmbH side. An interview conducted by the author, 16 May 2023

TARASUK, Valerie, and Randi Reynolds.. 'A Qualitative Study of Community Kitchens as a Response to Income-Related Food Insecurity'. Canadian Journal of Dietetic Practice and Research: A Publication of Dietitians of Canada = Revue Canadienne De La Pratique Et De La Recherche En Dietetique: Une Publication Des Dietetistes Du Canada 60 (1): 11–16. 1999

TARASUK, V.. 'A Critical Examination of Community-Based Responses to Household Food Insecurity in Canada'. Health Education & Behavior: The Official Publication of the Society for Public Health Education 28 (4): 487–99.. 2001, available online at https://doi.org/10.1177/109019810102800408

URBAN ABROAD.. 'Top 3 Community Gardens in Berlin'. Urban Abroad. 25 September 2022. https://www.urbanabroad.com/top-3-community-gardens-in-berlin/.

VEEN, Esther J.. 'Community Gardens in Urban Areas: A Critical Reflection on the Extent to Which They Strengthen Social Cohesion and Provide Alternative Food'. PhD thesis, Wageningen, NL: Wageningen University. 2015

The Contribution of Peri-Urban Characterisation to the Development of Sense of Place Indicators

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1 ABSTRACT

Peri-urbanisation is a phenomenon taking place worldwide and affecting not only large cities but also smaller towns and settlements. The diverse set of activities, land uses and processes, which are characteristic for peri-urban landscape, are often poorly regulated and planned by the spatial planning and development policies. This may give way to interests of individual investors, which are rarely supportive of preserving green open spaces to serve the population for their leisure and recreational purposes. In this paper, we focus on the unbuilt spaces of the peri-urban landscape and their role for retaining a sense of place of local inhabitants who use this landscape for their leisure and recreational purposes. This study approaches the sense of place (SOP) as a category of the cultural ecosystem service framework. SOP has previously been highlighted as a specifically difficult category to be directly quantified and assessed with standardised procedures, and is therefore poorly integrated in landscape and management plans. Accordingly, this study is an attempt to set a basis for the SOP indicators development in the peri-urban landscape by (1) exploring and clarifying the notion and spatial characteristics of the peri-urban landscape, (2) identifying spatial planning actions and their influence on the peri-urban land use and functioning, and (3) exploring possibilities for the cartographic representation of SOP in the peri-urban landscape. We conducted a literature review, document analysis and spatial analysis in three case study cities in Slovenia: Ljubljana, Kranj and Koper. Then we developed a framework for peri-urban landscape characterisation and applied it to case studies. We compared results with the characterisation of the peri-urban landscape in formal documents and identified spatial actions and their influence on the peri-urban land use and perception. Finally, we evaluated whether the proposed framework could help in identifying areas according to their SOP potential and in developing SOP indicators for preserving peri-urban open spaces for its users. Our findings can facilitate incorporating information on SOP in a format that can be used by city authorities and spatial planners in the formulation of spatial planning measures and guidelines.

Keywords: cultural ecosystem services, sense of place, peri-urban landscape, mapping approaches, Slovenia

2 INTRODUCTION

Peri-urban landscapes, located at the city's edge, are a collection of ecosystems supporting biodiversity, wildlife habitat, flood protection, local climate regulation, oxygen production, recreation and other regulating, provisioning, supporting and cultural ecosystem services, as MEA(2005) defines benefits which are provided to humans by nature. There is evidence that people value these areas for various reasons, including the naturalness and spaciousness of peri-urban green open spaces (Neuvonen et al. , 2007), and leisure and recreation (Cadieux, 2008; Neuvonen et al. , 2007; Palang et al. , 2011; Tyrväinen et al. , 2007), which has become even more evident during the COVID-19 lockdown when people, measures allowing, fled to the semi-natural green spaces for outdoor recreation and leisure as a substitute for closed-down indoor recreation centres. In Slovenia, too, when the strictest measures limited people to movement inside the municipality of residence only, the semi-natural green spaces outside towns became popular destinations for outdoor recreation (Ugolini et al. , 2020; Žlender & Gemin, 2023). Clearly, people migrate from urban centres to urban edges to be closer to green open spaces (Piorr, Ravetz, Tosics, et al. , 2011). However, unless such actions are planned and regulated, they can lead to negative consequences such as overcrowding of green spaces for leisure use, diminishing peri-urban biodiversity and even accelerating peri-urbanisation.

This study is focused on the unbuilt spaces of the peri-urban landscape and their role in sense of place (SOP) of local inhabitants who use this landscape for their leisure and recreational purposes. It investigates SOP as a category of the cultural ecosystem service (CES) framework. SOP has previously been highlighted as a specifically difficult category to be directly quantified and assessed with standardised procedures, used for other ecosystem services (ES), and is therefore poorly integrated in landscape and management plans. To investigate the problem of poor inclusion of SOP in formal spatial plans, we set the following research question: Can characterisation of the peri-urban landscape help in recognising spatial patterns indicating valuable places for SOP as a CES category?

Accordingly, this study is an attempt to set a basis for indicating valuable places for SOP in the peri-urban landscape by (1) exploring and clarifying the notion and spatial characteristics of the peri-urban landscape, (2) identifying spatial planning actions and their influence on the peri-urban land use and functioning, and (3) exploring possibilities for the cartographic representation of SOP in the peri-urban landscape. We conducted a literature review, document analysis and spatial analysis in three case study cities in Slovenia: Ljubljana, Kranj and Koper. We then present the framework we developed for the characterisation of the peri-urban landscape and its application to the case studies, results obtained, and an evaluation of the proposed framework for developing SOP indicators of peri-urban open spaces. This paper is the first step in a project which will explore CES in the peri-urban landscape and develop a valuation framework for landscape planning and policy.

3 LITERATURE REVIEW AND RESEARCH APPROACH

3.1 Approaches to characterising peri-urban landscape

The peri-urban landscape is a complex and multifunctional system with specific features and several dimensions which should be taken into account in planning of this space (Filyushkina et al. , 2022; Gottero et al. , 2023). To achieve a clearer definition of the peri-urban landscape, scholars to date have explored issues of terminology and understanding the difference between different spatial entities (Simon et al. , 2006), the driving forces behind peri-urbanisation(Aalbers & Eckerberg, 2013; Piorr, Ravetz, & Tosics, 2011), the peri-urban issues occurring due to different stakeholders' interests, such as land ownership conflicts, land consumption, decreased biodiversity and lack of public services (Cattivelli, 2021; Dadashpoor & Ahani, 2019; Kristensen & Primdahl, 2020) and its low identity and recognisability (Qviström & Saltzman, 2008; Shoard, 2000). The latter, especially, is important for the exploration of sense of place of different stakeholders and its role in characterisation of the peri-urban landscape.

In the Slovenian context, Marušič et al. (1998) have prepared a division of the whole Slovenian territory based on landscape patterns, which reflect spatial units with relatively homogeneous landscape features. Their criteria were based on the level of nature preservation, variety of landscape features, spatial order and harmony. In their division, the peri-urban landscape is characterised as a "generic pattern, which has been altered by human interventions to the extent that it does not reflect any local specifics anymore"(Marušič et al. , 1998 p. 64). Reviewing further literature, different interpretations of the peri-urban landscape and approaches to peri-urbanisation can be found. Increasingly popular are studies which deal with defining physical boundaries. Scholars have taken different criteria to demarcate the peri-urban landscape, among the most popular being population density (Piorr, Ravetz, & Tosics, 2011), land use (Aguilera et al. , 2011), a combination of land use and population density (Gonçalves et al. , 2017; A. Wandl et al. , 2017) or an addition of several more specific criteria such as experts' opinions (Gottero et al. , 2023). It should be noted that consensus regarding such demarcation has not yet been reached and, according to Mortoja et al. (2020) is not even possible. Accordingly, we focus our efforts on characterising the peri-urban landscape in identifying patterns of peri-urbanisation rather than trying to fix its borders. Planning the peri-urban landscape greatly refers to planning its open spaces, which (will) form green infrastructures of cities and the production of goods and ES. These, together with planning of built-up tissue, require holistic policies and regulations (Gottero et al. , 2023). For these reasons, understanding, identifying and defining peri-urban spatial patterns through place-based approach is necessary to understand the complexity of peri-urban landscapes (Gottero et al. , 2023). Specifically, establishing land use rules for peri-urban areas is crucial for ES preservation. Accordingly, we developed a replicable method to identify peri-urbanisation in a spatial planning context of municipal and supra-municipal spatial planning.

3.2 Sense of place as a category of cultural ecosystem services

SOP has been suggested as a valuable approach to assess and understand the complex subjective relation between people and place (Stedman, 2016) and it has been proved useful in the exploration of peri-urban green open space users and SOP too (Žlender & Gemin, 2020). One of the most widely used definitions of SOP comes from Tuan(1977) who defined it as the meanings and attachments people attribute to place. It addresses the emotional, symbolic, and spiritual aspects of places. According to Relph (1976), SOP is about a person's understanding of a place; it involves experience and a subjective dimension. Conversely, Stedman (2003), Twigger-Ross and Uzzell (1996), and Hidalgo and Hernández (2001), among others, argued that the

construction of meaning is, beside individual, also a composition of social interaction and the physical characteristics of the environment. We propose the definition of SOP as a complex affective bond between people and a specific location. The specific location, the place, is determined by geographical location, material form and investment with meaning and value (Gieryn, 2000).

A number of factors can influence the formation of SOP and have been explored, among which the attributes of a place, such as (lack of) accessibility to a place and geomorphology (Koohsari et al. , 2023; Žlender & Gemin, 2020), arrangement of architectural elements in the streetscape(Hu & Chen, 2018) or level of shoreline development (Stedman, 2003). Other studies used different methodologies to measure people's attitudes towards planned changes in the landscape which can be negative or positive. Examples include coastal restoration(Hawthorne et al. , 2022), dam construction (Ganzevoort & van den Born, 2019), and changes in water quality (Mulvaney et al. , 2020).

The reviewed literature indicates the value of the spatial assessment of SOP for informing spatial planning of the peri-urban landscape. The integration of spatial, social and perceptual data into land use planning can enhance the understanding of reasons and impacts of change (Ryan, 2011) and improve people's pro-environmental attitude (Žlender & Gemin, 2020). Such information can thus help spatial planners to integrate social values in spatial planning, which is usually based on biophysical indicators (Gottwald et al. , 2021) and prioritises effective policy responses to ensure the sustainable future of the peri-urban landscape.

The ecosystem services framework is an attempt to introduce both biophysical and individual, subjective perceptions in landscape planning. Accordingly, some international classification systems, such as MEA (2005) or CICES (2013) include also CES which refer to the non-material benefits people obtain from ecosystems. Although the ES framework has been present in research and used in spatial planning and policy for a number of years now, the integration of CES categories in landscape planning and policy, especially categories such as sense of place, spirituality and identity, has fallen short, the main problem being the ambiguity and lack of clarity in defining these concepts (Cheng et al. , 2019; Feld et al. , 2010; Plieninger et al. , 2013). While acknowledging definitional vagueness as one reason for the neglect of some categories of CES, we suspect that the key reason is that many instances of CES cannot be directly quantified and assessed with standardised procedures and are therefore poorly integrated in landscape and management plans. The literature confirms the lack of quantifiable CES data, and that the small number of available indicators cannot be measured directly (Feld et al. , 2010; Layke et al. , 2012), with consequent difficulties for mapping.

CES has received even less attention in investigations of peri-urban issues, especially with regard to the attitudes of local users to peri-urban open spaces. The problem is compounded by the indeterminate character of the peri-urban landscape and the ensuing lack of interest in peri-urban issues. Previous research highlighted two difficulties that experts encounter in developing guidelines and policies in relation to peri-urban space(Žlender, 2021b, 2021a): the diversity of terms used to demarcate the peri-urban landscape, and the lack of knowledge of what is perceived as a transient landscape that will be developed in the future by the government, the planning profession and the general public. In combination with weak land use planning, the lack of interest in the current state of these spaces exacerbates the consequences of urban densification, as the shortage of ES in cities exerts increasing pressure on peri-urban landscapes.

In this study, we investigate SOP as a category of CES, but we do not emphasise the non-materiality, intangibility and subjectivity of CES which reflect the difficulty of incorporating CES into the ecosystem framework, where the use of quantitative methods prevails (Ryfield et al. , 2019). As emphasising this weakness may inhibit the ES framework as a decision-making tool, we focus here on finding different patterns and work towards defining a tangible and measurable component to understand the people-nature relationship(Gottwald et al. , 2021; Stedman, 2016). In developing our conceptual and methodological approach, we rely on the CES definition of Fish et al. as "a concept around which researchers and decision makers can understand ecosystems in terms of their life-enriching and life-affirming contributions to human well-being. . . encompassing a broad symbolic, experiential and virtuous realm of human interactions and understandings of the natural environment"(Fish et al. , 2016, p. 208). Accordingly, we examine SOP as a material phenomenon, which reflects the relationship between determining biophysical conditions of a particular location and social and cultural conditions of human habitation (Ryfield et al. , 2019).

Operationally, we do this by drawing upon the identification of land use characteristics, spatial patterns and planned actions in the peri-urban landscape, as described below.

3.3 Research approach

We built our methodology on three main steps. First, based on the predefined criteria, we identified patterns of peri-urbanisation in each of the case study cities and identified areas with different SOP. Secondly, we analysed the municipal spatial plans of each city to identify the peri-urban landscape and meaningful parts of the peri-urban landscape for its users and local residents. Finally, we compared the outcome and selected measures which can be useful in developing SOP indicators for each case study.

4 METHODOLOGY AND ANALYSIS

4.1 Case study cities

We selected Ljubljana, Kranj and Koper as all three cities have been previously identified as being affected by peri-urbanisation. Ljubljana is the capital and largest city of Slovenia, and a subject to peri-urbanisation due to in-migration and a consequent need for new housing, along with the expansion of economic activities and infrastructure on the city edges. The city-region is threatened by sprawled development and other negative effects of urbanisation and peri-urbanisation in the absence of comprehensive planning. Kranj and Koper represent average-sized Slovenian towns with a historical city centre and (sub)urban growth after the second world war. Both are considerably smaller than Ljubljana, but regional cores and thus important economic, cultural and social centres. Both Kranj and Koper are faced with housing and infrastructure development pressures, which mainly affect agricultural land (K. Nilsson et al. , 2013; Spyra et al. , 2021). All three cities have been also a subject to various projects investigating peri-urban issues (for details, see Piorr, Ravetz, Tosics, et al. , 2011; RENATUR: Improving Regional Policies to Better Protect Natural Heritage of Peri-Urban Open Spaces, 2023; Žlender, 2021a).

4.2 The content analysis of spatial plans

In Slovenia, the importance of recognising (C)ES in spatial planning and policy is stressed in several strategic documents on national and regional level. e. g. : Spatial Planning Strategy of Slovenia 2050; Regional Development Programme of the Ljubljana Urban Region, 2020; Spatial Planning Strategy of Slovenia, 2004, mostly in connection to green infrastructure and referring to EU Green Infrastructure Strategy (European Commission, 2013). In Slovenia, spatial planning on the local level is regulated with municipal spatial plans (OPNs). These plans should be prepared by each municipality and revised within certain time periods; however, a considerable number of municipalities is still without a valid OPN. In existing OPNs, the peri-urban landscape is rarely mentioned and (C)ES even less (Žlender, 2021a), despite above-mentioned strategic documents stressing the importance of recognising (C)ES in spatial policy. The problem often lies in lack of data and expert knowledge for envisioning long-term sustainable development. For the analytical purposes of this paper, we performed a content analysis of OPNs of all three case study cities.

4.2.1   Ljubljana

With 293,820 inhabitants (Statistični urad RS, 2023) the municipality of Ljubljana is the most populated Slovenian municipality, although geographically, most of its population is concentrated in the city of Ljubljana, while its eastern part is of rural character. The city of Ljubljana has a star-shaped morphology with development along the main roads and five green wedges in between, connecting the green hinterland to the city centre. Its structure reflects the historical development of the city, with visible traces on the urban structure and tissue of all main historic periods (MOL, 2010). Throughout the 1990s, Ljubljana has been subject to sprawled development, mainly in a form of large shopping centres, hypermarkets, outlets, leisure activities (multiplex cinemas, restaurants, specialised shops),housing and transport, due to the absence of yet to be established new spatial legislation and market-driven economy. Primarily affected were city-edge greenfield and arable land (Pichler-Milanović, 2005). The Municipal Spatial Plan (OPN)(MOL, 2010)entered into force in 2010. The OPN recognises several problems in relation to past sprawled development of Ljubljana, among which, most relevant for this study, are the loss of local and national identity of settlements due to new (sprawled) development that often ignores natural forces as well as

traditional settlement characteristics, together with privatisation of open space. The OPN specifies four peri-urban areas and their future development. First is the Sava river area, its hinterland and the Ljubljana plain, which, due to its role as a main air ventilation corridor of the city, should preserve its open space and limit the urban development. The development of recreation within the two green wedges located on this area, the preservation of the cultural landscape and the Zajčja Dobrava landscape park should be emphasised. Secondly, the use of Ljubljanskobarje (Ljubljana marsh) for (mainly extensive) agriculture should be preserved, and spatial interventions around solitary hills should be monitored since they are an important identity element of Ljubljanskobarje. Urbanisation should be limited, if not prevented. The development of the third area, Posavskohribovje, should be based on agricultural activities, alongside the development of tourism and recreation and new urban development should be limited. The emphasis on the agricultural development is foreseen also for the fourth area, the Polhograjskohribovje. It should be noted that terminologically the OPN understands the peri-urban landscape as the recreational and semi-natural hinterland of the city. Cultural landscape areas surrounding Ljubljana city, solitary hills, parks, Ljubljana circular path (PST) and water bodies are identified as elements and areas which should be preserved due to their important role for people's identity and sense of place.

4.2.2 Kranj

With its area of 151 km2 and a population of 56,780 (Statistični urad RS, 2023) the municipality of Kranj is the third largest municipality in Slovenia in terms of population. Around two thirds of its population lives in the city of Kranj. Its medieval town centre is laid out in a narrow area between the Kokra and the Sava rivers in a characteristic pyramidal shape and prominently planned height dominants. In time, the city has spread out towards the suburban settlements on the Kranjsko-Sorško polje (plain) east of Kokra towards the northeast and on the right bank of river Sava. The city is divided into several distinct areas due to the morphology of the terrain(MOK, 2014). The Municipal Spatial Plan of Kranj (MOK, 2014) understands the peri-urban landscape as a multifunctional space which accommodates both urban and rural uses. More specifically, the development of Kranjsko polje should be focused on the preservation of the cultural landscape by interlinking agricultural and forestry activities, and accommodating housing and commercial activities/The Sorško polje should preserve its peri-urban characteristics, which combine the distribution of smaller settlements with the interlinkage of arable fields and forests. Due to its vicinity to the city, the development should emphasise the recreational functions of Sorško polje. Škofjeloškohribovje should develop multifunctionally in the areas around the Sava river, while areas further from the city should preserve their rural character, alongside with the development of tourism, sports and recreation. The OPN does not mention any specific areas, elements or measures regarding the presence or importance due to sense of place or identity, but it does specify quality natural and cultural structures and elements which should be preserved. These pertain to the cultural landscapes of Sorško polje, Škofjeloškohribovje, and the northern part of Dobrave, cultural heritage of historical settlement cores, and natural preservation areas.

4.2.3 Koper

With an area of 304 km2 and a population of 53,440 (Statistični urad RS, 2023) the municipality of Koper is a coastal municipality surrounded by the Adriatic sea on its western side. The sea, the hills and the karst edge are important carriers of landscape identity and, alongside the geostrategic importance of the city of Koper, main factors to influence spatial development of the municipality (MOK, 2022; Pintar et al. , 2013). The city of Koper accommodates about half the municipal population and is characterised by a compact medieval town centre, historically dating from Venetian times, the port area and the former area of salt planes which were filled in between the wars to join the island town centre with the mainland. There has been high pressure for urban growth in the municipality due to the attractiveness of the coastal area and the presence of the port. The challenge is how to balance urban expansion and the protection of open space for agricultural and leisure purposes(Pintar et al. , 2013). Sub-urbanisation is most evident in the urban fringe and in settlements close to Koper, mainly due to lack of sufficient housing capacity, a higher living standard and a changing socio-economic situation in the urban zone. Conversely, the rural hinterland has been struggling with a shrinking population in settlements, abandonment of agricultural activities and consequent forest overgrowth (Pintar et al. , 2013). Within the PLUREL project, three main land use issues have been identified: land pressure due to housing and industrial development, pressure on agriculture from built development, and possible deterioration of high value nature areas (Pintar et al. , 2013). The recently

enforced OPN(MOK, 2022) divides the territory into three belts to direct future spatial development of the municipality. First is the urban belt, encompassing the city, its immediate vicinity and the coast. Second is the peri-urban belt, which should accommodate further development of housing, retail and industry, but also preserve agricultural activities and space for recreation. The third belt refers to settlements in the rural hinterland with lower density. The spatial and cultural identity of the municipality should be strengthened by preserving the cultural landscape, heritage and natural protected areas.

4.2.4 Summary

All three municipalities divide the space into three areas: city centre, suburban/peri-urban landscape with recreational hinterland, and countryside. In all three cases, the city centre is the most precisely defined area. Koper has the most precisely defined peri-urban landscape, but the terminology used is not consistent throughout the document and geographically some areas overlap. Both Ljubljana and Kranj define their peri-urban landscape as an area of settlements with denser development that has merged due to suburbanisation, and their recreational hinterland as an area with rural-urban functions with emphasis on the preservation of the cultural landscape. The recreational function coincides with agricultural and forest areas close to the cities, with emphasis on the importance of non-conflicting uses and ecological functions.

4.3 Spatial extent of peri-urbanisation

This study builds its methodology upon Žlender (2021b), Wandl et al. (2014) and Gottero et al. (2023), who had developed methodologies to delineate the peri-urban landscape. Their methodology is refined in this study and adjusted according to some specific spatial characteristics of Slovenia: e. g. , very high forest cover and Natura 2000 areas, high permeability (even in the cities), relatively low population density in comparison with other EU countries. Furthermore, actions of data combination were selected in line with the purpose of this study, i. e. , to identify spatial patterns with potential SOP of peri-urban landscape users.

The peri-urban landscape was spatially characterised in a multiple-step procedure. We developed it through GIS tools (QGIS Desktop version 3. 28), by overlapping, merging, weighting, and interpreting the most recent and openly accessible spatial data. In selecting data sources, we strived to use formally valid datasets, but due to lack of some information, we also used data from Open Street Map (OpenStreetMap Contributors, 2023). Before inputting data into the model, we inspected its quality and adjusted possible deficiencies such as coordinate system, spatial index, geometry. We also cleaned the data's inconsistencies and inaccuracies in data collection by excluding polygons of less than 10 m2. We processed this data using the "Query Builder" tool before starting the analysis. This tool provides an interface for defining filters to create feature subsets within a layer. The use of logical commands enables the construction of complex queries(QGIS project, 2023). Using this tool, we obtained refined data suitable for our analysis, thereby reducing the possibility of preserving methodological inconsistencies of the original data.

A pre-condition to the whole procedure was a grid creation. Based on Wandl et al. (2014), we divided the whole territory into a 500 m x 500 m grid cells. Then we applied all the data onto the grid layer. To eliminate methodological errors that occurred during the transfer of input data to the grid (the grid cut the input data, which resulted in the appearance of some very small polygons and lines), we first removed, within each cell, polygons with a size of less than 1% of the cell size and lines of less than 0,1% of cell size. We thematically generalised land cover datasets (e. g. , we combined all hydrological layers into a single "Water bodies" layer), which enabled the consolidation of data from different sources, simplifying the complexity of data sets, and facilitating spatial analysis of similar data.

We included data on population density, infrastructure network, current land cover, mix of the built and unbuilt areas, nature and culture protection regimes. In our selection of data sets, we attempted to capture the specific characteristics of the peri-urban landscape, such as the mix of urban and rural land uses, intermingling of built and unbuilt, the presence of specific land uses such as waste and sewage treatment plants, logistic centres and others. Accordingly, we grouped our data in primary and secondary conditions for peri-urbanisation. Primary conditions were: areas with population density of 150-500 persons/km2; areas with population density of less than 150persons/km2 which intersect with transport infrastructure (main roads and railway); and imperviousness density areas (European Environmental Agency, 2020) of less than 45%. As the second conditions, we added land cover classes, which we divided into two sub-groups: one encompassing land cover of predominately rural character – arable fields; meadows, pastures, and

grasslands, bare land or scarce vegetation, overgrown areas, wetlands, conservation areas, water bodies, forests; the other of predominately urban character - infrastructure nodes; mining and brownfield sites, artificial vegetation areas and paths, cultural heritage, power lines, other infrastructure, non-inhabitable buildings, but excluding multi-residential buildings (for more information, see Appendix 1).

In the first step, we selected grid cells indicating areas with population density of 150-500 persons/km2and added grid cells with imperviousness density areas of less than 45%. To this new layer we added grid cells indicating areas with population density of less than 150 persons/km2that intersect with transport infrastructure. In the second step, we calculated the sum of all grid cells indicating predominantly rural land covers and predominantly urban land covers, the condition being the presence of at least one layer with land cover for each urban and rural land cover in each cell. In the third step, we intersected primary and secondary indicators, to demonstrate main patterns of peri-urbanisation. Due to the latter action, the results were restrained to populated areas. To achieve a more continuous area, which would also include open spaces for leisure activities, accessible to people by foot from their residencies, we added a buffer to these cells indicating main patterns of peri-urbanisation. Finally, we aligned the resulting indications of the peri-urban landscape with a layer indicating peri-urban area as defined in the OPN of each case study municipality in locations where the differences were not great.

4.4 The spatial patterns of SOP

To define the spatial pattern for SOP denotation, we used the method developed by Burkhard et al. (2009), which proposes assessing the capacities of the various land cover types to provide ecosystem services. Apart from the land cover types, we included also natural and cultural regimes, which were found to be important for SOP development (Kopperoinen et al. , 2014). We scored the layers of cells with generalised land cover types and regimes from -3 to 3 according to their prerequisite of being either favourable or harmful to supply SOP for local users. The scale was developed and scores were given based on selected literature (Adem Esmail et al. , 2023; Campagne & Roche, 2018; Kopperoinen et al. , 2014; Luiza Petroni et al. , 2022; Ribeiro & Hribar, 2019; Zhang & Muñoz Ramírez, 2019) and expert assessment. The results are shown in Table 1.

Id	Generalised land cover types and regimes	Score given
1	Arable land (e. g. , fields, gardens, greenhouses, vineyards, orchards)	2
2	Permanent crops	2
3	Meadows, pastures and grasslands	1
4	Bare/sparse vegetation	-1
5	Overgrowth	-1
6	Wetlands (swamp, saltpans)	2
7	Water bodies (river, lake, sea)	3
8	Forest	2
9	Road infrastructure lines and nodes (roads, rail, airport, port)	-3
10	Energy and environmental infrastructure (areas of energy production, power lines, waste management areas, etc.)	-3
11	Non-inhabitable buildings and accompanying areas of exclusive use (industry, logistic, military, etc.)	-2
12	Non-inhabitable buildings and accompanying areas for wider use (retail, education, etc.)	0
13	Mine, degraded and brownfield sites	-3
14	Maintainedgreen areas and paths for public use (parks, leisure facilities, hiking and cycle paths, etc.)	2
15	Maintained green areas and accompanying infrastructure for sport and tourist use (sports facilities, stadiums, camp sites, hippodromes, etc.)	1
16	Predominantly residential and/or residential-agricultural compounds	0
17	Mixed use areas of housing and, services, retail, tourism, etc.	1
18	Nature conservation areas (Natura 2000, landscape parks, etc.)	3
19	Cultural landscapes (archaeological areas, cultural landscape, outstanding landscapes, monuments, etc.)	3
20	Cultural heritage settlements (historic cores of villages and towns)	3
Effect of land cover types and regimes on the prerequisites for potential SOP supply: 3 = very favourable; 2 = favourable; 1 = slightly favourable; 0 = no connection between the land cover type or regime, and the capacity to provide the SOP or no relevant capacity to provide the SOP; -1 = slightly harmful; -2 = harmful; -3 = very harmful		

Table 1: Potential SOP supply values.

5 RESULTS

5.1 The peri-urban landscape of Ljubljana, Kranj and Koper

The images 1, 2 and 3 present the final output of spatial characterisation of peri-urban landscape. The newly defined peri-urban landscape coincides with the peri-urban landscape as defined in OPNs, but not always consistently. The results for each case are discussed below.
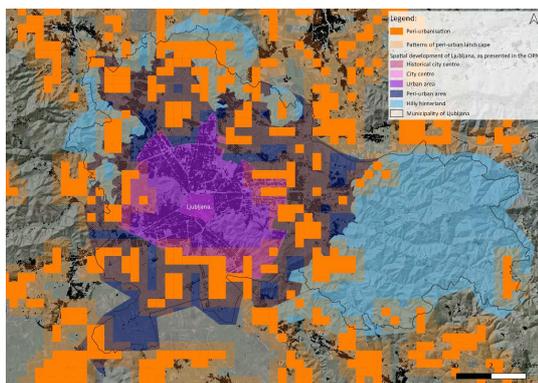
Fig. 1: The peri-urban landscape of Ljubljana. Data and background image sources: ARSO; DRSV; EEA; Geofabrik GmbH, OpenStreetMap Contributors; GURS; MK; MKGP; MNVP; MO Koper; SURS; Uradni list; ZGS

The results indicating the peri-urban landscape of Ljubljana coincide with the OPN's definition of the peri-urban landscape in the north, where the settlements of Šentvid, Polje and Črnuče are located, although our analysis indicated the extension of peri-urbanisation beyond the municipal border. The hills of Polhograjskohribovje on the west and Posavskohribovje on the east have restricted peri-urbanisation to spread to the west and to the east. Our results align with the OPN on the south, where peri-urbanisation occurs along Ižanskacesta (road), Tržaškacesta (road) and Črna vas (settlement). Barrier for peri-urbanisation on the south are hills Krimskohribovje. However, according to OPN, the peri-urban landscape covers the whole southern part of the municipality, where the Ljubljanskobarje (marsh) is located.
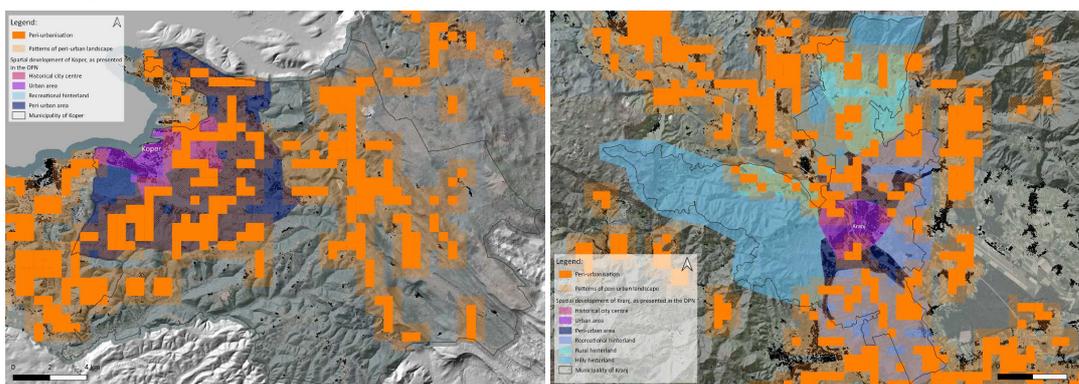

Fig. 2: The peri-urban landscape of Koper. Data and background image sources: ARSO; DRSV; EEA; Geofabrik GmbH, OpenStreetMap Contributors; GURS; MK; MKGP; MNVP; MO Koper; SURS; Uradni list; ZGS. Fig. 3: The peri-urban landscape of Kranj. Data and background image sources: ARSO; DRSV; EEA; Geofabrik GmbH, OpenStreetMap Contributors; GURS; MK; MKGP; MNVP; MO Koper; SURS; Uradni list; ZGS

Our results of the peri-urban landscape of Koper coincide with the OPN's characterisation of the peri-urban landscape in the north-eastern part which covers the settlements of Dekani, Pobegi, Sv. Anton and Škofije. The OPN indicates as peri-urban also Semedela and the Vanganel valley while our results indicate as peri-urban also the Šalara area and the coastal part towards the western side which belongs to the municipality of Izola.

In Kranj the analysis shows a tendency for peri-urbanisation developing along the main roads: to the north, in the thermal belt of Kranj below the mountains and around the highway junction, at train stops and the national airport. In the south, the whole plain (Kranjsko-Sorško polje) shows peri-urban characteristics, which is in alignment with the definition of this area in OPN as a multifunctional peri-urban area.

5.2 The spatial patterns of SOP provision potential in three case studies

In the three case studies, we identified spatial areas relative to the degree of SOP provision capacity by assigning scores of SOP provision capacity to various land cover types and protection regimes. Here it should be noted that we used the grid of cell size 100 by 100 metres because it showed better results as a grid of 500 by 500 metres cells. The images 4, 5 and 6 show results for each case study.

In the peri-urban landscape of Ljubljana, the resulting distribution of spatial patterns regarding SOP provision potential score from 'favourable' to 'slightly favourable' occurs in most of the open green land,

which aligns with green system hinterland from OPN. 'Very favourable' score was practically not present. Roads and larger settlements clusters exhibit 'no connection to provide SOP'. There are only few areas with a score of 'very harmful'. These are larger areas of built up and infrastructure use, such as the main shopping, business and leisure centre on the east (BTC City), mining areas and the city bypass.
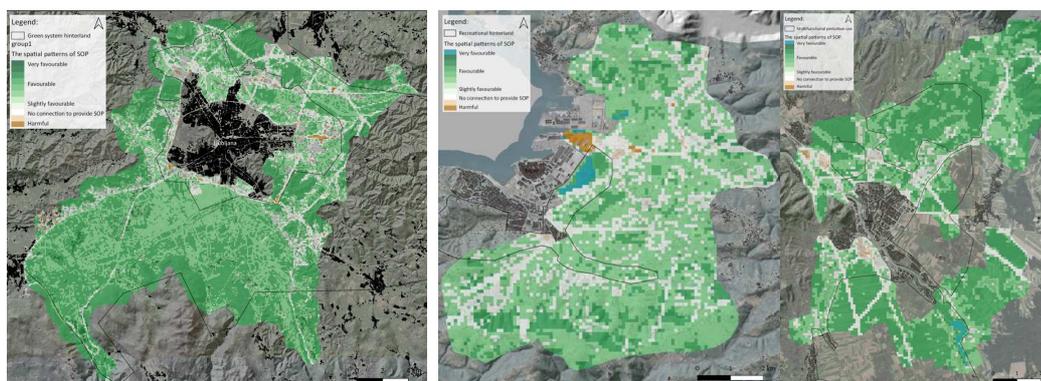

Fig. 4: The SOP provision potential map of Ljubljana. Data and background image sources: ARSO; DRSV; EEA; Geofabrik GmbH, OpenStreetMap Contributors; GURS; MK; MKGP; MNVP; MO Koper; SURS; Uradni list; ZGS. Fig. 5 and 6: The SOP provision potential map of Koper (left) and Kranj (right). Data and background image sources: ARSO; DRSV; EEA; Geofabrik GmbH, OpenStreetMap Contributors; GURS; MK; MKGP; MNVP; MO Koper; SURS; Uradni list; ZGS.

In the peri-urban landscape of Koper, the 'very favourable' spatial patterns occur in costal wetlands, especially in Škocjanski bay nature reserve. Spatial patterns of 'favourable' score are mainly exhibited along ridged hills and on the Karst edge. This is a very distinctive landscape because it is a geological and climatic border, where the Karst plateau turns into the flysch landscape of Slovenian Istria. Due to the scattered settlements, which show 'no connection to provide SOP', the border between 'very favourable' to 'no connection to provide SOP' is not clearly visible. Spatial patterns exhibiting the score of 'harmful' to 'very harmful' occur in the port of Koper and in industrial zones.

In the peri-urban landscape of Kranj, spatial patterns of 'very favourable' conditions can be observed on the lake Trboje on the south of the area. Spatial patterns of 'favourable' to 'slightly favourable' occur mostly on the open green land, indicating generally positive environmental characteristics. This evaluation aligns with green system hinterland from OPN. Railway, some small roads, transmission lines and settlements clusters show 'no connection to provide SOP'. Industrial, shopping, retail and leisure centres exhibit 'harmful' to 'very harmful' conditions.

In summary, we contend the analysis as being very illustrative of areas regarding their potential for SOP provision. We acknowledge that taking cells size of 100 by 100 metres improves the accuracy of the analysis (compared to taking cells size of 500 by 500 metres), since many land cover types are not necessarily large in size but can still have a distinctive effect on SOP. This may be especially relevant for identifying areas with 'harmful' conditions, which in none of studied cases appeared to be very extensive, when taking 500 by 500 metres cells. We also acknowledge that the use of different statistical analyses affects the results considerably. The summation method exposes water bodies, while the arithmetic mean method used exposes infrastructure and natural elements.

6 DISCUSSION AND CONCLUSION

6.1 Future actions for SOP in the peri-urban landscape

Taking the undetermined and ambiguous character of the peri-urban landscape as a challenge, our study demonstrated a scientifically guided method for indicating patterns of peri-urbanisation and assessing areas important for SOP of peri-urban landscape users.

Our results showed that the peri-urban landscape to support CES should not include only specific features such as population density or urbanisation, but also open spaces that have often multifunctional role in the peri-urban landscape. These open, unbuilt spaces therefore require unitary policies and integrated tools and regulation (Filyushkina et al. , 2022; Gottero et al. , 2023). We attempted to do this by including a variety of land cover types in the analysis and creating a buffer around the peri-urbanised areas to present peri-urban landscape more holistically.

Furthermore, our assessment of the potential of land cover types and regimes to provide SOP generated new insights into the spatial distribution of areas according to their SOP provision capacity, in three case studies. The used method allowed the presence of multiple land cover types and regimes in one cell. and the summed value indicated the interrelation of individual land cover types and regimes. We consider such an analysis more relevant in assessing SOP than the assessment of individual land uses, as suggested by Burkhardt et al. (2009)since SOP may be more likely manifested in a holistically perceived landscape(Ryfield et al. , 2019). This is especially relevant for Slovenia since finely structured land uses and covers are characteristic of the whole country's territory. Moreover, a mosaic of cultural landscapes of intermingling land covers and uses of arable fields, meadows and forest patches are recognised as valuable and a carrier of Slovenian national identity (Golobič & Lestan, 2016). This is emphasised also in the OPNs of all three case studies. Based on our results, we argue that the preservation of cultural landscape should be promoted due to its high potential for SOP capacity.

Our study provides valuable material for designing future policies with a direct impact on CES to enhance sustainable management of areas with high capacity to provide SOP. Of highest importance among them are the future regional spatial plans, as foreseen by the national Spatial Management Act (Uradni list 199/2021). The study can also be a starting point for a wider assessment of ecosystems and their services and consequent identification of land suited for future development based on its ES potential. That is to say that the peri-urban landscape is defined by high multifunctionality, thus not only conservation but also space for future urban development should be allocated there. The combination of different land cover types and regimes provides spatially explicit indication of meaningful places, which could be indicators of SOP (Knaps et al. , 2022). Spatial planners and managers can shape and foster place meanings by making these places accessible and allowing specific uses, thus encouraging the development potential of places to elevate their meaning and achieve more pro-environmental behaviour (Gottwald et al. , 2021; Žlender & Gemin, 2020). We are aware that not all land cover types or regimes within generalised land cover types and regimes support the same level of SOP. Assessing more specific land cover types and regimes, adding landscape features, points of interest and other elements may put additional values to the assessment of SOP provision. Nevertheless, we can evaluate the ecosystem service framework as having the capacity to capture evidence of SOP.

6.2 Evaluation of the methodological approach

This study was primarily scientist-driven and low stakeholder engagement is its main limitation. We are aware that the values used for the SOP supply assessment area theoretical estimation. However, we contend that the study contributes to much in demand capacity building. A natural progression of the study is the exploration of the perceptions of ES provision with the engagement of relevant stakeholders, to examine the extent to which the perceptions and opinions of different stakeholders may differ from each other, and compare those with literature-based values and those derived from modelling. Involving key stakeholders, especially the spatial planners and experts, collecting and confronting their opinions can culminate in producing more accurate assessments and new shared knowledge, which can elaborate an approach of both development and conservation plans and policies that build consensus among stakeholders, while supporting the concept of ecosystem services (Adem Esmail et al. , 2023; Filyushkina et al. , 2022).

Finally, we contend that the needs of peri-urban open space users and local residents are crucial in ecosystem management and spatial planning. In line with this, the actual supply of CES and use can be determined, rather than considering only the potential capacity. Thus, our future investigations will put efforts in engaging different stakeholders in our research of peri-urban landscape.

7 ACKNOWLEDGEMENT

8 APPENDIX

Dataset (model type)	Spatial data used	Source	Date
High Resolution Layer: Imperviousness Density (IMD) 2018 (raster, area)	Areas of imperviousness of below 45%	European Environment Agency (EEA)	August 2020
Population density 500mx500m (vector, polygon)	Population density	Statistical Office of the Republic of Slovenia (SURS)	2022
Economic public infrastructure (vector, line)	Highway and main roads, railways, sewage, oil, thermal energy, natural gas, waste, large power lines	Surveying and Mapping Authority of the Republic of Slovenia (GURS)	November 2022
Records of the actual use of agricultural and forest land (vector, polygon)	All groups except built-up and related land and water	Ministry of Agriculture, Forestry and Food (MKGP)	March 2023
Ecologically important areas (vector, polygon and point)	All ecologically important areas	Slovenian Environment Agency (ARSO)	July 2018
Protected areas (vector, point)	All protected areas	Slovenian Environment Agency (ARSO)	May 2010
Protected areas (vector, polygon)	All protected areas	Slovenian Environment Agency (ARSO)	August 2018
Register of natural features (vector, polygon)	All natural features	Slovenian Environment Agency (ARSO)	April 2015
Natura 2000 (vector, polygon)	All Natura 2000 areas	Slovenian Environment Agency (ARSO)	July 2018
Hydrography - surface waters (vector, line)	All surface water lines	Slovenian Water Agency (DRSV)	July 2021
Hydrography - objects and other (vector, line)	All hydrography objects and other lines	Slovenian Water Agency (DRSV)	July 2021
Hydrography - surface water (vector, polygon)	All surface water areas	Slovenian Water Agency (DRSV)	July 2021
Cadastre of Protective Forests (vector, polygon)	All protective forests	Slovenia Forest Service (ZGS)	December 2021
Cadastre of Forest Reserves (vector, polygon)	All forest reserves	Slovenia Forest Service (ZGS)	December 2005
Cultural Heritage Protection Regime (eVRD) (vector, polygon)	All cultural heritage protection regime areas	Ministry of Culture (MK)	December 2021
Open Street Map (vector, polygon)	college, graveyard,publicbuilding, school, kindergarten, university, bandstand, sauna, naturereserve, outdoorseating,schoolyard, campsite, picnicsite, themepark, viewpoint	Geofabrik GmbH, OpenStreetMap Contributors	2023
Building land records (vector, polygon)	All building land records areas	Ministry of Natural Resources and Spatial Planning (MNVP)	2023
Real property records (vector, polygon)	All real property records areas	Surveying and Mapping Authority of the Republic of Slovenia (GURS)	2023
Decree on the Municipal Spatial Plan of the Municipality of Ljubljana	Areas of spatial development	The Official Gazette of the Republic of Slovenia	October 2010
Decree on the strategic spatial plan of the municipality of Kranj	Areas of spatial development	The Official Gazette of the Republic of Slovenia	October 2014
Decree on the municipal spatial plan of the municipality of Koper	Areas of spatial development	Municipality of Koper (MOK)	January 2022
Base maps			
Digital orthophoto	Orthophoto	Surveying and Mapping Authority of the Republic of Slovenia (GURS)	2023
European Digital Elevation Model (EU-DEM), version 1. 1	Terrain	European Environment Agency (EEA)	April 2016
Real estate cadastre	Distribution of all built-up structures	Surveying and Mapping Authority of the Republic of Slovenia (GURS)	2023

9 REFERENCES

Aalbers, C. B. E. M., & Eckerberg, K. (2013). Governance and Sustainability of Peri-Urban Areas: A Comparative Analysis of the PLUREL Case Studies. In K. S. B. Nilsson, S. Pauleit, S. Bell, C. Aalbers, & T. A. Sick Nielsen (Eds.), Peri-urban futures: Scenarios and models for land use change in Europe. Springer Publishing Company.

Adem Esmail, B., Cortinovis, C., Wang, J., Geneletti, D., & Albert, C. (2023). Mapping and assessing ecosystem services for sustainable policy and decision-making in Eritrea. Ambio. https://doi.org/10.1007/s13280-023-01841-4

Aguilera, F., Valenzuela, L. M., & Botequilha-Leitão, A. (2011). Landscape metrics in the analysis of urban land use patterns: A case study in a Spanish metropolitan area. Landscape and Urban Planning, 99(3), 226–238. https://doi.org/10.1016/j.landurbplan.2010.10.004

Burkhard, B., Kroll, F., Müller, F., & Windhorst, W. (2009). Landscapes' capacities to provide ecosystem services—A concept for land-cover based assessments. Landscape Online, 15–15. https://doi.org/10.3097/LO.200915

Cadieux, K. V. (2008). Political ecology of exurban "lifestyle" landscapes at Christchurch's contested urban fence. Urban Forestry & Urban Greening, 7(3), Article 3.

Campagne, C. S., & Roche, P. (2018). May the matrix be with you! Guidelines for the application of expert-based matrix approach for ecosystem services assessment and mapping. One Ecosystem, 3, e24134. https://doi.org/10.3897/oneeco.3.e24134

Cattivelli, V. (2021). Planning peri-urban areas at regional level: The experience of Lombardy and Emilia-Romagna (Italy). Land Use Policy, 103, 105282.

Cheng, X., Van Damme, S., Li, L., & Uyttenhove, P. (2019). Evaluation of cultural ecosystem services: A review of methods. Ecosystem Services, 37, 100925–100925.

Dadashpoor, H., & Ahani, S. (2019). Land tenure-related conflicts in peri-urban areas: A review. Land Use Policy, 85, 218–229.

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Green Infrastructure (GI)—Enhancing Europe's Natural Capital, no. COM(2013)249 (2013). https://eur-lex.europa.eu/resource.html?uri=cellar:d41348f2-01d5-4abe-b817-4c73e6f1b2df.0014.03/DOC_1&format=PDF

European Environmental Agency. (2020). Imperviousness Density (IMD) 2018 [Data set]. https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/status-maps/imperviousness-density-2018?tab=metadata

Feld, C. K., Sousa, J. P., Da Silva, P. M., & Dawson, T. P. (2010). Indicators for biodiversity and ecosystem services: Towards an improved framework for ecosystems assessment. Biodiversity and Conservation, 19(10), Article 10.

Filyushkina, A., Komossa, F., Metzger, M. J., & Verburg, P. H. (2022). Multifunctionality of a peri-urban landscape: Exploring the diversity of residents' perceptions and preferences. Ecosystems and People, 18(1), 583–597. https://doi.org/10.1080/26395916.2022.2131911

Fish, R., Church, A., & Winter, M. (2016). Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosystem Services, 21, 208–217. https://doi.org/10.1016/j.ecoser.2016.09.002

Ganzevoort, W., & van den Born, R. J. G. (2019). Exploring place attachment and visions of nature of water-based recreationists: The case of the longitudinal dams. Landscape Research, 44(2), 149–161. https://doi.org/10.1080/01426397.2017.1415316

Gieryn, T. F. (2000). A Space for Place in Sociology. Annual Review of Sociology, 26(1), 463–496. https://doi.org/10.1146/annurev.soc.26.1.463

Golobič, M., & Lestan, K. A. (2016). Potential impacts of EU policies on cultural landscape diversity: Example of Slovenian coastal landscapes. Annales : Anali Za Istrske in Mediteranske Študije = Annali Di Studi Istriani e Mediterranei = Annals for Istrian and Mediterranean Studies. Series Historia et Sociologia, 26–2. https://doi.org/10.19233/ASHS.2016.16

Gonçalves, J., Gomes, M. C., Ezequiel, S., Moreira, F., & Loupa-Ramos, I. (2017). Differentiating peri-urban areas: A transdisciplinary approach towards a typology. Land Use Policy, 63, 331–341.

Gottero, E., Larcher, F., & Cassatella, C. (2023). Defining and Regulating Peri-Urban Areas through a Landscape Planning Approach: The Case Study of Turin Metropolitan Area (Italy). Land, 12(1), Article 1. https://doi.org/10.3390/land12010217

Gottwald, S., Brenner, J., Albert, C., & Janssen, R. (2021). Integrating sense of place into participatory landscape planning: Merging mapping surveys and geodesign workshops. Landscape Research, 46(8), 1041–1056. https://doi.org/10.1080/01426397.2021.1939288

Haines-Young, R., & Potschin, M. (2013). Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. In Contract No EEA/IEA/09/003.

Hawthorne, T. L., Toohy, K. R., Yang, B., Graham, L., Lorenzo, E. M., Torres, H., McDonald, M., Rivera, F., Bouck, K., & Walters, L. J. (2022). Mapping Emotional Attachment as a Measure of Sense of Place to Identify Coastal Restoration Priority Areas. Applied Geography, 138, 102608. https://doi.org/10.1016/j.apgeog.2021.102608

Hidalgo, M. C., & Hernández, B. (2001). Place attachment: Conceptual and empirical questions. Journal of Environmental Psychology, 21(3), Article 3. https://doi.org/10.1006/jevp.2001.0221

Hu, M., & Chen, R. (2018). A Framework for Understanding Sense of Place in an Urban Design Context. Urban Science, 2(2), Article 2. https://doi.org/10.3390/urbansci2020034

Knaps, F., Gottwald, S., Albert, C., & Herrmann, S. (2022). Using meaningful places as an indicator for sense of place in the management of social-ecological systems. Ecology and Society, 27(4). https://doi.org/10.5751/ES-13340-270409

Koohsari, M. J., Yasunaga, A., Oka, K., Nakaya, T., Nagai, Y., & McCormack, G. R. (2023). Place attachment and walking behaviour: Mediation by perceived neighbourhood walkability. Landscape and Urban Planning, 235, 104767. https://doi.org/10.1016/j.landurbplan.2023.104767

Kopperoinen, L., Itkonen, P., & Niemelä, J. (2014). Using expert knowledge in combining green infrastructure and ecosystem services in land use planning: An insight into a new place-based methodology. Landscape Ecology, 29(8), 1361–1375. https://doi.org/10.1007/s10980-014-0014-2

Kristensen, L. S., & Primdahl, J. (2020). Landscape strategy making as a pathway to policy integration and involvement of stakeholders: Examples from a Danish action research programme. Journal of Environmental Planning and Management, 63(6), 1114–1131. https://doi.org/10.1080/09640568.2019.1636531

Layke, C., Mapendembe, A., Brown, C., Walpole, M., & Winn, J. (2012). Indicators from the global and sub-global Millennium Ecosystem Assessments: An analysis and next steps. Ecological Indicators, 17, 77–87.

Luiza Petroni, M., Siqueira-Gay, J., & Lucia Casteli Figueiredo Gallardo, A. (2022). Understanding land use change impacts on ecosystem services within urban protected areas. Landscape and Urban Planning, 223, 104404. https://doi.org/10.1016/j.landurbplan.2022.104404

Marušič, J., Ogrin, D., Jančič, M., Bartol, B., Jug, M., & Maligoj, T. (1998). Metodološke osnove: [Uvodni zvezek]. In Regionalna razdelitev krajinskih tipov v Sloveniji. Ministrstvo za okolje in prostor RS, Urad RS za prostorsko planiranje.

MEA. (2005). Millenium ecosystem assessment. Ecosystems and human well-being (Vol. 5). Island press Washington, DC.

Odlok o strateškem prostorskem načrtu Mestne občine Kranj, (2014) (testimony of MOK). https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/119153

Odlok o občinskem prostorskem načrtu Mestne občine Koper, (2022) (testimony of MOK). https://www.koper.si/wp-content/uploads/2022/02/11_odlok_cistopis.pdf

Odlok o občinskem prostorskem načrtu Mestne občine Ljubljana – strateški del, 3504-4/201 (2010) (testimony of (Mestna občina Ljubljana) MOL). http://www.uradni-list.si/1/content?id=100182

Mortoja, M. G., Yigitcanlar, T., & Mayere, S. (2020). What is the most suitable methodological approach to demarcate peri-urban areas? A systematic review of the literature. Land Use Policy, 95, 104601.

Mulvaney, K. K., Merrill, N. H., Mazzotta, M. J., Mulvaney, K. K., Merrill, N. H., & Mazzotta, M. J. (2020). Sense of Place and Water Quality: Applying Sense of Place Metrics to Better Understand Community Impacts of Changes in Water Quality. In Water Quality—Science, Assessments and Policy. IntechOpen. https://doi.org/10.5772/intechopen.91480

696

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Neuvonen, M., Sievänen, T., Tönnes, S., & Koskela, T. (2007). Access to green areas and the frequency of visits—A case study in Helsinki. Urban Forestry & Urban Greening, 6(4), Article 4. https://doi.org/10.1016/j.ufug.2007.05.003

Nilsson, K., Pauleit, S., Bell, S., Aalbers, C., & Nielsen, T. S. (2013). Peri-urban futures: Scenarios and models for land use change in Europe. Springer Science & Business Media.

OpenStreetMap Contributors. (2023). Region extract retrieved from http://download.geofabrik.de/ [Data set]. https://www.openstreetmap.org

Palang, H., Spek, T., & Stenseke, M. (2011). Digging in the past: New conceptual models in landscape history and their relevance in peri-urban landscapes. Landscape and Urban Planning, 100(4), Article 4.

Pichler-Milanović, N. (2005). Urbs Pandens: Land use changes. http://www.pik-potsdam.de/urbs/projekt/lur_evidence2.pdf

Pintar, M., Perpar, A., Udovč, A., Zupan, M., Černič-Istenič, M., Miličić, V., Babič, T., Deranja, D., Bangiev, G., & Mlakar, A. (2013). Koper: Beyond the Rural and Urban Paradigm. In K. Nilsson, S. Pauleit, S. Bell, C. Aalbers, & T. A. Sick Nielsen (Eds.), Peri-urban futures: Scenarios and models for land use change in Europe (pp. 275–306). Springer. https://doi.org/10.1007/978-3-642-30529-0_11

Piorr, A., Ravetz, J., & Tosics, I. (2011). Peri-urbanisation in Europe: Towards a European Policy to sustain Urban-Rural Futures (pp. 144–144). University of Copenhagen / Academic Books Life Sciences.

Piorr, A., Ravetz, J., Tosics, I., & PLUREL. (2011). Peri-urbanisation in Europe: Towards European Policies to Sustain Urban-rural Futures : Synthesis Report. Forest & Landscape.

Plieninger, T., Dijks, S., Oteros-Rozas, E., & Bieling, C. (2013). Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Policy, 33, 118–129.

QGIS project. (2023, June 14). QGIS Documentation: 16.1.2.3. Query Builder. QGIS Project. https://docs.qgis.org/3.28/en/docs/user_manual/working_with_vector/vector_properties.html#query-builder

Qviström, M., & Saltzman, K. (2008). Ambiguous edgelands: Landscape studies beyond rural-urban divides and disciplinary trench-lines. Urban Forestry & Urban Greening, 7(3), Article 3.

Relph, E. (1976). Place and placelessness (Vol. 67). Pion London.

RENATUR: Improving regional policies to better protect natural heritage of peri-urban open spaces. (2023). https://projects2014-2020.interregeurope.eu/renatur/

Ribeiro, D., & Hribar, M. Š. (2019). Assessment of land-use changes and their impacts on ecosystem services in two Slovenian rural landscapes. Acta Geographica Slovenica, 59(2), Article 2. https://doi.org/10.3986/AGS.6636

Ryan, R. L. (2011). The social landscape of planning: Integrating social and perceptual research with spatial planning information. Landscape and Urban Planning, 100(4), 361–363. https://doi.org/10.1016/j.landurbplan.2011.01.015

Ryfield, F., Cabana, D., Brannigan, J., & Crowe, T. (2019). Conceptualizing 'sense of place' in cultural ecosystem services: A framework for interdisciplinary research. Ecosystem Services, 36, 100907. https://doi.org/10.1016/j.ecoser.2019.100907

Shoard, M. (2000). Edgelands of promise. Landscapes, 1(2), Article 2.

Simon, D., McGregor, D., & Thompson, D. (2006). Contemporary perspectives on the peri-urban zones of cities in developing areas in. In D. F. M. McGregor, D. Simon, & D. A. Thompson (Eds.), The peri-urban interface: Approaches to sustainable natural and human resource use Earthscan, London (pp. 1–17).

Zakon o urejanju prostora (ZUreP-3), (199 C.E.).

Spyra, M., Kleemann, J., Calò, N. C., Schürmann, A., & Fürst, C. (2021). Protection of peri-urban open spaces at the level of regional policy-making: Examples from six European regions. Land Use Policy, 107, 105480.

Statistični urad RS. (2023). SiStat [Data set]. https://pxweb.stat.si/SiStatData/pxweb/sl/Data/-/2640010S.px

Stedman, R. C. (2003). Is it really just a social construction?: The contribution of the physical environment to sense of place. Society & Natural Resources, 16(8), Article 8. https://doi.org/10.1080/08941920309189

Stedman, R. C. (2016). Subjectivity and social-ecological systems: A rigidity trap (and sense of place as a way out). Sustainability Science, 11(6), 891–901. https://doi.org/10.1007/s11625-016-0388-y

Tuan, Y. (1977). Space and place: The perspective of experience (pp. vi, 235 p.). Edward Arnold.

Twigger-Ross, C. L., & Uzzell, D. L. (1996). Place and identity processes. Journal of Environmental Psychology, 16(3), Article 3. https://doi.org/10.1006/jevp.1996.0017

Tyrväinen, L., Mäkinen, K., & Schipperijn, J. (2007). Tools for mapping social values of urban woodlands and other green areas. Landscape and Urban Planning, 79(1), Article 1. https://doi.org/10.1016/j.landurbplan.2006.03.003

Ugolini, F., Massetti, L., Calaza-Martínez, P., Cariñanos, P., Dobbs, C., Ostoić, S. K., Marin, A. M., Pearlmutter, D., Saaroni, H., Šaulienė, I., Simoneti, M., Verlič, A., Vuletić, D., & Sanesi, G. (2020). Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. Urban Forestry & Urban Greening, 56, 126888. https://doi.org/10.1016/j.ufug.2020.126888

Wandl, A., Rooij, R., & Rocco, R. (2017). Towards sustainable territories-in-between: A multidimensional typology of open spaces in Europe. Planning Practice & Research, 32(1), Article 1.

Wandl, D. A., Nadin, V., Zonneveld, W., & Rooij, R. (2014). Beyond urban–rural classifications: Characterising and mapping territories-in-between across Europe. Landscape and Urban Planning, 130, 50–63.

Zhang, S., & Muñoz Ramírez, F. (2019). Assessing and mapping ecosystem services to support urban green infrastructure: The case of Barcelona, Spain. Cities, 92, 59–70. https://doi.org/10.1016/j.cities.2019.03.016

Žlender, V. (2021a). Characterisation of peri-urban landscape based on the views and attitudes of different actors. Land Use Policy, 101, 105181. https://doi.org/10.1016/j.landusepol.2020.105181

Žlender, V. (2021b). Developing a spatially explicit method for delineating peri-urban landscape. Urban Challenge, 98. https://doi.org/10.5379/urbani-izziv-en-2021-32-02-03

Žlender, V., & Gemin, S. (2020). Testing urban dwellers' sense of place towards leisure and recreational peri-urban green open spaces in two European cities. Cities, 98, 102579–102579. https://doi.org/10.1016/j.cities.2019.102579

Žlender, V., & Gemin, S. (2023). Different Environments and Physical Activity before and during the COVID-19 Lockdown: Data from Slovenia. Land, 12(2), Article 2. https://doi.org/10.3390/land12020282

The Effect of Overtaking Distances on the Stress Occurrence of Cyclists in Urban Areas

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1 ABSTRACT

To further promote the share of cyclists in urban and rural areas, the focus lieson both improving objective road safety and increasing the subjective feeling of safety among cyclists. The subjective feeling of insecurity often forms a barrier to more frequent bicycle use for people who have so far cycled little or not at all, and who are therefore important for increasing the cycling share in urban and rural areas.

The focus of the research is to examine overtaking interactions involving bike and car traffic. Overtaking cars is one of the main causes of stress for cyclists. Not only does overtaking have physical suction and pressure effects on bike traffic because of air displaced by the car body, but also psychological stressors. There are proximity boundaries where people feel unsafe when someone does not maintain them, especially when imposed upon by large, fast vehicles. During overtaking interactions, there is no direct opportunity for communication due to the separation effect of the car body. The cyclist also cannot confirm that the driver is aware of their presence.

Since 2020, Germany has mandated that car drivers may only overtake cyclists on the roadway with a distance greater than 1.5 m in the inner city, and 2.0 m out of town. Other countries have similar regulations for overtaking interactions involving cyclists. France, Portugal and Spain have also adopted the 1.5 m law, in Australia, the distance is usually 1 meter on roads with speed limits less than 60 km/h and 1.5 meters on roads with higher speed limits. Distances set in the traffic regulations across different countries are primarily based on court rulings. Research is missing on which overtaking distance cyclists feel most safe and at which distance they are stressed.

This paper analyzes the effect of overtaking distances on cyclist stress. The research is based on test rides with 14 cyclists on urban streets. The bikes were equipped with sensors measuring the lateral distance between the bikes and overtaking cars. With the help of a stress-measuring method using medical fitness wristbands, stress-inducing overtaking interactions could be detected. The distance of the overtaking car and the stress events were compared by geometric and temporal coincidence. Through the Pearsons chi-squared test and the use of Cramer´s V, the results show a statically significant between closer overtaking distances and stress-triggering effects on cyclists: At distances under 1.6 meters, significantly more overtaking situations triggered stress.

The research has shown that the distance of cars overtaking cyclists has a big effect on the subjective safety of cyclists. The research also suggests that the 1.5 m approach is close to the measured "feel-safe" distance for cyclists and therefore supports regulations and enforcement around this value when planning streets to improve the safety of cyclists.

Keywords: overtaking cars, urban emotions, cycling, subjective safety , mobility planning

2 SUBJECTIVE SAFETY IN CYCLING TRAFFIC

2.1 Subjective and objective safety

The safety of cycling is composed of an objective and a subjective dimension and their interactions (Johannsen, 2013; Klebelsberg, 1982). Objective safety focuses on quantitative analysis of accidents and is usually based on an analysis of police accident statistics. Subjective safety looks at road users' emotional perception of the threat posed by a traffic situation (Fuller, 2005).

The term subjective safety describes the self-assessment of safety; i.e., how safe one feels in certain situations(Lange und Gasch 2006). From the Encyclopedia of Psychology of the scientific journal "Spektrum der Wissenschaft", subjective safety is described as a "typical experience-descriptive variable in the motivation theory-oriented research tradition on intraindividual conflicts and decisions" (Wenninger 2020). Thus, it is characterized by experiencesthat affect personal decisions (Jurczok 2019).

In road traffic, especially in cycling, the focus in recent years has been on objective safety. The goal is to use data to design the use and form of road infrastructure to prevent accidents or conflicts between road users. In recent years, however, the focus has increasingly turned to the "specific requirements and needs of local people and their perception of traffic"(Gehl 2018), hence subjective safety. The goal is now to incorporate aspects of subjective safety into the technical planning of transport infrastructure. The motivation behind the goal is to increase the acceptance of cycling in generalgeneral and thepotentialfor more frequent bicycle use. For many potential cyclists, a subjective feeling of insecurity is a barrier to more frequent use of the bicycle. In particular, for people who cycle infrequently – are also therefore highly important for increasing the cycling mode share - the subjective feeling of insecurity forms a barrier to more frequent cycling use (Aldred and Woodcock, 2015;Bill et al. 2015).

Since an objectively safer cycling infrastructure has no added value if it is not accepted by road users, cycling safety must be a combination of both subjective and objective road safety.

2.2 Factors of subjective safety in bicycle traffic

In recent years, the individual subjective feeling of safety among cyclists in Germany has grown steadily. This is shown, among other things, by data from the representative online survey "Fahrradmonitor" (Jurczok 2019), p. 48) conducted several times in Germany. A comparison of different years shows that the proportion of cyclists who feel "very/mostly safe" has increased from 53 % in 2017 to 63 % in 2021 (SINUS 2021, p. 48). This result shows that an improvement in subjective safety is achievable. In order to achieve an improvement in subjective safety, it must first be clear what stresses cyclists in traffic. In the study, dangers perceived by cyclists in the traffic flow are "too much car traffic," "no bike lanes," "inconsiderate behavior of other road users," "insufficient separation of bike lanes or bike paths from the lanes of cars" or "missing turn lanes". "Not sufficiently wide bike lanes or bike paths" tend to play a more subordinate role in the study (SINUS 2021, p. 121). Many of the stress triggers or uncertainty factors mentioned could also be related to overtaking: To much traffic means that cyclists are frequently overtaken. Reckless car drivers could be an indication of overtaking distance, and too-few separated bike lanes shows a clear general skepticism towards motor vehicle traffic.

A study by the Department of Transport (Gibbard et al. 2004) in Great Britain asked cyclists about elements that caused the most stress or feelings of vulnerability. Respondents perceive large roundabouts (36.4 %), fast traffic (11.2 %), a high proportion of heavy vehicles (17.8 %), and right turns in traffic (12.2 %) as most stressful or vulnerability-inducing. Many of the aforementioned points cover similar problems to the "Fahrradmonitor 2021" study. Due to the crossing of many conflict points when turning right - or, in countries with right-hand traffic, when turning left --it seems logical that cyclists tend to be more stressed than when riding through fewer conflict points.

In the study by Dennis Groß (2015), the stress of cyclists was made objectively measurable for the first time. By using a medical wristband, stress reactions of the human body were made visible. The evaluation of the study revealed a wide variety of stress triggers, which can be divided into three subcategories:

Horizontal effects are always related with the direction of travel of the cyclists. These include, in particular, intersections, merging into traffic, curves, road surface, obstacles, or narrow sections. Vertical effects involve the bicycle moving in a perpendicular direction. This is the case when cyclists ride over curbs, uneven pavement, or when the road has an incline or decline. Anthropogenic effects refer to all interactions triggered by other road users, such as an overtaking vehicle, oncoming traffic, pedestrians, or dooring. The various effects can also occur in combination, making it more difficult to identify the main trigger for the stressful situation. In addition, there may be other effects brought to the situation by the cyclist themselves (individual effects): Personal experiences and near-accidents at certain sections, but also the individual stress tolerance influences stress measurement (Merk 2019; Merk et al. 2021).

Another approach to measuring subjective stress is offered by the studiesof FixMyCity Team (2020)and Richter et al. (2019) about the safety and usability of cycling guidance. In both studies, cyclists were asked about their perception of safety when considering different traffic situations under variable infrastructure designs. The results of this showed that the street space design has a big impact of how safe cyclists feel on the street.

3 OVERTAKING INTERACTIONS INVOLVING BIKE AND CAR TRAFFIC

3.1 Legal Framework

Since 2020, Germany has mandated that car drivers may only overtake cyclists on the roadway with a distance greater than 1.5 m in the inner city, and 2.0 m out of town. Other countries have similar regulations for overtaking interactions involving cyclists. France, Portugal and Spain have also adopted the 1.5 m law.In Australia, the distance is usually 1 m on roads with speed limits less than 60 km/h and 1.5 m on roads with higher speed limits.

Distances set in the traffic regulations across different countries are primarily based on court rulings,such as the court decision from Hamm: "When overtaking, car drivers have to maintain a distance of at least 150 cm to the side and , when travelling above 90 km/h, they must maintain a 200 cm distance"(OLG Hamm, Az. 9 U 66/92).

However, no concrete justification forrecognizing these distances as "sufficient overtaking distances" (StVO, Germany) can be found in the technical literature.

3.2 Overtaking interactions in reality

Given that streets often have insufficient widths to allow for overtaking at a 1.5 m distance, many studies show non-compliance with prescribed minimum distances. Overtaking still takes place it is not legally permitted In the "SensorBike" project at the Karlsruhe University of Applied Sciences, only about 50% of recorded overtaking events had an overtaking distance of more than 150 cm (n=255 overtaking events). About 20% of recorded overtakes occurred at a distance of less than one meter (Röder et al. 2020). Other studies on overtaking distances also show corroborating results (Welz 2020; Baum 2019; Richter et al. 2019). Studies regarding overtaking distances under 150 cm in particular show that only about 50% of overtaking distances were greater than 150 cm in urban areas.

A closer look at the literature shows that the overtaking distances between motor vehicles and bicycles do not depend solely on the behaviour of the road users, but are influenced by the corresponding design of the road space. Although overtaking distances vary in different cities, the influencing factors are the same.

The lateral overtaking distance between motor vehicles and bicycles depends in particular on the width of the cycling infrastructure. A 100 cm wider cycling infrastructure leads to 33 cm wider overtaking distances. From a width of 1.85 m, cycling infrastructure leads to significantly larger overtaking distances than guiding cyclists in mixed traffic. Only the width of the cycling infrastructure is important, the type of cycling infrastructure is not decisive. If the width of the cycling infrastructure is smaller, the guidance in mixed traffic can lead to a smaller number of narrow overtaking distances. Thus, although overtaking does not occur at greater distances in mixed traffic, there are significantly more rejected overtaking manoeuvres than with cycling infrastructure under 1.5 m wide. In the case of cycle lanes or protective lanes less than 1.5 m wide, their benefits for the guidance of cycling traffic (e.g., recognisable guidance of cycling traffic, guidance in the field of vision of motor vehicle traffic, etc.) must be weighed against the lower overtaking distances compared to mixed traffic. It may be necessary to check whether a sequence of pictograms is suitable for the guidance of mixed traffic.

The width of the lane used by motor vehicle traffic also has an influence on the overtaking distances. Up to a lane width of 9.0 m, a widening of the lane results in an increase in overtaking distances. For every100 cm increase in lane width, the overtaking distances increase by 7 cm. Above 9.0 m, however, the lane width no longer has any influence on the overtaking distances. Overtaking by cyclists from oncoming traffic (encounter between car and bicycle) is rarely observed but is associated with narrow overtaking distances. On stretches of road with frequent overtaking manoeuvres with oncoming traffic, particular attention should be paid to ensuring sufficient overtaking distances. No influence on the overtaking distances between motor vehicles and bicycles was found for stationary traffic, the maximum permitted speed or the type of overtaking vehicle.

Objectively, motor vehicles overtaking bicycle traffic officially has only a minor negative influence on accidents. In accident statistics on cycling, overtaking rarely appears as a direct cause of accidents. According to a nationwide search engine query for online press reports of bicycle fatalities by Wordpress from early 2013 to 2018, only 6% of fatal bicycle accidents were due to ramming/striking with motor

vehicles(Wordpress 2018). The main causes of bicycle fatalities, according to this source, are solo accidents (32%) and right-of-way/crossings (28%). Other analyses of cycling accident statistics also assume a low direct involvement from overtaking motor vehicles(Peters 2010).

3.3 Potential factors influencing the occurrence of stress while overtaking interactions

Stress is generally understood as a reaction of the body to external or internal stimuli: so-called stressors. Stressors can be physical, psychological, or social. The body reacts to stressors when they disturb the balance in the body and the calmness of the person (Selye 1956). Stress can be seen as a type of adaptive response. As soon as a perceived stimulus is classified as relevant to the safety of the person, a protective mechanism takes place in the body through the release of hormones, such as adrenaline and cortisol, which puts the body on alert. A part of the autonomic nervous system, the sympathetic nervous system, is activated. The activation ensures "brain performance and behavioral responses of the body" (Zimbardo 1995). Evolutionarily, stress is a response that used to ensure human survival. The term "fight or flight," coined by the U.S. physiologist Walter Cannon (1915), plays a major role. By reacting to a stimulus with stress, the body was prepared for possible reactions necessary for survival and physical functions were ensured by hormones ("fight or flight"). Whether stimuli are perceived as threatening or irrelevant varies from person to person. The evaluation results from previous personal experiences, adoption of evaluations of others, change of knowledge and information, and personal theories (Tausch 2017). The subjective sense of safety starts here. Stress is seen as a reaction: the unsafe moments felt by each individual. In today's world, stress is mostly psychological in origin (Tausch 2017). In road traffic, however, stress can still be related to its former relevance. Thus, stress is mainly seen in pedestrian and bicycle traffic as a direct reaction to actual dangerous situations. Factors that function as stressors in everyday traffic are: Noise, proximity of stronger road users (fear of collision) or indirect factors, such as pressure or suction effects by other road users. All these stressors can be identified during (close) overtaking. For cyclists, potential stressors are triggered by their role as weaker road user on the roadway compared to motor vehicle traffic. Bicyclists, as weaker road users, are greatly outnumbered by faster motor vehicle traffic in a potential encounter and can thus feel a sense of being at their mercy. From the cyclist's point of view, this fear seems very understandable at first, but is not perceived as such by motor vehicle drivers. The car and the associated protective space act to separate from the real, threatening situation in possible collisions (Peters 2010).

A possible approach for maintaining sufficient overtaking distances can be derived from the four distance zones theory of ethnologist Edward Hall in 1982(Hall 1982). Hall assumes that every person allows certain distances to other groups of people without feeling uncomfortable. The intimate zone of a person or intimate sphere is reserved only for friends, family, or partners. It corresponds to an arm's length distance of60 cm. Strangers are perceived as threatening or intrusive in this zone their ejection of this intrusion can amass aggression ("stress"). The second zone is the personal zone, extending up to about 1.2m. Within this zone, only acquaintances or colleagues are tolerated. Sensory perception of these persons is already complete, but they are not perceived as directly unpleasant. In the social zone, people do not feel directly bothered or threatened by other people. In this zone, strangers are also tolerated; they are no longer fully perceived, sensory-wise. A direct threat or relevance for the well-being can be excluded. Overtaking can be assigned to this personal zone. Vehicles are therefore no longer completely sensory perceived from this distance and are therefore not seen as a nuisance or threat. With this approach, however, it must be considered that vehicles have a greater effect on cyclists due to their size, noise and other sensory perceptible influences and thus can still be perceived as threatening at distances beyond 1.2 meters.

So all in all overtaking by cars take a big role in the subjective safety of cyclists. There many reasons cycling people feels unsafe by big cars overtaking them real close. Also objective numbers show that there is no real reason to be really scared about. So what is the result of this inconsistency?: Is it really necessary to have rules which regulate the overtaking distances or is in the end the distance not that significant as it seems? These questions are to be investigated by the study of this work to increase the number of people cycling. In reality at least to enforce the rules you need more place for cyclists, otherwise near overtaking still will often take place on the streets. So the big question is has the overtaking distance impact on the stress occurrence of cyclists in urban areas and if so, at which distance the cyclists feel safe enough?

4 METHOD FOR DETERMINING STRESS PERCEPTION

4.1 Stress detection with the EmoCycling method

The EmoCycling methodology used in the project finds its origin in the "emotional cartography" initiated by Christian Nold in 2009. An essential component was the specially developed "Bio Mapping" device, which recorded biostatistical data in a georeferenced manner (Nold 2009). The recording of individual physiological responses is thus possible, with the individual acting as a "human sensor." Following a series of other research papers, Zeile et al. (Höffken et al. 2014) revealed the most common triggers for stress responses in cyclists using wearables, cameras, and smartphone-based applications. Specific traffic situations such as guidance patterns, high traffic volumes, dangerous overtaking, or the condition of the road surface were the most common stressors.

To measure the "stress level," the medical fitness wrist band "Empatica E4"is used(https://www.empatica.com/en-eu/research/e4/, 2020). The background use of this device is to generate real-time medical data for research purposes in order to perform analyses and visualizations. It records vitals data-- more precisely, the skin conductivity and temperature of the test persons during cycling -- and synchronizes the corresponding GNSS data to a smartphone. The basis for the recognition of moments of stress in the collected physiological data is done via a rule-based algorithm (Kyriakou et al. 2019). This assigns a stress moment when there is an increase in electrodermal activity (EDA) Activity (EDA) in conjunction with decreases in skin temperature values (ST).

When under stress, the human nervous system initially reacts with sweat production and an increased pulse. The sweat serves as a reaction to the imminent possible activation of corresponding body functions and the pulse is increased in order to supply corresponding body areas with sufficient blood. The extracted stress moments are each labelled with a timestamp and a geo-position so that they can be analyzed both spatially and temporally.

4.2 Structure and procedure of the study

When selecting the type of bicycle traffic routing, care is taken to select as balanced a proportion as possible of marked bicycle infrastructure (protective lanes/cycle lanes) and bicycle traffic routing in mixed traffic. For mixed traffic sections, both speed limits of 30 km/h and 50 km/h are included in the planning. Furthermore, when selecting the route, attention was paid to a clear course of the route, so that the route can be ridden by test persons without much prior knowledge. The test track has a length of about 7 km and leads across the inner city of Karlsruhe, Germany.

Fig. 1: Test Route in Karlsruhe, Germany

The test persons are selected according to two criteria. First, the subjects should have experience with cycling in urban traffic. Second, subjects should have a fairly homogeneous composition in terms of age and socio-cultural backgrounds. According to Geller's cyclist types, only people who can be classified as either

"Strong and the Fearless" or "Enthused and the Confident"are eligible for the survey. This grouping has already been used in several studies (Dill and McNeil, 2013, 2016; Portland State University et al. 2014) and are used as the basis for the present study.

The 14 test persons achieve good comparability within the group while controlling the study to focus only the effect of overtaking distances and the guidance of the bicycle infrastructure.

Test persons are equipped with anE4 to measure the occurrence of stress according to the EmoCycling method from Höffken et al. 2014. The bike is equipped with a OpenBikeSensor, cameras, and a GPS Tracker. OpenBikeSensor is an open-source project that has evolved over the last few years from a group of active everyday cyclists into an association. The goal of this project is mainly to provide and further develop a distance measuring sensor for the bicycle to record the lateral distance to other vehicles. It consists of ultrasonic sensors, an event trigger and GPS-recording.(OpenBikeSensor 2023)

In the present study, video recordings, distance measurements, and psychophysiological reactions of the test persons including GPS data are collected. In the analysis, the collected data is temporally connected to determine correlations between environmental parameters and overtaking distances and stress occurrences.

The processing and cleaning of the generated data sets of this research work is done by several steps:

First, the trips records from the camera are visually analysed for motor vehicle overtaking events. By overlaying the GPS points of the overtaking events and the distance data between bicycles and cars, a distance is assigned to each overtaking event. Since the GPS location of the distance data is sometimes very inaccurate, the overlay is verified using video time stamps and distance measurements. For this purpose, significant trip points such as the start and end of the test drive are overlaid with the respective time stamps.

The psychophysiological data of the fitness wristband are evaluated for stress moments by an algorithm based on the EmoCycling-method. Stress moments are identified and imported into a geographic information system using their GPS coordinates. By overlaying the stress moments with the overtaking distances, it can be determined in which overtaking events stress moments occurred. This results in a comprehensive data set with overtaking events, their lateral distance data, occurrences of stress, and other environmental parameters.

Statistical evaluation is performed using the chi-square test at the 95 % confidence level. Lower frequencies of expressions (n < 20) were not considered statistically, but only descriptively. The effect size of possible statistically significant parameters on the number of stress-inducing overtaking events is determined by the Cramer's V value. Additionally, two-step clustering is performed using the statistical software SPSS to identify possible groups of parameters "favouring" stress-inducing overtaking.
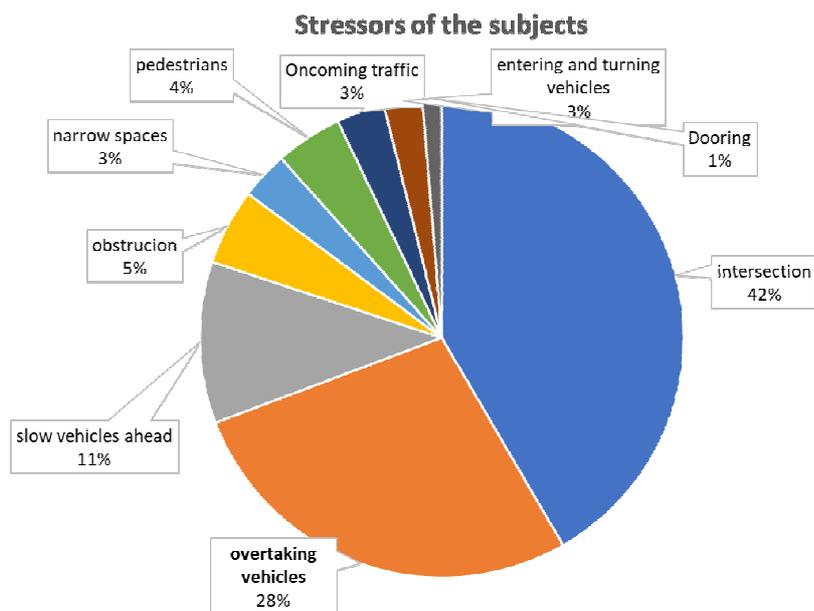

Fig. 2: Stressors of the test persons

704

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4.3 Results of the study

A total of 232 moments of stress were recorded in the study. These stress moments were first assigned to the overtaking processes and, in a further step, the remaining moments were assigned to other stressors through a second video analysis. With 42 %, the intersection aspect corresponds to the most stress occurrences. Overtaking vehicles occur as stressors in 28% of the assignable stress moments. At 11 %, slow vehicles ahead of the cyclist are a frequently occurring stressor in the study. The remaining stressors, including obstacles, bottlenecks, pedestrian traffic, oncoming traffic, and entering and turning vehicles, occur only sporadically as stressors. The classification of stressors according to Groß (2015)in the EmoCycling method, also used by previous studies, serves as an orientation. This first analysis shows that overtaking is the second largest stressor in this study.

A total of 226 overtaking events were recorded in this study. 38 (17 %) of the overtaking events can be attributed to a stress occurrence in the participants. 188 overtaking events are associated with no detected stress moments (83 %). Figure 17 shows the distances of all recorded overtaking events. The maximum overtaking distance is 230 cm and the minimum 70 cm. The 25 % quantile limit is at 130 cm and the 75 % quantile limit is 170 cm. Thus, the median 50 % of the values are between 130 and 170 cm. The median of all passing distances is 150 cm and the average of all passing distances is 152 cm. 50 % of the measured overtaking distances are above the often-used 150 cm and 50 % are below.
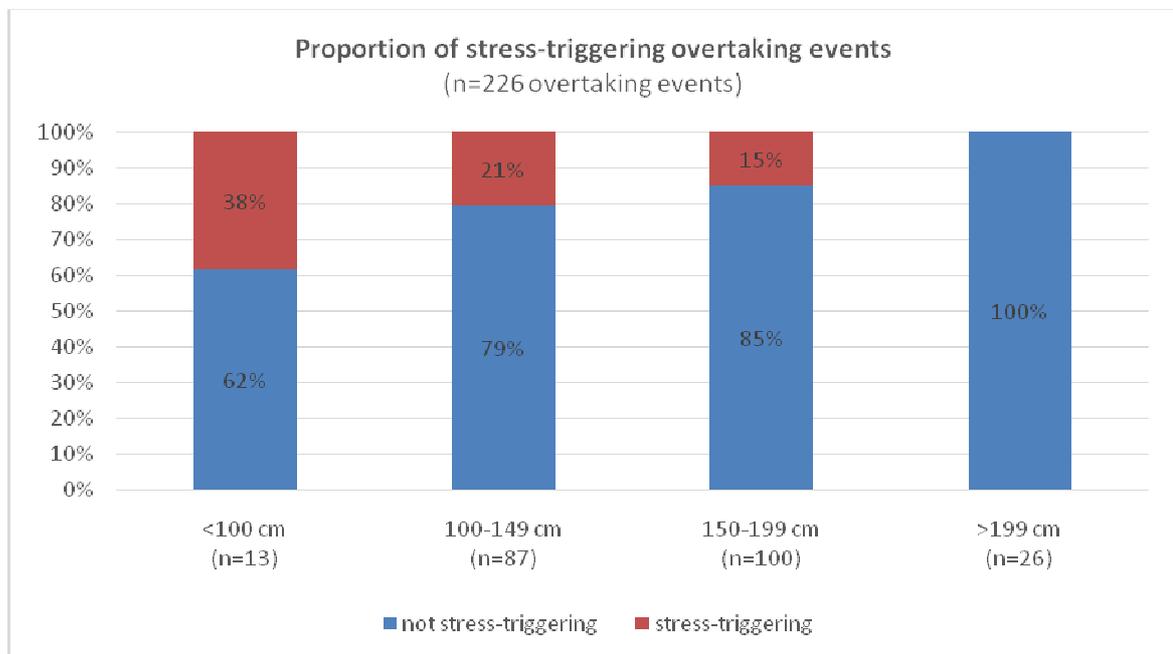

Fig. 3: Proportion of stress-triggering overtaking events

Using the Pearson's Chi-square test, the results show a statically significant between smaller overtaking distances and stress-inducing effects on cyclists:

For overtaking widths below 100 cm, the proportion of stress-triggering overtaking events was 38 %, for widths between 100-149 cm, it was 21 %, and for overtaking widths between 150-199 cm it was 15 %. At distances below 160 cm, significantly more overtaking manoeuvres triggered stress than at smaller overtaking-distances.

No stress-triggering overtaking events were recorded for overtaking events at distances above200 cm. However, the overtaking distances of the stress-triggering overtaking events above150 cm reveal that 13 overtaking events with a distance of 160 cm, 170 cm, and 180 cm were stress-triggering in certain cases (proportionately 15 %, 16 %, and 21 % of the overtaking events at these distances, respectively). These values indicate that, in these instances, the distance of 150 cm is insufficient or that perhaps other environmental parameters are responsible for the stress. 7 % of the overtaking events were thus still assessed as causing stress at overtaking distances greater than 160 cm.

Overtaking distances have a very large influence on the occurrence of stress among cyclists when overtaking by motor vehicle traffic. A statistically significant relationship between overtaking distance and the

frequency of stress-inducing overtaking was found for all distances below 160 cm. This relationship is most pronounced for overtaking distances less than 130 cm. However, overtaking events that did not have a stress-triggering effect also occurred below 130 cm and, at the same time, stress-triggering overtaking events occurred for overtaking events at a distance of more than 160 cm. These peculiarities are to be regarded as statistical outliers.
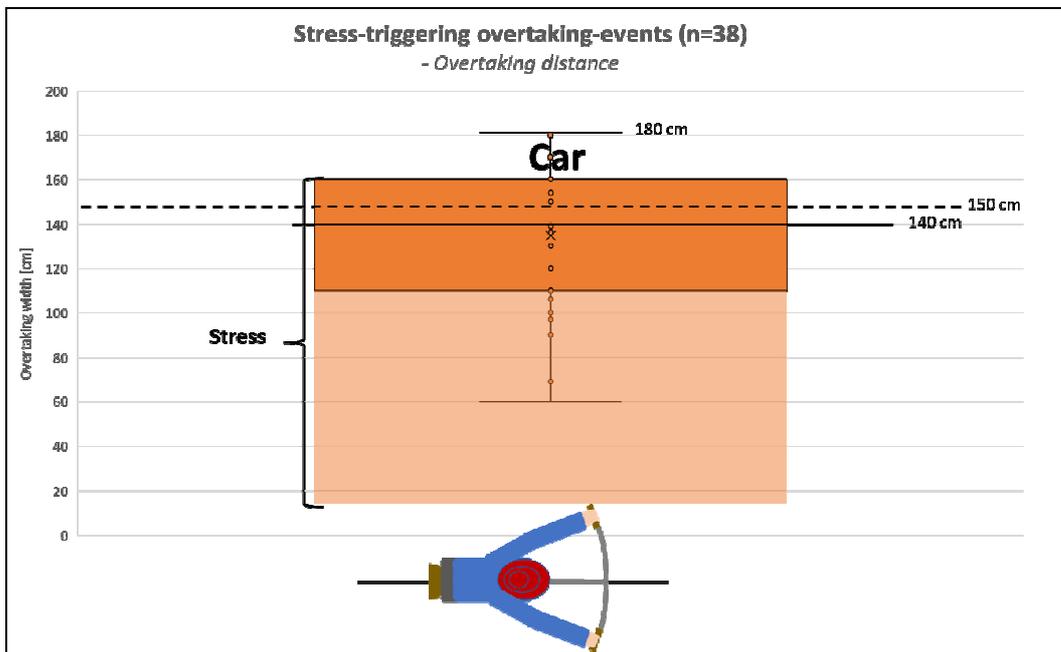

Fig. 4: stress-triggering overtaking-events depending on distance

Other environmental parameters did not provide any detectable influences on stress in the study: the influence of extra bicycle traffic guidance on the road such as protective lanes and bicycle lanes had no influence on stress occurrence. Also the difference between motor vehicle speeds of 50 or 30 km/h showed no influence in this study. However, these findings should not be considered definitive due to the small sample size.

5 DISCUSSION OF LOW-STRESS OVERTAKING INTERACTIONS INVOLVING BIKE AND CAR TRAFFIC

The present study shows that overtaking by motor vehicle traffic of cyclists has a measurable effect on objectively measurable subjective safety cyclists. Stressors such as crossing at 42% and overtaking vehicles at 28% occurred most frequently in the study. Stressors were measured in 17% of detected overtaking events. Thus, according to this study, motor vehicle overtaking events have a high influence on the occurrence of stress among bicyclists within urban areas.

The results show that the overtaking distance plays a decisive role: The larger the distance, the less stress was measured in motor vehicle overtaking events. Up to a value of 160 cm, a statistically relevant positive correlation was found between the small overtaking distances and the number of stress moments that occurred. For overtaking distances of less than 100 cm, the proportion of overtaking events causing stress was 38%, for distances between 100 and 149 cm it was 21%, and for overtaking distances between 150 and 199 cm it was only 15%.

In summary, the overtaking distances in overtaking events by motor vehicle traffic are most related to stress occurrences for cyclists. The overtaking distance of 150 cm regulated by, for example, the German Road Traffic Regulations (StVO) can therefore be seen as a sensible starting point for providing cyclists with sufficient subjective safety space. No negative or positive effect on the occurrence of stress among cyclists could be attributed to the environmental parameters of route type, bicycle traffic guidance type, maximum permitted speed for motor vehicle traffic, constricting elements in the right lane edge, and heavy traffic.

Measures should be taken to increase overtaking distances. Cyclists should be proclaimed to be respected on urban roads. The appropriate behavior of motor vehicle drivers should be encouraged through campaigns and notices. Some cities and states already launched campaigns to address the failure of motor vehicle traffic to

706

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

maintain the minimum overtaking distances with cyclists. In countries such as Switzerland, campaigns actively attempt to attract more attention to the issue of cyclist overtaking (Brenn 2021). The aim of these campaigns is to raise awareness of the current rules on minimum overtaking distance and to increase considerate behavior between motor vehicle traffic and bicycles. The long-term effects of these campaigns on overtaking are not yet foreseeable.

Another thing that derives from the study is that bicycle infrastructure must be built that promotes sufficient overtaking distances. In particular, sufficiently-large, on-roadbicycle facility widths of at least 1.85 m are important. If there is insufficient space for wide bike infrastructure, it should be checked whether mixed traffic on the roadway at low speed, possibly supported by pictogram sequences, present possible solutions. In some cases, a solution may be to prohibit overtaking of single-lane vehicles.

It is recommended to conduct further studies of this kind on a larger scale to make even more quantifiable statements. Additional factors, such as the influence of heavy traffic or the guidance of bicycle traffic on protected lanes on cyclist stress during motor vehicle overtaking events could be made. In addition, a further study should be conducted on the stress perception of cyclists when motor vehicles are following behind in order to be able to exclude potential stress occurrences for cyclists.

This research makes an important contribution towards determining the subjective feeling of safety of cyclists through an objectively-measurable method and therefore better understand the subjective safety of cycling. The statistical relevance of the overtaking distances with cycling traffic contributes to the so-far only partial implementation of minimum overtaking distance regulations and ultimately increases the subjective safety of cycling and promotes cycling in general.

6 REFERENCES

Baum, Andreas (2019): Radfahrer werden meist zu eng überholt. Studie bestätigt Tagesspiegel-Radmesser. Hg. v. Tagesspiegel. Berlin. Online verfügbar unter https://www.tagesspiegel.de/berlin/studie-bestaetigt-tagesspiegel-radmesser-radfahrer-werden-meist-zu-eng-ueberholt/24232800.html, zuletzt aktualisiert am 04.03.2022, zuletzt geprüft am 04.03.2022.

Bill, Emma; Rowe, David; Ferguson, Neil (2015): Does experience affect perceived risk of cycling hazards? STAR 2015.

Dennis Groß (2015): EmoCyclingConcept - Potentiale der emotionalen Stadtkartierung für Radverkehrskonzepte am Usecase Worms.

FixMyCity Team (2020): Studie zur subjektiven Sicherheit im Radverkehr - Ergebnisse und Datensatz einer Umfrage mit über 21.000 Teilnehmenden. Online verfügbar unter https://fixmyberlin.de/research/subjektive-sicherheit#statistische-auswertung, zuletzt aktualisiert am 20.04.2021, zuletzt geprüft am 20.04.2021.

Gehl, Jan (2018): Städte für Menschen. 4. Auflage. Berlin: Jovis.

Gibbard, A.; Reid, S.; Mitchell, J.; Lawton B.; Brown, E.; Harper, H. (2004): The effect of road narrowings on cyclists. Hg. v. Charging and local transport division, departement for Transport. Online verfügbar unter https://trimis.ec.europa.eu/sites/default/files/project/documents/20060728_163846_65628_UG171_Final_Report.pdf, zuletzt geprüft am 28.05.2023.

Hall, Edward Twitchell (1982): The hidden dimension. New York: Doubleday.

Höffken, Stefan.; Wilhelm, Johann; Groß, Dennis, Bergner, Benjamin; Zeile, Peter (2014): EmoCyclingConcept - Analysen von Radwegen mittels Humansensorik und Wearable Com-puting. proceedings. Plan it smart clever solutions for smart cities.

Jurczok, Franziska (2019): Fahrrad-Monitor Deutschland 2019. Hg. v. Sinus Markt- und Sozialforschung GmbH. Online verfügbar unter https://www.bmvi.de/SharedDocs/DE/Anlage/K/fahrradmonitor-2019-ergebnisse.pdf?__blob=publicationFile, zuletzt geprüft am 18.06.2021.

Kyriakou, Kalliopi; Resch, Bernd; Sagl, Günther; Petutschnig, Andreas; Werner, Christian; Niederseer, David et al. (2019): Detecting Moments of Stress from Measurements of Wearable Physiological Sensors. In: Sensors (Basel, Switzerland) 19 (17). DOI: 10.3390/s19173805.

Lange, Hans-Jürgen; Gasch, Matthias (Hg.) (2006): Wörterbuch zur Inneren Sicherheit. 1. Aufl. Wiesbaden: VS Verl. für Sozialwiss.

Merk, Jule (2019): Vergleich der objektiven Verkehrssicherheit und des subjektiven Verkehrsstresses bei Schutzstreifen und Radfahrstreifen im Vergleich zu eigenständigen Radwegen. Hochschule Karlsruhe.

Merk, Jule; Eckart, Jochen; Zeile, Peter (Hg.) (2021): Subjektiven Verkehrsstress objektiv messen – ein EmoCycling-Mixed-Methods-Ansatz. Unter Mitarbeit von REAL CORP 2021: CITIES 20.50. Vienna: CORP - Competence Center of Urban and Regional Planning. Online verfügbar unter https://corp.at/archive/CORP2021_72.pdf, zuletzt geprüft am 07.02.2022.

Nold, Christian (2009): Emotional Cartography: Technologies of the Self. Space Studios.

OpenBikeSensor (2023): OpenBikeSensor. Online verfügbar unter https://www.openbikesensor.org/, zuletzt aktualisiert am 28.04.2023, zuletzt geprüft am 07.06.2023.

Peters, Ervin (2010): Seitliche Sicherheitsabstände. Hg. v. Fachausschuss Radverkehr von ADFC und SRL. ADFC. Bremen (Fachwissen für den Fahrradalltag).

Richter, Thomas; Beyer, Oliver; Ortlepp, Jörg; Schreiber, Marcel (Hg.) (2019): Sicherheit und Nutzbarkeit markierter Radverkehrsführungen. Berlin: Gesamtverband der Deutschen Versicherungswirtschaft e.V., Unfallforschung der Versicherer (Forschungsbericht / Gesamtverband der Deutschen Versicherungswirtschaft e.V, Nr. 59).

Röder, Annika; Fassbinder, Julia; Hauenstein, Jan; Rabes, Max; Welz, Christoph; Weingärtner, Jan; Eckart, Jochen (2020): Projektbericht: Fahrradlabor. Erhebung von Überholabstände in Karlsruhe und Pforzheim. Hochschule Karlsruhe.

Selye, Hans (1956): The Stress of life. New York: McGraw-Hill.

Tausch, Reinhard (2017): Hilfen bei Stress und Belastung. [1. Auflage]. Reinbek bei Hamburg: Rowohlt Repertoire.

Welz, Christoph (2020): Erhebung und Analyse des Überholabstands vom motorisierten Individualverkehr zum Radverkehr auf Stadtstraßen. Am Beispiel der Stadt Karlsruhe. Hochschule Karlsruhe. Karlsruhe.

Wenninger, Gerd (2020): Lexikon der Psychologie. In: Spektrum der Wissenschaft. Online verfügbar unter https://www.spektrum.de/lexikon/psychologie/subjektive-sicherheit/15030, zuletzt geprüft am 13.05.2021.

Wordpress (2018): Radfahren - Das überschätzte Risiko von hinten. Online verfügbar unter https://radunfaelle.wordpress.com/details/, zuletzt aktualisiert am 15.11.2021, zuletzt geprüft am 18.02.2022.

Zimbardo, Philip G. (1995): Psychologie. 6., neu bearb. und erw. Aufl. Berlin, Heidelberg: Springer (Springer-Lehrbuch).

708

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

The Impact of Free Municipal Wi-Fi on the Citizens' Right to the City, Good Governance, and Service Delivery in an African Context: the Perspectives of the Residents of Pretoria Central Business District (CBD) in the City of Tshwane, South Africa

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1 ABSTRACT

Just after the year 2010, big cities in South Africa started to introduce programmes to provide free data, especially to their disadvantaged communities. This came in the context of a broader appreciation that access to data is no more a luxury, but rather a basic necessity for daily livelihood in the context of the fourth industrial revolution. The increasing explosion of the fourth industrial revolution is been driven partly by the pervasive digitization of things, which results in big volumes and a variety of data flowing from heterogeneous sources at increasing velocity. In this regard, all eight (8) metropolitan municipalities in South Africa (Buffalo City, Tshwane, Johannesburg, eThekwini, Ekurhuleni, Mangaung, Nelson Mandela Bay, and Cape Town) are currently implementing free Wi-Fi programmes to improve access to data. Some of the secondary cities in South Africa have also followed suit. Non-governmental role players have also started to provide free wireless internet sites as well. These efforts are most commendable in an African context, noting that the average internet penetration level in Africa is approximately 43.1%, compared to the global average of 66.2%. Significantly, these interventions are also commendable because they are in sync with the Sustainable Development Goal (SDG) 11, that of building sustainable cities and communities. However, from an empirical research perspective, the impact of such incredible initiatives on imperatives such as improving the citizen's right to the city, good governance, and enhanced service delivery in an African context is yet to be fully understood. So, the question is: to what extent can free municipal Wi-Fi to assist citizens to realize these three development imperatives, viz: realize their right to the city, good governance, and enhanced service delivery? To this end, this study empirically investigated the perspectives of the residents in the Pretoria Central Business District (CBD) in the City of Tshwane, South Africa. The City of Tshwane is the Capital City of South Africa. This study utilized a case study design and is qualitative in nature. Both primary and secondary sources were used. Fifty (50) residents in the Pretoria CBD responded to a randomly administered online survey. The results were analyzed by categorical aggregation and content analysis. The findings reveal that the Pretoria CBD residents feel that the Tshwane free Wi-Fi is making more impact in enabling the citizens to enjoy the informational right to the city and good governance, and lesser compared to improving service delivery. In conclusion, the researchers recommend an expansion of more free Wi-Fi sites in the Pretoria CBD to accommodate an increasing student population in the area, to make the Pretoria CBD more liveable, and sustainable, and to entrench social justice. However, the City of Tshwane would need to find an innovative funding model because the free Wi-Fi programmes are not cheap.

Keywords: Sustainable Development, Sustainability, Smart city, Free Wi-Fi. Tshwane

2 INTRODUCTION

In the past two decades, there have been different academic contributions on the role of smart technologies in cities and urban sustainability. One contribution is that smart city implementation reproduces the inequalities of marginalized people in the city (Willis, 2019). Another contribution is that smart cities do produce inequality (Caragliu and Del Bo, 2022). Yet another contribution is that the deployment of smart technologies makes cities/communities more sustainable (Hamza, 2021), thus bringing positive impacts on communities (Alavi, et al 2018). Yet, another contribution is critical to this notion (Hamza, 2021). So, despite all these diverse contributions, there are still some knowledge gaps. One of the gaps is that the majority of the studies are not based on empirical data. Another gap is that the majority of these studies are done in developed economies, and very few in the African context.

3 CONCEPTUAL FRAMEWORK

3.1 Framing the study conceptually

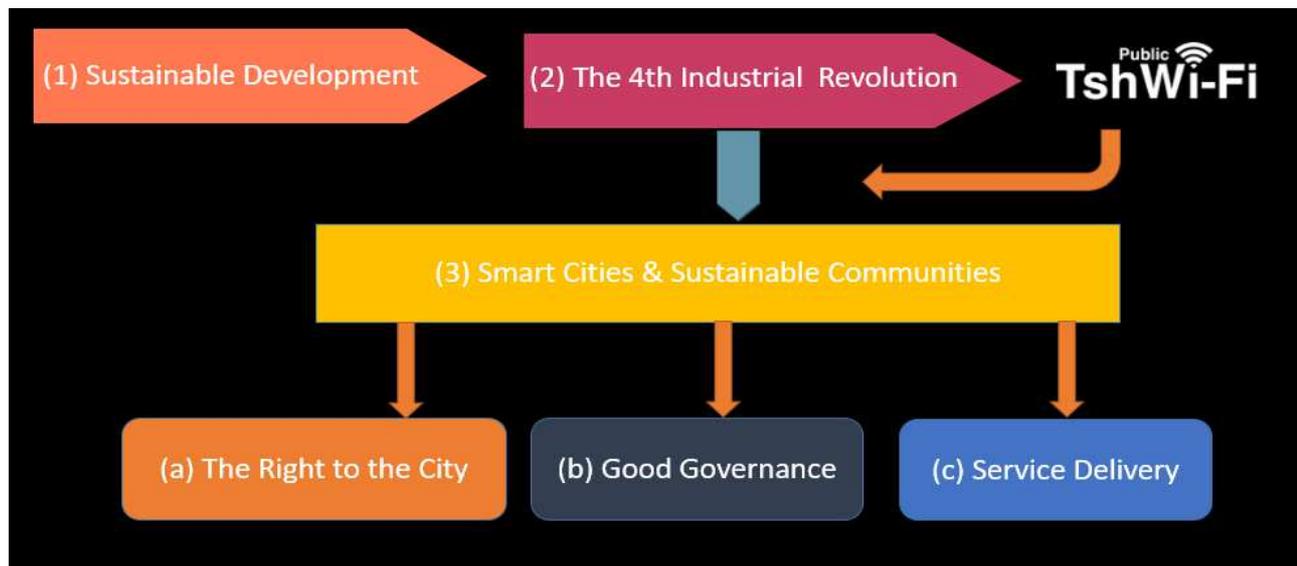There are several conceptual constructs that the study engaged with. They are discussed below:

Figure 1: Conceptual Framework of the study: Source, Author (2023)

3.2 Sustainable development

The concept of sustainable development encapsulates the pillars of the economy, society, environment, and governance (Cecchin, et al. 2021). However, in the context of the fast-changing digital world and rapid urbanization, some scholars, e.g. Mondini (2019), posit that the technological pillar is very relevant. It is believed, at least by scholars such as Kopnina (2020), and Schopp, et al. (2020) that sustainable development is about raising the living standards of the next generations. Many other scholars agree that smart digital technologies tend to address urban management challenges in the 21st Century (Onyango, et al 2021). However, the empirical efforts to assess the efficacy of smart city interventions in Africa remain limited. In the context of the fast-changing digital world, the technological pillar is also relevant to the discourse of sustainable development (Mondini, 2019).

3.3 The Fourth Industrial Revolution

The Fourth Industrial Revolution (4IR) is challenging all fields of life all over the world (Korczak and Kijewska, 2019). It has made access to data and the internet lifestyle more popular. In countries such as China, digital technologies and the internet are vital for public involvement in planning and governance processes. This is positively associated with economic and social transformation. However, it is still acknowledged that the huge digital divide in communities creates unequal power relations (Zhao, et al., 2018). The 4IR (Industry 4.0) is about connections (Onik, et al. 2019). These connections affect how people live their lives (Xu, et al., 2018). The 4IR also incorporates things such as Artificial Intelligence (AI), advanced robotics, data analytics nanotechnology, 3D printing, the Internet of Things (IoT), blockchain neurotech, cloud technology, and biotechnology. These bring some sophistication in terms of how things are being done now (Korczak and Kijewska, 2019).

3.4 Smart and sustainable cities and communities

The creation of sustainable cities is one of the most pressing central challenges of this age (Yang and Taufen, 2022), especially due to increasing technological advances (Steputat, et al., 2020). There is a need for sustainable cities and sustainable communities, as espoused by Sustainable Development Goal 11 (Mondini, 2019). The notion of smart cities and their linkages to sustainable communities is prominent today in policy discourses internationally. Zielinska-Dabkowska and Bobkowska (2022) underscore the need to build sustainable cities and communities. Similarly, Yang and Taufen (2022) emphasize this in the context of the COVID-19 disruptions that have challenged the resilience systems of cities. So, the implementation of

modern digital technologies by municipalities must make cities and communities more sustainable (Hamza, 2021) because, today, like never before, cities face the challenges of being sustainable (Fell and Mattsson, 2021). The high rate of urbanization is adding to the sustainability challenges (Vaidya and Chatterji, 2020). There is also a broader realization and appreciation that what is needed is not just smart cities, but sustainable smart cities (Yigitcanlar, et al., 2019). Sustainable smart cities deploy digital technologies to improve the quality of life for residents (Zvolska, et al., 2019).

3.5 The right to the city

The concept of the right to the city is a sustainability question. This concept was inspired by Henri Lefebvre's work The Right to the City (1968). Influenced by the thoughts of Henri Lefebvre's work The Right to the City, Willis (2019) asks a question: "Whose Right to the Smart City?" Ben-Lulu (2021) asks an important question: who has the right to the city? Urban policies should promote the notion of citizenship for all (Borja, 2019). The right to the city is seen as an agenda for social change (Vergara-Perucich, and Arias-Loyola, 2019), especially in the context of smart cities (Van der Graaf, 2020). Smart cities are not just about data; but they are about citizens (Breuer, and Pierson, 2021). So, citizen participation is an essential element of the right to the city (Anastasiu, 2019). The citizens must be able to inhabit the city freely (Aquino, et al., 2020). In the context of smart cities, pertinent questions are asked about the right of citizens to apply their rights (De Frantz, 2021). The right to the city is about citizen-centric digital cities (Breuer, and Pierson, 2021), as it is also about citizens claiming their rights within a city (De Frantz, 2021). When the playground is unequal, the attainment of the right to the city becomes a difficult feat (Diaz-Parra, and Jover, 2021). Progressive social movements have placed inclusion (Hintjens, and Kurian, 2019) and social justice agenda at the center of the right to the city (Yang, et al., 2019). The right to the city is also about the informational right to the city. In South Africa, the Promotion of Access to Information Act (PAIA) is important in this regard. It reinforces the constitutional right of access to information.

3.6 Service delivery and good governance

Smart cities are perceived to solve a range of complex urban management challenges (Allen, et al. 2020) to offer value to residents (Timeus, et al. 2020). One of the value offerings is efficiency in the delivery of public services because smart cities must be citizen-centered (Yang, et al. 2019). Allen, et al. (2020) found that most citizens use e-government platforms for complex issues than for basic service delivery routine services. Whereas Gil, et al. (2019) found that digital platforms do benefit citizens, other scholars argue that it benefits most technology-savvy citizens compared to the poorest of the poor. Aurigi and Odendaal (2022) posit that the use of smart digital technologies should be context and place-based so that they enhance social sustainability. It has been found that e-platforms encourage more citizen participation, and also improve service delivery (Gil, et al. 2019). Smart city technologies can also save traveling costs and time (Jaiswal, et al. 2020). In addition, smart digital tools and platforms can be used by cities to strengthen governance systems (Rodríguez Bolívar, 2019). Information Communication Technologies (ICTs) can introduce some governance reforms to enhance accountability (Basu, 2019). Smart city technologies allow citizens to be engaged, and participate in public consultations (Gade, 2019). However, different planning cultures in cities do affect governance aspects (Lim, et al. 2022). It is also noted that the use of modern technologies tends to attract younger people more than older people (Kopackova and Komarkova, 2020).

4 METHODOLOGY

This research investigated the views of the residents in the Pretoria CBD and surrounding suburbs in the City of Tshwane, South Africa, as far as the impact of the Tshwane free Wi-Fi on the citizen's right to the city, good governance, and service delivery. The study used an online survey tool, which was administered to fifty (50) residents in the Pretoria CBD. A majority were from Hatfield (48%), Sunnyside (24%), and CBD (12%). The profile of respondents is quite mixed and dynamic. In terms of occupation, 53% of the respondents were students; and 30% were employed. In addition, 10% were unemployed graduates, and 6% were self-employed residents. As far as the age is concerned 90% are youth between the ages of 18 and 34, followed by 10% above the age of 45. The education level of respondents is also mixed: 42% with a 3-year post-matric qualification, 44% with an honors degree and above, and 14% with just matric. The voices of these residents were captured, synthesized, and analyzed. Surveys are popular for qualitative data (Mellinger

and Hanson, 2020). In addition, secondary sources (reports, academic journals, books, etc) were used. So, the research is qualitative in nature and was guided by the qualitative approach.

5 FINDINGS

5.1 Findings regarding access to free data in Africa

5.1.1 The politicization of data in Africa

The internet penetration level in Africa is 43.1%, compared to the global average of 66.2% (Internet World Stats, 2022). Some of the underlying causes of the slow digital uptake of ICTs in African countries are related to political interference and the sheer lack of political vision. The use of digital technologies to fight political battles is also a major factor of concern. For instance, in the Democratic Republic of Congo, reports of the government quelling civil unrest by suspending internet services - referred to as "blackouts" are common (Braun, and Buse, 2020). In Ethiopia, Tanzania, and Uganda the central governments tend to implement 'Internet Shutdowns' and "social media shutdowns". In Angola, authoritarian politicians use internet control to disadvantage political opponents (Garbe, 2021). Cameroon is also known for muzzling the digital rights of the residents due to the autocratic government's tight grip on the media (Murrey, 2022).

5.1.2 Best-case African models in terms of access to data

There are approximately five (5) African countries whose share of internet users exceeds the 50% population threshold. These are Morocco (84%), Seychelles (79%), Egypt (71%), South Africa (68%), and Tunisia 66% (Statista, 2022). An interesting observation is that although free Wi-Fi initiatives provide approximately 40% of data in the African continent (Danquah, Marful, and Duah, 2019), in these African countries, it is not easy to establish if the provision of free Wi-Fi is the key/main driver of higher levels of access to the internet. This is an area worth researching because academic and empirical research on the provision of free Wi-Fi initiatives is generally scanty in the African continent.

5.1.3 Worst-case African models in terms of access to data

There are African countries that need to, as a matter of urgency, do more in terms of reducing the digital divide through free Wi-Fi programmes. These include Sudan (only 10% of the population have access to the internet); the Democratic Republic of Congo (only 17% have access); Tanzania (25% have access); and Ethiopia (25%). The case of Ethiopia requires urgent attention because of Internet Shutdowns. Other stats looks as follows: Rwanda (26%); Zambia (only 28%); Uganda (29%); Zimbabwe (30%); Angola (35); Cameroon (36); Kenya (42%); Nigeria (51%); and Ghana (53%) (Statista, 2022). These countries need to galvanize the private sector, NGOs, CBOs, global multinational organizations, etc, to invest more in digital transformation. Of course, they need to improve financial management, root out corruption, and maladministration, to attract local and Foreign Direct Investments (FDIs).

5.1.4 Internet user gender gap in Sub- Saharan Africa: an overview

As far as the internet user gender gap between men and women is concerned, the situation in Africa calls for serious concern. Internet access for men is 33, 8%, compared to women at a meager 22.6%. This does not compare favorably with the world average, with access for men being 58, 3%, compared to women at 48.4%. Neither does it compare favorably with the developed economies (average), where access for men is 87, 6%, compared to women at 86.0%, whereas, in the developing economies (average), access for men is 52, 8%, compared to women at 40.7% (ITU, 2019). So, Sub-Saharan Africa has a lot to catch up on as far as access to the internet is concerned.

5.1.5 African Countries with more than 10 million internet users

The top 3 African countries with more internet users are Nigeria (109 million), followed by Egypt secondly (75 million), and South Africa third at 41 million (Statista, 2022). Morocco has 31 million internet users, followed by Ethiopia at 29 million, and Kenya at 23 million. Then follows Ghana (16 million), the Democratic Republic of Congo (16 million), Tanzania (15 million), and Sudan, Uganda, Angola, and Cameroon at 14 million, 13 million, 12 million, and 10 million respectively (Statista, 2022).

5.2 African Countries with less than 10 million internet users

There are several African countries with less than 10 million internet users by 2022. Cote d'Ivoire has 9, 9 million, followed by Senegal and Tunisia (8 million) and Mozambique at 7, 5 million (Statista, 2022). Some African countries with less than 7 million internet users include Mali (6, 3 million), Burkina Faso (5, 9 million), Zambia (5, 4 million), Zimbabwe (4, 5 million), and Benin, Rwanda, and Libya at 3, 6 million, 3.5 million and 3, 4 million respectively (Statista, 2022).

5.3 African Countries with a share of internet users exceeding 50% of their population threshold

There are also African countries with a share of internet users exceeding 50% of their population. Morocco leads (84%), followed by Seychelles (79%), Egypt (71%), and South Africa (68%). Tunisia follows (66%), then Mauritius (64%), and Gabon, Cabo Verde, Western Sahara, Botswana, and Algeria at 62%, 61%.9, 61.3%, 61%, and 60% respectively (Statista, 2022). Those whose share falls below 60% include Djibouti (59%), Ghana (53%), and Lesotho, Nigeria, Namibia, and Gambia all averaging around 51% share (Statista, 2022). It is important to juxtapose the statistics about the share of internet users with the statistics on the number of internet users. Table 1 present this kind of analysis. For instance, even though Nigeria leads in terms of the number of internet users, those only make up 51% of the share of internet users.

African Country	Number of internet users	Share of internet users
Nigeria	109 million	51.0%
Egypt	75 million	71.9%
South Africa	41 million	68.2%
Morocco	31 million	84.1%
Ethiopia	29 million	25.0%

Table 1: Juxtaposing the share of internet users with the number of internet users in selected African countries, Mathane (2023), based on Statista (2022).

The African country with a bigger share of internet users in Morocco, but in terms of the number of users, the country lies fourth at 31 million – less than Nigeria, Egypt, and South Africa. Interestingly, Egypt has the second number of internet users in the continent, and the share of internet users is also equally competitively high at about 72%, followed by South Africa with 41 million internet users with a share of 68%. This is an important point about the possibly institutionalized digital divide within African nations themselves.

5.4 African Countries with a share of internet users below the 50% population threshold

There are over 35 African countries whose share of internet users is less than the 50% population threshold This speaks to the direness of the situation of a digital divide in the African continent. The worst-case scenarios are found in countries like Chad, where 19% of the population has access to the internet. The Democratic Republic of Congo (DRC) is also battling, with only 17% of the population accessing the internet, similar to Burundi, Niger, and Somalia – all of which have 14% of the population accessing the internet. South Sudan is no better at 10%, similarly with Comoros and Eritrez at 8% (Statista, 2022). These are cases in the African continent where digital access must be addressed as a matter of urgency.

5.5 Arguments for decolonization (neo-liberalization) in the context of access to data in African cities

The implementation of free data programmes must appreciate the fact that African cities have their peculiar urban management challenges, socio-economic inequalities, governance failures, etc. So, the implementation must be rooted in the contextual realities of the cities (Bandauko, and Nutifafa Arku, 2022). Some scholars suggest that African cities should free themselves from reliance on neo-liberal policies crafted by the West. In this regard, they suggest that one way of doing this is for African cities to start investing in accessing free WI-Fi and internet services (Wissink, 2020). Indeed, other scholars call for decolonial thinking about technology, cautioning that if Africa continues to rely on foreign capitalist actors, this would endanger their well-being and sustainability (Oyedemi, 2021).

5.6 Findings regarding the free Wi-Fi in the City of Tshwane

5.6.1 SWOT Analysis of Tshwane free Wi-Fi

Table 2 below shows Ramokgopa's (2018:226) insightful thoughts about the SWOT analysis of free Wi-Fi in Tshwane. From the perspective of strengths, strong executive commitment, coupled with administrative and technical internal competency in the area of ICT is a must. From a Business Continuity Management (BCM) perspective, it is also commendable that when the Democratic Alliance (DA) took over governance in the CoT, this programme was continued. From the perspective of weaknesses, the fact that the city does not own bandwidth is one of the strategic risks which should be managed judiciously. It can also be added that the fact that the City of Tshwane has not yet found a sustainable solution for theft and vandalism constitutes a weakness within the CoT management ecosystem. Another major weakness relates to the lack of clarity on the funding model.

STRENGTHS	WEAKNESSES
- Executive Leadership is committed to the programme. - Internal CoT ICT technical team. - Partnership model with competent service providers.	- The funding model is not yet clarified - Lack of CoT ownership of bandwidth - Lack of specialized and experienced legal team for contract management
OPPORTUNITIES	**THREATS**
- Increased smartphone usage in CoT. - Universal access to the internet - Increasing education levels of CoT residents - CoT enjoyed first-mover advantages - Online learning opportunities in CoT. - Revenue generation opportunities - Internet-based businesses can grow. - More private-sector investments - Increases engagements between city management and communities - Real-time communication	- The perception that the internet is a luxury can result in unfavorable funding decisions. - CoT can face possible litigation by some private sector internet providers. - Likely to commit mistakes as first movers - Negating the potential scale benefits. - Financial unsustainability. - Cyber security risks - Delayed legislative clarity because municipalities are not designated as internet service providers. - Impersonal community interactions

From the perspective of opportunities, there are many positives – increasing internet access, accelerating usage of smartphones, internet-based and/or online learning for teachers and learners, as well as opportunities for local online businesses Ramokgopa (2018). However, there are also missed opportunities currently, including opportunities for the CoT to partner with CBOs, NGOs, and the residents themselves. Opportunities for crowd souring funding also need to be explored. The City is not optimally pursuing raising its revenue (monetizing) with this platform. From the perspective of a threat, some of the key challenges include cyber security risks and financial unsustainability. At the level of social justice, the rate at which the CoT would engage citizens in impersonal ways would increase. Significantly, lack of legislative clarity considering that municipalities are not designated as internet service providers; including the fact that free data is not yet gazetted as a basic function of municipalities in South Africa is one of the strategic threats affecting free municipal Wi-Fi in South Africa as a whole. Policy and legislative lethargy and procrastination in this regard need to be corrected, particularly in the context of coalition politics, which have proven rather unpredictable.

5.6.2 Tshwane free Wi-Fi and the right to the city

The right to the city is a loaded and multilayered concept. So different aspects of this concept were dealt with in the survey. For instance, the respondents were asked their opinion regarding the Tshwane free Wi-Fi's contribution to enhancing the capacity of residents to exercise their informational rights to the city of Tshwane. In this regard, a majority of respondents (42%) felt that the free Wi-Fi is making a modest contribution, followed by 30% who believe that it is making a lot of contribution. About 22% felt that the contribution is there, but very modest in terms of impact. The respondents were also asked their opinion regarding the Tshwane free Wi-Fi's contribution to enhancing social justice in Tshwane. In this regard, 76%

agreed (of these, 56% just agreed, whereas 20% strongly agreed). Only 20% were not sure, and just 1% disagreed. The respondents believe that a significantly high proportion of Tshwane residents (80%) rely on the Tshwane free Wi-Fi to engage on social media platforms. However, only 32% of the respondents indicate that they use the Tshwane free Wi-Fi to engage on social media platforms. More respondents (46%) use their private data and use the Tshwane free data when their private data is exhausted. This means that a lot of the students (53%) tend to use private data first before they use Tshwane's free Wi-Fi.

The respondents were asked their opinion regarding the Tshwane free Wi-Fi's contribution to enhancing spatial justice in Tshwane. In this regard, 72% agreed. However, 18% disagree, and only 10% disagree. In addition, the respondents have diverse views about the Tshwane Free Wi-Fi serving all people of Tshwane equally well irrespective of their geographic location. About 48% agree, and 20% disagree. About 18% were not sure, and 14% strongly disagree. In terms of accessibility, 40% of the respondents feel that the Tshwane Free Wi-Fi accommodates all people (accessible for all), followed by 30% who disagree. In addition, only 46% of the respondents believe that in its current format, the Tshwane free Wi-Fi responds to the local contexts of communities. About 38% are neutral, whilst 26% disagree with the notion. Rather surprisingly, 60% of the respondents believe that the Tshwane Free Wi-Fi is directly informed by the socio-economic needs of the community. A small percentage (9%) disagrees, whilst 28% is neutral. As far as traveling inconvenience/costs are concerned, 62% of the respondents believe that since the introduction of the Tshwane Free Wi-Fi, some people no longer have to travel to the central city/town to do things that can be done through digital platforms. About 26% disagree, and 12% are neutral. The respondents were asked their opinion regarding the Tshwane free Wi-Fi's contribution to enhancing economic justice in Tshwane. In this regard, 44% of the respondents believe that the Tshwane free Wi-Fi makes a good contribution to enhancing economic justice in Tshwane. About 20% are of the view that the contribution is modest, and 22% believe that the contribution is low. On another factor, 78% of the respondents believe that many residents in Tshwane rely on the Tshwane Free Wi-Fi for economic opportunities such as job applications and business transactions. Only 10% disagree with this notion.

In terms of stakeholder analysis, the respondents were asked their opinion regarding whether the Tshwane free Wi-Fi implementation embraces partnerships and contributions. In this regard, 62% agreed, and 28% were not sure, whilst 9% felt that there is no involvement of external partners. Similarly, the respondents were asked their opinion regarding whether the Tshwane free Wi-Fi implementation embraces community involvement. About 64% agree, and 24% are neutral, whereas 9% disagree with the notion. As far as private sector involvement is concerned, 60% feel that there is adequate involvement, followed by 26% who are not sure; and 14% don't agree with the notion. The involvement of organized civil society formations also attracted diverse opinions; with 58% agreeing that there is adequate involvement of civil society groups in the conceptualization and implementation of the Tshwane Free Wi-Fi. However, 26% were not sure, whilst 16% disagreed with the notion.

5.6.3 Tshwane free Wi-Fi and service delivery and governance

Similarly, the respondents were asked their opinion regarding the Tshwane free Wi-Fi's contribution to enhancing service delivery in Tshwane. In this regard, 36% feel that a lot of contribution can be seen; whilst 32% believe the contribution is modest. About 26% of the respondents are not sure, whilst only 6% disagree. Nonetheless, approximately 44% of the respondents believe that many residents in Tshwane rely on the Tshwane Free Wi-Fi to engage the city on service delivery matters. About 34% are not sure; whilst 22% believe that generally, Tshwane residents prefer traditional (non-digital) ways of engaging the city. Similarly, about 22% of the respondents indicated that they are part of the Tshwane residents who use Tshwane Free Wi-Fi to engage the city on service delivery matters. Interestingly, 42% indicate that they use Tshwane free data for service delivery engagements only when their private data is finished. The rest (22%) indicate that they prefer residents prefer traditional (non-digital) ways of engaging the city.

The respondents were also asked their opinion regarding whether many residents in Tshwane rely on the Tshwane Free Wi-Fi to pay their bills, check statements, etc. Nearly half of the respondents (46%) believe that many Tshwane residents use the Tshwane Free Wi-Fi to pay their bills, check statements, etc. And, 12% believe that residents still prefer the traditional (non-digital) ways of paying their utility bills. Approximately 42% were not sure. Respondents were also asked if they are part of those Tshwane residents who use Tshwane Free Wi-Fi to pay their bills, check statements, etc. Interestingly, 42% of the respondents indicate

that they always use their private data. Another 42% indicate that they use Tshwane free data when their private data is finished. The rest (16%) indicate that they prefer residents prefer traditional (non-digital) ways of engaging the city. Finally, the respondents were asked to share their opinions regarding whether the Tshwane Free Wi-Fi is contributing to allowing residents to participate in governance processes in the City of Tshwane. Some 36% of the respondents feel that the Tshwane free Wi-Fi is making a lot of contribution in this regard. However, another 36% believe that the contribution does exist, albeit just modestly. Some feel that free Wi-Fi is not contributing in this regard. They make up 20% of the respondents. Finally, only 8% feel that the free Wi-Fi program is not making any contribution whatsoever in this regard.

6 CONCLUSIONS AND RECOMMENDATION

There are compelling reasons for African cities to deploy digital technologies so that they are not left behind as global cities are now more than ever before heavily influenced by intelligent technologies to interact directly with people. Africa is expected to reach a population of about 2.5 billion in 2050 (INED, 2019). This would be the fastest growth rate in the world. So, the deployment of sustainable and free Wi-Fi systems in African cities is more urgently needed (Ndiaye, et al 2022). The underlying problems causing poor access to internet connectivity in Africa have less to do with a lack of infrastructure, but more to do with a lack of commitment to good governance. African leaders and authorities need to do away with the politicization of data. This is untenable from a sustainable governance point of view. As far as the City of Tshwane Pretoria CBD case study is concerned, a majority of respondents agree that the Tshwane free Wi-Fi is greatly assisting in improving the citizen's right to the city. In terms of good governance, the study concludes that the Tshwane free Wi-Fi is also greatly assisting in entrenching social justice. However, when it comes to improving service delivery access and quality, the Tshwane free Wi-Fi is found to be used by fewer residents. In conclusion, there are some implications for the future. This means that cities can no longer approach planning from traditional planning approaches. Data is more than an essential need today, than it was in the pre Covid period. For the longer term, access to data will occupy similar position of significance as basic services such as water electricity, santiation, etc. Acces to data may even be a human right. Should such an eventuality arise, from a legal perspective, municipalities may not longer have an option of providing free access to data voluntarily, as this could be a Constitutionally mandated basic service. Cities should proactively plan for such eventualities, and partner with private and non governmental stakeholders to piggy back on therigh strenths and unique capabilities. past as well as projected future ones for the use of free wifi and its rolling out pace. In the case of Tshwane, the researchers recommend an expansion of more free Wi-Fi sites in the Pretoria CBD to accommodate an increasing student population in the area, thus increasing the possibilities of making the Pretoria CBD more liveable, sustainable, and entrenching social justice. However, the City of Tshwane needs to find innovative funding models because the free Wi-Fi programmes do not come cheap.

7 REFERENCES

Allen, B., Tamindael, L. E., Bickerton, S. H., & Cho, W. (2020). Does citizen coproduction lead to better urban services in smart cities projects? An empirical study on e-participation in a mobile big data platform. Government Information Quarterly, 37(1), 101412.
Anastasiu, I. (2019). Unpacking the smart city through the lens of the right to the city: A taxonomy as a way forward in participatory city-making. In The hackable city (pp. 239-260). Springer, Singapore.
Aquino, K., Wise, A., Velayutham, S., Parry, K. D., & Neal, S. (2020). The right to the city: outdoor informal sport and urban belonging in multicultural spaces. Annals of Leisure Research, 1-19.
Aurigi, A., & Odendaal, N. (2022). From "smart in the box" to "smart in the city": Rethinking the socially sustainable smart city in context. In Sustainable Smart City Transitions (pp. 53-68). Routledge.
Bandauko, E., & Nutifafa Arku, R. (2022). A critical analysis of 'smart cities' as an urban development strategy in Africa. International Planning Studies, 1-18.
Basu, I. (2019). Elite discourse coalitions and the governance of 'smart spaces': Politics, power, and privilege in India's Smart Cities Mission. Political Geography, 68, 77-85.
Ben-Lulu, E. (2021). Who has the right to the city? Reform Jewish rituals of gender-religious resistance in Tel Aviv-Jaffa. Gender, Place & Culture, 1-23.
Borja, J. (2019). The Right to the City: from the Street to Globalisation. Monografias CIDOB, 76, 33-42.
Braun, L. N., & Buse, R. N. B. (2020). Infectious Images: Viral Internet Content in the Democratic Republic of Congo. Critical Arts, 34(4), 103-116.
Breuer, J., & Pierson, J. (2021). The right to the city and data protection for developing citizen-centric digital cities. Information, Communication & Society, 24(6), 797-812.
Caragliu, A., & Del Bo, C. F. (2022). Smart cities and urban inequality. Regional Studies, 56(7), 1097-1112.

Cecchin, A., Salomone, R., Deutz, P., Raggi, A., & Cutaia, L. (2021). What is in a name? The rising star of the circular economy as a resource-related concept for sustainable development. Circular Economy and Sustainability, 1(1), 83-97.

De Frantz, M. (2021). The politics of the EU Urban Agenda: Mobilising the 'Right to the City' for European governance?. Urban Research & Practice, 1-24.

Diaz-Parra, I., & Jover, J. (2021). Overtourism, place alienation and the right to the city: Insights from the historic centre of Seville, Spain. Journal of Sustainable Tourism, 29(2-3), 158-175.

Fell, T., & Mattsson, J. (2021). The role of public-private partnerships in housing as a potential contributor to sustainable cities and communities: a systematic review. Sustainability, 13(14), 7783.

Gade, D. (2019). Technology Trends and Digital Solutions for Smart Cities Development. International Journal of Advance and Innovative Research, 6(1), 29-37.

Garbe, L. M. (2021). Authoritarian Survival in the Digital Age. Internet Access and Control in African Autocracies (Doctoral dissertation, Universität St. Gallen).

Gil, O., Cortés-Cediel, M. E., & Cantador, I. (2019). Citizen participation and the rise of digital media platforms in smart governance and smart cities. International Journal of E-Planning Research (IJEPR), 8(1), 19-34.

Hamza, M. (2021). Blockchain and Artificial Intelligence in Sustainable City: Can These Technologies Create Sustainable Cities and Communities? (Bachelor's thesis, University of Twente).

Hintjens, H., & Kurian, R. (2019). Enacting Citizenship and the Right to the City: Towards Inclusion through Deepening Democracy?. Social Inclusion, 7(4), 71-78.

Internet World Stats (2022). Internet penetration in 2021: https://www.google.com/search?q=access+to+data+in+africa+by+country+2021&oq=access&aqs=chrome.2.69i59j69i57j35i39j46i20i199i263i465i512j46i199i433i465i512j0i20i263i512j0i433i512l2j46i131i175i199i433j0i512.5647j0j15&sourceid=chrome&ie=UTF-8

ITU (2019). Access to the internet. https://www.itu.int/en/ITUD/Statistics/Pages/publications/wtid.aspx

ITU (2021), Measuring digital development Facts and figures 2021. https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2021.pdf

Jaiswal, R., Agarwal, A., & Negi, R. (2020). Smart solution for reducing the COVID‐19 risk using smart city technology. IET Smart Cities, 2(2), 82-88.

Korczak, J., & Kijewska, K. (2019). Smart Logistics in the development of Smart Cities. Transportation Research Procedia, 39, 201-211.

Mondini, G. (2019). Sustainability assessment: From Brundtland report to sustainable development goals. Valori e Valutazioni, (23).

Murrey, A. (2022). A decolonial political geography of resistance and digital infrastructural harm in Cameroon and Ethiopia. Globalizations, 1-27.

Onyango, J., Kiano, E., & Saina, E. (2021). Environmental Damage Theory Applicable to Kenya. Asian Journal of Business Environment, 11(1), 39-50.

Oyedemi, T. D. (2021). Digital coloniality and 'Next Billion Users': the political economy of Google Station in Nigeria. Information, Communication & Society, 24(3), 329-343.

Ramokgopa, K. D. (2018). Leadership in establishing the Gauteng City-Region: the case of the City of Tshwane Metropolitan Municipality (Doctoral dissertation, University of Pretoria).

Rodríguez Bolívar, M. P. (2019). In the search for the 'Smart' Source of the Perception of Quality of Life in European Smart Cities.

Schopp, K., Bornemann, M., & Potthast, T. (2020). The whole-institution approach at the University of Tübingen: Sustainable development set in practice. Sustainability, 12(3), 861.

Statista, (2020a), Technology spending into smart city initiatives worldwide from 2018 to 2023 (in billion U.S. dollars). Available at: https://www.statista.com/statistics/884092/worldwide-spending-smart-cityinitiatives/#:~:text=Technology%20spending%20on%20smart%20city,to%20189.5%20billion%20in%2 02023 (Accessed 15 December 2022).

Statista, (2020b), Spending on smart city projects worldwide from 2019 to 2025* (in billion U.S. dollars). Available at: https://www.statista.com/statistics/1111626/worldwide-smart-city-market revenue/#:~:text=Smart%20city%20market%20revenue%20worldwide%202019%2D2025&text=Global%20spending%20on%20smart%20city,U.S.%20dollars%20by%202024%20worldwide (Accessed 15 December 2022).

Statista,(2019), Smart city spending share worldwide in 2019. Available at: https://www.statista.com/statistics/884130/worldwide-smart-city-investment-initiatives-use-case/ (Accessed 15 December 2022).

Statista. (2021), Smart city initiatives spending share worldwide in 2020. Available at: https://www.statista.com/statistics/757638/spending-on-smart-cities-worldwide/ (Accessed 15 December 2022).

Statista. (2021), Smart city initiatives spending share worldwide in 2020. Available at: https://www.statista.com/statistics/757638/spending-on-smart-cities-worldwide/ (Accessed 15 December 2022).

Steputat, C.C., Ural, D. and Nanni, A. (2020). Sustainable cities and communities through GFRP secant-pile seawall innovation, sustainability, fortification and hurricane storm surge protection. In IOP Conference Series: Earth and Environmental Science (Vol. 588, No. 4, p. 042063). IOP Publishing.

Timeus, K., Vinaixa, J., and Pardo-Bosch, F. (2020). Creating business models for smart cities: A practical framework. Public Management Review, 22(5), 726-745.

Vaidya, H., & Chatterji, T. (2020). SDG 11 sustainable cities and communities. In Actioning the Global Goals for Local Impact (pp. 173-185). Springer, Singapore.

Van der Graaf, S. (2020). The right to the city in the platform age: Child-friendly city and smart city premises in contention. Information, 11(6), 285.

Vergara-Perucich, J. F., & Arias-Loyola, M. (2019). Bread for advancing the right to the city: academia, grassroots groups and the first cooperative bakery in a Chilean informal settlement. Environment and Urbanization, 31(2), 533-551.

Willis, K. S. (2019). Whose right to the smart city?. In The right to the smart city. Emerald Publishing Limited.

Wissink, H. (2020). Evaluating the Aerotropolis Model for African Cities: The Case of the Durban Aerotropolis. In Reflections on African Cities in Transition (pp. 183-211). Springer, Cham.

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. International journal of financial research, 9(2), 90-95.

Yang, L., Elisa, N., & Eliot, N. (2019). Privacy and security aspects of E-government in smart cities. In Smart cities cybersecurity and privacy (pp. 89-102). Elsevier.

Yang, Y., & Taufen, A. (2022). Sustainable cities and landscapes: Cultivating infrastructures of health. In The Routledge Handbook of Sustainable Cities and Landscapes in the Pacific Rim. Taylor & Francis.

Yang, Y., & Taufen, A. (2022). Sustainable cities and landscapes: Cultivating infrastructures of health. In The Routledge Handbook of Sustainable Cities and Landscapes in the Pacific Rim. Taylor & Francis.

Yigitcanlar, T., Han, H., & Kamruzzaman, M. (2019). Approaches, advances, and applications in the sustainable development of smart cities: A commentary from the guest editors. Energies, 12(23), 4554.

Zhao, M., Lin, Y., & Derudder, B. (2018). Demonstration of public participation and communication through social media in the network society within Shanghai. Environment and Planning B: Urban Analytics and City Science, 45(3), 529-547.

Zielinska-Dabkowska, K. M., & Bobkowska, K. (2022). Rethinking Sustainable Cities at Night: Paradigm Shifts in Urban Design and City Lighting. Sustainability, 14(10), 6062.

Zvolska, L., Lehner, M., Voytenko Palgan, Y., Mont, O., & Plepys, A. (2019). Urban sharing in smart cities: the cases of Berlin and London. Local Environment, 24(7), 628-645.

718

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

The Influence of Social Infrastructure Accessibility on Liveability in Urban Neighbourhoods

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1 ABSTRACT

The liveability in urban neighborhoods partially depends on the living conditions in the residential environment (Die Bundesregierung 2016: 3). These include the supply of goods and services as well as their quality and accessibility. The infrastructures that influence the liveability in urban neighborhoods vary depending on the age, social status and life stage of the residents. These include educational, administrative, health, cultural and recreational facilities. Reasonable accessibility may also be perceived very differently by young adults without children, families, baby boomers or the elderly. According to Prof. Carlos Moreno's model of the "15-minute city", each trip should have a maximum walking or biking distance of 15 minutes (Moreno 2021). However, the model of the 15-minute city does not specify speeds, i.e. what distance is achievable within the travel time. This can differ depending on the target group.

The focus of this paper is on the spatial analysis of factors that determine the quality of life of baby boomers (birth cohorts 1955-1969)[1] in urban neighborhoods in terms of infrastructure provision. It is likely that some existing infrastructural facilities will necessarily have to be maintained at the location, e.g. some educational institutions or large recreational, cultural and sport facilities. Others, however, could function in the future via delivery systems. Particulary in view of digital developments, some systems and offerings are outdated in their current form or need to be restructured and adapted. The question also arises as to what need there is for new infrastructure offerings.

In this context, this subproject of the research project "Ageing Smart – Intelligent development of spaces", which is funded by the Carl Zeiss Foundation, examines the following research question using the city Jena as an example: Which infrastructures condition a high liveability in urban neighborhoods and how must they be accessible? The results of the accessibility analysis can be overlaid with the population data of the city of Jena on the basis of selected infrastructures. In the next step, it is examined how many of these infrastructures can be reached by baby boomers within a reasonable distance in 15 minutes by foot and by bike. Based on this analysis, it will be discussed where infrastructures need to be supplemented or digitally substituted in order to promote a high quality of life for Jenas population – especially for baby boomers – or where accessibility on foot and by bike needs to be increased.

Keywords: livability index, accessibility, social infrastructure, 15minute city, walkability

2 THE CONCEPT OF THE "15 MINUTE CITY" AS A BASIS FOR ACCESSIBILITY ANALYSIS

A variety of uses can be found in urban neighborhoods. In addition to residential use, these include especially services, stores, businesses as well as social and technical infrastructures. The scope of the facilities is primarily determined by demand. This varies depending on the resident structure. The goal is to reach all necessary facilities through active mobility. This reduces motorized individual traffic so that air quality improves, noise is reduced and space is created.

The concept of the 15 minute city, first mentioned by Prof. Carlos Moreno, concretises the guiding principle of the city of short distances. In the "city of short distances", the aim is to reduce motorized private transport and increase the proportion of distances covered on foot, by bicycle or by public transport. It is backed up by the Leipzig Charta, a guiding document of national urban development policy, that also calls for "[...] compact, socially and economically mixed cities with well-developed infrastructures [...]" (BMI 2020: 3).

The goal of the 15 minute city was formulated as follows: "[...] all residents are able to access their daily needs (work, housing, food, health, education, and culture and leisure) within the distance of a 15-minute walk or bike ride." (Moreno 2021) Short distances covered through active mobility contribute to climate protection as well as to improving air quality in cities. In addition, city inhabitants save time and are

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[1] As defined in the research project "Ageing Smart – Designing Spaces Intelligently", funded by the Carl Zeiss Foundation.

physically active, which can have a health-promoting effect. Neighborhoods can be strengthened and space in public areas can be saved and reallocated by reducing stationary traffic.

The concept reduces the guiding principle of the city of short distances by public transport and specifies a specific time in which the infrastructures are to be achieved. Regardless of Moreno's definition, many accessibility studies based on that concept also consider accessibility by public transit. It only describes a tangible idea of how cities should be equipped. It is not universal and does not take into account that the walking distance is significantly less than bicycle distance. In addition, it does not take into account walking and cycling speeds. Different population groups move at different speeds. As a rule, the average walking speed is between three and six km/h. The average cycling speed is usually 15 to 20 km/h. Furthermore, not all urban inhabitants are able to get around by bicycle.

Accessibility models based on the 15 minute city concept only take into account whether there is a corresponding infrastructure within the radius. The different lifestyles of city inhabitants are not taken into account. Accordingly, it is quite possible that a resident can already find very good infrastructure facilities in their neighbourhood according to the analysis, but does not use them for various reasons. The concept of the 15 minute city can therefore be seen as merely a basic idea, which is further substantiated by the Liveability Index.

3 CONCEPTUAL MODEL: CONCEPTION OF A "LIVEABILITY INDEX" BASED ON THE ACCESSIBILITY OF SOCIAL INFRASTRUCTURES IN URBAN NEIGHBOURHOODS

In order to concretize the idea of the 15 minute city and to investigate the accessibility of infrastructures as part of the liveability in urban neighbourhoods, an index has to be formed. This index consists of different variables – in this case different infrastructure facilities. It forms a theoretical construct to measure the accessibility of infrastructures as a precondition for liveability of the inhabitants of urban areas.

The different variables can be weighted or combined according to their target group-specific importance. This procedure creates additional scope for decision-making for municipalities, as they can individually adapt each variable and their weighting to the demands of the resident structures in different urban neighbourhoods. By combining the variables, it is possible to examine how well the residents are equipped with infrastructures of general interest. In addition, two further options for action can be explored. On the one hand, the accessibility analysis based on the index shows deficits in infrastructure provision. On this basis, location decisions can be made regarding supplementary infrastructures in order to improve the liveability at the target groups' residential locations. On the other hand, this method can be used to identify residential locations that have a high liveability according to the variables examined. This can potentially trigger relocation chains that can counteract a housing shortage.

Public infrastructures as well as privately provided ones in urban areas that are periodically visited (see Table 1) and can only be provided digitally or as a delivery service in part or at considerable expense are examined. The distinction between public and private providers is important because the municipal options for action are very limited in the case of private infrastructures.

Approximation of a Liveability Index based on the accessibility of infrastructures

The social infrastructure in municipalities forms the basis of services of general interest. This includes "retail and everyday supply/local supply, education, social services, health and medical care, emergency services, disaster control and fire protection, leisure facilities, community facilities"." (Beirat fuer Raumentwicklung 2011: 4). These services are supplemented by "public and private local and long-distance transport" (ibid.). Specifically, according to the Academy of Spatial Development (ARL), the public social infrastructure essentially includes primary and secondary schools, universities, the library system, childcare, youth care and youth psychological services, care for the elderly, health care, sports and disaster control (Winkel 2018).

Local supply as well as restaurants, pharmacies and general practitioners are provided by private parties and can hardly be controlled by municipalities, they are part of the private infrastructure. The Land Use Ordinance does allow areas to be designated for these purposes. However, occupancy depends on private individuals, so these facilities are usually only available if they are economically viable. Vacancies can't be completely avoided by the municipality.

Areas for local recreation, sports facilities and public transport stops are usually provided by municipalities. The possibilities for planning and implementation are limited on the one hand by the availability of land. On the other hand, these usually are non-economic infrastructures whose operation and maintenance must be ensured by the municipalities. Thus, the financial resources of the municipalities are also decisive for their quality and quantity.

Local infrastructures whose daily or at least regular accessibility can significantly influence the liveability are selected here as examples for further investigation. Infrastructures that are visited only rarely or only by small parts of the population on a regular basis, such as universities, museums and churches, are excluded, as are the emergency services and services that are nowadays regularly perceived digitally, such as banking and postal services.

Public Infrastructure	*Private Infrastructure*
Public transport - Bus stops - Tram stops - Underground stops	Local supply (goods for daily needs): - Discounters/Supermarkets - bakery, butcher, drugstore (in close proximity) - Shopping centres with appropriate assortment
Environment and local recreation - Green spaces - Parks - Local recreation areas	Medical care - General practitioners - Pharmacies
Sports facilities - Sports halls - Sports fields - Other sports facilities	Gastronomy - Restaurants - Cafés - Bars
Child and youth care, schools - Day nurseries/kindergardens - Primary schools - Secondary schools - Playgrounds - Youth centres	

Table 1: Examples of local infrastructures whose accessibility can significantly influence liveability

To make the indicators measurable, the accessibility must be quantified. There are several ways to do this. Based on the concept of the 15 minute city, the assumption can be made that all variables are equally weighted and fulfilled if they are reached within 15 minutes on foot or by bicycle. However, due to the points listed in chapter 2, this approach is not meaningful. Based on this, further concretisations are made.

Therefore accessibility is classified in a three-stage evaluation scheme (very good, good and acceptable). For this study, an acceptable walking distance is assumed to be 15 minutes at an average walking speed of 5 km/h. Accordingly, a distance of five minutes is considered very good and a distance of 10 minutes is considered good.

Furthermore, the individual elements of the infrastructure are weighted, whereby the weightings can vary greatly depending on the cohort considered. As an example, a weighted scheme could be structured as below (table 2).

4 CALCULATION IN GEOSTATISTICAL GRIDS

To apply this research approach methodologically and to make the site assessment manageable, the results are aggregated in grid squares. The weighted accessibility values of the individual infrastructures are then summed up into an index value for each grid square. In the case study the 1 ha INSPIRE grid (100m x 100m grid cell) by the European Commission is used. This format was established by the Statistical Office of the European Union (eurostat) with the goal to provide comparable statistics at the EU level (Eurostat/European Union, n.d.). The datasets are based on surveys, the current one is from 2011. In 2022 the census was surveyed again, the data is expected to be available from March 2024 (Statistische Aemter des Bundes und

der Laender 2023). Usually the survey interval is every ten years, in this case eleven. The processing of the results takes an additional one to two years.

The advantage of this approach is to obtain a uniform and sufficiently accurate spatial comparison framework for the calculation of the index without having to take individual local conditions into account. It is also advantageous that data is increasingly being collected and evaluated in geostatistical raster form in order to have a neutral, comparable spatial basis on the one hand and to ensure data protection on the other.

	very good / x3	good / x2	acceptable / x1
Public Infrastructures			
Public transport - Bus stops - Tram stops - Underground stops	3	2	1
Environment and local recreation - Green spaces - Parks - Local recreation areas	3 6 6	2 4 4	1 2 2
Sports facilities - Sports halls - Sports fields - Other sports facilities	3 3 3	2 2 2	1 1 1
Child and youth care, schools - Day nurseries / kindergardens - Primary schools - Secondary schools - Playgrounds - Youth centres	6 6 3 3 3	4 4 2 2 2	2 2 1 1 1
Private Infrastructures			
Local supply (goods for daily needs): - Discounters / Supermarkets - bakery, butcher, drugstore (in close proximity) - shopping centres with appropriate assortment	9 3-9 9	6 2-6 6	3 1-3 3
Medical care - General practitioners - Pharmacies	6 3	4 2	2 1
Gastronomy - Restaurants - Cafés - Bars	3 3 3	2 2 2	1 1 1

Table 2: Example of a weighted scheme to to make the influence of various indicators measurable

5 CASE STUDY: LIVEABILITY FOR BABY BOOMERS IN THE CITY OF JENA

As an example, the conception of an area-wide Liveability Index for the population group of baby boomers in Jena is presented. The city of Jena is located in the federal state of Thuringia. The population includes 110,502 people (31.12.2021, Thueringer Landesamt fuer Statistik 2022a) on an area of 11.477 ha (31.12.2022, Thueringer Landesamt fuer Statistik 2022b).

The data basis for the example of Jena was partly provided by the city of Jena within the framework of the above-mentioned research project. The points of interest (POI's) were taken from Open Street Maps (OSM), the accessibility analyses were carried out with ArcGIS Pro.
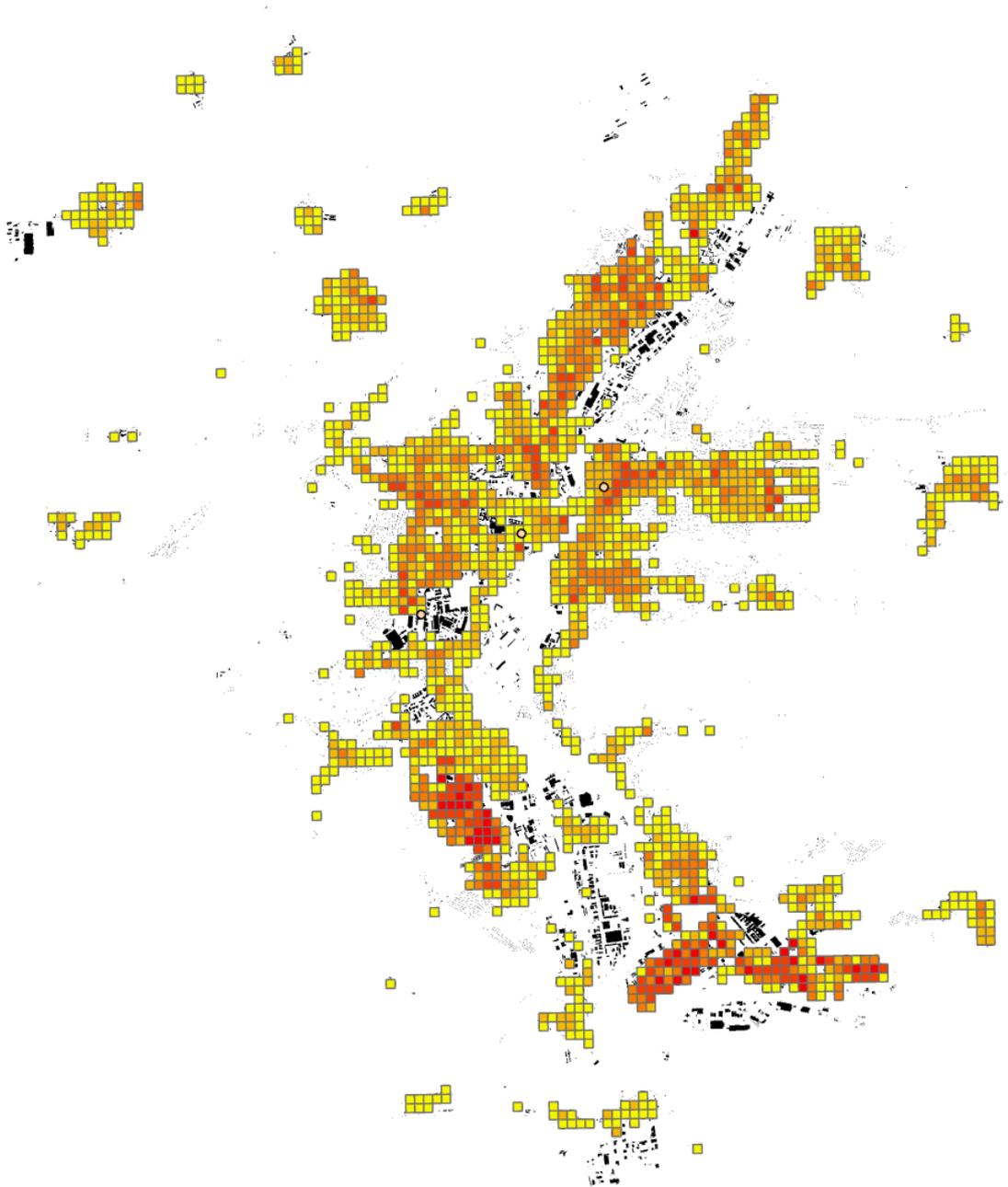
Fig. 1: Distribution of the total population in Jena (red many, yellow few)

The population density is particularly high in the large structures in Jena-Lobeda in the south (average age: 44.9 years) and in Jena-Winzerla in the southwest (average age: 46.8 years) (see Fig. 1). In addition, it is higher in the terraced housing west of the Saale. The population density is correspondingly lower in the districts with more dispersed building structures around Jena.
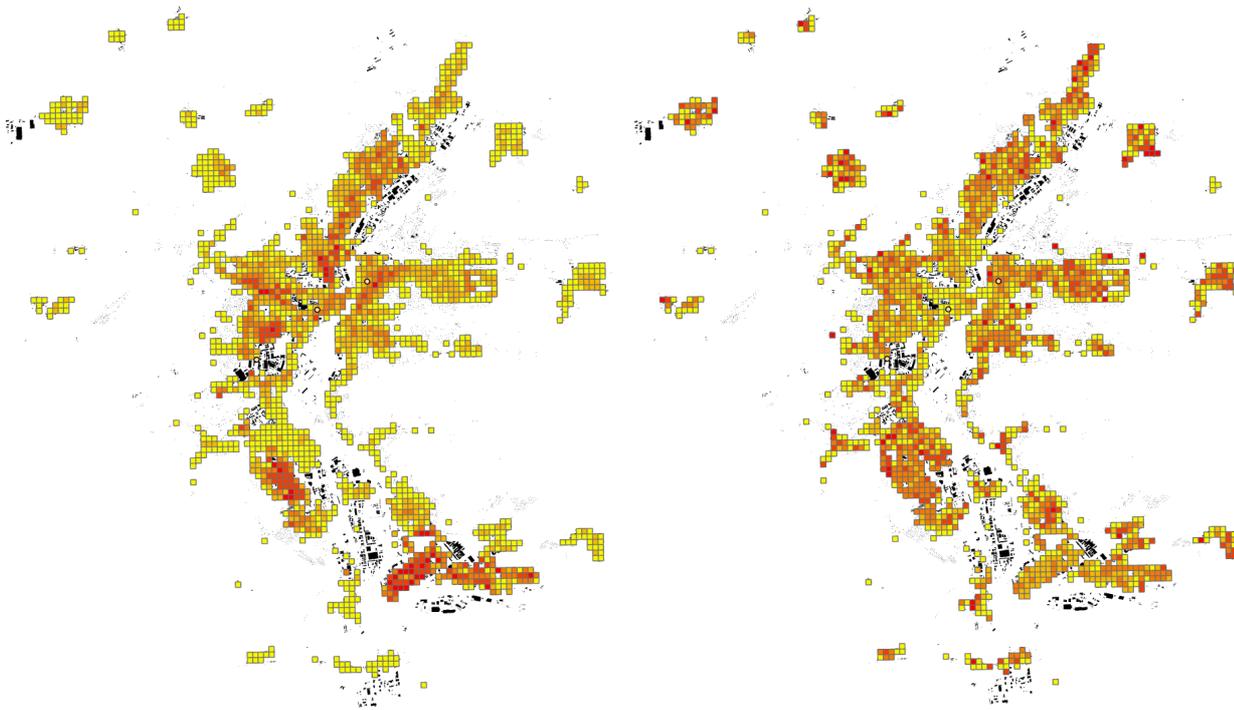
Fig. 2: Distribution of Baby Boomers in Jena – Absolute (red many, yellow few). Fig. 3: Distribution of baby boomers in Jena – Proportion of total population (red many, yellow few)

In absolute numbers, the baby boomers are distributed largely in line with the total population (Fig. 2). When looking at the distribution of the baby boomers as a proportion of the total population, it can be seen that the baby boomers make up a moderate to high proportion of the total population and are relatively evenly distributed in the urban area (Fig. 3).

The list of indicators presented above needs to be adapted for the specific study group. For example, childcare facilities and schools are rather irrelevant for the cohort of baby boomers.

The accessibility model is also specified. For this, a walking speed of 5 km/h is assumed, and accessibility by bicycle is not included because it is assumed that a relevant part of the group can no longer use a bicycle as they get older.

In the next step, the accessibilities for the individual infrastructure sectors are determined for the walking times 5, 10 and 15 minutes. As an example, a representation follows for the supermarkets available in Jena, which have a very different coverage of the populated urban area. While in central areas larger parts of the population live within the 5-minute range of one or more supermarkets, in decentralised parts of the city there are whole districts that lie entirely outside the 15-minute range.

In the next step, the accessibilities determined by network analysis are transferred to the inhabited grid squares of the city and the respective index value is stored.
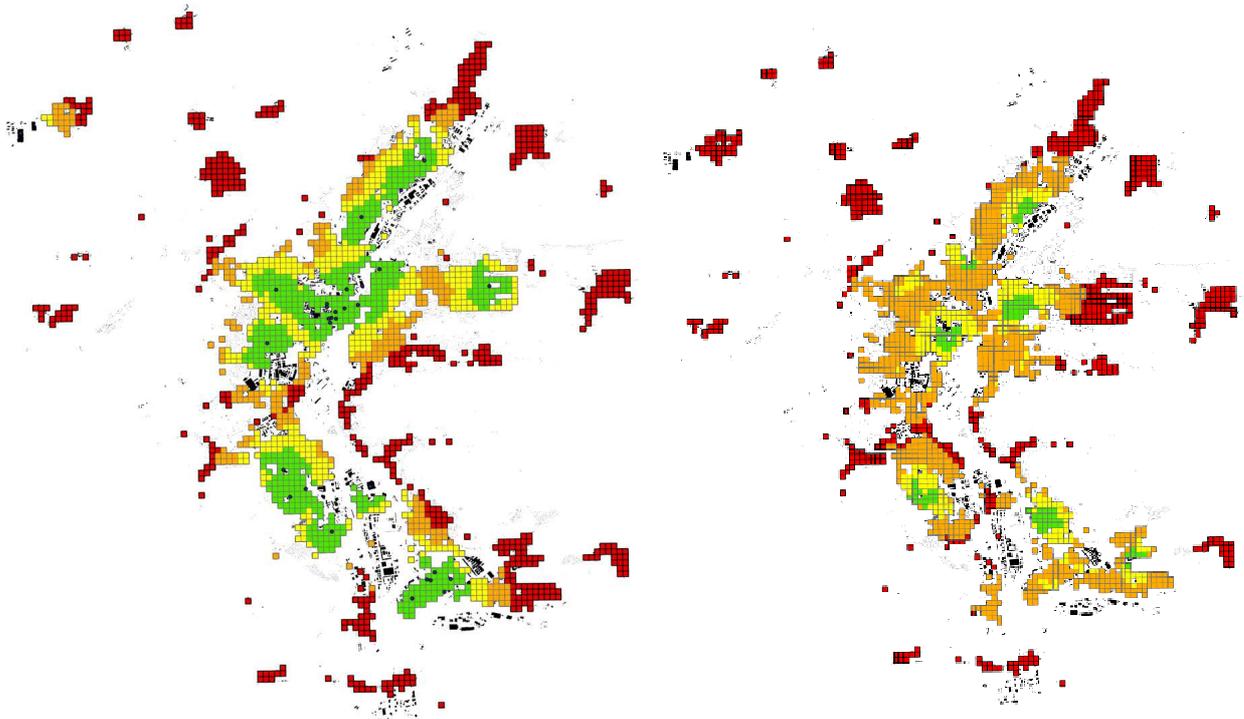
724

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Fig. 4: Rasterized index "supermarkets" (green: <5 min, yellow: <10 min, orange: <15 min, red: >15 min). Fig. 5: Rasterized index "general practitioners" (green: <5 min, yellow: <10 min, orange: <15 min, red: >15 min)

The network analysis and transfer of the index values to the population grid is then repeated for each infrastructure sector. The accessibility of supermarkets with a full range of groceries (Fig. 4) and of general practitioners. (Fig. 5) is shown here as an example. Due to the different number of locations and differences in the choice of location, there are large variations in accessibility. In general terms, it can be said that significantly more people in Jena live in the immediate vicinity (5 min) of supermarkets than of general practitioners. The part of the city area that does not have a doctor's practice within a 15-minute walking radius is also larger.

There are smaller areas in the city centre and around district centres that have excellent accessibility in (almost) all criteria. However, this is not the rule. Urban areas dominate in which accessibility is heterogeneous across infrastructures. There are also urban areas in which the infrastructure is mostly well accessible, but in which one or a few sectors are missing. The methodological handling of such cases must be discussed. Should these areas still be considered as 15-minute cities, or should exclusion criteria be set here? These considerations are essential when it comes to quantifying the theoretical and general model of the 15 minute city.
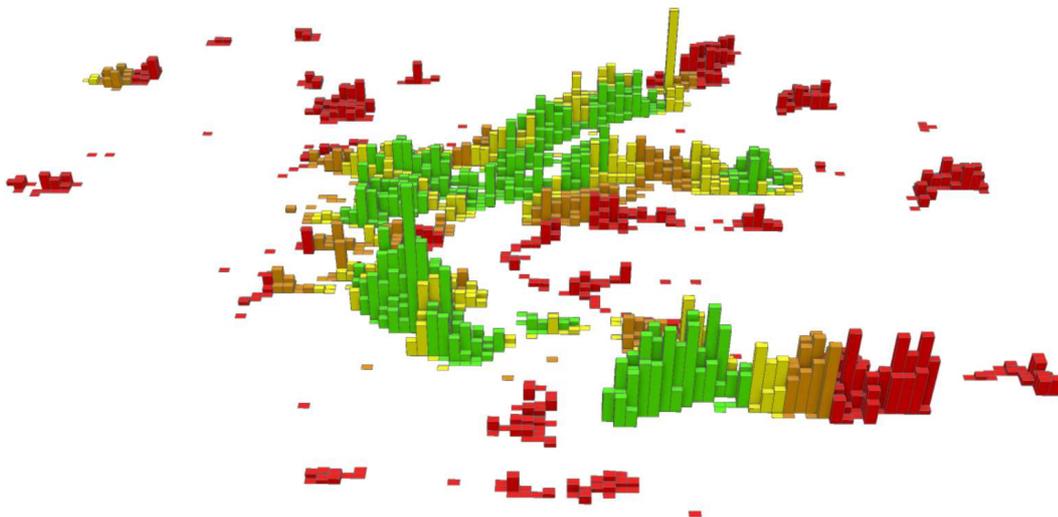

Fig. 6: population-weighted accessibility (green: <5 min, yellow: <10 min, orange: <15 min, red: >15 min)

In a last step the results of the accessibility analysis are overlaid with the population data of the city of Jena on the basis of selected infrastructures.

Various conclusions can then be drawn from this. On the one hand, it can be determined what proportion of the population lives in a "15 minute city" tailored to the needs of its age group and where this is the case. At the same time, deficits in the municipal and private infrastructure can be identified.

6 CONCLUSION

The concept of the 15 minute city is a very interesting approach to liveability in cities, but it has some gaps. For accessibility analyses, it can only be used in a highly concretized form. Parameters such as walking and driving speeds must be differentiated and defined. By concretizing the concept, it can serve as a framework for a Liveability Index. When creating this index, it is imperative that the responsible planners and decision-makers agree on comparable criteria and quality levels. In addition, the target group must be defined.

The hectare grid represents a good reference size for accessibility analyses. The spatial reference value is sufficiently concrete to show resilient decision options. Especially since spatial planning is already imprecise to a certain degree anyway due to assumptions and scenarios. If the above points are taken into account, the Liveability Index can be a good evaluation and decision-making aid.

In the next step the index is comprehensively applied to Jena as an example. Based on the results, recommendations on potential weightings and their consequences in the location analysis can be shown.

7 REFERENCES

BEIRAT FUER RAUMENTWICKLUNG DES BUNDESMINISTERS FUER VERKEHR, BAU UND STADTENTWICKLUNG 17. LEGISLATURPERIODE DES DEUTSCHEN BUNDESTAGS (2011): Region 2020: zur Zukunft peripherer, strukturschwacher, laendlicher Regionen – Denkanstoeße zur gleichwertigen Entwicklung und Handlungsansaetze zur Daseinsvorsorge. Berlin, 2011.

BMI - BUNDESMINISTERIUM DES INNERN UND FUER HEIMAT (2020): Neue Leipzig Charta. Die transformative Kraft der Staedte fuer das Gemeinwohl. Verabschiedet beim informellen Ministertreffen Stadtentwicklung am 30. November 2020.

DIE BUNDESREGIERUNG, PRESSE- UND INFORMATIONSAMT [Hrsg.] (2016): Bericht der Bundesregierung zur Lebensqualitaet in Deutschland. Berlin, 2016. Retrieved from: http://www.gut-leben-in-deutschland.de/downloads/Regierungsbericht-zur-Lebensqualitaet-in-Deutschland.pdf. on 26.04.2023.

EUROSTAT/EUROPEAN UNION (N.D.): What is the European Statistical System (ESS)? Retrieved from: https://ec.europa.eu/eurostat/de/web/european-statistical-system/overview on 22.06.2023.

MORENO, CARLOS (2021): Definition of the 15 minute city: WHAT IS THE 15 minute city? The Obel Award by the Henrik Frode Obel Foundation. October 2021. Retrieved from: https://www.researchgate.net/publication/362839186_Definition_of_the_15-minute_city_WHAT_IS_THE_15-MINUTE_CITY. on 22.06.2023.

STATISTISCHE AEMTER DES BUNDES UND DER LAENDER (2023): Zensus: Ergebnisveroeffentlichung verschiebt sich voraussichtlich in den Maerz 2024. Pressemitteilung vom 24.03.2023.Retrieved from: https://www.zensus2022.de/DE/Aktuelles/Zensus_2022_Ergebnisveroeffentlichung_verschiebt_sich_voraussichtlich_in_den_Maerz_2024.html on 22.06.2023.

THUERINGER LANDESAMT FUER STATISTIK (2022a): Bevoelkerung der Gemeinden, erfuellenden Gemeinden und Verwaltungsgemeinschaften nach Geschlecht in Thueringen. Erfurt. 2022.Retrieved from: https://statistik.thueringen.de/datenbank/TabAnzeige.asp?GGglied=1&GGTabelle=gem&tabelle=gg000102&startpage=99&csv=&richtung=&sortiere=&vorspalte=1&SZDT=&anzahlH=-1&fontgr=12&mkro=&AnzeigeAuswahl=&XLS=&auswahlNr=&felder=0&felder=1&felder=2&zeit=2021%7C%7Cs1&anzahlZellen=2199. on 31.07.2023.

THUERINGER LANDESAMT FUER STATISTIK (2022B): Flaeche der Gemeinden, erfuellenden Gemeinden und Verwaltungsgemeinschaften in Thueringen. Erfurt. 2022.Retrieved from: https://statistik.thueringen.de/datenbank/TabAnzeige.asp?tabelle=GG000101‖. on 31.07.2023.

WINKEL, RAINER (2018): Soziale Infrastruktur. In. ARL – Akademie fuer Raumforschung und Landesplanung [Hrsg.]: Handwoerterbuch der Stadt- und Regionalentwicklung. S. 2185-2196. Hannover, 2018. Retrieved from: https://www.arl-net.de/system/files/media-shop/pdf/HWB%202018/Soziale%20Infrastruktur.pdf. On 22.06.2023.

726

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The Planning and Utilisation of Green Spaces in South Africa: Potchefstroom as a Case Study

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1 ABSTRACT

Public green spaces, commonly known as parks, play an important socio-psychological, physical and ecological role within cities. They support active lifestyles, promote citizenships, reduce air pollution, decrease heat island effects and support environmental sustainability. However, previous studies have found that the quality of parks within settlements fluctuates depending on their location relative to the Central Business District (CBD) and wealth of residents. This variation in quality (supply of park area or facilities) effects the utilization (potential demand) of parks, which in turn reduces the benefits, derived from these spaces. This paper sought to investigate the quality and utilization of parks in Potchefstroom, South Africa. It explored 3 different parks in 3 suburbs on the basis of the wealth and racial history of the suburb. Qualitative data was collected at each park through semi-structured interviews to determine its utilization, and an observation study was used to determine the park quality. The analysis indicated that there are marked discrepancies in the quality of neighborhood parks between suburbs previously designated for different racial groups. However, the utilization was not determined by the quality of the neighborhood parks, with poor quality parks in previously disadvantaged areas being used more frequently. The study"s findings shed light on the green inequality of South African cities and calls for further intervention to bring in green equality.

Keywords: Green Inequality, Green spaces, Distributional Justice, Sustainability, South Africa

2 INTRODUCTION

Academically, public green spaces are defined as open areas, which are primarily covered by vegetation and which are provided and maintained by the local authorities. These open green spaces come in various sizes and are commonly known as parks. From a planning perspective, parks serve multiple functions and offer citizens social, psychological and environmental benefits (Rojas- Rueda et al., 2019). As a result, the World Health Organization considers green open spaces to be essential for the physical and emotional wellbeing of citizens.

However, research conducted in Australia, South Africa, Spain and America have all found that lower income residential areas or minority racial group suburbs within cities have less access to green spaces or street trees than more affluent areas (Astell-Burt & Feng, 2019). In the case of South Africa, the planning and design of public green spaces has been more complex due to its political history as well as the unique ways in which parks are used in the country. Neighborhood parks in South Africa are planned to provide recreational and cultural services (Shackleton et al., 2018). However, these public open spaces are also utilized by the public to address their individual needs which come from high poverty levels and African identity or spirituality (Khumalo & Sibanda, 2019). These aspects are culturally opposing at times and deter the traditional utilization of parks. Consequently, research conducted in South Africa found that although there are many parks in the cities, only the well maintained parks close to the CBD and affluent areas are utilized, while the others were simply ignored. However, Das and Honiball (2021) add that the underutilization of South African low-income neighborhood parks is attributed to the lack of amenities, inappropriate location, lack of attractiveness, lack of accessibility, no interest, and crime. This generates a vicious cycle in the level of green spaces and infrastructure provided (supply) by the government and the low demand of green spaces in these suburbs.

This paper seeks to engage the first dimension of environmental justice - that of distributive justice, which addresses fairness in provision of public spaces and related resources within the South African context (Low, 2013). In light of this, the paper examines the quality of parks and their utilization in three different suburbs located in Potchefstroom South Africa (Harnik, 2009:6). The paper starts by providing a brief backdrop of South African cities and their relationship with public green space planning. It then describes the methodology, discusses findings and draw conclusions. The next section provides a background to the study.

3 BACKGROUND

The South African apartheid city stands out as an extreme example of urban social engineering (Seekings, 2011:532; Venter et al. ,2020:106). Its spatial morphology was based on racial segregation and hierarchy that systematically disadvantaged those who were classified as „Coloured", „Indian/Asian" or „Black". During this period people of color were forcibly removed from urban areas and moved to „group areas" s located far from urban amenities. Within the apartheid city, White"s lived in high-income urban neighborhoods with good quality infrastructure and urban amenities, whilst South Africans classified as Coloured or Indian lived in lower class rural neighborhoods with poor services and no urban amenities. African"s or Blacks lived in townships that had minimal infrastructure and services (Seekings, 2011:540). Each of these group areas were then treated as separate local administrations, and infrastructures such as highways, industrial zones, and buffer zones were used to create physical divisions along the lines of race. Furthermore, regulations were put in place to control social interaction between racial groups in public spaces (Seekings, 2011:538). This created exclusion, spatial fragmentation and high levels of inequality in the country (Lehohla & Shabalala, 2014:501). In an analogous fashion, the environmental policy of apartheid South Africa was as cruel and perverse as the spatial one.

Under the colonial and apartheid governments, thousands of Black South Africans were forcibly removed from their ancestral lands to make way for game parks, and billions of Rands were spent on preserving wildlife and protecting wild flowers, while people in "townships" and "homelands" lived without adequate food, shelter, and clean water. The Whites-only policies in national parks meant that black South Africans could not enjoy the country"s rich natural heritage, and draconian poaching laws kept the rural poor from desperately needed resources (Kuruneri-Chitepo & Shackleton, 2011). A study conducted by McConnachie and Shackleton (2010) found that there was less public urban green infrastructure and fewer parks in the poorer neighbourhoods (African, Indian and Coloured residents) than the more affluent ones (White residents). The same was found with respect to the provision of street trees, with many areas in poorer neighborhoods having no street trees at all (Gwedla & Shackleton, 2017). Consequently, Black South Africans (and anti-apartheid activists in general) paid little attention to environmental debates during the apartheid era since the environment was seen to be a white, suburban issue of little relevance to the anti-apartheid struggle.

However, the liberalization of South African politics in the late 1980s created a discursive and institutional space for the rethinking of environmental issues, and a vibrant debate began on the meaning, causes, and effects of environmental decay. The most fundamental outcome of these developments was the broadening of the definition "environment" in legislation to include the working and living space of Black South Africans. Subsequently, a wide range of trade unions, non-governmental organizations, civic associations, and academics adopted the new environmental discourse. Within a few short years these bodies began to challenge the environmental practices and policies of the past, with the hope of bringing in environmental equality and distributional justice (Ramphele and McDowell 1991).

In 1994, the African National Congress (ANC) came into power and realized that social, economic, and political relations were also part of the environmental equation. As a result, the ANC pledged that environmental inequalities and injustices would be addressed as an integral part of the party"s post-apartheid reconstruction and development mandate (ANC, 1994: 38). Accordingly, in 1996 the South African Constitution granted all South Africans the right to human dignity, equality and freedom. In terms of the right to equality: it stated that everyone is equal before the law and has the right to equal protection and benefit of the law. In order, to promote equality, the Constitution put in place a number of legislative measures that could be adopted to protect the rights of people who were disadvantaged by unfair discrimination. In section 24 the Constitution further adds that all citizens have a right to an "environment that is not harmful to their health and well-being" and that development should be "ecologically sustainable". When these rights are read together it becomes clear that environmental justice is part of a larger social justice paradigm, which seeks to transform the lives of people for the better.

Consequently, over the past 29 years (1994-2023), numerous policies and legislation were passed in post-apartheid South Africa, including the   Reconstruction and Development program (RDP), Spatial Development Frameworks (SDF), Development Facilitation Act (Act 76 of 1995), Habitat and Local Agenda 21 initiatives, the Green Paper on Development Planning (1999), the National Environmental Management Act (Act 107 of 1998) and National Spatial Planning and Land Use Management Act (SPLUMA, Act 16 of

728

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2013). All of these made provision for equitable green space planning. However, before any decisions could be made on the implementation by the local authority, a broad framework of stakeholders was engaged. This included public participation and several objectives were met to ensure that what was required was implemented. This often resulted in the approval of green spaces having to continuously be balanced against other urban land-uses such as housing, infrastructure, economic and business development (Cilliers, Diemont, Stobbelaar & Timmermans, 2011: 695-698). As a result, parks were not prioritized practically and this is deeply felt in everyday life for South Africans (Makakavhule & Landman, 2020). This is especially, true in government-built social housing areas, where environmental justice, sustainability and quality of life aspects have been neglected (Chishaleshale et al., 2015).

However, to provide a perspective on the scale of the neglect, a study conducted by Venter et al. (2020) found that there is environmental inequality and distribution injustice in 49 out of the 52 district municipalities. With white urban households living within 700 m of a public park, whilst African households have to walk, on average, 1.7 km (Venter et al., 2020). Furthermore, Lategan and Cilliers (2016:13) found that the more affluent suburbs, which are primarily populated by whites, have the lowest housing density but more green space per capita. This can be compared with the new low-income housing suburbs, which are primarily populated by poor Black South Africans, having the highest housing density but the least green space per capita. Despite this, little empirical research has been conducted to examine the physical attributes of neighborhood park contexts and the correlation with utilization. This additional insight could assist in understanding the differences in quality and utilsation as well as provide insight into the level of inequality on a neighbourhood level. The next section provides brief descriptions of the methodology followed to determine the quality (supply) and utilization (demand) of neighborhood parks in Potchefstroom by analyzing the parks in three different suburbs within the city.

4 METHODOLOGY

Over the last decade there have been several urban ecological studies in Potchefstroom which have focused on urban biodiversity, ecosystem services, green spaces and green economy (Cilliers, 2010a; Cilliers et al., 2013). However, these projects were focused on parks within high- and middle-income areas, and they did not provide insight into the quality distribution of parks within the city. Consequently, this research sought to address the shortcoming by investigating the correlation between the quality of neighborhood parks and the utilization of these parks in Potchefstroom, South Africa (Brasington & Hite, 2005:4).

The study area was comprised of: Area A- Botanical Gardens in the Built area (High Income), Area B- Hospital Park in Baillie Park (middle income) and Area C- Ikageng park in Ikageng (Low Income) (see map below).
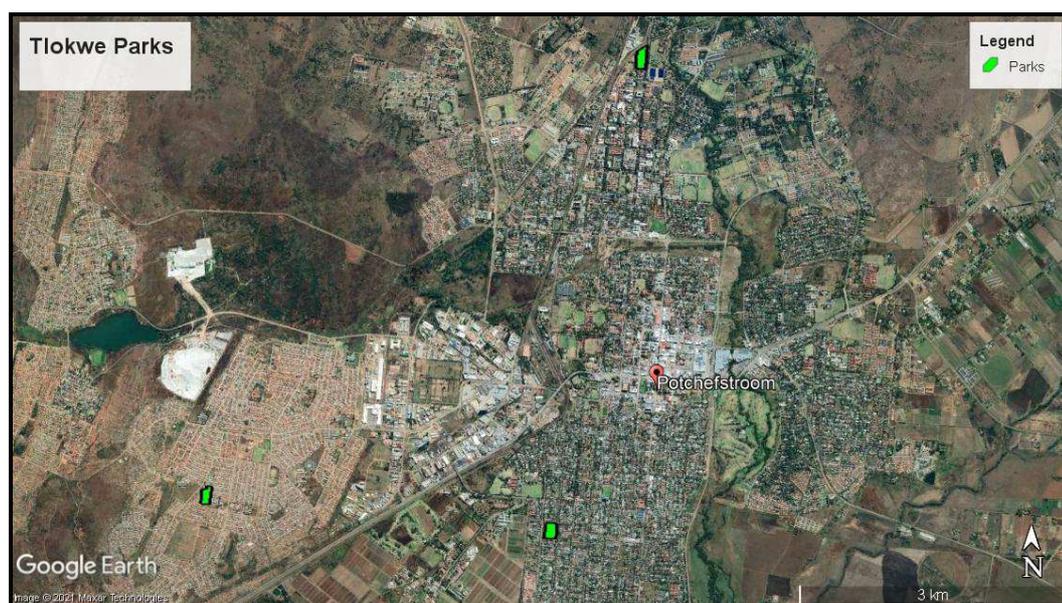

Fig. 1: Location of the three parks in Tlokwe local municipality (Source: Own composition)

These parks were chosen due to their location in the different suburbs and distance from the CBD. The researcher sought to determine if quality and utilization is affected by distance from the CBD . At each of these parks the researcher conducted semi-structured face to face interviews with randomly chosen participants from different ages, genders and races. In total 30 Interviews were conducted between 19/07/2021-22/07/2021. Responses were documented and analyzed. The next section discusses the key findings from the empirical study on the utilization and quality of parks in Potchefstroom.

5 RESULTS

There are 79 Parks in the Tlokwe Local Municipality (Potchefstroom) according to the Integrated Development Plan (IDP). Of these, 44 are considered developed, 6 semi-developed and 27 underdeveloped (JB Marks Local Municipality, 2018:246). The local municipality classifies developed parks as having green infrastructures which are regularly maintained, whilst underdeveloped parks are seen as not having adequate green infrastructure. The figure below illustrates all the open green areas around Potchefstroom.
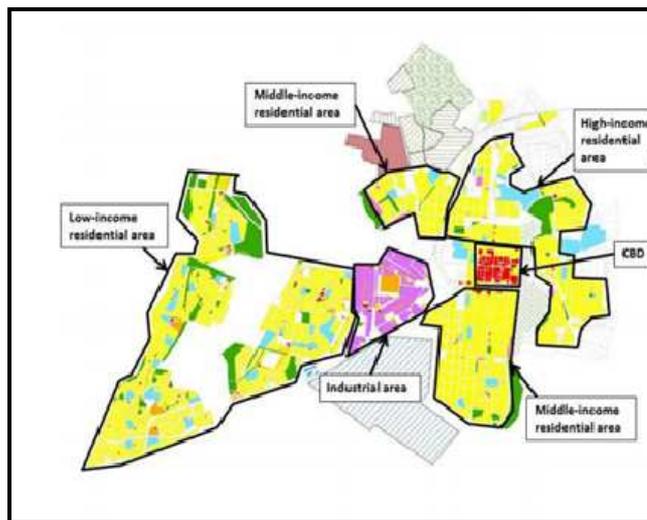
Fig. 2: Green spaces in Potchefstroom (Source: Authors Own)

Fig. 3: Location of Case study relative to CBD (Authors own)

Morphologically the map illustrates a typical Apartheid city model, and the green markings illustrate the neighborhood parks. High income localities are located in the North of the city and the lower-income residentss in the South, close to the industrial area. Analysis of the map reveals that green spaces across Potchefstroom are unequally distributed, with more green spaces in the low-income residential areas than the high-income residential area.

This finding was confirmed by the local IDP which also added that most of the "underdeveloped parks" are predominately located in the low-income residential and middle-income residential areas, while larger more well-developed parks are located in the higher income areas(JB Marks Local Municipality, 2018:246). According to the IDP the two of the three randomly chosen parks for this study that were categorized as "developed parks" (i.e Botanical Garden and Petersen park) and one of the parks was an "underdeveloped park" (i.e Ikageng Park). The next section captures the key findings on the quality of these parks (supply).

5.1 The quality of the parks

According to Urban Land Institute (2021), high quality parks have five key characteristics: 1.Are in excellent condition and are well maintained, 2. Accessible to all potential users, 3. Provide positive experiences for park users, 4. Are relevant to the communities they serve, and 5. Are flexible and adaptable to changing circumstances. In order to evaluate the quality of parks in Potchefstroom and to capture the quality of the parks, each park will be discussed under separate headings according to the above criteria and findings are motivated with images. The map below provides perspective on distance of the parks from the CBD.

A. The Botanical Gardens

The NWU Botanical Garden which is situated in the high income area was opened to the public in 1982. It is situated 4.1 KM North from the Potchefstroom CBD and covers 3ha. It has more than a 1500 plant species and provides a habitat for a variety of animals and insects. There is a variety of vast open spaces where people can come for recreational purposes and the paved footpath can be used for physical exercise (see Images below). The park also has lights, trash cans, restrooms and benches all along the paved footpaths. The park is maintained by the University but open to the public at no cost.

Fig. 4: Pictures of the Botanical Gardens (Source: Own Compositions)

This park is located in the former white suburbs and is considered to be a developed park by the Integrated Development Plan.

B. Hospital Park

This park is centrally located opposite the public hospital and is 2.7 km from the CBD. The researcher"s first observation of the park was that there is no parking available on the property and there was no fence around the park to ensure safety. The park also looked run-down, with the paving being uneven and the paint fading on buildings. The tennis court is also dilapidated and converted into a skateboard park. The restrooms are also neglected with several broken windows and no doors. While the park has various trees, many branches were cut (for fire wood) and the grass was over grown (see figure below). One of the participants also rightly pointed out that there are no benches, street lights and trash cans on the property, and as a result litter is scattered everywhere (see images below).

Fig. 5: Pictures of Petersen Park (Authors Own)

This park is considered to be developed by the Potchefstroom IDP.

C. Ikageng Park

Ikageng Park is located 7km away from the CBD in a suburb that was the former African township. At this park the researcher found that there is no parking and it could only be accessed by foot. The park has no grass and no infrastructure such as restrooms or play facilities (Swings, see-saws or jungle-gyms) lights, trash cans, benches and footpaths. The only infrastructure this park has is a set of goal posts. There is no maintenance in the park and the people of the neighbourhood use the open land to dump their trash (see figures below). Whilst the researcher was at the park there was not a lot of activity going on in the park, but those who were there stated that young boys use the park to play soccer in the afternoon and older people come to watch them play.

Fig. 6: Pictures of Ikageng Park (Source: Own Compositions)

732

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This park is considered to be under developed by the IDP.

In light of the above findings, one could conclude that the Botanical garden situated in a built area which is 4km from the Potchefstroom CBD offers the best quality green spaces, since it adheres to all 5 of the quality criteria (see table below). Both the hospital park and the Ikageng park are not considered to be high quality parks since they adhere to 0 of the five quality criteria (see table below).

Quality	Ikageng	Hospital	Botanical Garden
Distance from CBD	7km	2.7 Km	4.1 KM
Well Maintained	No	No	Yes
Accessible	No	No	Yes
Positive experience	No	No	Yes
Relevant to local community	No	No	Yes
Flexible and adaptable	No	No	No

Furthermore, the study found that the quality of parks did not depend on the distance from the CBD but rather the wealth of residents. With the hospital park, this is closer to the CBD but is of a poorer quality compared with the Botanical garden. However, parks located in the poorer area and former black townships are still found to be the least developed. The next section unpacks how each of these parks are used.

5.2 Utilization of the Parks

Utilisation can be defined as the manner in which the public use a particular space. The study found that the Botanical Garden which is located adjacent to the University had a lower utilization rate than the Hospital Park which is located opposite the hospital and the Ikageng Park in the low income area. The respondents (10) claim that they visit the botanical garden once a month, while those interviewed at the Hospital park (13) and Ikageng Park (7) claim to visit the parks daily.

The motivation for the frequent visits to the Parks (Hospital and Ikageng) was that they were easily accessible and that they offered space for recreation and exercise. However, the Botanical garden was not as frequently used due to time access restrains (8am to 4pm) and the distance from home. Additionally, many (6) respondents from the botanical garden stated that they have large gardens of their own and do not find the need to visit a park as often. Respondents from Ikageng (7) and Hospital Park (6) state that they have small gardens or no gardens and are dependent on parks for recreational space. The table below captures main findings.

Criteria	Botanical Gardens	Hospital Park	Ikageng Park
Income Group	High Income	Middle Income	Low Income
Frequency of usage	Once a month	Every day	Every day
Purpose of usage	Recreation	Recreation	Recreation
Like about park	Accessible and clean	Quiet, spacious and near home	Meeting place and soccer field
Dislike about Park	Lack of maintenance	No maintenance and insufficient infrastructure	No grass, litter everywhere, no facilities and no lights

Table 2: Findings on the utilization of Parks in Potchefstroom (Authors own)

Analyzing the responses, one finds that the botanical garden was found in the high income area and people liked it because it was accessible and clean, however, some respondents still did not like it because it was not "well maintained". However, Hospital Park which was located in the middle income area and closer to the CBD was favored since it was " Quiet, spacious and near their home". However, they also pointed out that the park was not well maintained and did not offer sufficient infrastructure such as parking, toilets, and playing facilities. On the other hand, people who used the Ikageng park claimed that they liked it because it offered them a common meeting place to play and watch soccer.

One of the main findings from the semi-structured interviews was the manner in which recreation was defined. Respondents, who were white and young (20-30 years), from the botanical garden stated that they used the park to walk, run and picnic. However, respondents who were mostly Black and middle aged (30-40years) from the hospital park used the park for recreation, but defined recreation as "sitting in the sun", "children skating" and "socializing". Some (2) stated that they use the park to sort out recycling material, since they have nowhere else to sort it. On a Sunday, if one was to drive past, one could also notice a group of people in white clothes who use part of the park, for "worshipping" purposes. On the other-hand the Park in Ikageng was used to play soccer, and the community uses it to socialize during these matches.

The main finding for the researcher was that parks offer a "sense of place", and the likes and dislikes are subjective. The researcher further asked each of the respondents if they visited any of the alternate parks in

Potchefstroom, to which they all stated that they don"t ever use other parks since they are not as accessible, and some just simply never thought of visiting parks in other suburbs.

The next section discusses the key finds to determine if there is equality of green spaces and if quality effects utilization.

6 DISCUSSION AND FINDINGS

In 1996, a one-city one tax base principle was implemented, which meant that all citizens in the city should be treated equally. This also meant that all suburbs within the city should have equal access to amenities, services and facilities- green spaces included. However, access in this case was not just about facilities being open for everyone to use, but it also meant that the quality of facilities within the city should also be the same throughout the settlement. Unfairness of distribution would foster conflict and undermine cooperation, furthermore the inequality of services would mean that some citizens would have greater benefits and a better quality of life in comparison to the rest. The section below discusses the key findings of the paper.

6.1 Inequality in green spaces

Not all impacts or benefits can be measured in monetary terms. Neither can all types of neglect and inequality be expressed in words, but some things have to be experienced first-hand, therefore the researcher attempted to capture images to provide undeniable insight into the reasons for inequality.

The study found that even though there are no restrictions on movement, the apartheid city model still has an effect on how cities look and are utilized today. The research revealed that many respondents live on city perimeters which are either due to self-limitation or economic barriers. Many low-income residents cannot access facilities within the city solely due to transportation costs, even though these facilities are free. High-income residents on the other hand have self-limitations due to "fear of others" or lack of interest, and this restricts them from exploring the poorer end of the city. Regardless, of which barrier is analyzed, we find that there are two different realities for people living within a 10 km radius in the same city. So, even though there are facilities and amenities in the city, they are only accessed by a few who live close by.

The study further found that, although GIS maps within policy documents claim that there are 79 Parks within the city, most parks are located in the former non-white areas (Ikageng, Promosa and Mohadin). However, when the researcher drove around in the vicinity to determine the utilization and quality of these parks, most of them were non-existent to an extent. "Parks" in these locations were merely open plots with no infrastructure, and were similar to the Ikageng Park. According to the inhabitants these open spaces have always been there and they were unaware that it was actually earmarked to be a park.

On paper, in 2013 the Ikageng park was supposed to be developed and its purpose was to provide the local low income residents of the community with much needed recreation facilities. It was also supposed to include multi-functional courts, a children"s play area, picnic and braai facilities and a large outdoor amphitheater. It was to have essential infrastructure such as lights, dustbins, grass patches and paving (See figure below).

However, nine years later in 2021, one can see the disparities between what was sold to the public and what was actually provided. Upon interviewing the persons within the municipality, no one could say why the project was not seen through and what happened to the money. This also brings into question the distributional injustice that children experience in the city. Children in the North (High-income) are exposed to 1500 different plants and species in the Botanical garden, while children in the South (low-income) have dirt patches, rubbish dumps and broken goal posts. The core notion of distributional justice in South Africa could therefore be questioned 30 years later.

However, the inequalities are not just spatial but they are environmental, socio and psychological. This is demonstrated through the parks in the south being poorly maintained, lacking infrastructure and not providing even grass for citizens to relax on. These green spaces which are supposed to be used for psychosocial and ecological benefits are instead being used to dump rubbish, accommodate homeless people and graze animals. It is clear that the benefits that green spaces ought to provide are not being provided in the low-income areas.

Figure 7: Ikageng Community park concept plan (Outlining landscape architecture, 2013)

6.2 Does Quality affect utilization of Green Spaces?

Parks are recognized as key public spaces that offer social value to adjacent neighborhoods. In these spaces, safety, infrastructure and maintenance are important measures of ensuring utilisation. However, the study found that these factors are not the only ones affecting the utilization of parks. The study found that the participants from low-income areas (Ikageng Park) use parks more often than the middle-income (Hospital park) and high-income participants (Botanical garden) (McConnachie & Shackleton, 2010:248). However, the question of who was utilizing the parks and for what purpose provides valuable insight into the social dynamic experience in the city.
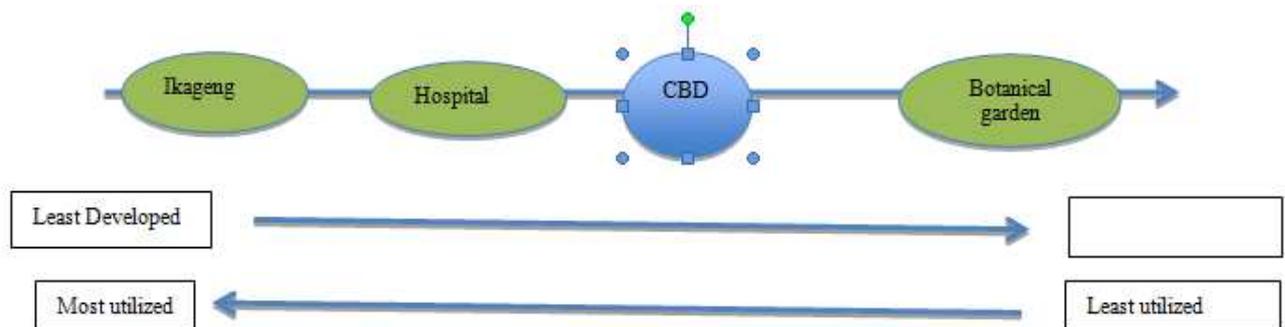

Figure 8 : The Quality vs Utilisation of Parks in Potchefstroom (Authors own)

In light of this, an article published in the local newspaper "The Herald" in August 2021, reported that homeless people live in the Hospital parks" bathrooms, and thieves, drug addicts and prostitutes loiter in the park during the day. Furthermore, the study also found that local recyclers also use the parking lot to collect and sort recyclables outside the park. As a result, local residents claim that the park is more of a stress to the local community then a recreational area. Consequently, the public has requested the municipality to demolished the park and replace it with an indoor gymnasium.

However, for the purposes of this study, it was revealed that the Hospital park and Ikageng Parks both do not have the best quality infrastructure or could be considered to be a high quality park. Nevertheless, they are still being utilized in an alternate fashion and they still offer unconventional benefits to the public. This shows that there is a difference of opinion about acceptable usages and there is still a fear of others.

In conclusion, the study found that the quality of the parks does not affect utilization; however utilization could influence the quality of the park and the neighborhood. It further revealed that the unconventional utilization of Parks deters investment, and the vicious cycle of inequality continues.

7 CONCLUSION

The study found the Apartheid city model still impacts how cities look in South Africa today. This was verified with the unequal distribution of green spaces and green infrastructure across Potchefstroom. It also found that high-income residential areas have fewer parks which are better maintained but rarely used, whereas low-income residential areas have more underdeveloped parks with almost no green infrastructure and maintenance but are used the most often. However, the less developed parks are utilized in an unconventional manner but still provide benefits to the public which include an area to socialize, graze animals, sort out recycling material, accommodation for the homeless and garbage disposal. It could be agreed that this inequality does not allow inhabitants to have the full benefit from green spaces and questions the provision of these spaces. The paper recommends that further research be conducted on the socio-psychological inequalities created by the lack of adequate facilities in the poorer neighborhoods.

8 RECOMMENDATIONS

8.1 Public awareness

There are various policies in place to support environmental equity, and the local municipality does have funds allocated to develop the underdeveloped and semi-developed parks. Nevertheless, the practical aspect is not that easy because funds are allocated according to need and officials indicate that the patching of potholes and provision of houses with water and electricity is more important than parks. That could be true and reiterates the lack of interest in green spaces. However, if the benefits of green spaces could be realized and the importance inculcated, the significance of these spaces might be realized. In light of this more public awareness and environmental knowledge is required to really bring in change.

8.2 Avoid Blue Print

Parks throughout the world have similar plans, structures and infrastructure. This structure paints the idea of high-quality parks which are implemented regardless of culture. The study has alluded to the idea that South African parks are not really considered a big deal in the higher income areas since building density is much lower and most houses have private gardens. However, parks are more valued in the lower income areas since houses and gardens are small and the needs of lower income individuals differ from high income individuals. As a result, it is important to conduct to participative planning in order to understand the needs to the community. For one, the community needs space to "worship" on a Sunday and to gather and socialize in the sun. Another need identified is for people to have space to organize their material recycling activities, and to skate. Although all these needs might not easily be accommodated within a traditional green open space, it is the requirement of the public. Therefore, planners should be innovative and willing to break from conventional blue-print development.

8.3 Access to Justice

On paper at least, South Africa"s constitutional provisions on equality, justice and freedom rank among the most progressive in the world. However, at a more practical level, many people in South Africa do not have the financial means to actively pursue costly court proceedings; especially those including environmental inequality and distributional injustices. The study has revealed the initial plan and the reality of the Ikageng park, however, the citizens of the community do not have the financial muscle or the funds to open a court case against the municipality to ensure justice.

As a consequence, public interest law firms and civil societies are required to look at cases such as Ikageng, and seek justice and equality for those who cannot achieve it themselves. If local government is not held accountable for empty promises, the vicious cycle of inequality will continue.

9 FUNDING

10 REFERENCES

ASTELL-BURT, T., & FENG, X. (2019). Does sleep grow on trees? A longitudinal study to investigate potential prevention of insufficient sleep with different types of urban green space. 100497–100497 SSM - Population Health, 2019.

CILLIERS, E.J. Creating Sustainable Urban Form. Germany: VDM Verlag. ISBN 978-3-639-22888-5.268p, 2010.

CILLIERS, E.J., DIEMONT, E., STOBBELAAR, D.J., TIMMERMANS. W. Sustainable green urban planning: the workbench spatial quality method, Environment and Planning B: Planning and Design 38 (4), 579-584, 2011.

CHISHALESHALE, M., SHACKLETON, C. M., GAMBIZA, J., & GUMBO, D. The prevalence of planning and management frameworks for trees and green spaces in urban areas of South Africa. Urban Forestry & Urban Greening, 14(4), 817–825, 2015.

DAI, D. Racial/ethnic and socioeconomic disparities in urban green space accessibility: Where to intervene? Landscape and Urban Planning, 102(4):234-244, 2011.

DU TOIT, M.J., CILLIERS, S.S., DALLIMER, M., GODDARD, M., GUENAT, S., and CORNELIUS, S.F. Urban green infrastructure and ecosystem services in sub-Saharan Africa. Landscape and Urban Planning. Vol. 180: 249-261, 2018.

FERGUSON, M., ROBERTS, H.E., MCEACHAN, R.R. and DALLIMER, M. Contrasting distributions of urbangreen infrastructure across social and ethno-racial groups. Landscape and Urban Planning, 175:136-148, 2018.

GWEDLA, N., and SHACKLETON, C. M. Population size and development history determine street tree distribution and composition within and between Eastern Cape towns, South Africa. Urban Forestry & Urban Greening, 25, 11–18, 2017.

JB MARKS LOCAL MUNICIPALITY. Final Integrated Development Plan, 2018.

KURUNERI-CHITEPO, C. and SHACKLETON, C, M. The distribution, abundance and composition of street trees in selected towns of the Eastern Cape, South Africa. Urban Forestry & Urban Greening. Vol. 10 (3).pp: 247-257, 2011.

LATEGAN, L. & CILLIERS, J. Considering urban green space and informal backyard rentals in South Africa: Disproving the compensation hypothesis. Town and Regional Planning, 69:1-16, 2016.

LEHOHLA, P. & SHABALALA, N. Inequality in South Africa. Development, 57(3):497-511, 2014.

LEONARD, T., POWELL-WILEY, T.M., AYERS, C., MURDOCH, J.C., YIN, W. and PRUITTE, S.L. Property Values as a Measure of Neighborhoods an Application of Hedonic Price Theory. Epidemiology. Vol. 27(4), 2018.

MCCONNACHIE, M., & SHACKLETON, C. M. Public green space inequality in small towns in South Africa. Habitat International, 34(2), 244–248, 2010.

OUTLINE LANDSCAPE ARCHITECTS. Ikageng Park, 2013.

RABARE, S., OKECH, R. and ONYANGO, G. The role of urban parks and socio-economic development: Case study of Kisumu Kenya. Theoretical and Empirical Researches in Urban Management. 4. 22-36, 2009.

RICE, J.L., COHEN, D.A., LONG, J. &; JURJEVICH, J.R. Contradictions of the climate-friendly city: newperspectives on eco-gentrification and housing justice. International Journal of Urban and Regional Research, 44(1):145-165, 2020.

ROJAS-RUEDA, D., NIEUWENHUIJSEN, M.J., GASCON, M., PEREZ-LEON, D., MUDU, D. Green spaces and mortality: a systematic review and meta-analysis of cohort studies. The Lancet Planetary Health. Vol: 3 (11) pp: 469-477, 2019.

ROJAS, C., PÁEZ, A., BARBOSA, O. & CARRASCO, J. Accessibility to urban green spaces in Chilean cities using adaptive thresholds. Journal of Transport Geography, 57:227-240, 2016.

SEEKINGS, J. Race, class and inequality in the South African city. The new Blackwell companion to the city. 532-546, 2011.

SHACKLETON, C.M., BLAIR, A., DE LACY, P., KAOMA, H., MUGWAGWA, N., DALU, M.T. & WALTON, W. How important is green infrastructure in small and medium-sized towns? Lessons from South Africa. Landscape and Urban Planning, 180:273-281, 2018.

THE HERALD. Die Hospitalpaark n" seer oog en gevaar vir publiek, 2021.

ULRICH, R. S., ZIMRING, C., QUAN, X., JOSEPH, A., & CHOUDHARY, R. The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity (pp. 1–69). The Center for Health Design, 2004.

URBAN LAND INSTITUTE. Five Characteristics of High-Quality Parks.Washington, DC: Urban Land Institute, 2021.

VENTER, Z.S., SHACKLETON, C.M., VAN STADEN, F., SELOMANE, O. & MASTERSON, V.A. Green Apartheid: Urban green infrastructure remains unequally distributed across income and race geographies in South Africa. Landscape and Urban Planning, 203:103-115, 2020.

WOLCH, J.R., BYRNE, J. & NEWELL, J.P. Urban green space, public health, and environmentaljustice: The challenge of making cities „just green enough". Landscape and Urban Planning, 125:234- 244, 2014.

ZUNIGA-TERAN, A.A., STADDON, C., DE VITO, L., GERLAK, A.K., WARD, S., SCHOEMAN, Y., HART, A. & BOOTH, G. Challenges of mainstreaming green infrastructure in built environment professions. Journal of Environmental Planning and Management, 63(4):710-732, 2020.

The Possibility of Including Habitat Types as Nature-Based Solutions in Spatial Planning Documents: the Case of Slovenia

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1 ABSTRACT

There are many forms of NBS for contemporary urban challenges that reflect individual elements or facilities in urban space, but a systematic and comprehensive implementation of NBS in urban planning documents has not yet been observed. In this paper, we use unaltered native habitat types (HTs) as innovative forms of NBS that originate from the natural or semi-natural environments of the same region as the targeted urban environment, which is the subject of urban planning. We draw on a planning approach that attributes added value (a function in addressing urban challenges such as air pollution, noise, stormwater management, and urban heat island) to HT, thus linking the concepts of NBS and HT in an innovative way to integrate them into urban planning. Based on a qualitative content analysis of spatial planning documents in the case of Slovenia, the paper presents a proposal for the inclusion of HTs as NBS in spatial planning documents at national, regional, and local levels. It was found that strategic spatial planning documents are suitable for defining the concept of NBS as a way of addressing urban challenges, while key to integrating HT as NBS into existing spatial planning practice are the spatial implementing document sat national and municipal levels, as well as the Urban Development Concept as a mandatory technical basic document for these acts.

Keywords: spatial planning documents, habitat types, nature-based solutions, urban challenges, environment

2 INTRODUCTION

The concept of nature-based solutions (NBS) is firmly established in European urban policy, but its systematic and integral implementation in urban planning documents is yet to be observed. NBS are based on natural or nature-mimicking processes with the aim of solving social challenges (Cohen-Shacham et al., 2016; European & Directorate-General for Research and, 2015; Goličnik Marušić et al., 2023). We focus on NBS in urban areas. The most typical urban challenges to which NBS can respond are mainly particulate and gaseous air pollution, noise, stormwater runoff, and urban heat island (Ferrini et al., 2020; Raymond et al., 2017).

There are many forms of solutions to urban challenges in the literature, referred to as nature-based solutions, that reflect individual elements or facilities in urban spaces (e.g., green roofs, urban gardens, rain gardens, permeable paving, urban woodland, vertical greening systems, open green systems, constructed wetlands, river floodplains). In this paper, we used unmodified natural terrestrial and freshwater habitat types (HTs) found in Europe as forms of NBS for urban challenges. HTs as NBSs originate from the natural or semi-natural environments from the same region as the targeted urban environment that is the subject of urban planning. HTs are notable spatial units for conservation practice and their spatial definition can be directly represented graphically in spatial planning documents. Recognizing their ability to effectively solve urban challenges such as temperature reduction, stormwater management, noise reduction, air quality improvement, and CO_2 concentration reduction through their ecosystem processes (such as evapotranspiration, shading, water purification, water retention, noise attenuation, particle deposition, carbon sinks) gives us the opportunity to treat them as NBSs represented directly in spatial planning documents. The following characteristics, defined by Dremel et al. (2023),represent a basic starting point for understanding natural HTs as NBS:

(a) They do not require (extensive) maintenance (e. g. supplemental watering) and are self-sustaining, unlike agricultural and urban Hats'

(b) They are more resilient to pests, weather and climate conditions, and other disturbances than HTs of non-native species.

(c) They contribute to the biodiversity of native species.

This paper focuses on the pilot attempt to integrate HTs as NBS in spatial planning documents, from the strategic and national level to the implementation level and the local level. The aim of the paper is to present a proposal for the inclusion of HTs as NBS in spatial planning documents using the example of spatial planning in Slovenia. The result of the pilot test is a conceptual proposal that shows how HTs can be included in binding spatial components that are NBS and not only as spatial units for nature conservation in mandatory spatial planning documents relevant for nature conservation.

In Slovenia, the urban environment faces the following urban challenges that could be addressed by the implementation of HTs and on which our research focuses:

(a) urban heat island (Cerar, 2020; Darko & Krevs, 2015; Komac et al., 2016) and thus the need to reduce surface temperature, especially during hot summer weather.

(b) urban pluvial flooding (Klemen et al., 2020; Krajnc, 2019)and thus the need for efficient stormwater management to regulate urban surface runoff.

(c) noise pollution from road and rail traffic (Cegnar et al., 2022; Prislan & Kvasič, 2021) and therefore the need for noise reduction.

(d) particulate matter (PM10) air pollution, mainly from traffic and small wood-fired biomass combustion plants (Cegnar et al., 2022; Koleša, 2021), and therefore need for air quality improvement.

2.1 Spatial documents in the planning system in Slovenia

The overarching law for spatial planning in Slovenia is the Spatial Management Act ("Zakon o urejanju prostora (ZUreP-3)", 2021). It defines in detail the objectives, principles and rules of spatial planning, actors, spatial planning documents and procedures for site selection, detailed planning and approval of spatial developments of national importance, as well as other spatial measures, instruments, monitoring, operation of the spatial information system and issuance of certificates in the field of spatial planning. Spatial planning is implemented through the preparation and drafting of spatial planning documents and national spatial planning procedures. A Spatial Management Act defines the spatial development of the country, regions and municipalities (strategic spatial planning documents), and determines the implementation of spatial regulation (spatial implementation documents). In addition to main spatial planning documents, all the mandatory documents under the ZUreP-3, which directly affect their preparation, are also important and are therefore also the focus of the study.

Spatial planning documents are both strategic and implementing. Strategic documents take precedence over the implementing documents and are coordinated so that the implementing documents do not conflict with strategic documents. In Figure 1, the strategic spatial planning documents are shown in the left column in the middle box and the spatial implementing documents in the right column in the same box. The central frame in Figure 1 also shows the relationships between them and the level of responsibility for their preparation (State, Region, Municipality).

In addition to the hierarchy and typology of spatial planning documents, Figure 1 shows that the overarching framework for spatial planning, which includes the approval and implementation of spatial planning interventions and the implementation of other spatial planning tasks, is the National spatial order (DPR) (represented by the outer frame surrounding the central framework of spatial planning documents), and the documents that are mandatory for certain spatial planning documents, which influence their preparation and approval (the list of documents is shown outside of the frame).

3   METHODOLOGY

To assess the potential of including HT as NBS in spatial planning documents that influence spatial planning in Slovenia, or in spatial planning instruments at the national, regional, and municipal levels, we developed a set of criteria for qualitative content analysis. Each document was evaluated according to the following three criteria:

 (1) Determination of the status of HTs and NBS participation in the document: in order to determine the situation, we analysed documents whose orientations are defined for the entire country of Slovenia, and which were therefore analysed in terms of their content objectives, recommendations, orientations, etc. When analysing each document, we asked whether it in any way involves HT and the NBS, or, if the NBS is not explicitly mentioned/referred to, whether the document's guidelines are consistent with the NBS concept.

740

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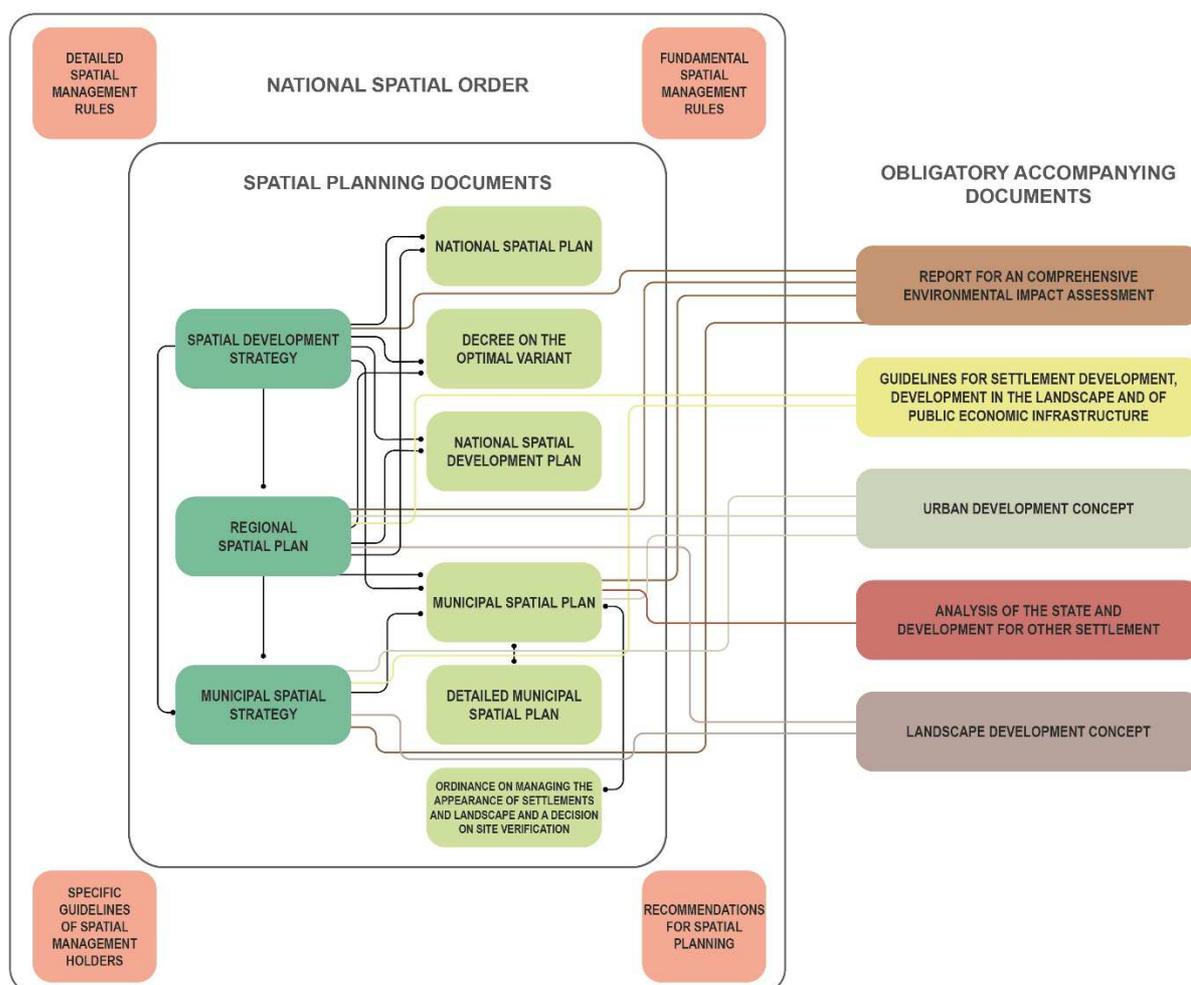
Figure 1: Spatial documents and their links under the Spatial Management Act (ZUreP-3)

The following documents were analysed for content: Draft Spatial Planning Strategy; Specific guidelines of spatial management holders of National spatial order, National spatial order (DPR) and DPR recommendations for spatial planning. For the spatial planning documents prepared for individual areas (Regional Spatial Plan (RPP), National Spatial Plan (DPN), Municipal Spatial Strategy (OPP),Municipal spatial plan (OPN),Detailed Municipal Spatial Planning Plan (OPPN), and mandatory background documents, we examined their drafting instructions, which are mainly contained in the Spatial Management Act (ZUreP-3) or in specific publications.

(2) Rationale for including NBS and HT as NBS in the documents: This was justified based on our knowledge of the concept of NBS, the content included in spatial planning documents, their scale, and their impact on lower-level spatial planning documents. In some documents, we acknowledged the reasonableness for including NBS as a concept, while in others, primarily the implementing documents, we fleshed out NBS as HT.

(3) Possibilities and opportunities to include NBS and HT as NBS in the planning document: These were identified primarily in the way each document is created to integrate with established spatial planning practices, rather than adding new procedures or documents.

Based on Criteria 2 and 3, if we have determined that it is appropriate to include HTs as NBSs or there are possibilities and/or opportunities for their inclusion in the graphic and descriptive parts of the relevant spatial planning document, we have proposed for each document how HTs can be included as NBSs.

4 RESULTS

4.1 Status of the inclusion of HTs and NBS in spatial planning documents

The results show that there is no analysed spatial document that explicitly refers to the NBS concept, but in terms of knowledge about NBS and urban planning, we were able to identify different paraphrases and terms in the documents that lead to the same goals as the implementation of NBS.HT as a spatial unit is mentioned only where the analysed document refers to nature conservation and thus understands and considers it in terms of limiting interventions in space.

4.1.1   Strategic spatial planning documents

The Draft Spatial Planning Strategy and Regional Spatial Plan (RPP) and the Guidelines for the preparation of Strategic Spatial Documents at the regional and municipal levels do not directly address the NBS concept. They focus only on green spaces, green infrastructure, and the region's green system. This is likely due to the fact that green infrastructure is a very strategic approach to planning and NBS can also be seen as a tool to implement green infrastructure principles and are therefore more applicable at other planning levels.

The Draft Spatial Planning Strategy identifies green areas as effective means of addressing urban challenges, as the goals and implementation of the Spatial Development Strategy of Slovenia(SPRS) concept includes efforts to address urban challenges through vegetation (e.g. preservation and creation of floodplains, and a greater proportion of well-managed and maintained green areas to mitigate extreme events and heat islands) or recognizing the value of vegetation and water bodies in general, which are the beginnings of the introduction of the NBS concept. The Regional Spatial Plan(RPP) emphasises the importance of the region's green system for ecological connectivity of ecosystems and creating conditions for their conservation, but does not recognise the importance of these areas for addressing urban challenges. Strategic spatial plans do not address HT, but efforts to conserve habitats in general can be recognised. The spatial scale of the maps in the strategic spatial planning documents is not detailed enough to show individual HTs for urban challenges.

4.1.2   Spatial implementing documents

The analysis shows that spatial implementing documents for individual areas are prepared according to guidelines that do not include the NBS concept. As for the HTs, only those that are relevant for nature conservation are addressed. For example, the National Spatial Plan (DPN)addresses HT in the planning of nature conservation areas established by the state and in the environmental reports for each plan if there are HT of nature conservation importance in the area of the proposed development. The Decree on the optimal variant(UNV) and National Spatial Development Plan (DPUN) also address the nature conservation importance of HT as a constraint to development. The spatial scale of implementation planning at municipal level (Municipal Spatial Plan and Detailed Municipal Spatial Plan) is suitable for highlighting HTs and addressing specific urban challenges, while the Municipal Spatial Plan (OPN) and Detailed Municipal Spatial Plan (OPPN), together with the Ordinance on Management of the Appearance of Settlements and Landscape(UONK), are key documents for permitting, promoting, or preventing certain interventions in the urban environment.

4.1.3   National Spatial Order (DPR)documents

Based on the content analysis of the National Spatial Order(DPR) documents, we note that the concept of NBS is implicit or potential in the guidelines documents from the field of settlement space, protection from natural and other disasters, energy, water management, and nature conservation, while HT as a spatial unit of nature conservation importance is included only in the Guidelines for Nature Conservation. The recommendations for spatial planning, as presented by Šuklje Erjavecet al. (2020), and Čufer and Ribič (2021), indirectly refer to the concept of NBS, but do not mention it explicitly and do not address HT or define green areas in relation to HT.

4.1.4   Obligatory accompanying documents

All obligatory accompanying documents to spatial planning documents or their drafting instructions address nature conservation-related HTs as constraints on spatial interventions, but the NBS concept is not found in them. We identify the Urban Development Concept (UZ) and Landscape Development Concept (KZ)as relevant for the NBS and HT, which provide an interdisciplinary and comprehensive expert basis and have

742

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the status of obligatory accompanying documents, and therefore focused only on these two documents in the further analysis of the accompanying documents for strategic and implementing spatial planning documents. For the urban challenges considered here, the Urban Development Concept, which targets urban areas, is more relevant than the Landscape Development Concept, which targets areas outside the built-up area.

4.2 Rationale and possibility to include NBS and HT as NBS in the documents

	Docume nt	Explanation of reasonableness and possibility	
		NBS	HT as NBS
Strategic Spatial Planning Documents	Spatial Develop ment Strategy of Slovenia (SPRS)	Development documents by area and sector must not contradict the strategy. Therefore, it is essential for the introduction of the NBS concept at the local level that these documents recognise it as an appropriate and effective way to address the challenges.	As we look for ways to use HTs to create a better quality of urban living environment, the scale of spatial planning at national level is too high for them and therefore it does not make sense to include HTs in the graphic representations of the SPRS. In the descriptive part of the SPRS, individual HTs in urban areas should be understood as smaller spatial units than green spaces and blue spaces or their individual elements that also occur in other areas, such as residential areas. The conservation or restoration of HTs in urban and periurban environments should be argued not only in terms of biodiversity, but also in terms of their direct contribution to solving urban challenges. The SPRS provides an opportunity to include this understanding of HT into the orientations for achieving the SPRS objectives, while also including it in the indicators for monitoring the implementation of the SPRS.
	Regional Spatial Plan (RPP)	Areas identified in the RPP as important for nature conservation should also be identified based on their functions in addressing societal challenges, making them part of the environmental infrastructure (and not just nature conservation). The NBS concept provides an opportunity to develop this kind of understanding of the region's green system. NBSs as means of addressing urban challenges should be identified and presented a guiding principle in the report. Prior to developing the RPP, urban challenges need to be well defined, especially those whose impact extends beyond municipal boundaries or need to be addressed on an inter-municipal level. In addition to the defined challenges, the RPP expert base can use the NBS concept to propose appropriate solutions. This can provide space for appropriate solutions already at the regional level and be can be directly transferred to the OPN.	The planning scale is too small to show in the graphic part the positioning of specific HTs to address urban challenges, which requires a scale of 1:5000.
	Municipa l Spatial Strategy (OPP)	The OPP should follow other national development documents and EU development objectives, including the NBS concept. As the OPP is prepared for urban communities, consideration of urban challenges (already in the expert bases) is even more important than in the regional plan. The OPP spatial scale may already be relevant for NBS planning for specific urban challenges.	The OPP shows the layout of the planned networks (e.g., municipal infrastructure, green system), so it is not yet a suitable spatial document for locating specific HTs as NBS. As it defines the areas for which the UZ or KZ is to be elaborated, HT as NBS can be considered as NBS within these two expert bases.
Spatial Implementing Documents	National Spatial Plan (DPN) Decree on the optimal variant (UNV) National Spatial Develop ment Plan (DPUN)	In the context of national spatial planning, NBS can serve primarily to mitigate the negative impacts that new planned elements cause in space (e.g., noise reduction, particulate matter deposition and thus air quality improvement, stormwater retention, etc.).	These spatial planning laws define the spatial implementation laws of the municipalities, so it is important that HT is provided as NBS in these documents. It is important that HT be more specifically defined as a form of NBS in the UNV, as this draft provides space for planned spatial development. A detailed graphic representation of the planned/warned HTs as NBS at a scale of 1:5000 is reasonable in the DPUN.
	Municipa l Spatial Plan (OPN)	The OPN is referred to as an important spatial planning tool for the introduction of the NBS concept in urban areas(especially for the settlements for which no UZ is prepared). However, it is important that the urban challenges and their management are defined in the development programmes and do not contradict the orientations in strategic documents.	HT can be mapped in the graphic part and presented in the descriptive part, while the content is transferred in more detail to the subordinate documents (OPPN and OUNK).
	Detailed	As a municipality can change the land use or spatial	HTs may be presented in the OPPN as NBS in

	Municipal Spatial Plan (OPPN)	implementation conditions through an OPPN without first changing the OPN, this spatial planning tool is particularly suitable for urban areas with an already defined OPN.	appropriate detail.
	Ordinance on managing the appearance of settlements and landscape (OUNK)		How HTs implemented in the urban environment to act as NBS are managed can be written into the OUNK.
National Spatial Order (DPR) documents		As spatial planning documents are prepared based on and in accordance with the various recommendations, the NBS concept should be properly identified, interpreted and recommended within the DPR, in particular in the recommendations in the areas of settlement development, water management, nature conservation, energy, protection and safety, sustainable mobility, road and rail transport and motorways. There is also an opportunity to develop specific spatial planning recommendations for the NBS concept.	An important improvement would be to start to identify existing HTs that are important for the quality of the living environment, in addition to HTs that are important to conservation, and to protect them accordingly.
accompanying Obligatory documents	Urban Development Concept (UZ)	The development of UZ is based, among other things, on spatial solutions that arise from the challenges of the settlements. It therefore makes sense to incorporate NBS in UZ to address urban challenges by addressing challenges and solutions in a holistic and systemic manner at the whole settlement level. NBS as a mean to address challenges should be defined in the development vision and professional backgrounds of the UZ. In this way, UZ can provide an important professional basis for the implementation of NBS in the preparation of RPP, OPP and OPN.	In IP/UZ, as an expert base, the NBS can be concretized by placing appropriate HTs.

Table 1: Spatial documents in which it makes sense to involve NBS and/or HT as NBS to address the urban challenges

The spatial documents that have proven to be suitable for the integration of HT as NBS for the urban challenges in their graphic and descriptive parts and in their elaboration procedures are the spatial implementing documents:

- at the level of national spatial planning, the National Spatial Plan (DPN), the Decree on the optimal variant (UNV) and the National Spatial Development Plan (DPUN),

- at the level of municipal spatial planning, the Municipal Spatial Plan (OPN) and its subordinate Detailed Municipal Spatial Plan (OPPN) and Ordinance on managing the appearance of settlements and landscape (OUNK),

- and Urban Development Concept (UZ) as an expert study for the OPP, OPN and/or RPP.

4.3 Proposal for how to include HTs as NBS into spatial planning documents

In the following, we make suggestions for the inclusion of HT as NBS in the existing components of the implementing spatial planning documents of national and municipal spatial planning, as well as UZ as expert studies that have proven to be relevant spatial planning documents for the inclusion of HT as an NBS.

4.3.1 Inclusion of HT as NBS in spatial implementation acts of national spatial planning

In developing the DPN, we suggest that expert studies identify and map HTs (especially bypasses, forest, wetlands) that already function as NBS and protect them in the same way as HTs of nature conservation importance (e.g., by prohibiting construction or creating alternative HTs). At the same time, the placement of appropriate HTs should be required to avoid negative impacts from development. This could be the subject of a separate expert study from the environmental report, as it is important to include the concept of NBS and HT in the initial stages of the developing potentially viable options, rather than in the evaluation of the selected option. HTs would be shown on maps at 1:5000 scale or smaller, depending on the size of the planned or protected area, or they would be shown in the descriptive part of maps at a larger scale, e.g., a specific (named) HT is established in a specific dry reservoir.

744

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4.3.2 Inclusion of HT as NBS in spatial implementation documents of municipal spatial planning

We suggest that in the development of the OPN, the assessment of the situation and future needs of the area identifies the urban challenges that can be solved by the NBS and proposes solutions to them in the expert studies by locating or protecting the corresponding HT at a scale of 1:5,000 or more detailed. This is crucial in the initial phase, in particular for dividing the area into the corresponding spatial planning units, determining the corresponding land use designations, and the spatial implementation conditions. As the division of the OPN area into spatial units should be based on the specificity of the urban space and may also be determined by specific protection regimes (e.g., water resources, Natura 2000) and not necessarily by infrastructure corridors, the space could be subdivided according to urban challenges and designated or protected HTs. Currently, the most characteristic spatial morphological units of unified spatial planning are land use zones such as single-family houses, dense (closed) housing, historic settlement core, production areas, green areas, economic zones, etc., which means that they are mainly defined by activities and facilities. For the areas where NBS interventions are foreseen, the OPN must provide for the preparation of an OPPN, since the OPPN, among other things, presents in more detail the technically justified spatial arrangements for the implementation of environmental and nature protection measures. Planners of the OPPN can either preserve the HT or create a new one through provisions on a specific parcel. It is important that, in addition to the existing HTs that are important for nature conservation, HTs that are important for maintaining a high quality living environment are identified and mapped, appropriately protected, and the possibility to use these areas is established.

In the already adopted OPNs, it is useful to identify urban challenges within specific spatial planning units, as these allow for different types of actions in the area. A single HT as NBS should not be equated with a land use designation when drafting or updating new spatial planning legislation, as they can occur in small areas within different land uses, e.g., within residential areas, economic zones, transport infrastructure areas. However, where larger contiguous areas of HT are envisioned to address challenges (flat ground occurrence of HT), it makes sense to provide for a separate, more detailed land use designation. Considering the existing types of basic and detailed land use designations, we suggest that the larger areas of HT be placed in one of the following detailed land use designations:

- other maintained green areas which, according to the regulations, are green belts with a protective or other function;

- wooded areas in the case of forest HT;

- water areas on land in the case of inland or marine water HT or water infrastructures, so that their ecological function can be specified, e.g., for water purification or water retention;

- areas related to protection against natural and other disasters for HTs that contribute to protection against natural disasters such as floods, landslides and fires;

- areas of environmental infrastructure if HT, which has an identified important function e.g., wastewater treatment, water retention for later use, etc., were defined as public economic infrastructure, which would require modifications in legislation to recognise the broader, not just nature conservation, importance of HT.

To address the challenges posed by HTs, it is important that their location or protection is adequately defined in the spatial implementation conditions, as these directly determine the design of spatial interventions. In a specific spatial planning unit, specific HTs, their uses (accessibility, types of recreation, etc.)protection regimes, specific restrictions and requirements should be defined. Within these provisions, there is an opportunity to understand and predict the occurrence of HT also on green roofs and vertical greening types, and not only on flat and paved surfaces. This will require further interdisciplinary research. HTs to be provided or protected should be shown in detail on the site.

For HTs that allow other land uses for residents in addition to their primary function as NBS (e.g. recreation), it is important that the established allowable land use of the particular spatial planning unit is appropriate for their placement in the spatial planning unit (allow for sufficiently large areas). In our opinion, HTs that do not serve recreational use for the population cannot be counted towards the absolute area of open green or other areas that serve the common use of the population. However, in addition to the so-called

required absolute area of open green spaces, it would also be useful to define the absolute area of specific HTs to address a specific urban challenge within a given spatial planning unit.

The OUNK provides the opportunity to define the appearance of HTs, their allowable or minimum size, design requirements, etc., which may vary from settlement to settlement, depending on their distinctive characteristics and identity. Care must be taken to ensure that the design of HT does not take precedence over its NBS function. As the decree aims to improve the quality of the environment and mitigate the effects of climate change, the municipality may include in this spatial planning document (which may be merged with the OPN) a requirement to implement NBS for certain spatial interventions, e.g., construction of rain gardens, green roofs with/or appropriate HTs.

4.3.3   Inclusion of HT as NBS in Urban Development Concept (UZ)

The UZ should identify HTs that are already part of the city's existing green system and have an important NBS function (e.g., flood protection, cooling of the surrounding area). Such areas should be given a conservation value and protected at a scale of 1:5,000 on a unit basis. In addition, their integration with urban functions (accessibility, recreational opportunities, sustainable mobility routes, etc.) should be determined. The determination of what percentage of the urban area should be occupied by HTs should be considered on a unit-by-unit basis and determined based on expert evidence on the effects of HTs.

5   CONCLUSION

In this paper, the concept of NBS and HT as a form of NBS is applied to the case of the Slovenian planning system, with the proposal to integrate it into the existing spatial planning documents and place it in the scope of spatial planning. Based on a systematic review of spatial planning documents, we found that in strategic spatial planning documents and national spatial planning documents, especially in the spatial planning guidelines for sectors and spatial planning recommendations, there is an opportunity to define the concept of NBS as a way to address the upcoming urban challenges, thus defining NBS as a vision and goals for spatial development. The key to the integrating HT as NBS into existing spatial planning practice is spatial implementation documents, both at the national and municipal levels, and UZ as the mandatory expert basis for these documents. Understanding and translating the concept of NBS from EU-level policy documents into national, regional and local strategic documents will be the key to their widespread adoption. However, further research on the performance and environmental requirements of HTs, with an emphasis on interdisciplinary and multi-criteria evaluation, is needed to promote a planning approach that spatially locates appropriate HTs as NBS for urban challenges.

6   REFERENCES

Cegnar, T., Bolte, T., Bernard Vukadin, B., Ulamec, P., Karo Bešter, P., Koleša Dobravc, T., . . . Sočan, M. (2022). Poročilo o okolju v Republiki Sloveniji 2022. 1 spletni vir (1 datoteka PDF (642)).

Cerar, K. (2020). Opazovanje mestnega toplotnega otoka : diplomska naloga [Diplomsko delo, Fakulteta za gradbeništvo in geodezijo]. Repozitorij Univerze v Ljubljani. https://repozitorij.uni-lj.si/IzpisGradiva.php?lang=slv&id=120606

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based Solutions to address global societal challenges. I. U. f. C. o. N. a. N. Resources.

Darko, O., & Krevs, M. (2015). Assessing urban heat island impact on long-term trends of air temperatures in Ljubljana. Dela, 41-59. https://doi.org/10.4312/dela.43.41-59

Dremel, M., Goličnik Marušić, B., & Zelnik, I. (2023). Defining Natural Habitat Types as Nature-Based Solutions in Urban Planning. In Preprints: Preprints.https://doi.org/10.20944/preprints202309.0054.v1

European, C., & Directorate-General for Research and, I. (2015). Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities : final report of the Horizon 2020 expert group on 'Nature-based solutions and re-naturing cities' : (full version). Publications Office. https://doi.org/doi/10.2777/479582

Ferrini, F., Fini, A., Mori, J., & Gori, A. (2020). Role of Vegetation as a Mitigating Factor in the Urban Context. Sustainability, 12(10).

Goličnik Marušić, B., Dremel, M., & Ravnikar, Ž. (2023). A frame of understanding to better link nature-based solutions and urban planning. Environmental Science & Policy, 146, 47-56. https://doi.org/https://doi.org/10.1016/j.envsci.2023.05.005

Klemen, K., Pergar, P., Fatur, M., Bevc Šekoranja, B., & Konda, K. (2020). Problematika načrtovanja sonaravnih ukrepov za celovito upravljanje padavinskih voda na urbanih območjih = The issues of planning nature-based solutions for integrated stormwater management in urban areas. (69), 73-81.

Koleša, T. (2021, 12.3.2021). Onesnaženost zraka z delci PM10 in PM2,5. Agencija Republike Slovenije za okolje. http://kazalci.arso.gov.si/sl/content/onesnazenost-zraka-z-delci-pm10-pm25-7

Komac, B., Ciglič, R., Loose, A., Pavsek, M., Čermelj, S., Oštir, K., . . . Topole, M. (2016). Urban Heat Island in the Ljubljana City. In (pp. 323-344). https://doi.org/10.1007/978-3-319-10425-6_12

Krajnc, U. (2019). Podnebne spremembe in poplavna ogroženost urbanih območij z lastnimi padavinskimi vodami = Climate change and urban pluvial flooding risk. (68), 110-119.

Prislan, U., & Kvasič, T. (2021). Izpostavljenost hrupu zaradi prometa. Agencija Republike Slovenije za okolje. Retrieved 28.5.2021 from http://kazalci.arso.gov.si/sl/content/izpostavljenost-hrupu-zaradi-prometa-0

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., . . . Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science & Policy, 77, 15-24. https://doi.org/https://doi.org/10.1016/j.envsci.2017.07.008

Zakon o urejanju prostora (ZUreP-3), (2021). http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO8249

Čufer, T., & Ribič, P. (2021). Ozelenitev streh in vertikalnih površin: priporočila. Ministrstvo za okolje in prostor, Direktorat za prostor, graditev in stanovanja.

Šuklje Erjavec, I., Kozamernik, J., Balant, M., & Nikšič, M. (2020). Zeleni sistem v mestih in naseljih : usmerjanje razvoja zelenih površin : priročnik. Ministrstvo za okolje in prostor, Direktorat za prostor, graditev in stanovanja.

The Potential of Bio-Based Insulation Materials for Healthy Living Spaces and Sustainable Architecture

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1 ABSTRACT

In Germany, 30 % of CO_2 emissions and 35 % of final energy consumption are due to the operation of buildings.[1] The building sector must therefore make an intensive contribution to the energy transition. In addition to the requirement to operate every new heating system with 65 % renewable energies from January 2024, the energy-efficient refurbishment of existing buildings, for example by installing new windows or upgrading thermal insulation, is to be massively promoted in order to reduce energy consumption and emissions. The renovation of the building stock should contribute significantly to the EU's goal of climate neutrality by 2050. In order to achieve a climate-neutral building stock, the operating energy and in particular the non-renewable share of primary energy must be drastically reduced and the remaining energy demand must be covered predominantly with renewable energy sources.[2] A large part of the operating energy of buildings is due to the heating or cooling systems in living spaces. Appropriate building insulation, especially in existing buildings, can save energy at this point. Do we want to continue this energy upgrade of our buildings with synthetic materials from finite resources, some of which have been proven to endanger our health, or will we succeed in the biological insulation turnaround that would bring energy-efficient, sustainable and healthy living spaces? With a view to the desired climate neutrality of the EU, is it not a logical conclusion to refurbish the building stock with insulation materials that consume as little energy as possible in their production, while causing virtually no emissions?

In answering these questions, it is important to consider the potential of biological insulation materials. What raw materials are available? What are the manufacturing processes? How are the material properties and durability of biological insulation materials to be assessed?

The paper examines biological insulation materials and their use for creating healthy living spaces in a sustainable architecture. It focuses on the raw material base, which often consists of residues and by-products, the construction-relevant properties and aspects of material health. Depending on the results of this analysis, the aim is to define the use of biological insulation materials as part of a sustainable resource management in the building sector, which can be understood as a Nature-Based Solution. According to the definition of the International Union for Conservation of Nature (IUCN) Nature-Based Solutions (NBS) are described as measures for the protection, sustainable management and restoration of natural and modified ecosystems.[3]

The following explanations are intended to show that the replacement of synthetic insulation materials, some of which contain substances that are harmful to health, with 100 % bio-based insulation materials can help to conserve non-renewable resources and thus combat the scarcity of resources. The mostly very environmentally damaging mining methods of non-renewable resources could be greatly reduced and, in this way, ecosystems could be protected. In addition, the increased use of renewable resources could positively address other challenges within the construction industry, such as the need to create healthy living spaces and drastically reduce emissions from the production of building materials.

Keywords: sustainable architecture, renewable raw materials, alternative resources, healthy building materials, bio-based insulation materials

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[1] Umweltbundesamt, UBA (Federal Environment Agency): Energiesparende Gebäude (2022). URL: https://www.umweltbundesamt.de/themen/klima-energie/energiesparen/energiesparende-gebaeude#gebaude- important-for-climate-protection [Accessed: 03.05.2023]

[2] Umweltbundesamt, UBA (Federal Environment Agency)(ed.): Klimaneutraler Gebäudebestand 2050. Energieeffizienzpotentiale und die Auswirkungen des Klimawandels auf den Gebäudebestand. Dessau- Roßlau, November 2017. URL: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2017-11-06_climate-change_26-2017_klimaneutraler- gebaeudebestand-ii.pdf [Accessed: 30.05.2023]

[3] International Union for Conservation of Nature (IUCN): About Nature-based Solutions. URL: https://www.iucn.org/our-work/nature-based-solutions [Accessed: 01.03.2023]

2 INSULATING MATERIALS ON THE MARKET

A survey by the Agency for Renewable Resources (Fachagentur Nachwachsende Rohstoffe e. V., FNR) identified the market shares of the most commonly used insulation materials. Insulation materials based on fossil raw materials had the largest market share of insulation sales in 2019 with 48 %. Mineral insulation materials had a share of 43 %. Insulation materials made from renewable raw materials were only sold at 9 % in 2019 (2 % more than in 2011). However, manufacturers are noticing an upward trend.[4] Finally, the topic of sustainable construction has also arrived in society, so that more and more building owners are making a more conscious choice of materials when building a house or renovating an existing building.
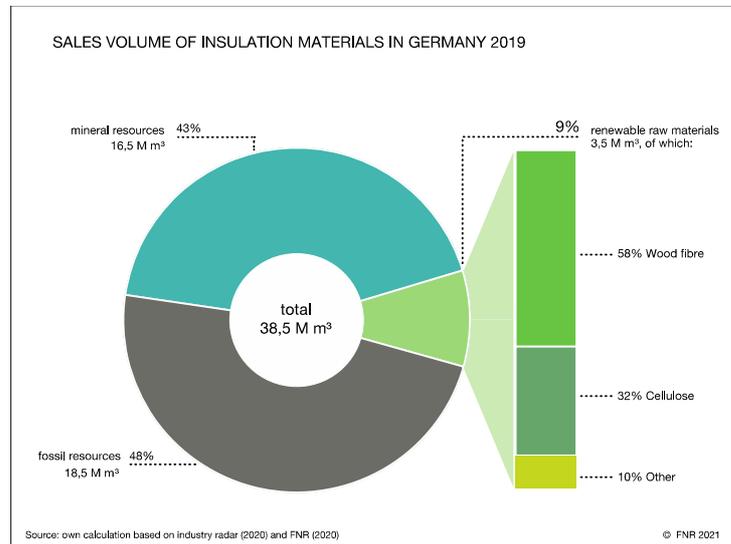

Fig. 1: Sales volume of insulation materials in Germany 2019. Source: Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources): Aktuelle Nachricht, 24.02.2021. Marktanteil von Nawaro-Dämmstoffen wächst. URL: https://www.fnr.de/presse/pressemitteilungen/aktuelle-mitteilungen/aktuelle-nachricht/marktanteil-von-nawaro-daemmstoffen-waechst [Accessed: 14.06.2023]. Translated and traced by Sandra Böhm and Luca Diefenbacher

In 2017, Pforzheim University published a market and social research study on the very low market share of insulating materials made from renewable raw materials, but also on their potential for further development. The Pforzheim University of Applied Sciences summarises the results of the study on its website and addresses a change from the "attitude-behaviour gap" to the "producer-people gap".[5] In the past, building owners often had a positive attitude towards bio-based insulation materials, but did not act on their attitude. Today, however, according to the study, they would very much act according to their attitude and buy insulation materials made from renewable raw materials, but they are prevented from doing so by a lack of supply on the market. The main focus was on bio-based façade insulation, for example from wood fibres, cellulose or hemp. This study on "Renewable raw materials in the industry" is based on 340 interviews with private building owners, specialised companies, authorities, traders and architects.

A statement on the study emphasises the special role of architects as independent, advising and competent protagonists of the building sector. However, the manufacturing companies should lose their shyness about investments in research and development of insulating materials made from renewable raw materials, as the insulating materials sector plays a decisive role for the "ecological development" in Germany.[6]

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[4] Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources): Marktanteil von NawaRo-Dämmstoffen wächst, Umfrage zum Einsatz biobasierter Baustoffe (2021). URL: https://www.fnr.de/presse/pressemitteilungen/aktuelle-mitteilungen/aktuelle-nachricht/marktanteil-von-nawaro-daemmstoffen-waechst [Accessed: 19.05.2023]

[5] Hochschule Pforzheim (Pforzheim University): From the Attitude-Behaviour-Gap to the Producer-People-Gap. 2018. https://www.hs-pforzheim.de/news_detailview/news/vom_attitude_behaviour_gap_to_the_producer_people_gap_1 [Accessed: 13.05.2023]

[6] Bundesministerium für Ernährung und Landwirtschaft (Federal Ministry of Food and Agriculture): Akzeptanz von Baumaterialen aus nachwachsenden Rohstoffen. 2018. URL: https://www.waldkulturerbe.de/aktuelles/aktuelles/akzeptanz-von-baumaterialen-aus-nachwachsenden-rohstoffen [Accessed: 30.05.2023]

The desire for more ecological insulation materials on the part of building owners is therefore present. The range of products on offer in the trade should be expanded accordingly. Some biological insulation materials already exist, some of them have been used for centuries, but they have been pushed out of the market by the development of modern synthetic materials. Today we realise that these synthetic materials are not the solution in the long run. The corresponding resources are coming to an end and their disposal is partly highly problematic - to name only two aspects relevant for the life cycle. In the following, exemplary insulating materials on a biological, synthetic and mineral basis will be presented and comprehensively compared with each other. The aim is to obtain an initial overview of possible potentials of biological insulation materials.

2.1 Origin and availability of raw materials and the production of insulation materials

2.1.1   Biological insulation materials from residues and by-products

Insulation materials made from renewable raw materials should be produced from domestic or regionally available resources in order to keep transport costs and the associated CO_2 emissions as low as possible. In addition to the main raw material, however, different and partly synthetic additives are also added to bio-based insulation materials. These are intended to improve fire protection, prevent mould or pest infestation or stabilise the fibre structure of the insulation material. In order to obtain a recyclable biological insulating material, however, it is essential to do without such additives during production. If the insulation materials are 100 % biological, they could be composted in one's own garden.

In addition to the flawless processing of renewable raw materials into building materials while avoiding harmful and/or synthetic substances, the efficient use of these raw materials is particularly relevant in protecting our ecosystems. Even renewable raw materials are not available in unlimited quantities. The raw material base of bio-based insulation materials consists, for example, of wood chips, flax fibres, cellulose flakes, straw, seaweed or cork scrap. These are residual materials and by-products from other material flows. Flax short fibres, for example, are a by-product of the textile industry. Seaweed accumulated on the coast is often removed at great expense and disposed of in landfills, as it is considered a nuisance on the beaches, which are mostly used for tourism, and is regarded as waste. However, these residual materials, which accumulate anyway, can be further processed into pressure-resistant boards, flexible mats, blow-in or plug-in insulation and used for building insulation.

Fig. 2: Accumulated seaweed in the Baltic Sea. Source: Lübecker Nachrichten: Seegras war früher ein Nebenverdienst für viele Fischer. URL: https://www.ln-online.de/lokales/nordwestmecklenburg/seegras-war-frueher-ein-nebenverdienst-fuer-viele-fischer-ESLCPAW7PUEGKZWUAEHEBMBWS4.html [Accessed: 14.06.2023], Copyright Foto: Maik Freitag.

In addition to the raw materials and additives used, the primary energy used in the manufacturing process plays a decisive role in assessing the sustainability of building materials. The use of insulation materials should reduce energy consumption in the use phase. With regard to the overall energy balance, it also makes sense to use insulation materials that are produced with as little energy as possible.

The following will discuss these aspects in more detail based on the selected insulation materials. Wood fibre insulation boards, a cellulose fibre blow-in insulation material, insulation fleeces made of flax and hemp are being compared with rock wool as a representative of mineral insulation materials and foamed polystyrene and PUR rigid foam insulation boards as representatives of fossil-based insulation materials. In addition, seaweed is presented as a niche product within the insulation industry.

Wood fibre insulation boards are made from residual wood from the sawmill industry. An insulation board consists of at least 80 % wood fibres.[7] It has a thermal conductivity of 0.040 W/(mK) and building material class B2, normally flammable. The wood information service describes the production of wood fibre insulation boards using the wet process as a process in which no additional binding agents are needed, as only the wood's own binding forces in the form of lignin come into play. The wood fibres are first thermo-mechanically broken down and finally set under heat. Wood fibre insulation boards are dried at 160 and 220 °C. Additives containing resin or bitumen are added to individual products to improve their strength, for example.[8]

The process data set of wood fibre insulation board (wet process) of Ökobaudat, refers also to the use of various additives, e.g. to PVAC (polyvinyl acetate), a plastic used in glues. Paraffin is also mentioned, which is used in special products to produce a water-repellent layer. So, you have to look closely and consider additives product by product. The recycling of residual materials, in this case wood chips, into a high-performance insulation material is particularly useful, but the total non-renewable primary energy demand (PENRT) in the production (module A1-A3) of wood fibre insulation boards from the wet process is very high (through the drying process) at 1823 MJ per m3 compared to other bio-based insulation materials.[9]

Cellulose insulation flakes are produced from waste paper with comparatively little manufacturing energy. The total non-renewable primary energy demand (PENRT) in production (module A1-A3) is 94.79 MJ per m³.[10] The insulation material has a thermal conductivity of 0.037 to 0.045 W/(mK) and is normally flammable (building material class B2). If the cellulose insulation is properly and tightly stuffed, a dense structure is created which prevents the spread of fire and on which a protective layer of carbon is formed.[11] Nevertheless, borates are added to the recycled fibres for fire and glow protection. Boric acid and borax were classified by the European Commission in 2010 as toxic to reproduction and as a substance of very high concern.[12] If the mixture contains more than 5 % borax or boric acid, it would ultimately have to be classified as well. The quantities actually added are even higher, for example 12 % borax and 8 % boric acid.[13]

When installing the flakes, a high dust load can occur, which is why work should only be carried out professionally with appropriate equipment and comprehensive cleaning of the construction site afterwards. There is no special occupational safety labelling for cellulose fibres, but the added borates are also contained in the dust. In the meantime, more compatible flame retardants are used, such as ammonium polyphosphate, which is classified by the Federal Environment Agency (Umweltbundesamt, UBA) as unproblematic in application.[14] With regard to the availability of the raw material, the relatively simple production and the physical building properties, blow-in insulation made of cellulose flakes is a good alternative to established synthetic insulation materials. However, they should not be used carelessly and special attention should be paid to professional installation and, if possible, borate-free mixtures should be used.

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[7] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page 254

[8] Verband Holzfaserdämmstoffe (ed.): Informationsdienst Holz: Holzfaserdämmstoffe. Revised 3rd edition, 2018, Wuppertal. Page 5

[9] Ökobaudat: Prozess-Datensatz: Holzfaserdämmplatte (Nassverfahren) (de) ende. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=393f494d-8738-4330-aa5e-1652bb29b574&version=20.19.120&stock=OBD_2021_II&lang=de[Accessed: 01.06.2023]

[10] Ökobaudat: Prozess-Datensatz: Zellulosefaser Einblas-Dämmstoff(en) en de. URL. https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=c355d75b-9026-4899-a41c-e5d221c424f2&version=20.19.120&stock=OBD_2021_II&lang=de [Accessed: 01.06.2023]

[11] Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources) (ed.): Marktübersicht. Dämmstoffe aus nachwachsenden Rohstoffen. 10 revised edition, 2019, Gülzow-Prüzen

[12] WECOBIS Ökologisches Baustoffinformationssystem (Ecological Building Materials Information System): Borate, Überblick. URL: https://www.wecobis.de/service/sonderthemen-info/svhc-fsm-info/svhc-borate-info.html [Accessed: 30.05.2023]

[13] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page 115

[14] Ibid.

Flax insulation boards or flax fleece consist of short fibres of the flax plant. These short fibres are a by-product of the textile industry. The cultivation of flax is in sharp decline in Germany, but is being further expanded in neighbouring countries. The cultivation and harvesting of flax are labour-intensive, but almost all parts of the plant can be processed into different products.

Fig. 3 (left): Cellulose insulation. Source Fig. 3: Bio-Solar-Haus® GmbH: Zellulosedämmung URL: https://www.bio-solar-haus.de/ratgeber/zellulosedaemmung [Accessed: 14.06.2023], Fig. 4 (right): Flax dew roasting in the field. During dew roasting, undesirable substances are broken down by bacteria and fungi. Source: Wikipedia: Flachsfaser. URL: https://de.wikipedia.org/wiki/Flachsfaser, Copyright Foto: Rilegator - Eigenes Werk, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=14690380[Accessed: 14.06.2023]

Flax insulation boards have a thermal conductivity of 0.040 to 0.045 W/(mK) and are classified as normally flammable (building material class B2). The fibres are glued with starch or mixed with bicomponent plastic fibres. These bicomponent plastic fibres consist of either petroleum-based plastics or bioplastics. As with insulating materials made of cellulose, fire protection is also achieved by adding ammonium polyphosphates or borates. In some cases, soda ash is also used as an alternative.[15] In principle, the composition must also be taken into account, depending on the product. Against the background of recycling or possible later composting, insulation boards mixed with plastic should not be used. However, it can be said that a residual material that is available anyway is put to a sensible use. Some manufacturers take back the insulation boards after use for reuse or recycling. For example, material that is not damaged or soiled can simply be reused or processed into stuffing wool.[16] Loose flax insulation materials are also offered without additives and can be used as insulation material without any problems. They are naturally resistant to pests and resistant to mould.

Hemp insulation mats or hemp fleece consist of various parts of the hemp plant, especially the hemp fibre, have a thermal conductivity of 0.040 to 0.045 W/(mK) and are classified as normally flammable (building material class B2). The fibres are mixed with bicomponent plastic fibres. In some cases, supporting fibres made of starch are also used, but this process is still very cost-intensive. For fire protection, ammonium polyphosphates or soda are added. If handled properly, the flame retardants are considered harmless, but there is still potential for savings here. Material that has been used purely for this purpose is sometimes taken back by the manufacturers to be used in the production of new boards or stuffing wool. Undamaged mats can simply be reused.[17] The availability of hemp fibre from Germany is currently very limited, as the cultivation of hemp fibre has only been permitted under strict conditions since 1996. In the meantime, however, one can observe an upward trend in the expansion of cultivated areas for this undemanding and versatile plant.[18]

Despite the still limited availability of hemp and flax products in Germany, these rapidly renewable fibre plants should not be underestimated. Due to the versatility of the high-performance fibres, they will certainly play a greater role in our country again in the future. What is striking about both products is the high non-

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[15] Ökobaudat: Prozess-Datensatz: Flachsvlies (en) en de. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=af13e5a8-0961-454a-ad3a-7093a37fc802&version=20.19.120&stock=OBD_2021_II&lang=de [Accessed: 30.05.2023]

[16] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page 185

[17] ibid., p. 240.

[18] Bundesinformationszentrum Landwirtschaft: Welches Potenzial hat Hanf als Nutzpflanze? (2022) URL: https://www.landwirtschaft.de/landwirtschaft-verstehen/wie-arbeiten-foerster-und-pflanzenbauer/welches-potenzial-hat-hanf-als-nutzpflanze [Accessed: 13.05.2023]

renewable primary energy demand in production (module A1-A3) with about 1500 MJ per m³.[19] There is certainly still potential for savings here.

Jute insulation boards are made from old cocoa or coffee sacks that were previously used to transport goods to Germany and may not be used again for the same purpose.[20] They have a thermal conductivity of 0.038 to0.041 W/(mK) and are classified as normally flammable (building material class B2). Up to 10 % biopolymeric support fibres are added for stabilisation and up to 5 % soda ash for fire protection.[21] The soda is already used for cleaning the shredded fibres. The insulation boards can be installed very easily and quickly by the user without special protective clothing. The boards can be assembled by the customer or delivered prefabricated. Like many natural insulating materials, jute insulation boards have a high absorption capacity and can compensate moisture well due to this property. After absorbing moisture, they do not lose their function as long as the moisture can be released again.[22] In addition, they offer particularly good heat protection in summer.

Fig. 5 (left): Thermal insulation from used coffee or cocoa sacks made from jute fibre. Source: mb-netzwerk GmbH, Portal Ökologisch Bauen: Jutedämmung, Wärmedämmung aus Jute. URL: https://www.oekologisch-bauen.info/baustoffe/naturdaemmstoffe/jutedaemmung/, Copyright Foto: Thermo Natur GmbH & Co. KG [Accessed: 14.06.2023].
Fig. 6 (right): Washed-up Neptune balls on a Mediterranean beach. Source: NeptuGmbH: Was ist NeptuTherm®, woher kommt und wie entsteht es? URL: http://neptusan.com/was-ist-neptutherm.html, Copyright Foto: NeptuGmbH [Accessed: 14.06.2023]

Naturally occurring residues that do not come from agriculture or an already existing production lines represent further interesting resources for material recycling. Seaweed is also such a natural residual material, particularly well suited for the production of insulation materials. However, insulation materials made from seaweed have been used by the local population for a long time and are naturally suitable for use in the construction sector they are still absolute niche products.

Two different species of seaweed are used for the production of insulation materials. Common sea grass (Zostera marina) grows at a depth of 14 m in the form of meadows along the Baltic Seacoast. The blades of grass die in autumn and are washed up on the coasts in large quantities. Due to its availability and beneficial properties, it has been used for centuries for upholstery, roofing and insulation. It does not rot, does not mould and is resistant to vermin due to its high silicate content. The dried seaweed is used without any other additives. The long seaweed fibres have a pleasant paper-like appearance in their feel and can be stuffed by

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[19] Ökobaudat (ed.): Prozess-Datensatz: Flachsvlies (en) en de. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=af13e5a8-0961-454a-ad3a-7093a37fc802&version=20.19.120&stock=OBD_2021_II&lang=de. AND Process dataset: Hemp fleece (en) en de. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=5ef0c519-f5b2-4d45-809d-5f417f90e90b&version=20.19.120&stock=OBD_2021_II&lang=de [Accessed: 01.06.2023]

[20] Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources)(ed.): Marktübersicht. Dämmstoffe aus nachwachsenden Rohstoffen. 10 revised edition (2019), Gülzow-Prüzen

[21] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page318

[22] Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources)(ed.): Marktübersicht. Dämmstoffe aus nachwachsenden Rohstoffen. 10 revised edition (2019), Gülzow-Prüzen

hand. The thermal conductivity is0.043 to 0.045 W/(mK). The insulation material has building material class B2.[23]

Neptune grass (Posidonia oceanica) can also be used to make insulation material. Plant remains are used here, which are formed into spheres by the movement of the waves after they die. These balls can be found on beaches throughout the Mediterranean, where they are removed and disposed of at great expense.

An architect from Karlsruhe carried out initial tests with these balls a few years ago. He was particularly struck by the very good fire behaviour. Today, the balls are processed into stuffing wool and sold as insulation material. Although the raw material is transported from the Mediterranean region to Germany, very little energy is needed for the entire further processing. In a simple mechanical process, the fibres are prepared and the sand is sieved out. No additives are necessary. The material is naturally mould-resistant and normally flammable (building material class B2). It is not attractive to vermin and has a thermal conductivity of 0.039 to 0.046 W/(mK).

These two positive examples show that it is entirely possible to use natural resources that are 100 %natural for building insulation. In the case of the previously described insulation materials made of wood, cellulose, flax, hemp or jute, synthetic fibres are currently too often added for stabilisation or borates as flame retardants. However, there are corresponding biological and sustainable alternatives that manufacturing companies should focus on in the future. because this is the only way to produce sustainable building materials that can be recycled or composted again and again for a closed-loop system as we need it.

2.1.2 Insulation materials from petroleum-based or mineral raw materials

Extruded polystyrene foam boards (short: XPS insulation boards) consist of polystyrene, a petroleum-based plastic. They have a thermal conductivity of 0.035 to 0.040 W/(mK) and building material class B1, flame retardant. XPS insulation boards are resistant to moisture and do not rot. The insulation material is repeatedly criticised because of the flame retardants and blowing agents used. Some of the blowing agents are extracted during production, some remain in the insulation material and are released into the ambient air over years when installed.

In addition, flame retardants and other synthetic additives are used.[24] The flame retardant Hexabromocyclododecane (HBCD) is no longer approved. However, it was used for many years and is therefore still found in large quantities in existing buildings. Until 2017, corresponding products were allowed to be installed in Germany, although the toxic effect was already proven in 2008 and the substance was classified by the EU as being of extreme concern.[25] The substance, which is difficult to break down, has already been found in breast milk, fish, marine mammals and birds of prey in Arctic regions.[26] Furthermore, the dismantling and especially the disposal of thermal insulation systems made of XPS containing HBCD is complex and associated with high costs, as the ingredients of concern may only be disposed of in special incineration plants.[27] In the meantime, for example, brominated polymer is used as a flame retardant, which is non-toxic and non-bio-accumulative. In addition, however, a TBBPA derivative (Tetrabromobisphenol A) is also used, the effect of which is currently being investigated by an EU programme. Like HBCD, it is also

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[23] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page 552

[24] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page 638

[25] Umweltbundesamt, UBA (Federal Environment Agency) (ed.): Wie werden HBCD-haltige Dämmstoffe abfallrechtlich eingestuft? (2022) URL: https://www.umweltbundesamt.de/service/uba-fragen/wiewerden-hbcd- haltige-daemmstoffe-abfallrechtlich [Accessed: 26.03.2023]

[26] Umweltbundesamt, UBA (Federal Environment Agency): Welche negative Eigenschaften hat HBCD für Umwelt und Gesundheit? (2016) URL: https://www.umweltbundesamt.de/service/uba-fragen/welche-negativenproperties-has-hbcd-for-environment [Accessed: 26.03.2023]

[27] Interessengemeinschaft Thermischer Abfallbehandlungsanlagen in Deutschland e.V. (ITAD): Entsorgung von HBCD-haltigem Polystyrol (Styropor). Düsseldorf, Deutschland: ITAD, 2016. URL: https://www.sabprofil.de/assets/user/Duits/HBCD_document.pdf [Accessed: 26.03.2023]

said to be bio-accumulative, persistent and hormonally active in vitro.[28] There are numerous other variants of flame retardants and blowing agents that are used in XPS insulation materials and whose effects cannot be described here in individual cases. However, we have learned from the past that substances once considered unproblematic later turned out to be problematic in terms of environmental and health aspects, for example the CFC-12 blowing agent that was used in the past.

According to Ökobaudat, the total non-renewable primary energy demand (PENRT) in the production (module A1-A3) of XPS insulation materials is 2839 MJ per m³.[29] This is a very high energy demand that cannot be justified, considering the mass use of XPS in building insulation and numerous other applications, for example in the packaging industry. For PU insulation boards made of slab stock foam, the total non-renewable primary energy demand (PENRT) in production (module A1-A3) of 325 MJ per m² is given in the Ökobaudat dataset.[30] Using the layer thickness of 0.12 m given in the data set, this value can be converted to P 2708, 3 MJ per m³.

PU insulation boards made of slab stock foam or polyurethane rigid foam boards are petroleum-based rot proof products that are created in a chemical reaction, with the help of the blowing agent pentane. HCFC-141b was also used as a blowing agent, but has been banned in Germany since 2004. Furthermore, the Ecological Building Material Lexicon (Ökologisches Baustofflexikon) lists many other formerly and currently used blowing agents, flame retardants and additives, some of which have been banned over time and then replaced by alternatives. Polyurethane rigid foam panels are considered harmless to health when installed, but during production employees come into contact with numerous toxic substances. Subsequent outgassing of the blowing agents can also be assumed. In addition, the plastic may only be disposed of in small quantities and is therefore incinerated, producing toxic hydrochloric acid. The insulation value of rigid Polyurethane foam boards with a thermal conductivity of 0.025 to 0.030 W/(mK) is particularly good. In addition, depending on the product, building material class B2 (normal flammability) or B1(low flammability) is possible.

Fig. 7: Installation of PU rigid foam panels as above-rafter insulation. Source: Baustoffwissen, RM Handelsmedien GmbH & Co. KG: Dämmstoffe, Einsatzbereiche von PU-Hartschaum. URL: https://www.baustoffwissen.de/baustoffe/baustoffknowhow/daemmstoffe/pu-hartschaum-polyurethan-daemmstoff-platten-einsatzbereiche-dach-boden-wand-wdvs-brandriegel-sandwich-elemente/ [Accessed: 14.06.2023]

The possible building material class B1of XPS insulation boards or rigid Polyurethane foam boards is certainly an advantage. However, if a fire does occur, the fire behaviour is very dangerous. Rigid

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[28] Christian Sinn, Christoph Semisch, Michael Braungart, Peter Mösle: Flammschutzmittel für ein effektives Recycling von expandiertem Polystyrol (EPS). URL: https://muellundabfall.de/ce/flammschutzmittel-fuer-ein-effektives-recycling-von-expandiertem-polystyrol-eps/detail.html [Accessed: 31.05.2023]

[29] Ökobaudat (ed.): Prozess-Datensatz: XPS-Dämmstoff (en) en de. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=43e99b8c-90d8-4fcd-90ce-342fb0b7366e&version=20.19.120&stock=OBD_2021_II&lang=de [Accessed: 01.06.2023]

[30] Ökobaudat (Hrsg.): Prozess-Datensatz: PU-Dämmplatten aus Blockschaumstoff (de) ende. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=880e05ea-55c6-4346-a3ea-5af0e5f299e2&version=00.09.000&stock=OBD_2021_II&lang=de [Accessed: 14.06.2023]

Polyurethane foam boards burn with a strong formation of smoke, which makes orientation and escape in the burning building difficult and can lead to health damage. XPS insulation boards are suspected of emitting toxic gases in case of fire. The question arises as to what risks we should accept for a good insulation value. The Ecological Building Material Lexicon (Ökologisches Baustofflexikon) points out that these insulation materials should only be used from an ecological point of view if their efficiency (very good insulation value, thus thin component layer) is absolutely necessary and no other insulation material can be used accordingly.[31]

As an example of the mineral insulation materials, the most important aspects of rock wool are explained below. Its thermal conductivity is 0.035 to 0.040 W/(mK). Rock wool is considered non-combustible with building material class A1. It consists of artificially produced mineral fibres based on sedimentary or magmatic rocks. Binding and water-repellent agents are added as additives.

A mixture of the rock, coke, recycled wool and lime is prepared for the melting process. Binding and impregnating agents are used when the threads are pulled out of the molten mass. The binder polymerises in the curing oven. The fibres of rock wool can cause irritation of the respiratory tract, itching and reddening of the skin if they come into contact with it. Mineral wool fibres were classified as suspected carcinogens in the 1980s. The so-called WHO fibres, dust fibres of a certain size and geometry, are respirable and therefore banned.[32] Products available on the market today no longer contain respirable fibres. In terms of non-renewable primary energy demand (PENRT) in production (module A1-A3), rock wool with a value of 1137MJ per m³[33] is better than XPS insulation (2839 MJ per m³) and wood fibre insulation board from the wet process (1823 MJ per m³).

The recycling of clean used rock wool is possible, but the take-back options by manufacturers are still in their infancy and are only offered sporadically, especially for the commercial sector. The lamination of rock wool with paper, aluminium or plastic film further complicates or prevents recycling. This example again clearly shows how important it is to use pure building materials that can be reused or recycled accordingly.

With regard to the total non-renewable primary energy demand (PENRT) in production (modules A1-A3), the values of bio-based insulation materials are mostly in the lower range, provided that the processing intensity is relatively low or if residual materials were recycled anyway, as in the case of jute or seaweed, for example. Overall, it can be said that little-processed bio-based insulation materials or recycled insulation materials have the best values here and the energy requirement is amortised in less than one year.[34] Insulation materials from renewable raw materials also offer the advantage that the raw materials store CO_2 during the growth phase, i.e. during the production of the insulation resource, while CO_2 is already released during the production of the basic materials for the synthetic insulation materials.

2.2 Building physical properties and material health of insulation materials

The data on thermal conductivity in W/(mK) differ slightly in the third digit after the decimal point. This minimal distinction is due to the production by different manufacturers. According to Table 1, the values in the preceding text from the Ecological Building Material Lexicon (Ökologisches Baustofflexikon) are in part minimal worse in terms of insulation value than the data from the Agency for Renewable Resources (Fachagentur Nachwachsende Rohstoffe e. V., FNR). In summary, it can be said that the values of petroleum-based and mineral-based insulation materials turn out to be somewhat more advantageous than the values of biological insulation materials.

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[31] Wolfgang Linden, Iris Marquardt (eds.): Ökologisches Baustofflexikon (Ecological Building Material Lexicon), Ökologisches Baustofflexikon. Bauprodukte, Chemikalien, Schadstoffe, Ökologie, Innenraum. 4th completely revised and expanded edition (2018). Berlin, Offenbach: VDE Verlag GmbH. Page 485

[32] ibid., p. 571.

[33] Ökobaudat (Hrsg.): Prozess-Datensatz: ROCKWOOL Steinwolle-Dämmstoff im mittleren Rohdichtebereich (de) ende. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=eca9691f-06d7-48a7-94a9-ea808e2d67e8&version=00.07.000&stock=OBD_2021_II&lang=de[Accessed: 14.06.2023]

[34] Db deutsche bauzeitung: Dunkelziffer graue Energie? Primärenergiegehalte von Dämmstoffen. URL: https://www.db-bauzeitung.de/wissen/energie/dunkelziffer-graue-energie/ [Accessed: 11.06.2023]

Insulating material	Thermal conductivity W/(m·K) Rated value λ	Bulk density ρ kg/m³	Water vapour diffusion resistance μ	Heat capacity c J/kg·K	Building material class according to DIN 4102-1	Fire behaviour according to DIN EN13501-1
Flat mats	0,039	30–40	1–2	1.550–2.300	B2	E
Hemp (stuffing wool)	0,045	50–60	1–2	2.200	B2–B1	E, C-s2, d0
Hemp jute	0,043	35–40	1–2	2.300	B2	E
Hemp mats	0,043	30–110	1–2	1.600–2.300	B2	E
Wood fibre (loose)	0,040	30–45	1–2	2.100	B2	E
Wood fibre mats	0,038	40–55	1–3	2.100	B2	E
Fibreboard	0,040	110–270	2–5	2.100	B2	E
Wood chips	0,045	90–360	2	k. A.	B2	E
Wood wool panels	0,090	330–500	2–5	2.100	B1	B, s1, d0
Jute mats	0,039	30–40	1–2	2.350	B2	E
Corkboard (exp.)	0,040	120	5–10	1.800	B2	E
Cork clay board	0,080	200–300	10	1.254	B2–B1	E
Sheep's wool	0,036	20–90	1–2	1.300–1.730	B2	E
Reed panels	0,065	150	3–6,5	1.200	B2	E
Seaweed	0,045	65–75	1–2	2.502	B2	E
Straw bale	0,052	85–115	2	2.000	B2	E
Straw blow-in insulation	0,043	105	2,8	2.100	B2	E
Cellulose flakes	0,039	28–65	1–2	2.100–2.544	B2	E bis B-s2, d0
Cellulose boards	0,042	70–145	2–3	2.000	B2	E
Polystyrene (exp.)	0,035	11–30	20–100	1.400	B2–B1	E
Rock wool panels	0,035	15–130	1–2	830–1.000	A1	A1

Table 1: Overview of the most important technical values for insulation materials. Source: Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources): Marktübersicht. Dämmstoffe aus nachwachsenden Rohstoffen. 10 überarbeitete Auflage (2019), Gülzow-Prüzen. Table translated by Sandra Böhm.

The bio-based insulation materials can score points with regard to other building physics properties. Materials with a low water vapour diffusion resistance factor are able to transport moisture that has penetrated the material and allow it to dry out again elsewhere. The mostly different sized pores in natural insulation materials lead to the fact that the moisture first migrates through the small pores while the effectiveness of the larger pores for the insulating effect is maintained. In an insulation material with uniform pore size, this effect does not occur. In Table 1, the very low water vapour diffusion resistance values of most bio-based insulation materials are striking compared to the values of extruded polystyrene. This absorption behaviour of biological insulation materials has a regulating effect on the humidity level of indoor spaces and is particularly advantageous for a pleasant indoor climate in today's increasingly airtight residential buildings.[35]

The specific heat capacity refers to the thermal protection in summer. Materials with high values offer better thermal protection here, as they pass on incident heat only very slowly. In the summer heat, the high heat storage capacity of natural insulation materials means that the absorbed heat is only released with a long delay, i.e. during the night, and not in the afternoon, as is the case with synthetic insulation materials, for example.[36]

Such beneficial properties of natural insulation materials have already been proven in studies. In contrast to mineral and synthetic insulating materials, natural insulating materials can compensate moisture fluctuations to a certain extent and thus have a positive influence on the indoor climate, which is particularly beneficial for allergy sufferers. The fire behaviour should also be mentioned again. The bio-based insulation materials burn rather slowly and only a small amount of smoke is produced. As long as no chemical components have been added, it can also be assumed that no toxic smoke gases are produced. Rigid foams, on the other hand, melt, drip burning and burn very quickly overall; this is accompanied by strong, dark smoke formation.[37]

For special applications, insulation materials such as XPS or PUR insulation materials are still justifiable to a certain extent, for example, in areas exposed to moisture, e.g. as perimeter or base insulation, inverted roof and terrace insulation. It is always necessary to weigh up which insulation material is best suited to which application in order to use the appropriate products in a targeted manner and to reduce building materials from finite resources as much as possible. The goal should therefore be to establish pure insulation materials from renewable raw materials (NawaRo) on the market and to use them on a broad scale. However, this will

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[35] Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources) (ed.): Marktübersicht. Dämmstoffe aus nachwachsenden Rohstoffen. 10 revised edition (2019), Gülzow-Prüzen
[36] ibid.
[37] Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources): Aktuelle Nachricht: Weg frei für mehr Natur-Dämmstoffe beim Bauen. (2020) URL: https://www.fnr.de/presse/pressemitteilungen/aktuelle-mitteilungen/aktuelle-nachricht/weg-frei-fuer-mehr-natur-daemmstoffe-beim-bauen [Accessed: 25.05.2023]

758

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only work if we use these raw materials efficiently, for example the residues and by-products from already existing material flows, and exclusively in a closed-loop system.

Looking at the material health of 100 % biological insulation materials, it becomes clear that their use in living spaces could be of outstanding importance especially for vulnerable population groups. In the future, the need for housing and care facilities for the elderly and those in need of care, as well as childcare facilities in our communities, will increase. In planning these facilities, material health will play a huge role in improving the quality of life and well-being of these target groups, rather than compromising them. Natural building materials, including biological insulation materials, which positively influence the indoor climate and do not emit pollutants, will be increasingly in demand.

The people who work in the production of insulation materials should not be ignored. Particularly in the production of synthetic insulation materials, there is a great potential for health hazards that must be minimised as far as possible through appropriate alternatives.

3 CONCLUSION

The petroleum-based insulation materials, e.g. XPS insulation boards, or the mineral insulation materials, e.g. rock wool, undoubtedly have very good technical properties and a high insulation value. However, if one considers ecological and health-relevant aspects, they are no longer convincing. If one looks at the long lists of ingredients of synthetic and mineral insulation materials, they are not an alternative from an ecological point of view. Crude oil as the raw material basis for synthetic plastics can possibly only be used for a few more decades. According to Wecobis, coal is an alternative base material, also a non-renewable raw material, the processing of which would require even more energy – from an ecological point of view and, with a view to our descendants, also from a social point of view, thus not an alternative either.[38] Some of the numerous additives are considered worrying or even toxic. This also makes disposal time-consuming and expensive, recycling difficult or impossible – depending on the condition of the used insulation materials. Land filling is usually no longer permitted because toxic substances are contained and landfill space is running out. In addition, toxic substances are produced when some synthetic insulation materials are burnt. We must realise that we owe it to future generations not to produce more hazardous waste that will sooner or later end up in the environment.

The renewable raw material base of NawaRo insulation materials speaks for itself. Of course, biological insulation materials are not free of concerns. Here, too, additives are mixed in that could either have health effects (borates) or interfere with recycling or composting (bicomponent support fibres). However, these additives are used to a much lesser extent. In addition, alternative flame retardants and biological support fibres are already available. With insulation materials made from seaweed, there are even products that manage entirely without additives. Insulation materials made from renewable raw materials are usually easier to reuse or recycle at the end of their life cycle and can be thermally recycled without any problems. Ideally, they are even compostable.

Insulation materials made from renewable raw materials are convincing overall because of their contribution to healthier living spaces, if they are installed on the inside of the room - for example, in the case of retrofitted insulation in an existing building. Due to their natural properties, they contribute to moisture regulation in this case. In addition, they have a higher thermal capacity than mineral or synthetic insulation materials and are therefore particularly advantageous in terms of heat protection. Even if the insulation values are sometimes somewhat lower than those of mineral wool and co., they are still convincing due to their overall balance with regard to their renewability, CO_2 storage during growth and the advantageous properties with regard to heat protection, room climate regulating properties and easily assessable fire behaviour.

The sourcing of raw materials plays a major role in ecological considerations. Of course, it makes no sense to transport coconut fibres halfway round the world to insulate our houses with them, but there are exceptions such as seaweed from the Mediterranean region and many domestic alternatives. The seaweed insulation materials, jute insulation mats or cellulose insulation materials also require relatively little

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[38] Wecobis (Hrsg.): Polyurethan-Hartschaum (PUR/PIR), Lebenszyklus, Rohstoffe, Verfügbarkeit. URL: https://www.wecobis.de/bauproduktgruppen/daemmstoffe/aus-synthetischen-rohstoffen/polyurethan-hartschaum.html [Accessed: 07.06.2023]

manufacturing energy. However, softwood fibreboards from the wet process, for example, are an exception, because a lot of energy is used for their drying process. Such production processes worsen the ecological balance and counteract CO_2 storage during plant growth.

The demand for insulation materials will rise sharply in the near future due to climate change and the new directives and laws. All in all, it will be worthwhile in the future to use insulating materials made from renewable resources that are 100% biological if possible. Only in this way will we be able to combat the already existing scarcity of resources. The use of renewable raw materials and in particular the full use of biological residues and by-products will conserve the non-renewable or only very slowly renewable raw material sources of our earth.

In order to meet the responsibility of the building sector towards climate, environmental and nature protection, it is necessary to establish a sustainable resource management in the building sector (Nature-Based Solutions, NBS) in order to coordinate the material flows better. In this context, the availability of renewable raw materials must be recorded and monitored across all sectors. This is an important basis for the development of new alternative building materials and thus also for the development of sustainable biological insulation materials. After all, what use are new products if their production has to be stopped again due to a shortage of raw materials?

In building practice, sustainable resource management would lead to building materials being used efficiently and individually adapted to their application. Building materials from renewable raw materials produced according to certain ecological, economic and social criteria should always have priority. Building materials from finite resources should only be used in exceptional cases. The guidelines for such sustainable resource management would be based on the principles of recyclability, renewability, health and environmental compatibility and, of course, the necessary technical properties.

Numerous research projects continue to work on the development of new, efficient insulation materials from renewable raw materials. For example, a team of researchers from Osnabrück and Hamburg is developing an aerogel insulating material made of lignin, which is a residual material from paper production. Aerogels consist almost entirely of air, i.e. of very many microscopically small pores, which is why heat is conducted extremely poorly in them. The size of the pores in the nano-meter range is the decisive factor in comparison with other insulation materials such as Styrofoam, whose pores are around 200 micrometres in size.[39] Aerogels have been around for a long time and are used in the aerospace industry, for example. Until now, however, they were mostly made of plastics or silicates. Mark Fricke, who was also involved in the development of the "conventional" aerogels, has now developed the innovation from renewable raw materials with his team. Mark Fricke considers the potential of the new insulation material to be particularly high. Large quantities of lignin are available as residual material and due to the particularly good insulating value, the insulating material can be installed in a material-saving and thus very versatile way. The team is currently still working on market readiness.[40]

This example shows that it is possible to produce bio-based and sustainable insulation materials that have no limitations in terms of technical properties compared to petroleum-based insulation materials. Currently, the great potential of bio-based insulation materials is that they are renewable, often produced with low energy consumption, and that biogenic residues are used as a resource within a biological cycle-based system - i.e. without the use of synthetic additives or substances that are harmful to the environment and health. In the future, it is essential that all information about all additives and substances used in production be disclosed. Such full declarations are a prerequisite for the use of building materials in a cycle-based system.

The advantages of biological insulating materials with regard to their physical properties, in particular summer heat insulation and the regulating properties on the indoor climate, as well as the assessable properties in case of fire, were made clear in this paper. It aimed to show that the origin of the raw materials, the production, the properties during use and disposal of biological insulation materials are advantageous for environmental protection, the fight against climate change, the conservation of resources and the creation of healthy living spaces.

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[39] Wille, Joachim auf Klimareporter: Der neue Super-Dämmstoff. URL: https://www.klimareporter.de/gebaeude/der-neue-super-daemmstoff (2023) [Accessed: 13.05.2023]
[40] ibid.

4 REFERENCES

Bundesministerium für Ernährung und Landwirtschaft (Federal Ministry of Food and Agriculture): Akzeptanz von Baumaterialen aus nachwachsenden Rohstoffen. 2018. URL:

https://www.waldkulturerbe.de/aktuelles/aktuelles/akzeptanz-von-baumaterialen-aus-nachwachsenden-rohstoffen

Bundesinformationszentrum Landwirtschaft: Welches Potenzial hat Hanf als Nutzpflanze? (2022) URL: https://www.landwirtschaft.de/landwirtschaft-verstehen/wie-arbeiten-foerster-und-pflanzenbauer/welches-potenzial-hat-hanf-als-nutzpflanze

Db deutsche bauzeitung: Dunkelziffer graue Energie? Primärenergiegehalte von Dämmstoffen. URL: https://www.db-bauzeitung.de/wissen/energie/dunkelziffer-graue-energie/

Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources): Aktuelle Nachricht: Weg frei für mehr Natur-Dämmstoffe beim Bauen. (2020) URL: https://www.fnr.de/presse/pressemitteilungen/aktuelle-mitteilungen/aktuelle-nachricht/weg-frei-fuer-mehr-natur-daemmstoffe-beim-bauen

Fachagentur Nachwachsende Rohstoffe e. V., FNR (Agency for Renewable Resources): Marktanteil von NawaRo-Dämmstoffen wächst, Umfrage zum Einsatz biobasierter Baustoffe (2021). URL: https://www.fnr.de/presse/pressemitteilungen/aktuelle-mitteilungen/aktuelle-nachricht/marktanteil-von-nawaro-daemmstoffen-waechst

Hochschule Pforzheim (Pforzheim University): From the Attitude-Behaviour-Gap to the Producer-People-Gap. 2018. URL: https://www.hs- pforzheim.de/news_detailview/news/vom_attitude_behaviour_gap_to_the_producer_people_gap_1

Interessengemeinschaft Thermischer Abfallbehandlungsanlagen in Deutschland e.V. (ITAD): Entsorgung von HBCD-haltigem Polystyrol (Styropor). Düsseldorf, Deutschland: ITAD, 2016. URL: https://www.sabprofil.de/assets/user/Duits/HBCD_document.pdf

International Union for Conservation of Nature (IUCN): About Nature-based Solutions. URL: https://www.iucn.org/our-work/nature-based-solutions

Ökobaudat: Prozess-Datensätze:

Flachsvlies (en) en de. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=af13e5a8-0961-454a-ad3a-7093a37fc802&version=20.19.120&stock=OBD_2021_II&lang=de

Hanfvlies (en) en de. URL:
https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=5ef0c519-f5b2-4d45-809d-5f417f90e90b&version=20.19.120&stock=OBD_2021_II&lang=de

Holzfaserdämmplatte (Nassverfahren) (de) ende. URL:
https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=393f494d-8738-4330-aa5e-1652bb29b574&version=20.19.120&stock=OBD_2021_II&lang=de

PU-Dämmplatten aus Blockschaumstoff (de) ende. URL:
https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=880e05ea-55c6-4346-a3ea-5af0e5f299e2&version=00.09.000&stock=OBD_2021_II&lang=de

ROCKWOOL Steinwolle-Dämmstoff im mittleren Rohdichtebereich (de) ende. URL:
https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=eca9691f-06d7-48a7-94a9-ea808e2d67e8&version=00.07.000&stock=OBD_2021_II&lang=de

XPS-Dämmstoff (en) en de. URL: https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=43e99b8c-90d8-4fcd-90ce-
342fb0b7366e&version=20.19.120&stock=OBD_2021_II&lang=de

Zellulosefaser Einblas-Dämmstoff (en) en de. URL:
https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=c355d75b-9026-4899- a41c-e5d221c424f2&version=20.19.120&stock=OBD_2021_II&lang=de

Christian Sinn, Christoph Semisch, Michael Braungart, Peter Mösle: Flammschutzmittel für ein effektives Recycling von expandiertem Polystyrol (EPS). URL: https://muellundabfall.de/ce/flammschutzmittel-fuer-ein-effektives-recycling-von-expandiertem-polystyrol-eps/detail.html

Umweltbundesamt, UBA (Federal Environment Agency): Energiesparende Gebäude (2022). URL:
https://www.umweltbundesamt.de/themen/klima-energie/energiesparen/energiesparende-gebaeude#gebaude-important-for-climate-protection

Umweltbundesamt, UBA (Federal Environment Agency)(ed.): Klimaneutraler Gebäudebestand 2050. Energieeffizienzpotentiale und die Auswirkungen des Klimawandels auf den Gebäudebestand. Dessau- Roßlau, November 2017. URL:https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2017-11-06_climate-change_26-2017_klimaneutraler- gebaeudebestand-ii.pdf

Umweltbundesamt, UBA (Federal Environment Agency) (ed.): Wie werden HBCD-haltige Dämmstoffe abfallrechtlich eingestuft? (2022) URL: https://www.umweltbundesamt.de/service/uba-fragen/wiewerden-hbcd- haltige-daemmstoffe-abfallrechtlich

Umweltbundesamt, UBA (Federal Environment Agency): Welche negative Eigenschaften hat HBCD für Umwelt und Gesundheit? (2016) URL: https://www.umweltbundesamt.de/service/uba-fragen/welche-negativenproperties-has-hbcd-for-environment

Verband Holzfaserdämmstoffe (ed.): Informationsdienst Holz: Holzfaserdämmstoffe. Revised 3rd edition, 2018, Wuppertal

WECOBIS Ökologisches Baustoffinformationssystem (Ecological Building Materials Information System): Borate, Überblick. URL: https://www.wecobis.de/service/sonderthemen-info/svhc-fsm-info/svhc-borate-info.html

Wecobis (Hrsg.): Polyurethan-Hartschaum (PUR/PIR), Lebenszyklus, Rohstoffe, Verfügbarkeit. URL:
https://www.wecobis.de/bauproduktgruppen/daemmstoffe/aus-synthetischen-rohstoffen/polyurethan-hartschaum.html

Wille, Joachim auf Klimareporter: Der neue Super-Dämmstoff. URL: https://www.klimareporter.de/gebaeude/der-neue-super-daemmstoff (2023)

The Potentials of Digital Tools to Contribute to Spatial Transformations – the Example of the Digital Twin of the City of Helsinki

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1 ABSTRACT

Spatial transformations are a key challenge for communities and regions. The term is rooted in the assumption that in the Anthropocene era, human ways of life and modern economic systems have led to an unsustainable consumption of natural resources and a failure to adhere to planetary limits, which ultimately endangers the natural basis of human life (Engel and Knieling 2018, WBGU 2011).

Nowadays we see, in particular with the example of climate change, how environmental threats of different types and intensities affect cities and regions. It creates a strong demand for action. Cities and regions are thus directly affected by transformations. At the same time, they define the spaces where approaches of action and implementation of instruments of spatial planning have the chance to make cities more sustainable and resilient to risks. Thus, active processes which include the whole society are required (Engel and Knieling 2018).

Such proceses as is likely to present many municipalities with a major challenge with many difficulties, which raises the question of what options there are for providing them support. The mega-trend of digitalization affects almost all areas, including spatial planning (Pallagst et al. 2022). It can be observed that digital tools have been increasingly used in spatial planning in recent years, offering new technical possibilities. The paper will look in particular at the digital twin of the city of Helsinki and its relevant fields of application. The city faces a variety of different risks in terms of climate change (City of Helsinki 2019). Recent research by the authors investigates which potentials the digital twin of Helsinki offers to support the necessary transformative processes and triggers potential changes of strategies and methods in spatial planning.

In order to measure spatial transformations, various theories and multi-level perspective approaches from transformation research are already available (Zolfagharian et al. 2019, Bauknecht et al. 2015, Engel and Knieling 2018). On this basis, the paper discusses to what extent digital tools, can be applied in order to support transformation processes. In addition, the paper intends to contribute to a methodology for comparative case study research.

Keywords: Digital Twin, Digital Tools in Spatial Planning, Spatial Transformation, Helsinki, Climate Change Risks

2 INTRODUCTION

The Digital Twin of the City of Helsinki is a digital 3D model that can be enriched with various sectoral data. As a tool, it has already been established in urban development in Helsinki and is used, among other things, for the visualization of planning scenarios, specific analyses and public participation (Hämäläinen 2021, Tuukkanen 2023, City of Helsinki 2022, City of Helsinki 2023).

Finland is one of the leading countries when it comes to digitalization and the development of technological innovation. (Edquist and Hommen 2008).

Transition Theory teaches us that technological innovation in the social system is created at a niche level by pioneers of change. In the case of sudden shocks, crises, but also slowly advancing mega-trends, pressure is exerted on the socio-technical regime. As a result, the mainstream becomes more open and technological innovations have the opportunity to get established in the mainstream (Engel and Knieling 2018, WBGU 2011, Geels 2011, Grin et al. 2010).

Such mega-trends or crises very often have a large global relevance. In the case of Finland, these include dealing with risks related to the effects of climate change, ageing of society, social disparities, but also digitalization itself. (Cit of Helsinki 2017, Purkarthofer 2023).

These issues have a direct spatial reference and impact on regions and cities. Spatial planning bundles the instrumental possibilities to design the space in a way that is necessary to deal with the challenges of mega-trends and crises.

In terms of spatial transformation, climate-related challenges, especially decabonization and adaptation to changing conditions, are particularly relevant (Engel and Knieling 2018, WBGU 2011).

The question therefore arises to what extent such new technological innovations, such as the digital twin of the City of Helsinki, that are being used in spatial planning have the potential to support transformative processes and contribute to this.

This paperfirst deals with the theory of spatial transformation, digitalization in spatial planning, and planning cultures as an important contextual field of research. It then looks specifically at the digital twin of the City of Helsinki. Among other things, it will be shown how this tool is used in planning and it will be analyzed to what extent a contribution to spatial transformation is made by the digital twin. On the basis of the knowledge gained, the conclusions are discussedthat can be drawn from this for the methodological approach. The steps that need to be taken into account in order to be able to measure a contribution to transformation processes are identified. For the purpose of future comparative case study research, a standardized procedure is proposed.

3 THEORY BASED CONSIDERATIONS

3.1 The Phenomenon of Spatial Transformation

The term transformation goes back to the reflections on the Great Transformation. In Karl Polanyi's 1944 book of the same name, the term is used in connection with the processes of change in society related to the changing conditions of the economic system during the Industrial Revolution (Ebner 2017). However, the terminology "Great Transformation" is still used today and usually describes processes of change in society starting from mostly global mega-trends or crises. An example of this can be the mega-trend of digitalization. The social process of change that goes hand in hand with this would therefore be digital transformation in this context. The goal of the transformation can be seen here as sustainable establishment. Transformation research describes the examination of change processes of social systems towards more sustainable structures as well as their support from a scientific perspective (translated from Wittmayer and Hölscher 2017).A strong interest in the research of transformation is emerging, driven among other factors by the dramatic sociocultural, political, economic, and technological challenges society faces (Pereira et al. 2018, Bruns 2022).

Despite its applicability to many different topics and trends, the discourse as a whole is very much dominated by the topic of the environment as a resource and basis of human life. In Germany, it is the "Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen" (translated: Scientific Advisory Council of the German Federal Government on Global Environmental Change) that enjoys great attention in the scientific discourse with its publication on the Great Transformation and sees decarbonization as the main task here. The currently prevailing modern economic forms and consumption practices in the world are seen here as the main triggers for above all climate- and environment-related mega-trends and crises of today. One of the triggers identified is that resource consumption is not regenerative and planetary boundaries are not respected. Against the backdrop of the Anthropocene era, it is therefore humans themselves who are having a negative impact on the environment and thus endangering their own basis of life. On the other hand, the humans themselves also have the influence to react to the dangers with a process of change. One can differentiate here, whether this reaction from a pure survival will and danger defence happens, or whether it is an active process carried into the society, in which the change is arranged in a union of the people. The latter is seen as the actual transformation process, since it is assumed that such processes can only take place and succeed at the level of society as a whole (Engel and Knieling 2018, WBGU 2011).

Transition Theory aims to describe and explain the societal processes within the scope of transformation. The theory is based on the assumption that innovations arise primarily in niche areas through so-called pioneers of change (Engel and Knieling 2018, WBGU 2011). It goes back to Grin et al. 2010, who proposed a multi-level perspective approach to the question of how to be able to understand the process of change. The considerations in this regard have already been discussed and modified several times in the literature, for

764

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

example by Geels (2011) and by WBGU (2011). According to this theory, transformation is understood as a comprehensive change of socio-technical systems. In the theory, the dominant socio-technical regime is the meso-level. Above this is the macro-level and below it is the micro-level. Both levels affect the socio-technical regime. The macro-level forms the external context, meaning overarching themes from which mega-trends are derived (Engel and Knieling 2018). The macro-level thus influences the events of the socio-technical regime and puts pressure from it (Geels 2011). From below, on the other hand, the micro-level affects the socio-technical regime. This is the niche level. Here, the so-called pioneers of change act and develop technology and innovation outside the mainstream of the meso-level (Engel and Knieling 2018).

According to the theory, the actual process of change occurs at the moment when, at the level of mega-trends, sudden shocks or long-term but fundamental crises put the socio-technical regime under such pressure that a restructuring of the system is forced. At this moment, the socio-technical regime opens up to the developments of the niche level and enables technological innovation to become established in the mainstream (Engle ans Knieling 2018).

Transition Theory with its Multi-Level Perspective approach "serves as a middle range theory" (Zolfagharian 2019). Transition research relies on creative interpretation of the result obtained through the Multi-Level Perspective method, making it clear that despite the attempt to quantify, qualitative methods have an important place (Geels 2011, Zolfagharian 2019).

The concept of spatial transformation is directly related to the great transformation and transfers the level of consideration to the spatial context. Sustainable development plays a key role in urban and regional planning (Knieling and Kreschmann 2016, United Nations n.d.). The establishment of sustainability as a planning principle, often also defined as a principle in legal documents, can be observed worldwide. However, the relevance of the spatial perspective also stems from the fact that threats directly affect spaces and create direct pressure for taking action among cities and regions. At the same time, the administrations and organized civil society have the possibility and competence to shape the space at the respective administrative level, e.g. of a city, in such a way that necessary steps to cope and manage change can be implemented. Cities or urban spaces in particular have a special potential to foster exchange between different groups and movements and thus have a particularly inventive and experimental power to develop innovations (Engel and Knieling 2018, WBGU 2011). Possible courses of taking action for municipalities include the adaptation or creation of necessary infrastructures, spatial development adapted to new needs, the adaptation or creation of new governance processes, governance structures and working methods, and an adapted prioritization of financial support and investments.

The spatial scope in the study of transformation has an important meaning in transformation research. According to Engel and Knieling 2018, transition theory raises the question of concrete spatial conditions. They identify a further need for spatial research here.

3.2 Topical Planning Cultures and digitalization in spatial planning

Pallagst et al. investigated shrinking cities as a window for possible changes in planning cultures in the frame of the EU project PlanShrinking (2010-2015). In order to derive a typology of planning cultures applicable for the context of shrinking cities, the authors modified Othengrafen's culturized planning model (Othengrafen 2010) describing the general context of planning cultures towards shrinkage (see figure 1). Figure 1 demonstrates general criteria of planning culture, supported by a specific criterion for shrinking cities: shrinkage context. "Societal context" displays the "backbone" of a planning culture with a range of more general understandings, "planning context" describes the beliefs of the planning profession, and "planning toolset" refers to the methods at hand. The category "shrinking context" comprises those aspects which might trigger change in planning cultures due to shrinkage and its implications on urban development and planning reactions.

In addition, the PlanShrinking research traced several preconditions for the joint research of planning cultures and shrinking cities:

Both topics -- planning cultures and shrinking cities -can be labelled emerging topics in spatial planning. Just like planning cultures, shrinking cities have been widely underrepresented in international comparative urban and regional research.
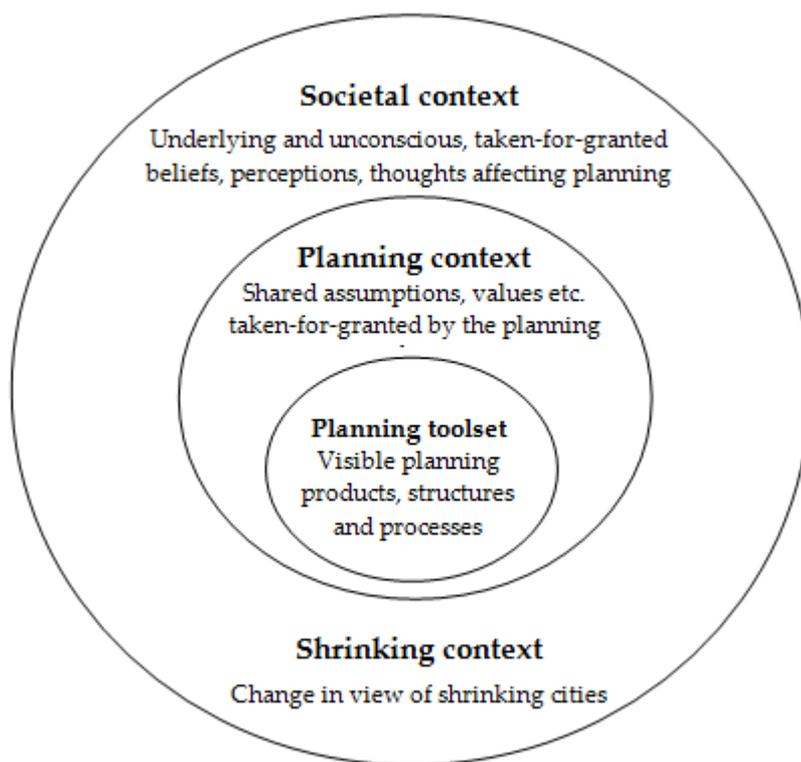
Figure 1: Facets and layers of planning culture with reference to shrinking cities, Source: Pallagst et al 2013.

The shrinking city phenomenon is a multi-dimensional process, comprising cities, parts of cities or metropolitan areas that have experienced dramatic decline in their economic and social bases. Urban decline and the loss of employment opportunities are closely linked in a downwards spiral, leading to an out-migration of population (Pallagst, 2008). However, despite the fact that globalisation is a trigger for urban shrinkage, economic transformations do not affect all cities in the same way; on the contrary, shrinkage can show very different characteristics depending on national, regional and local contexts (Cuningham-Sabot and Fol, 2007). Research on planning cultures is usually attributed to a national context of a planning system – however, this also involved different levels of planning (from national to local).

Planning cultures serve as an academic concept which is lacking an evidence base, whereas shrinking cities is a planning challenge vividly engaging practitioners and academics likewise in search of urban or regional solutions.

The author's previous research on shrinking cities made clear that planning cultures can be investigated by evidence based research utilizing the shrinking cities phenomenon. Nonetheless, planning offers a plethora of topics potentially serving as windows of investigation for planning cultures – one of them being digitalization. Research by Sorensen (2015) further underpins this argumentation: He suggests that planning cultures might change when faced with as he calls it "critical junctures of institutional change and innovation in planning systems" (Sorensen 2015). One of these critical junctures might be the context of digitalization.

Thus one of the aims of this paper is to shift the window of investigating planning cultures from the evidence base of shrinking cities towards the realm of digitalization. The following paragraphs will make a first attempt in order to derive preconditions from shrinking cities research for the field of digitalization.

In a first attempt to conceptualize planning cultures and digitalization, the author suggests a research frame (see figure 2) derived from the facets and layers of planning culture in terms of shrinking cities (see figure 1). This research frame (figure 2) adds digitalization as a new component to the planning cultural context.
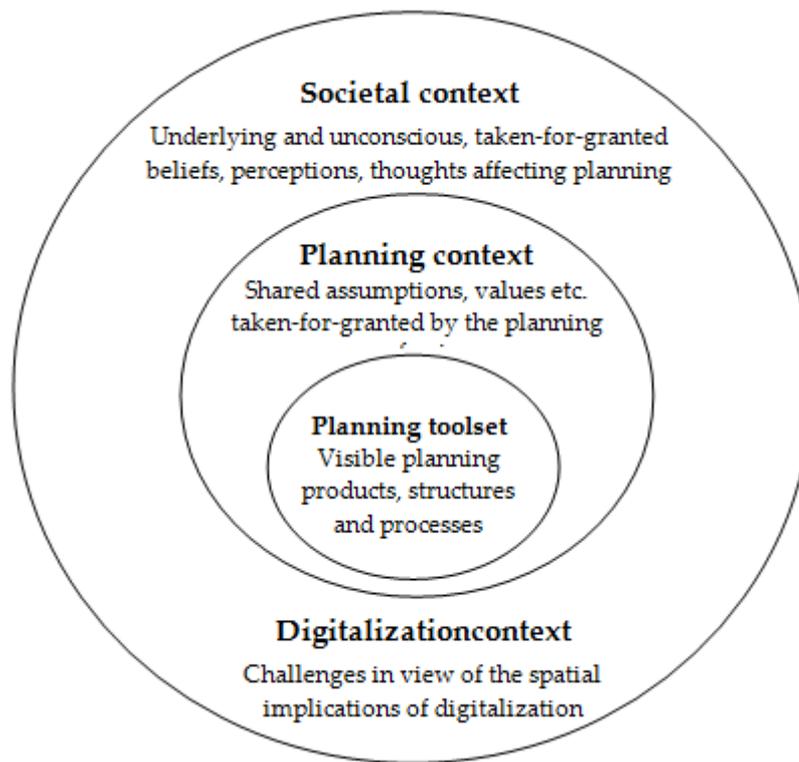
Figure 2: Facets and layers of planning culture with reference to border regions, Source: Own design based on Pallagst et al., 2013.

Pallagst et al. (2022) framed first ideas for an operative definition of planning culture. Accordingly, planning cultures are defined as follows: "Planning cultures encompass the societal aspirations towards planning – its processes and its outcomes. It refers to the values and shared beliefs of stakeholders involved in planning, and the methods and tools they are applying and producing. Planning cultures are not static but constantly evolving in line with societal changes or planning related challenges. Planning cultures as we see it can be attached to specific territorial entities, be it nations, sub-nations, regions, or cities – most likely but not necessarily within administrative boundaries. In addition, they can be attributed to cities or regions having to face specific planning problems".

The research on changing planning cultures in view of digitalization will certainly add to the notion of topical planning cultures.

Digitalization has been a field of action in spatial development for quite some time. Building on the digitalization trend and starting from the approach of digital and networked smart cities, the synopsis of networked digitalization and spatial development has been planned and researched since the turn of the millennium (Hollands 2008). At the core of this is more efficient management but also a broader understanding of sustainable and more efficient urban development (Leitheiser and Follmann 2019; Herrschel 2013). In the highly competitive segment of smart cities, standardized platform solutions from large international IT or consulting firms are often implemented (Hollands 2015). Furthermore, an international discourse has been established in research that critically reflects the smart city movement (Grossi and Pianezzi 2017). Smart cities also continue to be an issue in German urban development policy, as manifested, among other things, in the Smart City Charter presented in 2017 (BBSR 2017). Accordingly, digital development should take place in the sense of sustainable and integrated urban development.

Digitalization has an impact on spatial planning and development in various fields of action (Spellerberg et al. 2021). With regard to services of general interest and the centrality of settlements, this enables a new perspective on the principle of equal living conditions. Likewise, the use of different digital tools such as Artificial Intelligence, visualizations and platform solutions poses new requirements for the design of planning, decision-making and participation processes. This, in turn, has consequences for the planning tools and the competencies of spatial planners and other actors in the planning and development process.

While smart cities as a concept have been widely researched, there is a lack of references and answers with regard to the design of the nexus of digitization and spatial planning and development for resilience, sustainability and transformation.

Furthermore, there is still limited research on the transformative forces of these concepts for the development of cities and regions. There is a lack of fundamental research on the effectiveness of smart tools, concepts and applications. Questions that such a conceptualization of smart spaces should encompass include:

To what extent can cities and regions use the digital transformation as an opportunity for spatial development?

What is the role of model projects? What are the spatial effects of these concepts, and where are the opportunities and limitations?

Whether and to what extent are methods, instruments and paradigms of spatial planning changing in this context in the course of digitization?

While not all of these general research questions can be covered in this paper, the following paragraphs will shed light on the digital twin as a potential tool of fostering spatial transformations with the example oft the city of Helsinki.

4 THE DIGITAL TWIN OF THE CITY OF HELSINKI

4.1 Planning cultural Context of Helsinki and Finland

Helsinki is the capital city of the Republic of Finland and is located in the south of the country on the coast of the Gulf of Finland of the Baltic Sea. Administratively, it forms the Finnish capital region together with the cities of Espoo, Vantaa and Kauniainen. The cities are strongly intertwined spatially and together form a large-scale agglomeration with approximately 1.2 million inhabitants (Statistics Finland 2023a). The city of Helsinki is located in the centre of this region and has a population of just over 660,000 (Statistics Finland 2023a).

About 5.5 million people live in the entire Republic of Finland (Statistics Finland 2023a). In Finnlad, there are a total of 293 municipalities (Purkarthofer and Mattila 2023). In terms of administrative tasks, many areas of competence lie with the municipalities. The local identity of the people is therefore mostly strongly related to the municipality. At the medium administrative level in Finland, the country is divided into 18 regions, in which the respective municipalities are organized into regional councils on the one hand, and 15 Centres for Economic Development, Transport and the Environment on the other hand. The Swedish-speaking Åland Islands are excluded from the above stated administrative structure. They have an autonomous status and have an independent administrative structure (Purkarthofer and Mattila 2023).

Finland is very rural overall and extremely sparsely populated, especially in the northern municipalities. Overall, the country has a population density of only about 16 inhabitants per square kilometer (Statistics Finland 2023a, NLS 2018). This contrasts sharply with the highly urbanized capital region with 1,533 inhabitants or Helsinki alone with 3,073 inhabitants per square kilometer (Statistics Finland 2023a, NLS 2018). In terms of Finland's demographic structure, it is noticeable that the population is ageing. This can also be seen in the population projections. For example, the population in the 0 to 44 age groups is expected to decline by 2040. This contrasts with the population group of 75-year-olds and older, where a very strong increase is forecast. Here, too, the capital region stands out from the statistics for the country as a whole. Although the older population cohorts are also expected to increase here, at the same time there is no discernible downward trend among the younger cohorts (Statistics Finland 2021). Overall, Finland is experiencing increasing immigration from other countries, but this is most visible in the more urbanized areas, such as the capital region. At the same time, in the context of intermunicipal migration movements in Finland, it can be observed that many people move from rural areas to urbanized areas (Statistics Finland 2023b, Statistics Finland 2023c). Finland is characterized by a rural exodus.

In terms of the economy, industry and services both play an important role in Finland. In urbanized areas, however, there are particularly many employees in the service sector. In rural areas, agriculture, forestry, wood production and paper production can be identified as important in the industrial sector, in contrast to urban areas. In these areas, there are particularly large numbers of employees on the rural side (Statistics Finland 2022).

Culturally, Finland is characterized by a self-image as a country with a geogrpahically and politically peripheral location (Purkarthofer 2023). It can be assumed that in this context, a social sense of duty to adapt to global political and economic trends and movements on the one hand and personal responsibility with

regard to growth and prosperity on the other hand lead to a country with a certain openness with regard to a culture of learning from failure, trial and error and innovation. The country's technology and innovation policy deliberately creates an environment to link science, industry and administrative authorities and to strategically promote start-ups in the innovative technology sector. Since the mid-1990s, Finland has experienced a strong economic upswing with this strategy and is considered one of the world's leading countries in terms of innovative strength (Edquist and Hommen 2008). In this context, Finland is also seen as a model country with exemplary function in the field of digitalization.

This cultural background also plays an important role in spatial planning and illustrates the mindset behind the approach of meeting solutions to existing tasks with new technological possibilities and a willingness to experiment. Furthermore, the historical background of Finland also influences the planning cultural context. In this context, the era in which Finland belonged to the Swedish kingdom and the era in which Finland was a grand duchy in the Russian Empire should be mentioned in particular (Purkarthofer 2023). Despite the country's independence since 1917, influences from both eras can still be found in culture and architecture today. Linguistically, for example, Swedish is still a widely spoken language in Finland. As a country with a very rural landscape and hardly populated areas, a close relationship to nature plays an important role in society, despite the noticeable urbanization and rural exodus since the 1950s. The contrast between the traditionally rural structures on the one hand and the modernization and investment developments in the urban areas on the other hand often leads to conflicts in society. In addition, social disparities, both within urbanized areas and between urban and rural areas, also cause tensions in society. Finland is traditionally a welfare state. The fact that the state provides for the economic security of the individual is an important value. Against this background, the aforementioned social disparities trigger social and political discourse (Purkarthofer 2023). These spatially relevant issues are crucial in the context of capturing the planning context.

On the other hand, environmental issues should not be underestimated when examining the key challenges of spatial transformation. In a publication, the City of Helsinki has analyzed how it is affected by climate change. Among the important factors identified are the risk of flooding due to rising sea levels and storms with heavy rainfall, as well as the general increase in precipitation in the winters, which can lead to dramatic amounts of snow or a high safety risk in road traffic as temperatures rise and hover around the freezing point more frequently than before. However, rising temperatures in summers are also increasingly perceived as a problem, both as a health risk for people and as a threat to native species of flora and fauna (City of Helsinki 2019). In planning, on the one hand, there is a general awareness of the need to make decisions that take the dangers into account (City of Helsinki 2019) and, on the other hand, sustainable urban development and mobility as a specific set of issues (Purkarthofer 2023).

In terms of systematizing the cultural factors mentioned, these can be applied to the extended theory according to Knieling and Othengrafen described in section3.2. Additionally it includes the context of the spatial transformation.The following table summarizes some important factors.

General Context	Societal context	• Self-image as peripheral geographical and political location of Finland • Rural character and closeness to nature • Experimental mindset with an open culture of learning from failure and innovation • Welfare state
	Planning context	• Rural exodus and urbanization processes • Sustainable urban development and sustainable mobility • Rather low understanding of overall planning and stronger focus on single object development with focus on design and architecture
Specific Context	Spatial transformation	• Dealing with risks associated with climate change impacts • Ageing society • Social disparities
	Digitization	• Good digital infrastructure • High social relevance • High level of innovation through exploitation of digital opportunities

Table 1: General and Specific Context aplied to the case of Helsinki, Finland

When dividing the various factors into the individual fields of context, it becomes clear that some points cannot be clearly assigned in terms of content and that a different division would also be conceivable. It is important to remember that the Specific Context is a more concrete part of the Planning Context and that the Planning Context is a more concrete part of the Societal Context. In the case of spatial transformation, for example, all points also fit into the planning context. Therefore, it is necessary to analyze beforehand which of the points that play an important role in connection with the planning context also represent a central mega-trend in society, and especially in world politics.

According to the theory of Knieling and Othengrafen, the planning artifacts are still missing for a complete consideration of the planning cultures. Here, the planning system is considered in particular. Especially the different administrative levels, relevant legal documents, formal planning instruments and plans with their legal effects, and relevant actors are to be considered. This structure is also followed by the so-called "Country Profiles" of the Academy for territorial Development in the Leibniz Association. In special cases, it may also be necessary to deal with exceptional informal planning instruments or working methods. The following explanations are taken from the "Country Profile" for Finland by Purkarthofer and Mattila 2023.

In the case of Finland, the relevant levels are the national level, the regional level (in particular the 18 regions with the regional councils) and the municipal level. The legal basis for the planning instruments at all these levels is the Land Use and Building Act of 1999. At the national level, there are the "National Land Use Objectives". These are general, central issues for which corresponding goals are formulated. The Finnish federal government, in particular the Ministry of the Environment, is responsible for this. The defined objectives must be observed and taken into account at the regional planning level. At the regional level, the "Regional Land Use Plan" is the central instrument. Here, non-parcel-specific representations of linear and areal structures are mapped on topics such as infrastructure routes, protected zones, settlement areas and development areas. The Regional Council is responsible for this. The plan has legal force for the development of plans at the Municpal level. At the Municipal level, there are two different formal planning instruments. First, there is the "Local Master Plan." This maps similar issues to the plan at the regional level, but has a higher degree of detail due to its scaling for only one municipality at a time, and also performs the function of zoning the various land uses. Here, the development visions of the municipalities are presented, which have a legally binding effect on the second instrument at this level, the "Local Detailed Plan". This plan has the purpose of developing a specific area within a municipality. It can define, among other things, permitted land uses, number of stories, building heights, certain design regulations, and other prohibitions and restrictions. It forms the basis for building permits for structures. The Municipal Council is responsible for both the Local Master Plan and the Local Detailed Plan (Purkarthofer and Mattila 2023).

Despite the structure of the planning system, in which specific sectoral planning topics are integrated in the sense of integrated planning, especially in the "Regional Land Use Plan" or the "Local Master Plan", the understanding of planning is rather less coordinative but more strictly local and design-oriented (Purkarthofer 2023).

In the specific case of Finland and Helsinki, in addition to the formal planning tools, it is necessary to mention that innovative digital possibilities are increasingly being applied and tried out in planning and are now established as a working method in many Finnish cities. Among these, the case study considered here, the digital twin of the City of Helsinki, should be mentioned. It will be explained in more detail in the next two sections.

4.2 Development and Technical Issues

Digital twins as a tool or software program have their origins in the industrial sector, where they are used in manufacturing to increase productivity and efficiency and are used in the fields of "designing/planning, optimization, maintenance, safety, decision making, remote access, and training, among others" (Singh et al. 2021). It is a "dynamic digital representation of a 3D-designed product or solution which, in the most optimal cases, represents the same features and provides the same information as its physical counterpart" (Hämäläinen 2021). Applied to the context of the digital twin of a city it is thus a 3D city model of the physical city. But it is a "solid data infrastructure forms the foundation for [...] digital twins" and has to be enriched by "city data, such as energy consumption or traffic data" (Hämäläinen 2021).

The beginnings of the City of Helsinki's digital twin go back to considerations in the 1980s. At that time, the city had seen the need to simplify processes related to road maintenance and construction. The many different departments responsible for different technical infrastructure, such as telephone, water pipes or electricity, was identified as a problem, as each department only had its own data available. The idea was therefore to share and connect these data with each other. This provided a first use case. However, in the early stages of development, it was a simple 2D basemap that was developed, but digital and therefore flexible in terms of how the map could be used to map data. Over time, more and more use cases were added and the map has finally evolved into a 3D model of the city (Tuukkanen 2023).

Important actors in the development of the digital twin of the city of Helsinki were and are the City Survey Department of the city administration and also the private sector. The City Survey Services of the City of Helsinki have the responsibility to provide the basic data for the creation of the model, so in particular the modeling of terrain, to map the topography, as well as the built environment. This involves, for example, taking measurements, but also flying over the built environment from various perspectives. The private sector with companies in the field of software development play an important role in the technical development of the tool, since here the City of Helsinki can access the necessary expertise and resources. In addition, however, individual pioneers or visionaries with the relevant competence function are also important in order to be able to implement existing ideas. In the case of the city of Helsinki, a mayor at the time provided the necessary budget for development due to his personal affinity for architecture and urban planning. The main user of the digital twin is the Urban Planning Department of the City of Helsinki, which uses the tool in urban development. However, there are other city departments that interface with and use the tool. Citizens also use the digital twin, on the one hand for public services and on the other hand within the context of participation processes initiated by the Urban Planning Department (Tuukkanen 2023).

The digital twin of the City of Helsinki was built specifically for the needs of the city. Two basic digital models have been created. On the one hand, there is the mesh model, which does not contain exact geodata, but offers a more detailed modeling and is therefore mainly used for visualizations, and on the other hand, the GML model, in which each object has an exact geoinformation, which can be stored with data, and in which measurements can also be performed. Therefore, the GML model is usedmainly for analytical use. In particular, the terrain, building bodies, but also partly underground areas and the interior of buildings are modeled. Each object in the model has a uniquely assigned ID. This makes it possible to bundle data from different departments in the same model. The digital twin is thus also a platform for data collection and links the various application areas and users, enabling coordinated collaboration. Points, lines, surfaces and volumes in the model can be used to visualize the data. The digital twin is also linked to the portal for openly accessible data, the "Heslinki Region Infoshare" (Tuukkanen 2023, City of Helsinki 2022).

4.3 Application in Urban Planning

The digital twin of the city of Helsinki is used by the city administration for urban planning and has already established itself here as a tool and working method in spatial planning (Tuukkanen 2023).

Many different functions can be used in planning. In traditional urban development, the plans for their implementation lead to a Local Detailed Plan. In the preparatory planning process, however, the drafts are visualized with the help of the digital twin. This makes it possible to compare different planning scenarios with each other and also to use them in the context of public participation integrated in the tool (City of Helsinki 2023). At the same time, urban planners can use basic functions of the GML model, such as taking different spatial perspectives, shading at certain times of the day and year, and measurements (City of Helsinki 2022). As a result, the digital twin of the city of Helsinki is a kind of new and innovative informal planning tool that can be used as a multifunctional tool.

The tool is not only mutlifunctional, but also multisectoral. There are many different use cases for special topics in spatial planning. On the one hand, these can be used within the specific spatial planning sector, but on the other hand, they are also available to planners for coordinated planning, e.g. for the development of new urban areas. Planners can thus map different thematic analyses into the model and superimpose them as needed to make data- and fact-based decisions. This has happened, for example, in the development of Helsinki's Smart City lighthouse project, the revitalization of old harbour areas to develop the Kalasatama urban district (Hämäläinen 2021).

The city of Helsinki presents some of these sectoral use cases on its website (City of Helsinki 2023). These include, for example, the visualization of data on offers and possible plans in the field of mobility analysis, the visualization of radiation on building surfaces for the analysis of solar energy potential, the visualization of technical infrastructure for the optimization of maintenance and planning and execution of construction works, the modeling of inner-city trees, the so-called Urban Tree Database, for use in the maintenance of the tree population, but also in the preparation of necessary environmentally relevant documents in permit procedures in urban planning, as well as the projection of heat islandsin the city, which also makes use of weather data (City of Helsinki 2023, Tuukkanen 2023).

Not all of these use cases are openly accessible. Especially in the case of data on critical infrastructures or sensitive information to which individual people could be linked, the city is the exclusive user of the tool. Despite the numerous possibilities offered by the tool, it is currently still mainly used for development and planning, especially the visualization of planning scenarios, analytical sectoral factors and citizen participation. Not yet strongly used are the possibilities in the daily city operations, which can be implemented with the help of technologies such as sensors, machine learning and artificial intelligence. In this area, the tool offers much more potential and could be the next step in the tool's development (Tuukkanen 2023).

5 CONTRIBUTION TO SPATIAL TRANSFORMATION

In order to be able to make a conclusion about the contribution of the digital twin of the City of Helsinki to spatial transformation, the first question to be asked is which transformative process exactly is being considered here. In addition to the core topic of spatial transformation, the management of issues relevant to climate change, there are other mega-trends, such as demographic change or digitalization, that are relevant in the context of societal transformative processes.

It can be stated without a doubt that the digital twin of the city of Helsinki makes an important contribution to climate-related issues related to global warming and the goal of decarbonization and adaptation to the changing conditions cities are confronted with.

There are many use cases of the Digital Twin where planning decisions are supported by data, analyses and visualizations of planning scenarios with regard to sustainable urban development. For example, the tool's application functions have the purpose of highlighting potentials for the development of emission-free energy production. The projection of heat islandsin the city makes it possible to recognize where intervention is needed, for example, to create more resilient spaces with greening. Mobility analyses enable the strategic planning of sustainable mobility offers and promote therefore sustainable urban development.

The contribution to coping with a spatial environmental transformation process is definitely given, however, the impact on the consequences of the mega-trend of climate change is not extraordinarily high, and can also be compared with other projects that have a similar output without using digital twins. On the other hand, the digital twin as a technological innovation in spatial planning makes many processes easier. Considering the enormous challenges faced by municipalities, the tool offers enormous advantages and puts the City of Helsinki in a privileged position here compared to other cities. The administration of the City of Helsinki is responsible for tasks that other cities in the world are responsible for, too. In the era of crises, digitalization and increasing regulation of public tasks and competencies, the City of Helsinki has a tool in the form of the digital twin that takes away some of the complexity and enables the city administration to work more efficiently. Ultimately, this also benefits efforts to achieve sustainable and resilient urban development.

When considering digital transformation, the contribution to the transformative process can also be confirmed. Both the transformation in terms of climate change-related issues and digitalization demonstrate a direct connection with the functions and effects of the tool on the working methods in the city. Particularly with regard to the digital transformation, it can be seen that the impact is extraordinarily high, as the public tasks from different areas and departments are functionally linked with each other and the work becomes more efficient. The digital twin of the city of Helsinki is thus a project that is driving digitization in the city very strongly and has the potential of having an influential impact on other cites as well.

772

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6 CONCLUSION FOR METHODOLOGICAL CONSIDERATIONS FOR FUTUR RESEARCH

From the example of the Digital Twin in Helsinki, it is possible to reflect on the methodological approach to analyze the contribution of an innovatiove digital tool used in spatial planning to spatial transformation processes.

Transition theory can be used in transformation research to identify transformative processes as such and to trace their development and course. It is important, however, that the specific element to be measured is no longer in the realm of the niche, but has already established itself at the regime level.

It is important to clearly define a coping and management objective for the mega-trend or crisis, as this is the only way to check whether the development of the niche innovation and its establishment at regime level will contribute to fulfilling the coping and management objective. The goal here should not be to fully achieve the coping objective. Since spatial transformation can be a very long process that is usually approached from many different directions, it is unlikely that the contribution of a single aspect alone will achieve the complete coping and management.

However, when comparing the impact of an innovation established at regime level with a potential contribution to a defined coping and management objective, the question arises as to its quantifiability. In order to assess the existence of a contribution, only the general knowledge of solution approaches to the mega-trend or crisis in question prevailing at the time of the analysis can be applied. This results in the necessity of naming the corresponding solution approaches in advance, at least roughly and with reference to the specific topic of the innovation. In the case of climate change, for example, a solution approach according to the prevailing current state of knowledge would be the creation of inner-city green spaces. If the impact of an innovation, such as a tool that identifies green space potentials, is matched with its contribution to addressing climate change, the contribution can be confirmed by this finding. However, the expression of a contribution can vary widely even when it exists. Therefore, it is recommended to categorize the contribution, based on different levels of expression. Possible categories could be:

- only an indirect contribution
- direct contribution with low or no extraordinary impact on the mega-trend
- direct contribution with extraordinary impact on the mega-trend

This categorization in turn creates quantifiability to a certain degree.

When considering an innovation, however, it can happen that the contribution of different sub-aspects, such as different functions of a ditial tool, are also assessed in different ways. Therefore, care must be taken in the procedure not to combine different aspects to be distinguished in the investigation.

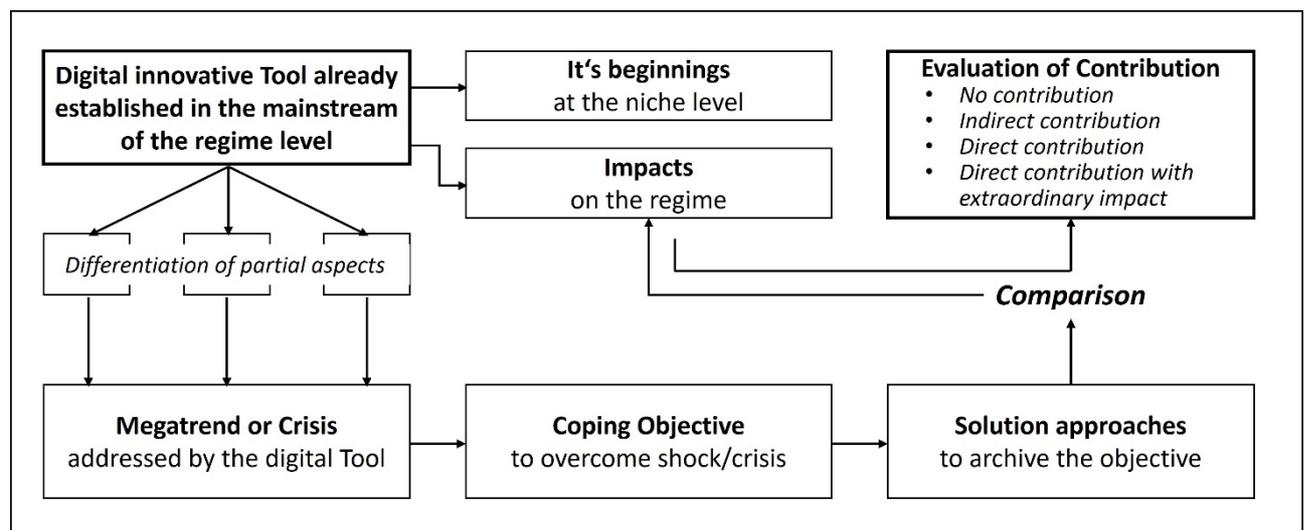The following figure summarizes the considerations regarding the methodological approach.

Figure 3: Proposed methodological approach to analyse and evaluate the contribution of a technological innovation in spatial planning to a transformative process by making use of the Multy-Level Perspective approach of transition theory; own design

However, it also became clear that for a holistic view of a technological innovation in spatial planning, further components must support the analysis. This includes, in particular, the identification of the planning culture context, taking into account the specific context of digitalization and the relevant mega-trend or crisis.

Another component to be added is the observation of the digital tool itself. Development, functions and actor structures must be identified. The technical dimension plays a particularly important role here. The methodology proposed so far is not yet able to accomplish enough in this regard. With the goal of applicability for future case study research, a standardised research grid is needed in this area that can measure technological, functional and data-based factors. There is a need for further research in this area.

7 REFERENCES

BAUKNECHT, D., Brohmann, B. and Grießhammer, R. (Publisher): Gesellschaftlicher Wandel als Mehrebenenansatz. Dessau-Roßlau, 2015

BBSR (Publisher): Smart City Charta: Digitale Transformation in den Kommunen nachhaltig gestalten. Bonn, 2017

BRUNS, A.: The Anthropocene and the great transformation – perspectives for critical governance and transformation research in the spatial sciences. In: Abassiharofteh, M., J. Baier, A. Göb, et al. 2022. Spatial Transformation - Processes, strategies, research design. pp. 50-60, Hannover, 2022

CITY OF HELSINKI (Publisher): Digital Twin - experimental development project. Webside of the City of Helsinki, https://www.helsinkikanava.fi/fi/web/helsinkikanava/folder?groupItemId=234766482, Accessed on 10.06.2023, 2023

CITY OF HELSINKI (Publisher): Helsinki's digital twin and city models. Website of the City of Helsinki, https://www.hel.fi/helsinki/en/administration/information/general/3d/3d, Accessed on 10.06.2023, 2022

CITY OF HELSINKI, Urban Environment Division (Publisher): Weather and climate change risks in Helsinki. Helsinki, 2019

EBNER, A.: Karl Polanyi: The Great Transformation. In: Kraemer K. and Brugger F. (Publisher), Schlüsselwerke der Wirtschaftssoziologie, pp. 169-175. Wiesbaden, 2017.

EDQUIST C. and Hommen, L.: Comparing national systems of innovation in Asia and Europe: theory and comparative framework. In: Edquist C. and Hommen, L (Publisher), Small Country Innovation Systems – Globalization, Change and Policy in Asia and Europe, pp. 1-30. Cheltenham, 2008

ENGEL, T. and Knieling, J.: "Große Transformation" und nachhaltige Raumentwicklung – Stand der Diskussion und Theoretische Zugänge. In: Knieling J. (Publisher), Wege zur Grossen Transformation / Herausforderungen für eine nachhaltige Stadt- und Regionalentwicklung, pp. 13-31. München, 2018

GEELS, F.W.: The multi-level perspective on sustainability transitions: Responses to seven criticisms. In: Environmental Innovation and Societal Transitions Vol. 1, Issue 1, pp. 24-40. 2011

GRIN, J., Rotmans, J. and Schot J.: Transitions to Sustainable Development - New Directions in the Study of Long Term Transformative Change. New York, 2010

GROSSI, G. and Pianezzi, D.: Smart cities: Utopia or neoliberal ideology?. In: Cities, Vol. 69, pp. 79-85, 2017

HÄMÄLÄINEN, M.: Urban development with dynamic digital twins in Helsinki city. In: IET Smart Cities, Vol. 3, Issue 4, pp. 201-210, 2021

HERRSCHEL, T.: Competitiveness AND Sustainability: Can 'Smart City Regionalism' Sqare the Circle?. In: Urban Studies, Vol. 50, Issue 11, pp. 2332-2348, 2013

HOLLANDS, R. G.: Critical interventions into the corporate smart city. In: Regions, Economy and Society, Vol. 8, Issue 1, pp. 61-77, 2015

HOLLANDS, R. G.: Will the real smart city please stand up? Creative, progressive or just entrepreneurial?. In: City: Analysis of Urban Trends, Culture, Theory, Policy, Action, Vol. 12, Issue 3, pp. 303-320, 2008

KNIELING, J. and Kretschmann, N.: Nachhaltige Stadtentwicklung im 21. Jahrhundert – klimaangepasst, smart, postfossil?, In: Freeden, W. and Rummel, R. (Publisher): Handbuch der Geodäsie. pp. 1-45, Bonn, 2016

KNIELING, J. and Kretschmann, N.: Nachhaltige Stadtentwicklung im 21. Jahrhundert – klimaangepasst, smart, postfossil?, In: Freeden, W. and Rummel, R. (Publisher): Handbuch der Geodäsie. pp. 1-45, Bonn, 2016

LEITHEISER, S. and Follmann A.: The social innovation-(tr)politicisation nexus: Unlocking the political in actually existing smart city campaigns? The case of SmartCityCologn, Germany, In: Urban Studies, Vol. 57, Issue 4, pp. 894-915, 2019

NLS (National Land Survey of Finland) (Publisher): Suomenpinta-ala kunnittain. Helsinki, 2018 (https://www.maanmittauslaitos.fi/sites/maanmittauslaitos.fi/files/attachments/2018/01/Suomen_pa_2018_kunta_maak maak.pdf, accessed 10.06.2023)

OTHENGRAFEN, F.: Spatial planning as expression of culturised planning practices: the examples of Helsinki, Finland and Athens, Greece. In: Town Planning Review, Vol. 81, pp. 83-110, 2010

PALLAGST, K., Fleschurz, R., Nothof, S., Uemura, T.: Shrinking cities - implications for planning cultures? In: Urban Studie, Vol. 58, Issue 4, pp. 164-181, 2019

PALLAGST, K., Heß, S. and Liggesmeyer, P.: Smarte Räume - Anwendungsfelder der Digitalisierung am Beispiel Smart Rural Areas. In: RaumPlanung, Vol. 217, Issue 2/3-2022, pp.8-14. 2022

PALLAGST, K.: Shrinking cities - planning challenges from an international perspective. In: Urban Infill, Special Issue 'Cities Growing Smaller', pp. 6-16, 2008

PEREIRA, L. M.,Karpouzoglou, T., Frantzeskaki, N., Olsson, P.: Designing transformative spaces for sustainability in socialecological systems. In: Ecology and Society, Vol .23, Issue 4, Art. 32,2018

PURKARTHOFER, E., MATTILA, H.: Finland. Website of ARL Internationel, https://www.arl-international.com/knowledge/country-profiles/finland. accessed on 08.06.2023, 2023

PURKARTHOFER, E: Expert talk on 06.06.2023 at Aalto University on Finish Planning Cultures, 2023

SINGH, M., Fuenmayor, E., Hinchy, E. P., Qiao, Y., Murray, N. and Devine, D.: Digital Twin: Origin to Future, Vol. 4, Issue 2, pp. 1-19. 2021

SORENSEN, A.: Taking path dependence seriously: an historical institutionalist research agenda in planning history. In: PlanningPerspectives, Vol. 30, Issue 1, pp. 17-38, 2015

SPELLERBERG, A., Berg, M., Memmel, M., Ricarda, M.: Digitalisierung und künstliche Intelligenz. In: IzR – InformationenzurRaumentwicklung, Vol. 3, pp. 286-290, 2021

STATISTICS FINNLAND (Publisher): Employed labour force in area (workplaces) by Area (workplace), Industry, Sex, Information and Year. Website of Statistics Finnland, https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__tyokay/statfin_tyokay_pxt_115h.px/table/tableViewLayout1/. Accessed on 10.06.2023, 2022

STATISTICS FINNLAND (Publisher): Immigration and emigration by age, sex and area, 1990-2022. Website of Statistics Finnland, https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__muutl/statfin_muutl_pxt_11a7.px/table/tableViewLayout1/. Accessed on 10.06.2023, 2023b

STATISTICS FINNLAND (Publisher): Intermunicipal migration by Area of arrival, Area of departure, Sex, Information and Year, 1990-2022. Website of Statistics Finnland, https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__muutl/statfin_muutl_pxt_11a1.px/table/tableViewLayout1/. Accessed on 10.06.2023, 2023c

STATISTICS FINNLAND (Publisher): Population projection 2021. Website of Statistics Finnland, https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__vaenn/statfin_vaenn_pxt_139f.px/table/tableViewLayout1/. Accessed on 10.06.2023, 2021

STATISTICS FINNLAND (Publisher): Population Structure. Website of Statistics Finnland, https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__vaerak/statfin_vaerak_pxt_11s1.px/table/tableViewLayout1/. Accessed on 10.06.2023, 2023a

TUUKKANEN, T.: Expert talk on 07.06.2023 in Helsinki, Director Strategic Partnerships at Bently Systems, on development of the Digital Twin of the City of Helsinki, 2023

United NationsUNITED NATIONS (Publisher): Goal 11: Make cities inclusive, safe, resilient and sustainable. Website of United Nations, https://www.un.org/sustainabledevelopment/cities/, Accessed on 10.06.2023, n.d.

WBGU (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen) (Publischer): Welt im Wandel – Gesellschaftsvertrag für eine Große Transformation. Berlin, 2011

WITTMAYER J. and Hölscher K. (Publisher): Transformationsforschung – Definitionen, Ansätze, Methoden. Dessau-Roßlau, 2017

ZOLFAGHARIAN, M., Walrave, B., Raven, R. and L. Romme, A. G.: Studying transitions: Past, present, and future. Research Policy, Vol. 48, Issue 9, pp. 1-16. 2019

The Role of Electric Vehicles in Greening the Environment: Prospects and Challenges

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1 ABSTRACT

Electric cars, also known as Electric vehicles (EVs), possess a smaller ecological footprint compared to traditional internal combustion engine vehicles (ICEVs). While certain aspects of their production may have comparable, reduced, or different environmental impacts, they have the advantage of emitting minimal to no tailpipe emissions. Furthermore, they help reduce reliance on petroleum, decrease greenhouse gas emissions, and mitigate the health effects caused by air and environmental pollution. In recent years, there has been a noticeable research focus on incorporating EVs into smart cities, as they offer a means to reduce urban carbon dioxide (CO_2) emissions. Consequently, a limited number of studies have sought to enhance the widespread integration of EVs in order to promote environmental sustainability and contribute to the advancement of the built environment. Consequently this study aims to explore existing literature pertaining to the impact of electric vehicles in promoting a sustainable urban transportation system and fostering an environmentally friendly ecosystem. To accomplish this, the study will employ the Prisma methodology, which involves extracting relevant information from peer-reviewed journals and conference papers. The outcomes of this research endeavor will yield valuable policy implications, aiding policymakers and decision-makers in their efforts to combat climate change and enhance the efficiency of the electric vehicle market.

Keywords: Electric Vehicles, Transport Planning, Smart Cities, Sustainability, Mobility

2 INTRODUCTION

Transportation stands as a pivotal pillar within modern civilization, serving as both a catalyst for economic progress and a generator of employment opportunities (Krishna, 2021). Yet, despite its undeniable significance and the advantages it brings, the observations of Ritchie (2020) underline an alarming reality: the transportation sector emerges as one of the largest and swiftest contributors to carbon dioxide emissions, accounting for a substantial 16.2 percent of the total global CO_2 emissions in 2020. This disconcerting trend exacts a toll on human well-being and the environment, as highlighted by Degirmenci and Breitner (2017).

In response to this pressing challenge, Sendek-Matysiak (2019) emphasizes the necessity of addressing air pollution concerns and reducing the overreliance on crude oil for road transportation. Achieving this transformation necessitates the adoption of innovative mobility concepts aligned with principles of sustainable socioeconomic advancement. On an international scale, countries grapple with the imperative to curtail carbon emissions originating from the transportation sector. Alternative energy sources have emerged as promising candidates to supplant fossil fuels, which currently power nearly 92 percent of transportation fleets/vehicles (Khalili et al., 2019).

Within this landscape, electric vehicles (EVs) emerge as a beacon of promise, providing nations the opportunity to shift away from fossil fuel-dependent vehicles towards more environmentally friendly energy alternatives like electricity. By doing so, they effectively address the adverse consequences of climate change that grip the global stage. Sun et al. (2023) underscore the predominant focus on limiting climate change to below 2°C, spurring nations to enact transformative measures. To significantly reduce greenhouse gas emissions, including CO_2, a widescale embrace of low-carbon technologies across all sectors becomes paramount (Lamb et al., 2021). While progress strides forward in certain sectors such as electricity, the transportation domain confronts formidable hurdles (Xu et al., 2021). Research by Hao et al. (2016) accentuates road vehicles as the primary emissions source, projecting a doubling of the passenger vehicle fleet by 2050. As all energy sectors grapple with the demand for decarbonization, addressing emissions in transportation emerges as particularly pivotal, given its substantial contribution to greenhouse gas emissions. Consequently, adopting alternative modes of transport like electric vehicles, which do not rely on fossil fuels, becomes a compelling imperative.

An electric vehicle (EV) is characterized by its dependence on one or multiple electric motors to propel it, drawing power from stored electrical energy within batteries or alternative storage systems (Rudatyo & Tresya, 2021). With the potential to address mounting environmental, economic, and energy challenges within transportation—ranging from air quality to climate change and urban expansion (Haddadian et al., 2015)—electric vehicles stand out for their minimized emission of greenhouse gases and pollutants in comparison to traditional gasoline or diesel vehicles (Ehrenberger et al., 2019). Moreover, the integration of electric vehicles holds the potential to bridge the divide between the energy and transportation sectors. This integration generates a wealth of data within smart cities, ushering in fresh prospects and business models for forward-looking enterprises. Thus, companies embracing EVs not only enhance their competitive edge but also fortify their strategic standing. The crux of our study revolves around dissecting the role of electric vehicles in sustainable planning, while simultaneously pinpointing the barriers obstructing their triumphant integration.

3 CONCEPTUAL SYNOPSIS

In recent years, a discernible research trajectory has emerged focusing on the integration of Electric Vehicles (EVs) within smart cities. This strategic movement stems from the potential of EVs to contribute significantly to the mitigation of urban carbon dioxide (CO_2) emissions, thus aiding in the reduction of environmental impact.

3.1 Historical Development of Electric Vehicles

In the study conducted by Anderson and Anderson in 2005, the evolutionary trajectory of electric vehicles (EVs) becomes apparent, tracing their development as a collaborative endeavor involving diverse scientists, each contributing significantly to their progression. The historical timeline of EVs can be segmented into three distinct periods: an initial era spanning from 1890 to 1929, marked by their early dominance within the market from approximately 1895 to 1905; an intermediate phase from 1930 to 1989; and the contemporary years from 1990 to the present day. The origins of EVs are rooted in the emergence of batteries, which marks the inception of their early history. In 1821, the English chemist Michael Faraday introduced the world's inaugural electric motor, followed closely by the practical application of Faraday's motor to rotate a wheel by the English mathematician and physicist Peter Barlow in 1822. The creation of "the Faraday disc," the world's pioneering dynamo by Faraday in 1831, laid the foundation for generating electrical energy through mechanical means.

This forward momentum persisted with notable innovations such as the construction of an electric motor-powered drifter in New England, United States, in 1835, and the introduction of an electric locomotive to the public in 1838. In 1841, Davidson devised the larger Galvani locomotive; however, due to the prohibitive cost of disposable batteries and resistance from railroad workers, the invention failed to thrive. Concurrently, between 1832 and 1839, Robert Anderson conceptualized a battery-powered horseless carriage. Regrettably, the absence of rechargeable batteries hindered this invention from reaching the market. A pivotal breakthrough arrived with the efforts of Dutch chemistry professor Sibrandus Stratingh, who developed a more efficient and practical battery-powered carriage. While it displayed enhanced performance, issues like noise, smoke, and discomfort persisted. Over time, Belgian scientist Gaston Plante addressed the challenge of recharging batteries, effectively overcoming the limitation of their inability to recharge post-depletion. This led to the successful creation of the first EV powered by rechargeable batteries in 1881.

Thus, the evolution of electric vehicles (EVs) encompassed a series of crucial contributions from scientists and inventors, culminating in the realization of rechargeable battery-powered automobiles. In 1881, Gustave Trouve introduced a three-wheeled EV to the public in France. Subsequently, in 1882, an English company emerged to produce rechargeable batteries, while Thomas Edison in America worked on an innovative battery type employing nickel-iron. Between 1910 and 1925, substantial advancements in battery technology materialized: battery storage capacity increased by 35%, service life improved by 300%, and maintenance costs plummeted by 63%. EVs proved to be cleaner, odorless, quieter, easier to initiate, less intricate, and more convenient in comparison to horse-drawn carriages or internal combustion engine vehicles (Burton, 2013). In 1894, the collaboration of Henry Morris and Pedro Salom yielded an "electrobat," a two-person transportation vehicle. Recognizing its potential, Isaac Leopold Rice, president of the Electric Storage Battery Company of Philadelphia, proposed a joint venture with Morris and Salom. Subsequently, the

778

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Electric Vehicle Company (EVC) was established, concentrating on the manufacture of both batteries and EVs. The first commercially viable EV was produced at the Columbia factory in Hartford, Connecticut, and unveiled in May 1897. Shortly after, a service station for charging infrastructure was inaugurated in Newport. From 1897 to the summer of 1899, Columbia manufactured several hundred EVs for both domestic and international markets.

3.2 Overview of Electric Vehicle Adoption in the Developed and Developing Countries

Lambert (2022) posits that the advancement of electric vehicles is gaining momentum across the majority of developed nations worldwide. Presently, the global roads host a fleet of over 16 million electric vehicles (EVs), with a predominant 90 percent concentration observed in China, Europe, and the United States. Notably, various countries, particularly those classified as developed, have demonstrated remarkable progress towards the widespread adoption of EVs. Fortuna (2019) identifies the leading 15 nations in terms of EV market share, all of which are European countries. Norway emerges at the forefront with an impressive 82.7 percent market share in the first half of 2021, followed by Iceland (55.6%), Sweden (39.9%), Finland (28.3%), Denmark (26.8%), Germany (22.1%), Netherlands (19.7%), Luxembourg (18.3%), Switzerland (18.2%), Austria (17.2%), France (15.5%), Portugal (15.4%), Belgium (15.3%), the UK (14.9%), and Ireland (13.4%). While the United States (US) does not claim a spot within the top 15 countries in terms of EV market share, it stands as the third-largest market, trailing behind China and Europe. Notably, by 2020, Europe has superseded China, holding the consistent record of dominating the global electric vehicle market in terms of sales growth since 2012 (Perkins, 2021).

Furthermore, the transition from internal combustion engine vehicles (ICEVs) to more ecologically sustainable EVs has gained acceptance in numerous developed nations across the globe. Scholars such as Carranza et al. (2014), D'Egmont (2015), and Olson (2018) conducted studies on EV adoption in Norway, revealing that while the country faced obstacles such as elevated EV costs relative to ICEVs and insufficient charging infrastructure, these challenges could be surmounted through strategic incentives and a well-defined plan for establishing adequate charging networks. In a study exploring electric mobility in Europe, Biresselioglu et al. (2018) identified impediments to widespread EV adoption, including a dearth of charging infrastructure, escalating electric vehicle prices, extended charging durations, heightened electricity consumption by EVs, and scarcity of battery raw materials. Greene et al. (2014) delved into the transition to EVs in the United States and concluded that factors inhibiting the shift included uncertainties surrounding EV technology and the limited influence of governmental regulations. They also emphasized the importance of forthcoming studies to address EV-related uncertainties, thus providing a foundation for policy formulation. Vassileva and Campillo (2017), in their analysis of EV adoption barriers in Sweden, deduced that the absence of a robust incentive structure acted as a potential hindrance. Overall, the trajectory is clear: the majority of developed nations are embarking on the path of adopting electric vehicles as a prominent alternative to fossil fuel-dependent vehicles.

3.3 Electric vehicles adoption in the Developing countries.

Between 2015 and 2020, the market share data concerning new electric vehicle (EV) sales in "other countries" (excluding China, Europe, and the United States) remained below 2%, underscoring the prevalent challenges that many countries, particularly those in the developing sphere, continue to encounter in their quest for EV adoption (IEA, 2021). The insufficiency of a well-established market structure, network infrastructure, and robust economy stands as the chief explanation for the lag in EV adoption within developing nations, as elucidated by Asif et al. (2021).

Prakash et al. (2018) delved into the impediments faced by India, a developing country, regarding widespread EV adoption, identifying barriers that encompassed, among other factors, inadequate charging infrastructure, absence of governmental incentives, and customer traits. Similarly, Asadi et al. (2021) undertook a study exploring factors influencing EV adoption, revealing that range anxiety, post-sales support, and a dearth of charging infrastructure were the principal roadblocks to progress in Malaysia's EV adoption journey. Bigot (2020) turned attention to Russia, uncovering the slow integration of EVs, primarily attributed to the elevated cost of EVs, harsh winter conditions, and a deficiency in charging infrastructure. Encouragingly, Bigot also revealed a promising trajectory, as Russia's charging infrastructure is expanding, poised to surmount this barrier in the future.

Habich-Sobiegalla et al. (2018) concluded a study probing the intentions behind EV purchases in Brazil, pinpointing the elevated cost of EVs relative to internal combustion engine vehicles (ICEVs) and the inadequacy of public infrastructure to support their deployment. Moeletsi (2021), in a survey examining EV barriers in Gauteng, South Africa, brought forth the primary factors contributing to people's reluctance in acquiring electric vehicles—namely, the elevated purchase price and steep battery expenses.

However, although the pace of EV adoption in developing countries is arguably sluggish, with research in this domain still scarce (Asif et al., 2021), several developing nations have set ambitious targets and long-term strategies for EV integration. For instance, India has set an audacious goal to replace all ICEVs with EVs by 2030 (Chhikara et al., 2021; Das et al., 2019). Malaysia aims to establish 125,000 charging stations by 2030, while Thailand has laid out an extensive EV policy with the objective of having 1.2 million operational EVs and 690 charging stations by 2036 (Schröder et al., 2021). In Africa, South Africa is ambitiously targeting to account for 1% of global EVs (Wilberforce, 2021). To conclude, it is evident that the pace of EV adoption within developing countries lags behind that of their developed counterparts, although various initiatives and strategic plans have been set in motion to bridge this gap.

4 METHODOLOGY

The review on the role of electric vehicles (EVs) in environmental sustainability and their potential barriers to adoption was conducted using the Prisma approach. To gather comprehensive information, the study drew upon the latest academic literature on the topic and supplemented it with case studies from selected countries. These case studies served as crucial sources of information for defining the methodology and identifying the main application testbeds. The primary objective of the proposed multilayer approach was to assess the impact of EV adoption compared to vehicles reliant on fossil fuels, specifically focusing on its contribution to maintaining and achieving a greener environment. Additionally, the study explored the prospects of EVs while also identifying the obstacles and challenges that hinder their widespread adoption.

5 FINDINGS

This section presents information on the contributions of electric vehicles to the environment, its prospects and challenges.

5.1 Prospects of Electric Vehicles in Greening the Environment

Climate change and greenhouse gas emissions have become increasingly serious in recent years and transportation has been identified as one of the greatest contributor to this menace. While transportation is an integral part of any country, it cannot be denied that it is also a significant contributor to greenhouse gases. Based on this, there is need to identify ways of curtailing these, especially in cities and countries with great automobile dependance. One of the ways of the ways of reducing the reliance on cars that uses fossil fuels which is one of the greatest contributor to environmental problems and increasing the greening of the environment is the use of electric vehicles. Below are some of the Pros/ Prospects of Electric vehicles in achieving a green environment.

- Energy Savings: Electric vehicles are particularly effective in conserving energy at lower speeds and in situations that involve frequent changes in driving dynamics. This characteristic makes cities an ideal target market for their adoption. As the generation of electricity is expected to become greener in the future, electric vehicles have the potential to significantly reduce greenhouse gas emissions. Given the ongoing global discourse on climate change, this becomes a crucial consideration. Notably, the transportation sector accounts for over a fifth of the European Union's greenhouse gas emissions and is the only sector experiencing emission growth. While there is still potential for reducing emissions per kilometer driven through improvements in internal combustion engines, achieving emission reductions beyond 50% necessitates the implementation of new technological solutions like electric vehicles. Compared to conventional vehicles, electric vehicles exhibit approximately 50% lower emissions based on the current average electricity supply. Moreover, additional environmental benefits can be realized as the carbon intensity of power generation continues to decrease through the integration of greener and renewable energy sources.

- Societal and environmental cost: A report by Tseng et al. (2013) stated that the overall emission costs associated with the lifetime of a car encompass three primary sources of emissions: upstream

production and disposal of car components, tailpipe exhaust, and upstream energy production. Collectively, these three categories of emission costs are commonly referred to as the societal and environmental cost over the vehicle's lifespan. Specifically, tailpipe emissions during the driving cycle contribute to the release of air pollutants that have detrimental effects on human health. A comprehensive study conducted by Michalek et al. (2011) focused on vehicular emissions across a wide range of vehicle types based on gasoline consumption. The study revealed that, except for electric vehicles (EVs), tailpipe emissions of greenhouse gases (GHGs) constitute more than 50% of the total lifetime GHG emissions for most vehicle types. Furthermore, these emissions have a significant impact on health outcomes, including mortality and morbidity, as well as adverse effects on the environment such as reduced visibility, crop loss, forest degradation, depreciation of natural resources, and material depreciation. Hence, the electric vehicle is considered accounts for the least in terms of societal and environmental cost.

- Reductions in Noise Pollution: According to the research conducted by Hatt et al. in 2020, electric vehicles (EVs) offer distinct advantages over gas-powered (internal combustion engine) vehicles, providing benefits to their users. Notably, experts in transportation and electricity, as highlighted by Noel et al. in 2018, have identified noise reduction and improved performance as the top three advantages of EVs.

One significant benefit is the reduction in noise levels associated with EVs. This attribute contributes to a more pleasant driving experience for individuals and helps maintain low noise levels within communities. By minimizing noise pollution, EVs offer a quieter and more peaceful environment for both drivers and nearby residents.

- Lower Maintenance: Electric vehicles offer significant advantages compared to vehicles that rely on fossil fuels, including reduced maintenance requirements and economic savings. Studies by Egbue and Long (2012) and Noel et al. (2018) highlight these benefits. According to Lin and Sovacool (2020), users of electric vehicles have reported lower maintenance needs and reduced operating costs, primarily due to the absence of fuel expenses and the availability of inexpensive electricity.

When electric vehicle owners were asked to assess the advantages of their ownership, "less maintenance" emerged as the second most popular benefit, as it translates to both monetary and time savings (Egbue & Long, 2012). The reduced need for maintenance not only contributes to financial savings but also allows owners to allocate their time more efficiently. From the foregoing, it can be asserted that electric vehicles is very vital in achieving a green environment through the reduction in various environmental problems such as pollution and overall improvement in human health.

5.2 Barriers to the use/adoption of Electric Vehicles

Despite the role of electric vehicles in greening the environment, there are numerous barriers in both the developed and the developing countries of the world militating its effective adoption. Below are some of the barriers to its use:

- High Cost of Acquisition: The substantial initial purchase cost stands as a major deterrent to the widespread adoption of electric vehicles (EVs) across a global spectrum of countries. To illustrate, Sidabutar (2020), in a study focusing on electric vehicle utilization in Indonesia, highlighted that the typical purchasing capacity for cars in the country rests around 200 million Rupiah. Comparatively, the most affordable electric vehicle available in Indonesia, the DFSK Gelora E, carries a price tag of 480 million Rupiah—a sum surpassing the average car purchasing power by more than 200 percent. Consequently, this fiscal discrepancy compels consumers in Indonesia to lean towards internal combustion engine vehicles as their preferred choice. The elevated cost of EVs primarily emanates from the lofty battery prices, particularly pronounced in developing nations that often rely on battery imports from China— a pivotal constituent in EV manufacturing (Umah, 2021).

- Insufficient amount of charging infrastructure/ stations: The absence of a robust charging infrastructure constitutes a substantial barrier to the widespread adoption of electric vehicles, as underscored by Raksodewanto (2020). Serving as the bedrock for providing the primary energy source for electric vehicles, charging stations play an indispensable role in facilitating their adoption. However, the existing infrastructure remains far from attaining the envisioned goal of 25,000 gas

stations by the year 2030. Presently, a mere 200 operational charging stations exist, revealing a stark disparity due to the elevated installation costs, particularly prominent in most developing countries, with Indonesia serving as a prominent example.

The twin challenges of range anxiety and the dearth of adequate charging infrastructure frequently engender stress and unease among electric vehicle (EV) owners. The prospect of undertaking long-distance journeys amplifies these concerns, especially when navigating areas beyond urban domains, a concern illuminated by She et al. in 2017. The predicament intensifies when EV owners must rely on unfamiliar sites, such as hotels, often necessitating appeals for access to charging facilities, thereby compounding stress and uncertainty. In the context of Indonesia, the installed charging infrastructure remains notably inconsequential in comparison to the sheer volume of gas stations. This imbalance prompts prospective Indonesian electric vehicle buyers to deduce that the nation is yet to establish a comprehensive preparedness for transitioning to electric vehicles (Jati, 2021).

- The safety and performance of the lithium ion battery used in EVs are both notable barriers to purchasing and present a challenge once the EV has been purchased. One particular aspect that raises concerns among individuals is the performance of lithium-ion batteries in electric vehicles (EVs), primarily due to the lengthy charging time compared to the quick refueling process of gas-powered vehicles (Lin and Sovacool, 2020). Charging a battery in an EV may require several hours, posing a potential inconvenience to users. In addition to the charging time, safety represents another significant apprehension associated with the adoption of EVs, primarily due to the inherent risks of battery-related incidents. Instances of battery fires or explosions, particularly in the event of an accident, have been identified as valid safety concerns (She et al., 2017; Hatt et al., 2020). Ensuring the safety of EVs and their battery systems remains a key consideration for widespread acceptance and adoption.

- The performance and reliability of an EV once purchased are also a major barrier barriers to the widespread adoption of EVs. For example, one aspect that has raised concerns among electric vehicle users and experts is the durability of the battery and the potential need for replacement, particularly considering the high cost associated with replacing the lithium-ion battery. In relation to this, Lin and Sovacool (2020) highlighted the issue of reliability, particularly during the winter season, as the battery might require more frequent charging and longer charging times.

- Lack of model diversity: Studies have shown that electric vehicles face limitations in terms of price range and available features, leading to a lack of diversity. The options for consumers to customize their EVs according to their specific needs are limited. For instance, certain EV models may be too small and impractical for individuals with families, failing to meet their requirements. Additionally, there is a noticeable absence of functional diversity, particularly for those who require towing capabilities, as there are no current EV truck models available (Haddadian et al., 2015).

5.3 Sustainable Urban Mobility

Crafting a sustainable urban transport system encompasses the enhancement of multiple facets, including but not limited to mobility, accessibility, affordability, social equity, efficiency, safety, security, convenience, low carbon footprint, comfort, and harmonious coexistence with both people and the environment. Achieving this vision necessitates a comprehensive approach to address diverse challenges, which collectively encompass: the mitigation of urban air pollution, grappling with climate change, curbing the toll of road accidents, taming excessive motorization, bolstering public transportation services, fostering pedestrian and cycling culture, and acknowledging the distinct requirements of marginalized urban populations, women, the elderly, individuals with disabilities, youth, and children.

It remains pivotal to recognize that urban transport, or mobility, transcends mere isolation; its dimensions are intricately intertwined with various other aspects of urban existence. United Nations Environment Programme (UNEP) (2010) underscores that the transport sector stands as the second-largest contributor to global carbon dioxide (CO_2) emissions stemming from fossil fuel combustion. Of this share, a significant 23 percent of CO_2 emissions emanate from transportation, with road transport constituting a substantial 73 percent, trailed by international shipping and aviation. Paradoxically, transport's role in global climate change mitigation initiatives remains disproportionately limited in comparison to other sectors. Among the

782

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prominent environmental concerns, urban air pollution emerges as a pervasive hazard, casting a shadow over numerous locales.

	PM10 (µg/m3)	SO$_2$ (µg/m3)	NO$_2$ (µg/m3)
WHO Air Quality Guidelines:	20	20	40
Beijing	89	90	122
Delhi	150	24	41
Tokyo	40	18	68
Seoul	41	44	60
Mexico City	51	74	130
Bangkok	79	11	23
London	21	25	77
New York	21	26	79
Paris	11	14	57
Shanghai	73	53	73
Santiago	61	29	81
Sao Paulo	40	43	83

Table 1: Air pollution in selected cities. Source: World Bank, 2009

Table 1 presents the World Bank's comprehensive assessment of air pollution levels across select cities in both developed and developing countries worldwide. A striking trend emerges from the data: cities in developing countries consistently exhibit higher levels of various air pollutants in comparison to their developed counterparts. Despite this observation, only a handful of cities manage to adhere to the recommended thresholds established by the World Health Organization (WHO) to ensure air quality. Across the global landscape of cities, the road transport sector stands out as the primary contributor to urban air pollutants, alongside elevated levels of carbon monoxide and hydrocarbons, among other noxious substances. Consequently, these emissions play a substantial role in triggering an array of respiratory and cardiovascular afflictions. An array of epidemiological investigations have unequivocally linked pollutants stemming from transportation to ailments like asthma, bronchitis, heart attacks, and strokes. Those particularly vulnerable to the perils of urban air pollution include infants, the elderly, and individuals afflicted by chronic respiratory ailments. For instance, as reported by Majumdar (2010), a staggering 25.6 percent of children in Bangalore, India, experienced asthma between 1999 and 2009. Furthermore, according to the World Health Organization (WHO) (2008), air pollution is implicated in nearly 2 million premature fatalities globally, with road transport emerging as a substantial contributor to this grim toll due to its role in exacerbating outdoor air pollution.

To effectively combat these issues, it is imperative for cities to recognize that concerted, collective actions are essential, aligning with global mitigation objectives. Adopting a diversified array of measures rather than relying solely on a single approach yields manifold advantages. This multifaceted strategy encompasses:

Push and Pull approach:

Examining the predicament through the lens of "where" individuals should position themselves in the realm of transportation—effectively where to "guide" them—and discerning which modes warrant their engagement, constitutes a methodological perspective referred to as the "push and pull" approach. This approach underscores the necessity for urban transport strategies to not only incentivize the public to opt for public transport and nonmotorized alternatives but also to devise tactics that gently nudge them away from the confines of automobiles and analogous modes of transport. Attaining the "pull" dimension entails delivering a commendable standard of service within public transport, erecting robust infrastructures catering to public and non-motorized modes, and implementing policies that enhance the usability of these modes. Concurrently, achieving the scenario where individuals are "restrained from car usage" necessitates the enactment of policies designed to discourage vehicular reliance. Such policies encompass the termination of fuel subsidies, the establishment of fees associated with automobile ownership and operation, and a comprehensive implementation of measures that escalate the overall costs incurred by utilizing these modes. Critically, the revenue generated from these charges should be channeled to reinforce the sustainable urban transport alternatives.

Public Transport, Non-motorized transport, Transport demand management, and Transit oriented development: An alternative perspective on implementing sustainable urban transport hinges upon the utilization of the four delineated measures. Public Transport represents a pivotal dimension of this approach, necessitating the creation of robust public transport systems, encompassing the establishment of comprehensive mass transit networks. Within this ambit, the Bus Rapid Transit (BRT) system has emerged

as a favored solution in recent years, celebrated for its moderate implementation costs, expedited setup, exceptional service quality, and impressive passenger capacity, thereby translating to diminished vehicular congestion. Additionally, other rapid and ecologically benign urban passenger transport systems such as subways and light-rail configurations ought to be embraced as supplementary transport modes, thereby encouraging the establishment of multi-modal transport systems.

For instance, a notable 116 cities, predominantly situated in industrialized nations, operate their own metro systems, catering to an estimated daily ridership of 155 million individuals. Furthermore, approximately 400 light rail systems operate worldwide, with a staggering 200 additional systems currently in the planning phase. Many burgeoning megacities in developing nations are also directing investments toward the establishment, enhancement, and expansion of urban light-rail networks. Despite the formidable construction and maintenance expenses associated with metro and urban light-rail systems, they offer substantial, far-reaching benefits across the economic, social, and environmental spectrums. Non-Motorized Transport, alternatively labeled as "Active Transport," encapsulates pedestrian and cycling modes, as well as their associated infrastructure, policies, and educational initiatives. In recent times, these modes have gained notable traction due to their pronounced merits in curbing transport emissions and bolstering human well-being (Godefrooji et al., 2009).

Transit Oriented Development: This concept pertains to an urban design strategy characterized by policies that endorse intensified urban development along mass transit corridors (Cervero, 1998). The underlying logic driving this approach is rooted in the potential for substantial gains in energy efficiency and transport efficacy achieved through urban layouts in which mass transit networks enable swift connectivity to key urban hubs encompassing residences, workplaces, educational institutions, recreational venues, and healthcare facilities.

Avoid, Shift, Improve Framework:

- Avoid: The initial strategy centers on curtailing unnecessary travel and minimizing trip distances. This entails seamless integration of land use and transport planning, the promotion of mixed-use developments, and leveraging information and communication technologies (ICT) to curtail individual travel frequency. Strategic implementation can effectively augment accessibility, curbing travel distances and durations. Achieving proximity between residences, workplaces, and commercial centers through comprehensive urban development master plans is a pivotal facet. Furthermore, this approach capitalizes on the potential of ICT to replace activities previously mandating physical travel. Given its potential for profound social, economic, and environmental benefits, the "Avoid" strategy takes precedence, as its comprehensive application can significantly transform urban transport dynamics.

- Shift: The subsequent strategy is dedicated to facilitating a transition towards more sustainable transportation modes. This entails encouraging automobile and motorcycle users to pivot towards public and non-motorized alternatives. Leveraging an array of travel demand management tools, the strategy orchestrates an enhanced development of both inter-city passenger and cargo transport. Moreover, it cultivates an environment that retains existing public and non-motorized transport users, acknowledging their role in promoting sustainability. Properly executed, the "Shift" approach ranks as the second most potent avenue for instating sustainable urban transport. When Avoid and Shift strategies synergize within a city, the foundation for transformative change is laid, although continued enhancements remain feasible.

- Improve: The final strategy revolves around policies that seek to elevate transport practices and technologies, embracing a technological perspective to address urban transport challenges. This encompasses refining fuel quality, enhancing vehicle fuel efficiency standards, instituting vehicle emission regulations, introducing vehicle inspection and maintenance (I&M) protocols, and transitioning towards "intelligent transportation systems" capitalizing on information and communication technologies for enhanced transport management. This strategy also underscores the urgency of refining freight transport technologies and logistics for comprehensive transformation.

Overall, even though the success rate of electric vehicles in achieving sustainable transportation planning is enormous, there is a need to explore other measures which will promote sustainable planning, especially in the developing countries of the world where the rate of adoption and utilization of electric vehicles is low.

6 CONCLUSION

Transportation stands as a pivotal conduit linking individuals, locations, commodities, and services, fostering community growth, augmenting quality of life, and nurturing economic vitality. However, it concurrently serves as a noteworthy contributor to greenhouse gas emissions. In response, the global arena is actively endeavoring to address these challenges by pivoting towards greener energy sources and transitioning from fossil fuel-propelled vehicles to electric alternatives. Nevertheless, the widespread adoption of electric vehicles (EVs) remains an intricate challenge, particularly in developing nations. Obstacles encompassing inadequate charging infrastructure, elevated EV costs, and limited public awareness collectively hinder the swift embrace of EVs. By discerning the paramount catalysts and impediments in electric vehicle adoption, these nations can strategically chart pathways to surmount these barriers and bolster the integration of electric vehicles into their landscapes. Additionally, alternative sustainable transportation methods such as such as integration of all modes of transport such as the use of active travel/public transport in combination with other modes such as road, rail and air. Also, it is pertinent that to avoid total eradication of vehicles that use fossil fuels on our roads, there is a need to generate ways to adapt fossil fuel vehicles to use of renewable energy. This will allow road users/motorists to focus on diverse options instead of a single track which is not beyond human ingenuity.

7 REFERENCES

Anderson, C.D., & Anderson, J. (2005). Electric and Hybrid Cars: A History. United States of America: McFarland, 2005, p. 189.

Asadi, S., Nilashi, M., Samad, S., Abdullah, R., Mahmoud, M., Alkinani, M. H., & Yadegaridehkordi, E. (2021). Factors impacting consumers' intention toward adoption of electric vehicles in Malaysia. Journal of Cleaner Production, 282, 124474. https://doi.org/10.1016/j.jclepro.2020.124474

Asif, M., Jajja, M. S. S., & Searcy, C. (2021). A Review of Literature on the Antecedents of Electric Vehicles Promotion: Lessons for Value Chains in Developing Countries. IEEE Transactions on Engineering Management. https://doi.org/10.1109/tem.2021.3099070

Bigot, S. (2020). 8 things to know about electric cars in Russia. Eurasia Network. https://eurasianetwork.eu/2017/08/19/7-things-to-know-about-electric-cars-in-russia/

Biresselioglu, M. E., Demirbag Kaplan, M., & Yilmaz, B. K. (2018). Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes. Transportation Research Part A: Policy and Practice, 109, 1–13. https://doi.org/10.1016/j.tra.2018.01.017

Burton, N. (2013). History of Electric Cars. Ramsbury, England: Crowood.

Carranza, F., Paturet, O., & Salera, S. (2014). Norway, the most successful market for electric vehicles. Proceedings of the 2013 World Electric Vehicle Symposium and Exhibition (EVS27). https://doi.org/10.1109/EVS.2013.6915005

Chhikara, R., Garg, R., Chhabra, S., Karnatak, U., & Agrawal, G. (2021). Factors affecting adotion of electric vehicles in India: An exploratory study. Transportation Research Part D: Transport and Environment, 100, 103084. https://doi.org/10.1016/j.trd.2021.103084.

D'Egmont, R. (2015). Electric Vehicles: The Norwegian Experience in Overcoming Barriers. Bellona Europa, 32(0), 2–5. https://bellona.org/assets/sites/4/Bellona-EV-Brief_The-Norwegian-Success-Story1.pdf

Das, M. C., Pandey, A., Mahato, A. K., & Singh, R. K. (2019). Comparative performance of electric vehicles using evaluation of mixed data. Opsearch, 56(3), 1067–1090. https://doi.org/10.1007/s12597-019- 00398-9

Degirmenci, K., & Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range? Transportation Research Part D: Transport and Environment, 51, 250–260. https://doi.org/10.1016/j.trd.2017.01.001

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. Energy Policy, 48, 717-729

Fortuna, C. (2019). If We Want To See More EV Adoption, We Need To Educate The Masses. CleanTechnica. https://cleantechnica.com/2019/03/31/if-we-want-to-see-more-ev-adoption-we-need-to-educate- the-masses/

Godefrooij, T., Pardo, C.F., & Sagaris, L. (eds) (2009). Cycling Inclusive policy Development: A handbook. Eschborn.

Greene, D. L., Park, S., & Liu, C. (2014). Analyzing the transition to electric drive vehicles in the U.S. Futures, 58, 34–52. https://doi.org/10.1016/j.futures.2013.07.003

Habich-Sobiegalla, S., Kostka, G., & Anzinger, N. (2018). Electric vehicle purchase intentions of Chinese, Russian and Brazilian citizens: An international comparative study. Journal of Cleaner Production, 205, 188–200. https://doi.org/10.1016/j.jclepro.2018.08.318

Haddadian, G., Khodayar, M., & Shahidehpour, M. (2015). Accelerating the Global Adoption of Electric Vehicles: Barriers and Drivers. Electricity Journal, 28(10), 53–68. https://doi.org/10.1016/j.tej.2015.11.011

Hao H., Geng Y., & Sarkis J. (2016) Carbon footprint of global passenger cars: scenarios through 2050. Energy 101:121–131. https://doi. org/10.1016/J.ENERGY.2016.01.089.

Hatt, K., Wilson, B & Butt, P. (2020). Benefits and Barriers to Electric Vehicle Adoption in the City of Guelph. Guelph, ON: Community Engaged Scholarship Institute. https://atrium.lib.uoguelph.ca/xmlui/handle/10214/8902.

IEA. (2021). Global EV Outlook 2021 - Accelerating ambitions despite the pandemic. Global EV Outlook 2021, 101. https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

Jati, G. (2021). The Government's Electric Vehicle Infrastructure Target is Still Creating Range Anxiety. Institute for essential Services Reform. https://iesr.or.id/en/the-governments-electric-vehicle-infrastructure- target-is-still-creating-range-anxiety

Khalili, S., Rantanen, E., Bogdanov, D., & Breyer, C. (2019). Global transportation demand development with impacts on the energy demand and greenhouse gas emissions in a climate-constrained world. Energies, 12(20). https://doi.org/10.3390/en12203870

Krishna, G. (2021). Understanding and identifying barriers to electric vehicle adoption through thematic analysis. Transportation Research Interdisciplinary Perspectives, 10, 100364. https://doi.org/10.1016/j.trip.2021.100364

Lamb W.F, Wiedmann T., Pongratz J., Andrew R., Crippa M., Olivier J.G.J., Wiedenhofer D., Mattioli G, Al Khourdajie A., House J., Pachauri S., Figueroa M., Saheb Y., Slade R., Hubacek K., Sun L., Ribeiro S.K., Khennas S., De La Rue Du Can S., & Minx J. (2021) A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. Environ Res Lett 16(7): 073005. https://doi.org/10. 1088/1748-9326/ABEE4E

Lambert, F. (2022, February 2). Global market share of electric cars more than doubled in 2021 as the EV revolution gains steam. Electrek. https://electrek.co/2022/02/02/global-market-share-of-electric-cars-more-than- doubled-2021/

Lin, X., & Sovacool, B. K. (2020). Inter-niche competition on ice? Socio-technical drivers, benefits and barriers of the electric vehicle transition in Iceland. Environmental Innovation and Societal Transitions, 35, 1-20.

Majumdar, S. (2010). More and more kids falling prey to asthma in Bangalore. DNA. (Available at http://www.dnaindia.com/bangalore/report_more-and-more-kidsfalling-prey-to-asthma-in-bangalore_1342244)

Michalek, J.J., Chester, M., Jaramillo, O., Samaras, C., Shiau, C.S. & Lave, L.B. (2011). Valuation of plug-in vehicle life-cycle air emissions and oil displacement benefits. Proceedings of the National Academy Sciences 108 (40), 16554–16558.

Moeletsi, M. E. (2021). Socio-economic barriers to adoption of electric vehicles in South Africa: Case study of the gauteng province. World Electric Vehicle Journal, 12(4), 1–11. https://doi.org/10.3390/wevj12040167

Noel, L., Zarazua de Rubens, G., Kester, J., & Sovacool, B. K. (2018). Beyond emissions and economics: Rethinking the co-benefits of electric vehicles (EVs) and vehicle-to-grid (V2G). Transport Policy, 71, 130-137.

Olson, E. L. (2018). Lead market learning in the development and diffusion of electric vehicles. Journal of Cleaner Production, 172, 3279–3288. https://doi.org/10.1016/j.jclepro.2017.10.318

Perkins, R. (2021). Europe overtakes China in EV sales growth in 2020. S&P Global. https://www.spglobal.com/platts/en/market-insights/latest-news/coal/012021-europe-overtakes- china-in-ev-sales-growth-in-2020

Prakash, S., Dwivedy, M., Poudel, S. S., & Shrestha, D. R. (2018). Modelling the barriers for mass adoption of electric vehicles in Indian automotive sector: An Interpretive Structural Modeling (ISM) approach. 2018 5th International Conference on Industrial Engineering and Applications, ICIEA 2018, 458–462. https://doi.org/10.1109/IEA.2018.8387144

Raksodewanto, A. A. (2020). Compare Electric Car With Conventional Car [Membandingkan mobil listrik dengan mobil konvensional], 89–92. http://technopex.iti.ac.id/ocs/index.php/tpx20/tpx20/paper/viewFile/331/192

Ritchie, H. (2020). Sector by sector: where do global greenhouse gas emissions come from?. OurWorldInData. https://ourworldindata.org/ghg-emissions-by-sector

Rudatyo, & Tresya, R. (2021). Construction of Electric Vehicle Policies in Indonesia , Types , and Prices. International Conference For Democracy and National Resilience (ICDNR 2021). http://dx.doi.org/10.2991/assehr.k.211221.016

Schröder, M., Iwasaki, F., & Kobayashi, H. (2021). Promotion of Electromobility in ASEAN: States, Carmakers, and International Production Networks. Economic Research Institute for ASEAN and East Asia (ERIA). https://www.eria.org/uploads/media/Research-Project-Report/2021-03-Promotion-Electromobility-ASEAN/Promotion-of-Electromobility-in-ASEAN.pdf

Sendek-Matysiak, E. (2019). Electric cars as a new mobility concept complying with sustainable development principles. Computational Technologies in Engineering (TKI'2018) AIP Conference Proceedings 2078, 020026-1–020026-6; https://doi.org/10.1063/1.5092029

She, Z. Y., Sun, Q., Ma, J. J., & Xie, B. C. (2017). What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. Transport Policy, 56, 29- 40.

Sidabutar, V. T. P. (2020). A study of the development of electric vehicles in Indonesia: prospects and constraints. [Kajian pengembangan kendaraan listrik di Indonesia: prospek dan hambatannya]. Jurnal Paradigma Ekonomika, 15(1), 21–38. https://doi.org/10.22437/paradigma.v15i1.9217

Sun, D., Kyere, F., Sampene, A.K., Asante, D. & Kumah, N.Y.G. (2022). An investigation on the role of electric vehicles in alleviating environmental pollution: evidence from five leading economies. Environmental Science and Pollution Research (2023) 30:18244–18259. https://doi.org/10.1007/s11356-022-23386-x .

Tseng, H.K., Wu, J.S. & Liu, X (2013). Affordability of electric vehicles for a sustainable transport system: An economic and environmental analysis. Energy Policy 61 (2013) 441–447.

Umah, A. (2021). This is the reason electric cars are still expensive in Indonesia. [Ini lho Alasan Mobil Listrik Masih Mahal di RI]. CNBC. https://www.cnbcindonesia.com/news/20210921093008-4- 277837/ini-lho-alasan-mobil-listrik-masih-mahal-di-ri

United Nations Environment Programme (UNEP) (2010). 2009 Annual Report - Seizing the Green Economy. UNEP, Nairobi

Wilberforce W, C. (2021). Electric vehicles market Intelligence Report. GreenCape. https://www.readkong.com/page/electric-vehicles-market-intelligence-report-greencape-2289456

World Bank (2009). World Development Indicators 2009. World Bank, Washington, D.C.

World Health Organization (WHO) (2008). Air quality and health. WHO online article. (Available at http://www.who.int/mediacentre/factsheets/fs313/en/index.html)

Vassileva, I., & Campillo, J. (2017). Adoption barriers for electric vehicles: Experiences from early adopters in Sweden. Energy, 120, 632–641. https://doi.org/10.1016/j.energy.2016.11.119

Xu B., Sharif A., Shahbaz M., & Dong K. (2021) Have electric vehicles effectively addressed CO2 emissions? Analysis of eight leading countries using quantile-on-quantile regression approach. Sustain Prod Consum 27:1205–1214. https://doi.org/10.1016/J.SPC.2021.03.002

786

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The Role of Global Governance Systems in Shaping Responses in the Era of Pandemics: Lessons from Chinese Covid-19 Experiences for South Africa

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1 ABSTRACT

The South African government has set up sound governance structures to respond to growing demands for services since 1994. Although the country has functional institutional structures and is one of the largest economies in the African continent; the healthcare system was substantially impacted by the outbreak of the global Covid-19 pandemic. As with countries around the globe, South Africa struggled to devise timeous response strategies to the pandemic resulting in huge losses of lives and depressed socio-economic activities. As co-members of the BRICS power bloc, the South African and Chinese economies share commonalities. This paper therefore draws some significant lessons from China's experience in managing the epidemic, while also taking account of uneven social and economic impacts. Chinese experiences of good governance systems and meaningful capacities to engage in trial-and-error responses to the pandemic resulted in the containment of the disease. A systematic analysis of literature was conducted to answer clearly formulated questions. This research adopted a case study design together with a qualitative research approach. The results reveal that there are weaknesses in South Africa's constitutional democracy with a three-tier system of government and an independent judiciary. This aggravated the severity of Covid-19 which negatively impacted the people and put more strain on the healthcare system and the economy. The governance structures' late response to adjust led to losses of lives and the rapid spread of the virus, which resulted in the implementation of strict lockdown measures. On the contrary, the Chinese government's robust global governance structures enhanced its ability to promulgate laws and guidelines which informed rapid changes across all aspects of its functions. This resulted in the swift implementation of initiatives that ensured strict safety protocols to reduce the spread of Covid-19 and generated advanced analytical technological systems and created new markets for new technologies. As a result, of the global phenomenon, South Africa has learnt from Chinese experiences as the largest developing economy in the world. In view of the findings of the study, it is recommended that South Africa collaborates with other countries to facilitate real-time information and skills transfer and to avoid being left behind. As part of the proactive measures to enhance emergency responses to pandemics, commitment to planning and implementation of long-term strategies is required to circumvent future pandemics. In conclusion, the study reveals that governance system reforms are needed to improve and strengthen primary healthcare and to ensure that government processes and systems foster good governance. The paper further suggests that South Africa should consider investing in competent skills, technology and adequate budget to ensure good governance systems, as well as actively conducting research studies in preparation, responding to any future infectious diseases.

Keywords: Global governance, Covid-19 pandemic, Construction sectors, Economic and population growth, spatial planning

2 INTRODUCTION AND BACKGROUND

The era of the Covid-19 pandemic has had a severe impact on the global economy and social well-being of many people, both from the physical and mental health viewpoints, with regard to how global-geo-politics affects national systems of governance. Clearly, South Africa was not prepared for the COVID-19 pandemic. In fact, the 2020 report of the Global Preparedness Monitoring Board concluded that the majority of countries were unprepared for COVID-19 because "our understanding of pandemic preparedness has been inadequate" (GPMB, 2020). In some cases, preparedness was understood too narrowly. For example, some countries laid in stocks of PPE but failed to complement this with a robust testing system to identify infected people. They also did not build community-level systems for handling outbreaks (GPMB, 2021).

The Covid-19 pandemic was regarded a global public health emergency; the first case was reported in the City of Wuhan, and Hubei Province in China in 2019. These patients most notably presented with clinical

symptoms of dry cough, dyspnea, fever, and bilateral lung infiltrates on imaging. Cases were all linked to Wuhan's Huanan Seafood Wholesale Market, which trades in fish and a variety of live animal species including poultry, bats, marmots, and snakes. Subsequently China cautiously informed the World Health Organization (WHO) given that many of the Chinese's reported cases were from vendors at sea point and poultry amongst others. The spread of the disease to other countries including South Africa prompted the WHO to declare a global pandemic in March 2020. This resulted in China declaring "peoples war" against the virus and adopting a model which became a Chinese Covid-19 diplomacy and policy instrument which set the global political agenda (Nian, 2021).

This paper, therefore, draws some significant lessons from China's experience in governance and policy perspectives in the fight against the Covid-19 pandemic. The Chinese model is a very useful benchmark for policy instruments and sets a political agenda for the effective implementation of governance systems. The Chinese government understood that in order to successfully conquer the Covid-19 pandemic, it was imperative to strengthen its power relations and maintain cordial ties with neighbouring countries to improve and restore its national image, given that the first victim of Covid-19 was detected in China (Nian, 2021). Nian further reveals that the dynamics and changing power relations as a result of the Covid-19 pandemic have reshaped China- Southeast relations in the political ties, and economic co-operation in the immediate and long term. For instance, Singapore drew a valuable lesson from China's experience to combat the spread of the pandemic. Once the virus was detected, it expanded its screening process to all checkpoints including airports and sea points.

Compared to China, which is the second-largest economy, the African continent has been dealing with a rapidly changing global environment since the early 90s. These changes have major implications for the continent's future development. However, they are also a part of an era of greater global structural weakness, which has posed complex challenges for the continent, and where the spectra of global marginalization has always loomed large. In this regard, steering mechanisms of global governance take on added meaning in the African context. These evolve "through the sponsorship of states, and the efforts of actors other than states at the transnational or subnational levels, or through states and other types of actors jointly sponsoring the formation of rule systems" (Rosenau, 2009).

As an example, the threat of avian flu led to calls for "pandemic preparedness," but readiness entails preparation of a certain kind (Buck & Ghiglione, 2020). This became evident in the context of the current pandemic. The European countries had enough ventilators to meet the challenge related to coronavirus except Germany, which had to order an additional 10,000 ventilators from a domestic supplier. Another example was the Global Outbreak Alert and Response Network (GOARN) developed in 2000. This is a global partnership among public health institutions, laboratories, NGOs, and other organizations designed to observe and respond to epidemics. The WHO provides much of the staffing and assistance for GOARN but does not directly fund it, and there are currently proposals to enlarge and strengthen this network so that it can engage in emergency interventions at the local level, where the WHO is not designed to assist (Obstfeld, 2020).

Global governance offers an alternative perspective from which to reimagine the world order. As it becomes a serious contender for explaining how we see the world, it is guiding us in legitimizing our actions in the world.

The erratic workings, inadequacies, and flaws of institutionalized structures, rule systems and norms of global governance have conspired to bring Africa to a critical juncture. This is compounded by the view that global governance is devoid of any grand logic, made up as it is of a borderless web of interactions by formal or informal institutions, states, markets, and citizens. This multiplication of spheres of authority gives global governance its myriad of control mechanisms which derive from "different histories, goals, structures, and processes". Thus, the " global Covid-19 pandemic health emergency crisis brought into unambiguous relief the magnitude and scope of the challenges that the world should confront". In this regard, the world found itself in a storm which was the novel coronavirus epidemic (Global Preparedness Monitoring Board, 2020).

This paper examines the role of the global governance system during the Covid-19 outbreak, and the experiences in South Africa in the context of learning from the Chinese, model and public policy discourse. The paper further provides an argument and a deep sense of reflection on South Africa's response to the Covid-19 pandemic, and whether it had a mechanism in place to mitigate the spread of the disease, in

particular since the pandemic's emergence in early March 2020. The pandemic further provided an opportunity for researchers to understand that the global response to the infectious Covid-19 pandemic would play a very critical role in improving future policy discourse and governance systems in the management of public healthcare systems. The impact of the pandemic exposed some existing socio-economic inequalities in developing countries including policy gaps in both public and private healthcare systems.

In essence, the pandemic has widened the existing gap between the rich and the poor, and the urban and rural communities. Hence, Fourie and Lamb (2023) argue that those who lived in developed countries and in the past had access to adequate health care facilities including regular income found themselves to be living in the best times during Covid-19. This paper further provides an overview analysis of how South Africa, the African continent, and the world have responded to diseases and pandemics that had a much more severe impact on the global economies of scale and healthcare systems. The paper also provides significant opportunities for natural and social scientists, as well as researchers to learn more about the pandemic and future healthcare emergencies.

The paper depicts how the Covid-19 pandemic disrupted the world economy and led to public health fatalities and increased mortalities. It negatively impacted the country's gross domestic product (GDP) leading to a high rate of unemployment arising from strict lockdown measures which were imposed to mitigate the spread of the disease.

3 CONCEPTUAL SYNOPSIS

3.1 State governance

The notion of global governance is referred to in the context of the movement towards political cooperation amongst transnational actors, aimed at negotiating responses to problems that affect more than one state or region. Studies show that a global governance perspective helps elucidate how scale mattered in relation to the Covid-19 crisis. For instance, Rosenau and Czempiel (1992) view Global Governance "as a process of confluence and cooperation among multiple actors, state, and non-state actors". However, Weiss and Wilkinson (2014) stress that the unevenness of power has always been present in global governance, where some states have been far more capable actors than others, and non-state actors. In order to deal with such unevenness's, the South African government has adopted its long-term National Development Plan 2030. This unpacks the role of different sectors of society in contributing to the achievement of its desired long-term goals. In shaping its global governance, however, compared to the development plans of other countries such as China and their strategies of bi-lateral and multi-lateral institutions, the South African plan places a great deal of emphasis on good governance as part of the non-physical infrastructure that must be developed to support socio-economic change. Thus, South Africa has determined its critical role to participate in the global governance space.

In South Africa, the case of the Covid-19 pandemic had far reaching implications for all sectors of society across all spheres including at the global level. Its impact was mostly felt in the health sector, as it had to respond to the growing pressure of the virus and ensure that the health facilities were not overrun and consequently health services did not collapse. South Africa consequently adopted a governance approach in managing the pandemic and understanding the role of the cities and patterns of human behavior during the outbreak.

3.2 Political system

In this discussion, it is necessary to reflect on reasons why China remains the second largest economy and continues to pursue the dominant player in global and political governance. This can simply be tracked to the fact that the Chinese firmly believe that the political system must first be founded on a sound system to ensure political stability in the country. This can be traced back to the generation of leadership in China since the founding of the Republic of China in 1949. The Chinese rise to global economic power can also be attributed to its huge growing population and its rapid implantation of reforms, particularly in the economic sectors (Zhu, 2019).

Furthermore, it should be noted that China's political system is socialist and pursues a state governance system under the Communist Party of China (CPC). This focuses on developing a sound system for the

party's visionary leadership. It gives priority to developing the economy, stable politics, its culture and society and the military as well as foreign affairs to enhance state governance. According to Zhili and Juan (2020), the Chinese state governance model has led China to be relatively successful in the implementation of policy instruments and economic development since its reform to achieve developmental goals. It is therefore the reason why China's foreign trade policy remains significant in the country's integration into the global economy. Hence, China plays a dominant role in or is party to many treaties and institutions involved in the Group Twenty (G20).

This phenomenon was proved sound when China was faced with the mammoth task and responsibility to contain the spread of the very first difficult global public health emergency Covid-19 pandemic in modern history.

The notion of global governance provides a better understanding of the various practices that fall within the concept of globalization. Hence, Lederer and Muller (2005) state in more practical terms that global governance combines both domestic and international institutions, which includes both political and economic power relations as determined by the process of globalization. This provides a much broader interpretation and understanding of the concept of global governance and political economy which in essence includes how political choices can shape patterns of economic integration and development.

4 STUDY AREA

The paper sketches the challenges faced during Covid-19 with a focus on all nine provinces in South Africa. In response to the global and domestic challenges confronting the provinces, the government has committed to the plan which reflects a collective vision for the city region in a decade's time and beyond. The plan seeks to address the fundamental problems of unemployment, poverty, and hunger, as well as health, inequality as a consequent effect of the pandemic. Hence in the main, South Africa has committed to rebuilding its economy after the devastating effects of the coronavirus pandemic.
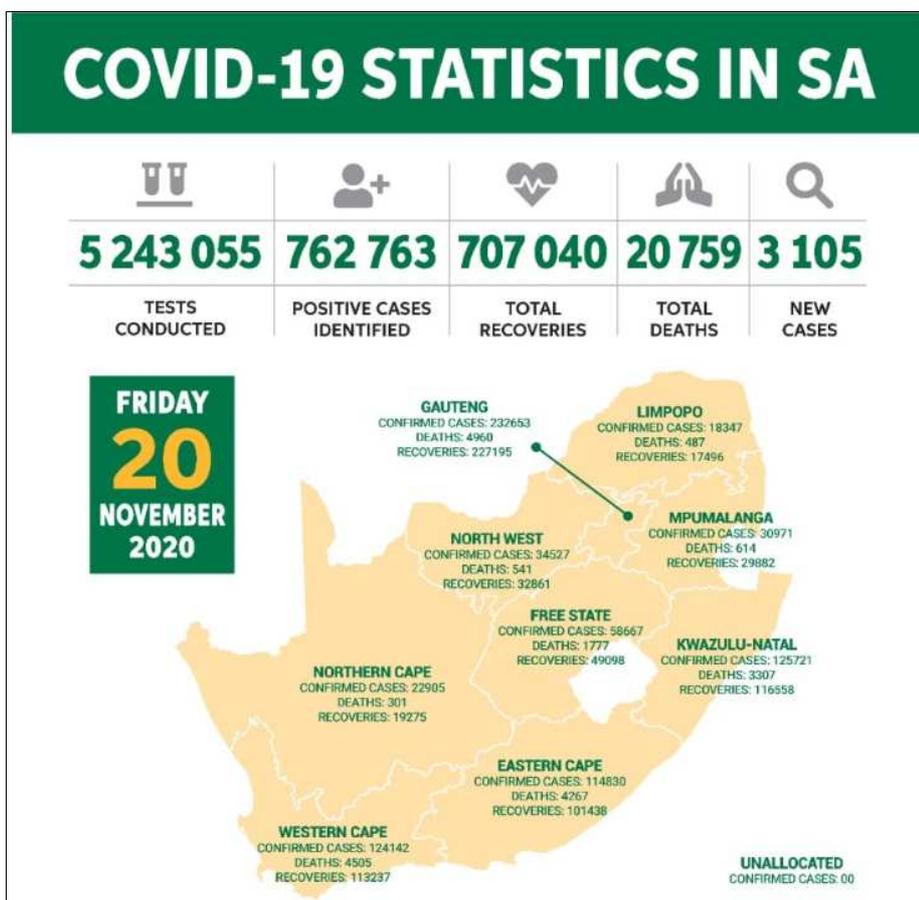

Figure 1. Reported cases in South Africa by November 2020, across all nine (9) provinces. Source: https://sacoronavirus.co.za/2020/11/20/update-on-covid-19-20th-november-2020/

The Covid-19 pandemic has given impetus to efforts in adaptive governance which have existed since South Africa achieved democracy, given that all measures had to be put in place to collectively achieve a cooperative system across all spheres of government. At the helm of these collaborative efforts to address the pandemic government announced a solid governance structure and systems intended to coordinate decision-making processes faster, as well as enhancing the flow of information and responsiveness.

According to the World Health Organization, by November 2020 the number of Covid infections had sharply increased, leading to more deaths reported. This negatively impacted social wellbeing, and created economic pressure thereby increasing the current material conditions of inequality and unstainable infrastructure. South African Covid-19 Statistics for 2020 reveal that South Africa remained one of the 20 most infected countries with a high rate of reported Covid-19 cases. Figure 1 below shows the extent of reported cases in South Africa by November 2020, across all nine (9) provinces.

The severity of this Covid-19 outbreak resulted in it being declared by the WHO as a global pandemic. This prompted the South African government to declare a national disaster, and to establish a command council to coordinate South Africa's response to the Covid-19 challenges (Government Gazette, 15 March 2020). The command council announced measures to combat the pandemic including a nationwide lockdown for 21 days with effect from 26 March until 16 April 2020. This meant that all South Africans had to stay at home except for health workers in the Public and Private sectors, Security Services, as well as those in the categories deemed to be providing essential services. According to Beaubien (2020), Covid-19 was a global phenomenon, considering the rapid chain of events, and it seemed that the lockdown model allowed governments throughout the world to act decisively and effectively from both a public health and governance perspective. The turn to lockdowns also highlighted the prominence of centrally driven or 'centre of government' (CoG) arrangements to coordinate the government machinery to respond to a pandemic (Kunicova, 2020). An over-arching lesson was gleaned from how various countries employed CoG mechanisms to fight Covid-19. This was that trans-national learning that feeds into 'good practice' is a necessary but insufficient marker of success – the structure and character of CoG mechanisms must also demonstrate 'good fit' with individual country contexts. Good practice features might include hands-on executive leadership, clearly defined roles, responsibilities, and interfaces between policy command and operational structures, as well as public awareness campaigns. Figure 2 below shows South African demographics for all nine provinces, and their reported Covid-19 cases by June 2021.
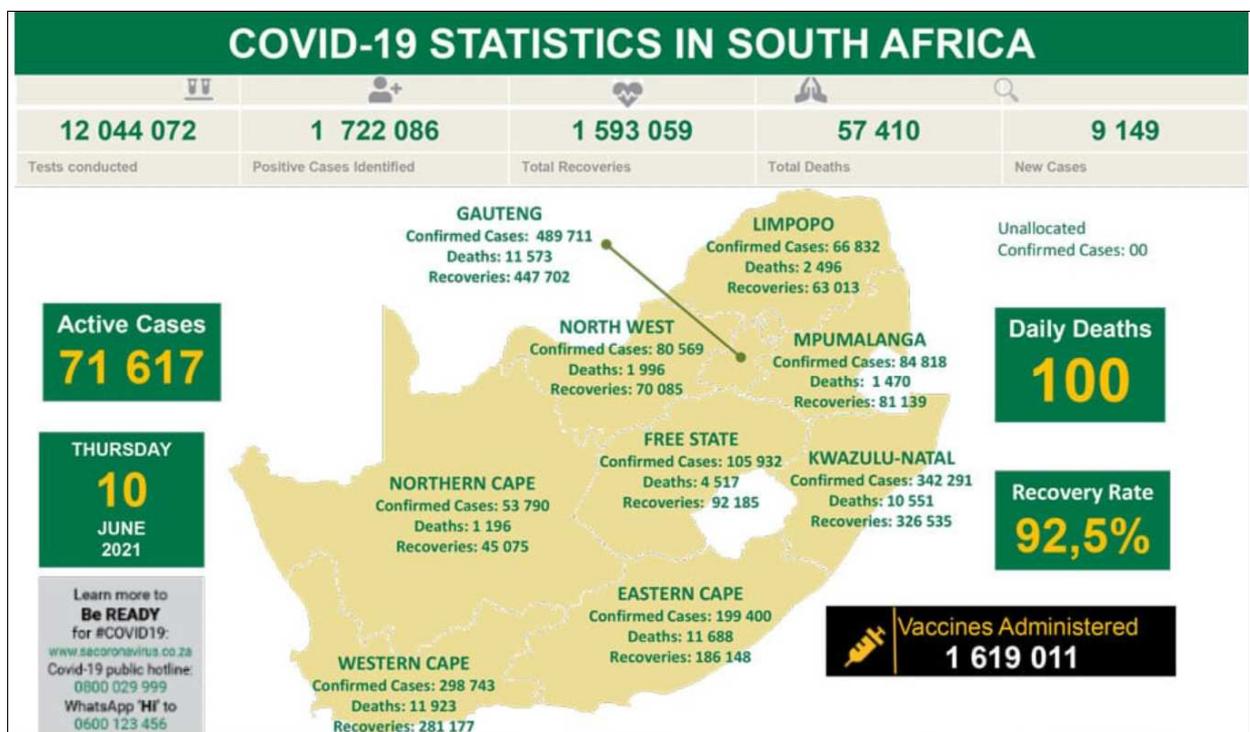

Figure 2. South African demographics for all nine provinces and their reported Covid-19 cases by June 2021.Source:http://sacoronavirus.co.za/2021/06/10/latest-confirmed-cases-of-covid-19-in-south-africa-10-june-2021/

4.1 Significance of Data Management in Decision-Making Process and Governance

An effective integrated model of governance required coordinated efforts in ensuring that the quality of information flowed properly through the system. This denotes that a proper structure was required to provide a synoptic view of the progress of the pandemic ranging from the collective planning of responses and interventions including monitoring of the effects of the pandemic.

The Chinese government has played a critical role in ensuring epidemic prevention and control, thereby leveraging the digital data platform. Digital technology is a very important means of communication, and it should be noted that China is largely a mobile society with many of the Chinese community using smart technology. Hence, China became the first country to use artificial intelligence data to meaningfully fight the Covid-19 pandemic. The key lesson to be learned from the Chinese governance system was their investment in digital platforms and data. This played a very critical role during the prevention and control of the Covid-19 epidemic, as it is said that every Chinese app had some added features for a dedicated hub specific to the coronavirus.

This app played a crucial role in helping both the urban and rural communities get updates on developments during the pandemic. More importantly, the Chinese app helped many people in rural communities to reduce their travelling patterns to the cities, through usage of "We Chat" for the collection of necessary medicine for their well-being. Even truck drivers made great use of the app in terms of becoming "solidarity social forces" during the lockdown period.

The positive spin for these Chinese initiatives is that South Africa had to adapt to changing demand in technology and subsequently initiated its own mobile app to fast communicate messages and data related to the impact of the Covid-19 pandemic. Thus, it was able to reach millions of South Africans including those in the rural areas who might not be privy to news broadcasting.

4.2 The Impact of the Pandemic on the Economy

The Covid-19 outbreak had a severe impact on the global economy and the ability of countries to trade in view of the lockdown measures which were implemented. This was also seen in China, wherein the first quarter of its economic performance declined and was resuscitated through business resumption and economic recovery after the lifting of the lockdown. The Republic of China's strategy has been to focus on the domestic market economy whilst pursuing to maintain and expand its international markets domination and in that way remaining the second-largest economy.

In South Africa, the implication meant the rising rates of unemployment and poverty as businesses were now faced with severe pressure to close down leading to the financial markets and the banking system opting for the introduction of relief funds for business. To mitigate the dire economic consequences arising from these lockdown measures, the South African government adopted a 'risk-adjusted strategy' with five different levels of lockdown.

The introduction of the framework for the risk-adjusted strategy provided guidance to different sectors of the economy to return to economic activities using a phased approach. This, however, was done to ensure that the WHO safety protocols were adhered to and were ultimately mandatory for all citizens. These protocols related to social distances, regular hand washing and sanitizers, wearing of face cloth masks, as well as reducing social public gatherings including limiting the number of people attending funerals. These measures were applicable until the lockdown restrictions were lifted, and the economy was fully reopened.

The South African government further advocated for the provision of social grant relief packages and support of households through the distribution of food parcels and vouchers to the poorest communities, as well as relief packages for firms or businesses in distress. Central to that was the allocation of the Covid-19 budget to support health workers through the procurement of personal protective equipment (PPE's), surgical masks, ventilators, and oxygen equipment to support Covid-19 patients. Covid-19 revealed that the focus on WHO as the sole instrument of global health governance may have been misplaced. A pandemic creates problems of scale, and many of these require international cooperation. However, many of these may not be resolvable by an international organization, no matter how broad its reach. This pandemic has reinforced the message that stockpiles of PPE need to be preserved and updated at regional, national, and subnational levels (Feinmann, 2020).

4.3 Impact of Pandemic on Mental Health and Depression

The Covid-19 virus spread like wildfire across the world in a very short space of time. The high infection rate and associated health risks prompted the world to impose restrictions which had a major effect on people's mental health, causing fear, depression and anxiety (Oman et al., 2022). This is attributed to a lack of income and social support, as well as access to social amenities. A study by Oman et al. (2022) in Malaysia revealed that the psychological effect of the pandemic placed tremendous emotional stress on people. The rising death toll from Covid-19 also instilled more fear within people of losing their loved ones, their income and the possible next wave of the Covid pandemic.

5 METHODOLOGY

The authors analyzed literature by using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) tool, specifically adopting guidelines in the PRISMA flow diagram and PRISMA checklist. PRISMA helped to pinpoint and review research relevant to the role of global governance systems in shaping responses during the pandemic. The papers found were screened for relevance using a selection of defined criteria including the number of citations and the journal impact factor. The authors used the PRISMA checklist to assess the quality of the identified sources and only the most relevant papers were included. A variety of filters was also applied to the search to narrow the results, such as eliminating articles that fell outside a specified timeframe. Both journal and non-journal articles were included. The PRISMA flow diagram below (Figure 3) shows the four criteria which were used to guide the authors in their research: identification, screening, eligibility, and inclusion.
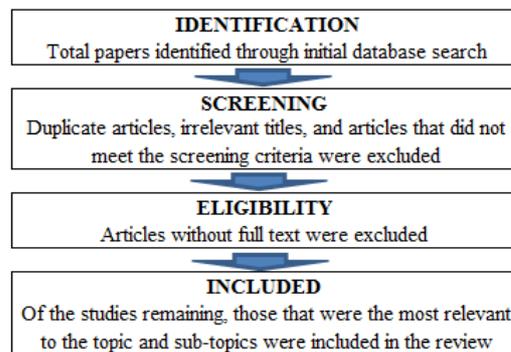
Figure 3. Simplified flow chart showing the selection process for the articles

6 RESULTS AND DISCUSION

This paper illustrates the value of global governance systems for South Africa in shaping responses during pandemics, and lessons leant from the Chinese Covid-19 experiences. The research strategy for this paper involved a number of case studies to achieve its desired outcome. The study used data from books, conference papers, articles, and journals mapped in the form of tables and figures, as well as lessons learned.

Covid-19 created a sharp focus on the existing structural inequalities and institutional weaknesses in the Public Health sector in South Africa. Whilst the country had made tremendous progress in ensuring the quality and access to healthcare facilities for numerous people who were unable to afford private healthcare, studies still show that the healthcare sector had been under severe strain even prior to Covid-19.

This study focuses particular attention on the nine provinces, in South Africa, as shown in Table 1 below, Stats SA Mid-Year Estimate Population (2021) reflects the densely populated provinces in South Africa due to high in-migration. This required a swift response and effective management to reduce the increasing number of Covid-19 infections.

The outbreak of the Covid-19 pandemic in South Africa necessitated the health system to have adequate capacity to be able to deal with the emerging crisis. This meant that South Africa had to adopt a multisectoral and multidisciplinary approach at the political and leadership level in order to save lives and livelihoods. The comprehensive health plan response was also prepared to ensure that health facilities had enough beds, particularly in the public sectors so that patients diagnosed with Covid-19 could access basic health facilities. Figure 4 below illustrates the daily infections and active cases in South Africa experienced during the third wave.

Nine Provinces in South Africa	2021 Mid-Year Estimated Population	
	n	% of total
Eastern Cape	6 738 223	11.1
Free State	2 913 531	4.8
Gauteng	15 882 396	26.3
KwaZulu-Natal	11 563 357	19.1
Limpopo	6 063 742	10.0
Mpumalanga	4 733 276	7.8
North West	4 158 730	6.9
Northern Cape	1 320 924	2.2
Western Cape	7 092 527	11.7
Total	**60 466 705**	**100.0**

Table 1: Mid-Year Estimate Population (2021). Source: 2021 Mid- Year Estimate Population.
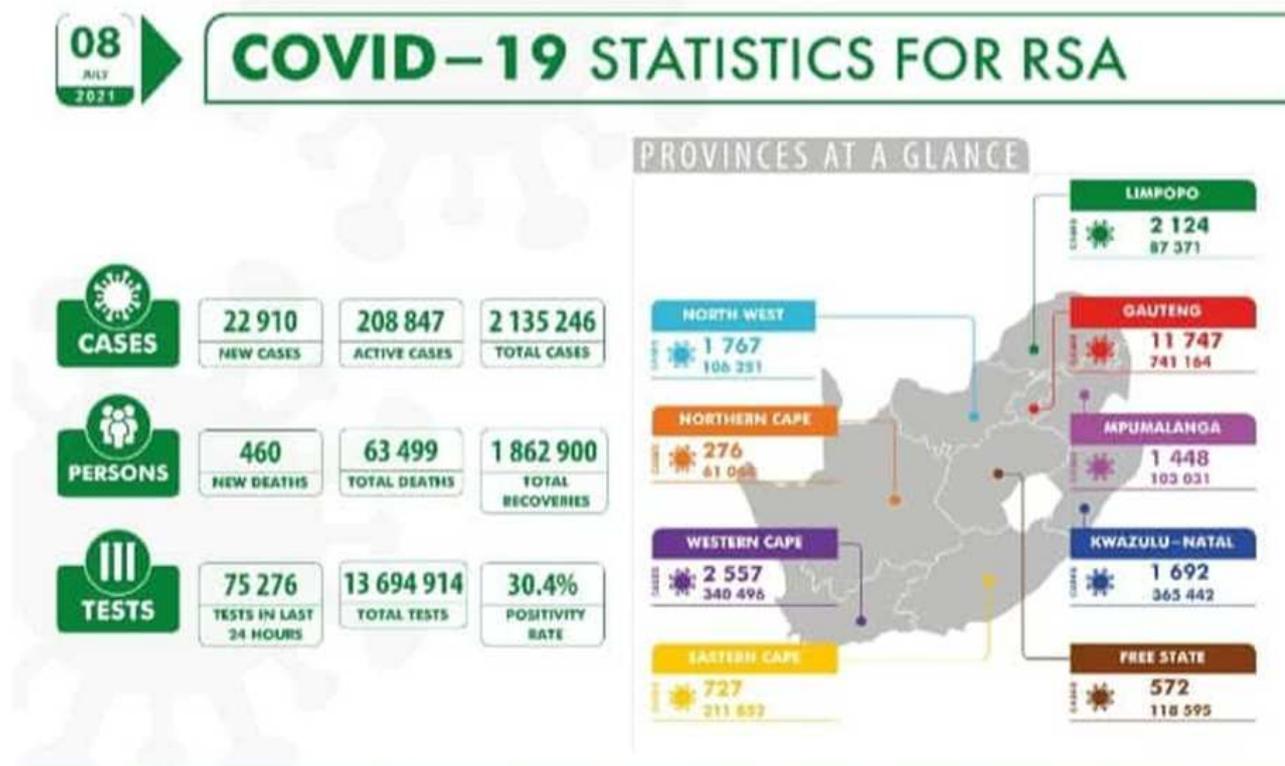
Figure 4. Daily infections and active cases South Africa. Source: https://www.nhls.ac.za/latest-confirmed-cases-of-covid-19-in-south-africa-08-july 2021/#iLightbox[gallery19033]/1

The health plan response also had to address the challenges of health infrastructure to avert the fatalities that the other parts of the world experienced as a result of the increased burden of disease and poor infrastructure maintenance. South Africa had to reprioritize its healthcare system, create hospital wards and beds in facilities to accommodate Covid-19 patients, and repurpose additional identified spaces in certain health facilities. The discussion below illustrates the use of three spheres of government in regulating the Covid 19 pandemic in an effective manner.

6.1 South African governance system

The government is divided into three spheres: national, provincial and local. The legislatures in all three spheres are directly elected every five years by South African citizens of 18 years and older (SA Constitution 1996, S. 46). Only the second house of Parliament, the National Council of Provinces (NCOP) is not directly elected. Its ten (10) members per province are indirectly elected by the provincial legislatures.

The Constitution (S. 55 (2)) also requires that the National Assembly provide mechanisms to ensure that the executive organs of state remain accountable to it. This was the framework of government within which the Covid-19 pandemic had to be managed in line with the Constitution's provisions regarding a state of emergency (S. 37). In order to curb the spread of Covid-19, the country put measures in place such as restrictions on public gatherings; cancellations of events; closures of workplaces, schools and public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel controls.

794

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6.1.1 National level

South Africa's experience with the Covid-19 pandemic and the manner in which its government coped raised concerns about its impact on the country's democracy. This was because several democratic states' constitutional and political dispensations were directed towards more autocratic tendencies. During the pandemic, predictions were made that this trend could end in permanent regressions in democratic systems.

The current research assesses the South African government architecture, especially in the context of accountability and oversight requirements. In this regard, the relationship between the legislature and the executive is most relevant. The South African government decided on a state of disaster to manage the pandemic in contrast with a state of emergency as the constitutional alternative. Its implementation is analysed, especially the institutional framework underlying it. The role of Parliament during the pandemic is thus used as an important test of the quality of democracy. The summary is that South Africa's democratic principles did not degenerate during the pandemic, as determined by Freedom House (2021), but the pandemic's major impact was on the quality of democracy. The state of disaster's institutions, for example, were not those prescribed by legislation. Moreover, Parliament's involvement in the state of disaster's decision-making was limited. The 2021 local government election, on the other hand, was judged free and fair and its outcomes have been implemented without any public challenges. The main negative outcome is the public's trust deficit in the ruling party's use and abuse of pandemic regulations (Public Health and Democratic Governance, 2022).

6.1.2 Provincial level

The institutional arrangements of South Africa during the pandemic mainly included the Cabinet as led by the President, as well as the national and provincial Coronavirus Command Councils which were responsible for coordinating government's response by all spheres of government and society. The key role-players in these structures were the President of the Republic of South Africa (as the head of the NCCC), the various Ministers who issue regulations, Premiers of Provinces (as heads of Provincial Coronavirus Command Councils) and MECs, as coordinators of implementation (De Visser and Chigwata, 2020). In terms of sub-level governance, the question of who was responsible for the implementation of the directions issued in terms of the Disaster Management Act 57 of 2002 (RSA 2002) arises. This was placed on all premiers, Members of the Executive Councils (MECs) responsible for Local Government in the provinces, the President of the South African Local Government Association (SALGA), all mayors (whether executive or non-executive) and institutions of traditional leadership (De Visser and Chigwata, 2020). The directions issued to deal with the Covid-19 pandemic instructed each province to establish a Provincial Command Council (PCCC) and coordinating structures to support the national institutional arrangements (COGTA, 2020d).

The delivery of major infrastructure projects on time and within quality standards is largely a concern in the South African public sector. This had further implications and challenges when it came to the delivery of functional beds to mitigate the challenges of accommodating the Covid-19 patients. These challenges also included the procurement of capital infrastructure, which was a consequence of poor planning. The national treasury consequently issued instruction number 08 of 2019/2020 to specifically deal with issues of emergency procurement for Covid-19. This was implemented, although infrastructure delivery management system provides a clear process that must be followed in the procurement of infrastructure in practice note number SCM 3 of 2003.

6.1.3 Local government level

At a local government level, the South African Local Government Association (SALGA) directed the Committee on the actions which had been taken to assist local government to implement the Covid-19 disaster management directives. SALGA subsequently highlighted a wide range of challenges faced by municipalities as a result of the pandemic's economic impact. A major concern was the projected reduction in revenue collection by the municipalities owing to job losses, reduced household incomes, and local authorities being unable to rent out their facilities or generate the normal level of revenue from areas such as traffic fines. Simultaneously, the lockdown required people with reduced incomes to stay at home, resulting in higher-than-normal water and electricity usage. Municipalities were heeding SALGA's call not to disconnect residents who were unable to pay their electricity or water bills, but Eskom did not support the

proposal that municipalities be granted a payment holiday because of their revenue collection challenges. Moreover, R20 billion had been set aside by the Treasury to assist municipalities (Role of local government in combating the spread of Covid-19 virus, 2020).

6.2 Global governance structures in China and Covid-19 responses

The results reveal that there are weaknesses in a constitutional democracy with a three-tier system of government and an independent judiciary. This aggravated the severity of Covid-19 which negatively impacted people and put more strain on the healthcare system and the economy. Governance structures' late response to adjust led to losses of lives and the rapid spread of the virus led to strict lockdown measures to contain the virus. On the contrary, the Chinese government's robust global governance structures enhanced its ability to promulgate laws and guidelines which informed rapid changes across all aspects of its functions. This resulted in the swift implementation of initiatives which ensured strict safety protocols to reduce the spread of Covid-19 and generated advanced analytical technological systems to control the virus and create new markets for some new technologies. As a result, of the global phenomenon, South Africa has learnt from China's experiences as the largest developing economy in the world.

7   LESSONS LEARNT AND POLICY IMPLICATIONS

The Covid-19 pandemic was unprecedented in the history of humankind, and South Africa was not an exception in experiencing these uncertainties. Nevertheless, South Africa succeeded in providing infrastructure in the form of functional beds to accommodate Covid-19 patients. This was necessary for the country to adapt to changing needs which required an innovative approach and comprehensive strategy to respond to the health plan. Despite shortfalls in the delivery of capital infrastructure and planning processes, Covid-19 provided an opportunity for the public health system to be strengthened. Through these lessons, the health system responses were tried and tested which could help mitigate the negative impact of future emergencies should they arise. Studies show that a single source of data management, digital technology is critical for monitoring and reporting. This serves as an important lesson to be learned in cases of future healthcare diseases and emergencies since such data plays a very critical role in decision-making. These resources strengthen the centralized data repository for record-keeping, as well as for data analysis.

South Africa has, therefore, learned a valuable lesson through the intervention's measures implemented against great challenges and experiences. This has helped to shape its governance model. These experiences are not limited to the role of all stakeholders from both public and private sectors, academia in the form of researchers and scientists, civil society organizations, and communities in the fight against infectious disease. Effective political and administrative leadership has also played a critical role in the establishment of necessary governance structures and systems needed to coordinate and drive interventions and responses to future pandemics.

8   CONCLUSIONS

The emergence of the Covid-19 pandemic largely impacted the global governance system and led to growing concerns and uncertainties amongst the world's economies. South Africa like other countries, had to ensure that there were prevention strategies in place and functional health facilities to respond to the growing crisis. The World Health Organization 2020 provided the necessary expeditious guidance regarding responsive policies and frameworks which different countries implemented to manage the impact of the pandemic.

From this study, it is evident that Covid-19 pandemic had a negative impact on global governance. Nevertheless, lessons could be drawn from China's response in the application of its governance system, and in reshaping its governance model during the pandemic. South Africa was able to move decisively to construct systematic responses to the threat of the pandemic. However, the pandemic had an impact on the GDP demand and supply economies which led to increasing rates of unemployment, poverty, and hunger, impacting millions of livelihoods of South Africans.

For example, Stats SA in its published Quarterly Labour Force Survey, indicated that the country's unemployment rate had increased by 1.0 percentage points thereby increasing to 30.1% in the first quarter of 2020 (Stats SA Quarterly Labour Survey, March 2020). The Covid-19 pandemic further demonstrated the need for the leadership management to close the existing gap between policy, planning and implementation in the immediate short-term. In this regard, a capable and effective state requires a long-term investment in

its communication systems as well as appropriate use of technology to respond to complex and changing demands in future emergencies. This study concludes by showing that an integrated planning approach is key for the country to achieve its intended outcomes in managing the pandemic and reshaping its governance model and systems.

9   REFERENCES

Beaubien, J. (2020): Modelers suggest pandemic lockdowns saved millions from dying of COVID-19. NPR News, Retrieved from https://www.npr.org/sect ions/goat sandsoda/2020/06/09/872441984/ modelers-suggest-pandemic-lockdowns-saved-millions-from-dying-of-covid-19.

Buck, T., Ghiglione, D. (2020): European countries search for ventilators as virus cases surge. Financial Times. [Google Scholar].

COVID-19: Regulations and Guidelines, 2022.

Department of Co-Operative Governance and Traditional Affairs. (25 March 2020d): Disaster Management Act, 2002: (Act no. 57 of 2002): COGTA COVID-19 Disaster Response Directions, 2020 (NO. R.399). Retrieved from https://openbylaws.org.za/za/act/gn/2020/r399/eng/.

Disaster Management Act 2002. (2003): Retrieved from http://www.cogta.gov.za/cgta_2016/wp-content/ uploads/2016/06/DISASTER-MANAGEMENT-ACT.pdf.

Disaster Management Act 57 of 2002.

Department of Public Service and Administration. Circular No. 07 of 2020. State of Disaster: Guidelines for the Containment/ Management of the Corona Virus (Covid-19) in the Public Service. Pretoria.

De Visser, J. and Chigwata, T.C. (2020): Municipalities and COVID-19: A summary and perspective on the national disaster management directions. Local Government Bulletin, 15(1). Retrieved from https://dullahomarinstitute.org.za/multilevel-govt/local-government-bulletin/volume-15-issue-1-march-2020.

Feinmann, J. (2020): PPE: What now for the global supply chain? BMJ, 369, m1910. https://doi-org.ezproxy.library.tufts.edu/10.1136/bmj.m1910 [PubMed] [Google Scholar].

Fourie, P and Lamb, G. (2023): The South African Response to Covid-19, The Early Years. Routledge Studies in Health in Africa.

Freedom House (2021): Freedom in the world 2021: Democracy under siege. https://freedomhouse.org/report/freedom-world/2021/democracy-under-siege. Accessed 15 May 2022.

GOVERNMENT GAZETTE, 15 March 2020

GPMB (Global Preparedness Monitoring Board) (2020): A world in disorder: Global Preparedness Monitoring Board annual report 2020. https://www.gpmb.org/annual-reports/annual-report-2020.

GPMB (Global Preparedness Monitoring Board) (2021): From Worlds Apart to a World Prepared: Global Preparedness Monitoring Board report 2021. https://www.gpmb.org/annual-reports/annual-report-2021.

Gosenau, J. and Czempiel, E.O. (1992): Governance without Government Order and Change in World Politics. Cambridge University Press. London.

https://sacoronavirus.co.za/2020/11/20/update-on-covid-19-20th-november-2020/.

http://sacoronavirus.co.za/2021/06/10/latest-confirmed-cases-of-covid-19-in-south-africa-10-june-2021/.

https://www.news24.com/news24/southafrica/news/covid-19-gauteng-approaching-peak-says-provincial-government-20210709.

https://www.nhls.ac.za/latest-confirmed-cases-of-covid-19-in-south-africa-08-july 2021/#iLightbox[gallery19033]/1

Kunicova, J. (2020): Driving the COVID-19 response from the center: institutional mechanisms to ensure whole-of-government coordination. Working paper, World Bank Governance Global Practice. Washington, DC: World Bank.

Lederer, M. and Muller, P. (2005): Criticizing Global Governance: Pulgrave, Macmillan.

Moher, D.; Liberati, A.; Tetzla, J.; Altman, D.G.; Prisma, G. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Med. 2009, 6, e1000097. [CrossRef] [PubMed].

Moher, D.; Altman, D.G.; Liberati, A.; Tetzla_, J. PRISMA statement. Epidemiology 2011, 22, 128. [CrossRef].

National Development Plan Vision (2030): The Presidency. November 2011. Pretoria.

National Treasury Instruction No. 08 of 2019/2020: Emergency Procurement in Response to National State of Disaster. Pretoria.

National Treasury Instruction Practice Note Number Supply Chain Management 3 of 2003: Policy: SCM- PracNote-Appoint Consultants. Pretoria.

Nian Peng, (2021): The Reshaping of China- Southeast Asia Relations in light of the Covid-19 Pandemic, Springer nature Pte Ltd. Singapore.

Obstfeld, M. (3 April 2020): The G20 must step up to confront the global health crisis. Peterson Institute for International Economics (PIIE). [Google Scholar].

Oman Sukman, Salahudin, Iqbal Robbie, Ali Roziqin, Shannaz Mutiara Deniar, Iradhad T. Sihidi, Dedik F. Suhermanto. (2022): Social and Political issues on sustainable development in the post Covid-19 Crisis, 1st Edition. London.

Public health and democratic governance: COVID-19's impact on South Africa's democracy. Published: 07 March 2023. Zeitschrift für Vergleichende Politikwissenschaft. volume 16, pages733–752 (2022).

President Cyril Ramaphosa: South Africa's response to Coronavirus Covid-19 pandemic. Disaster Management Act, 2002 (Act No. 57 of 2002), risk adjusted strategy 25 April 2020.

Rosenau, J. N., & Czempiel E. O. (1992). Governance without Government: Order and Change in World Politics. Cambridge: Cambridge University Press.

Rosenau, J.N. (2009): Governance in the Twenty-First Century, in J. Whitman (ed.), Global Governance. London: Palgrave Macmillan.

Role of local government in combating spread of COVID-19 virus: SALGA briefing. Cooperative Governance and Traditional Affairs. 28 April 2020.

SA Constitution. (1996): Constitution of the Republic of South Africa, 1996 (Act 108 of 1996).

STAS SA Mid-year population estimates 2021, Pretoria

STAS SA Quarterly Labour force Survey, March 2020. Pretoria.

Weiss, T. G. and Wilkinson, R. (2014): Global Governance to the Rescue: Saving International Relations? Vol. 20, No. 1 (Jan.–Mar. 2014), pp. 19-36 (18 pages). https://www.jstor.org/stable/24526179.

World Health Organisation. Critical preparedness, readiness and response actions for Covid-19. Interim guidance. 4 November 2020.

Zhu Ming, (2019): Occasional Paper, 7: The domestic origins and global implications of China's reform and opening up, University of Johannesburg Centre for Africa- China Studies.

Zhili Bai & Juan Liu (2020): China governance model and system in transition, Journal of Contemporary Est Asia Studies: DOI: 10.1080/24761028.2020.1744229.

798

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The Role of Secure Land Tenure Policy and Practise on Economic and Social Development: Lessons from Edendale and Ambleton, City of Pietermaritzburg

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1 ABSTRACT

Land is a valuable resource which contributes towards the economic and social well-being of communities, and secure land tenure is therefore a crucial factor towards addressing poverty and inequality. This paper examines the role of secure land tenure policy and practice in relation to the socio-economic development of communities and sustainable human settlement planning in South African cities. It explores the statutory mechanisms in place for the enablement of secure land tenurewhich addresses the negative effects of the fundamental structural challenges left by the apartheid planning regime on the current urban policy context. It draws lessons from the Edendale Unit H and Ambleton Townships, Pietermaritzburg, as well as case studies at Msunduzi Local Municipality in the KwaZulu-Natal province. A qualitative case study design was employed, and primary and secondary data were gathered through open-ended interviews with key stakeholders responsible for land tenure restoration. The findings highlight efforts to formalize ownership and engage communities, but challenges persist. For Ambleton's unauthorized occupants, the upgrading of the Land Tenure Rights Act should be used to formalize ownership. It is recommended that Edendale's boundary disputes can further be addressed through an approach which integrates the Systematic Theory. The Adaptation Theory can ensure that fair community involvement, and eviction procedures should align with the Prevention of Illegal Eviction Act. Regular monitoring and evaluation will enhance its implementation, where integrating legal and theoretical frameworks, adjusted for subsidized housing, can lead to a just and secure tenure system for Ambleton and Edendale Unit H.

Keywords: Land Tenure Policy, Sustainable Human Settlements, Land Tenure Restoration, Spatial Planning, South Africa

2 INTRODUCTION

There are various types of legislation established in South Africa as a backbone for Title Deed Restoration, Land Reform, provision of housing, and Security of Land Tenure Rights. Access to housing and ensuring the security of tenure rights is part of the government's strategy to eradicate poverty and improve the lives of all South Africans through providing socio-economic related opportunities (Hull and Whittal, 2018). A land audit report conducted by the Department of Land Affairs in 2017, showed that a total of 30% of individuals (1 579 543 ha) in KwaZulu Natal own private and secured land compared to the 39 % (37 031 283 ha) in the rest of South Africa. The South African Institute of Race Relations (IRR) also published a report in March 2018 indicating that "114m ha of 122m ha of land in South Africa is registered with the Deeds Office", with urban land constituting of 3,2m ha. Therefore, in KZN, 39,5 % of Africans on urban land and 3.5 % in rural areas are registered individual landowners. There exists slow progress of securing land tenure rights with the main focus being placed on agricultural land but not individual properties. Government is also providing more RDP housing without title deeds, while there is still a huge number of households who have not received title deeds since 1994. The aim of the study is to examine the impact of the South African Urban Policy governing land tenure security and restoration on the economic potential of people in the Edendale and Ambleton areas in Pietermaritzburg. The study also identifies the strategies used by the government to implement this policy and secure land tenure rights in these areas. The objectives of the study are firstly to evaluate, the effects of secure land tenure in the Edendale and Ambleton areaswithin the framework of the South African Urban Policy for land tenure security and restoration. Secondly, it examines the effectiveness of the government strategies used to secure land tenure rights in the Edendale and Ambleton areas and identifies the challenges and opportunities for improvement in the implementation of the policy within Pietermaritzburg. Finally, it provides recommendations for improving the strategies and informs policy development and implementation in other similar contexts for the benefit of the residents.

3 CONCEPTUAL SYNOPSIS

Secure land and property rights play a crucial role in reducing poverty and promoting economic development,while mismanaged land can lead to conflicts and disruptions, causing land degradation and loss of socio-economic opportunities (UN-Habitat, 2014). Therefore, ensuring land tenure security is internationally recognized as a key factor in positioning a country for global competitiveness (UN-Habitat, 2014). Land tenure systems encompass both customary and statutory rights that exist between land, society, and people, and each country develops its own land tenure concept based on historical and current legislation (UN-Habitat, 2014). To understand this concept, it is important to break down the meanings of land tenure and tenure security. Land tenure refers to the rules and institutions governing land use and property rights, and it encompasses the allocation and control of natural resources in society (UN-Habitat, 2008 cited in Kasimbazi, 2017). Tenure security, on the other hand, is challenging to measure as it depends on the landholders' perceptions of security for their property. It generally includes rights that allow property owners to use their property as collateral and which provide legal protection against eviction (Barnes and Enemark, 2020; Aliber and Popoola, 2018). It involves land administration processes that protect land tenure security and allow for dispute resolution and adjustments of rights (Aliber and Popoola, 2018; Pienaar, 2013). Land tenure security also ensures individuals have the legal right and confidence to transfer their properties, leading to social stability and economic opportunities (La Croix, 2002; Pienaar, 2013).Thus, tenure security relates to land ownership and the protection of landholders' rights.South Africa's Constitution commits to rectifying historical land injustices, establishing a foundation for secure land tenure. Key policies like the Land Reform (Labour Tenants) Act 3 of 1996 protect labor tenants, while the Interim Protection of Informal Land Rights Act 31 of 1996 shields communities in resource-rich areas. The 1998 Prevention of Illegal Eviction Act balances property owners' rights with those of occupants, and the Upgrading of Land Tenure Rights Act 112 of 1991 formalizes traditional land ownership. Together, these policies represent South Africa's comprehensive approach to addressing land rights and tenure security.

3.1 Overview of the South African land tenure system

In the context of South Africa, ensuring that people have secure rights to their land is also a crucial goal for reducing poverty, boosting the economy, and maintaining social stability. This is a challenging task due to the country's historical background. Having proper ownership and rights to land is now recognized worldwide as a key factor for any country's competitiveness (UN-HABITAT, 2014). Looking back at how land was lost and regained in the past can give us useful information about how stable land ownership is today (Sunderlin and Holland, 2022). Moreover, to comprehend the current challenges of the land tenure system in South Africa, it's essential to consider the enduring repercussions of apartheid-era policies. For example, the impact of the Natives Land Act of 1913 and the1936 Native Trust and Land Act remains evident in the form of "Trust Land," characterized by insufficient surveys and the restrictive "permission to occupy (PTO)" system (Ntsebeza, 1999). Kloppers and Pienaar (2014) emphasize that these Actsentrenched inequality and denied black individuals ownership rights, shaping the landscape for post-apartheid land reform.

Following 1994, South Africa embarked on ambitious land reform initiatives aimed at addressing historical injustices. This reform seeks to strike a balance between land redistribution, restitution, and tenure security, a complex endeavor with far-reaching implications (Adams, 2000). Nevertheless, despite progress in land reform, obstacles persist such as inadequate funding and limited private sector involvement which hinders effective implementation(Lekaba, 2016). The major challenge is misunderstanding the role of these land reform initiatives in securing land rights. For example, in a study conducted by Makombe (2018) the government aimed to redistribute 30% or 24,5 million ha by 2014. Anseeuw and Mathebula (2008) cited by Makombe (2018) mention that between 1995 to 1999 about 41 restitution claims were made on 112 919 ha, between 1999-2004 about 56679 claims were settled and in 2012 about 32% of the target was met. However, Makombe (2012) mentions that Land reform in South Africa between 1994 and 2010 progressed slowly, with about 3 million hectares redistributed for land reform, and tenure to189,633,000 individuals. Costs exceeded R29 billion, split between redistribution, restitution, and compensation. While redistribution made strides, land tenure security lagged, impacting economic growth. South Africa has been dealing with land challenges since 1990, and they still existing within the democratic developmental state in terms of the need to address disparities in land distribution, tenure security and ownership conflicts.Kingwill et al. (2017)

highlight that land tenure remains problematic in South Africa, particularly for farm workers and their families on privately owned land, as well as individuals residing in areas established under the Group Areas Act. As from observations from working at Human Settlement dealing with tenure related matters, many properties are still registered under deceased great grandparents, complicating the transfer of ownership due to family disputes and document accessibility issues. The sluggish pace of land reform, lack of clear vision, and misalignment with pro-poor initiatives further hinder progress. This indicates that despite efforts, the land tenure situation in South Africa remains complex and inadequately addressed.

3.2 Exploring theoretical frameworks shaping land tenure security

Understanding the different theories guiding land tenure security in South Africa offers insights into how the country manages its land ownership systems. For example, the Conservation Theory supports the idea that customary land ownership provides the most effective tenure security. It emphasizes that land holds social, political, and economic importance, especially in African countries where land plays a pivotal role in socio-economic development. The theory suggests that land titling overlooks the social dynamics within rural communities and proposes that "de facto" tenure security, rooted in land control rather than legal formalities, holds greater significance. Traditional leaders are significant in this context, as they allocate land in rural areas, however, it's worth noting that historical practices show that traditional leaders may not have always prioritized community interests. This theory tends to align well with subsistence agriculture but might face challenges in commercial farming, where economic interests and traditional leadership might conflict (Hull et al., 2018). Secondly, the Adaptation Theory is important for justice and government accountability. It aims to find a balance between South Africa's customary and statutoryland tenure systems. Its goal is to safeguard people from abuse by traditional leaders while protecting the rights of poor rural and urban individuals facing illegal evictions. This theory also addresses the issue of traditional leaders perceiving land as their possession and sometimes benefiting themselves over the community. The study by Buthelezi and Yeni (2016) highlights the need to rectify this perception. There's a distinction between formal rules, which establish legitimate land tenure systems, and informal rules based on community values, and the challenge lies in harmonizing these rules. The theory also emphasizes community involvement in formalizing property rights and tenure security, which is vital for subsidized housing. This approach encourages practical solutions that provide secure housing for those in need (Hull et al., 2018).

Thirdly, the Replacement Theory suggests replacing outdated land management methods with new approaches. It advocates for private property rights supported by clear title deeds and registrations. While this approach seems promising, critics argue that its applicability to South Africa might be limited. There's concern that it could exacerbate existing power imbalances, potentially granting more control to those already in influential positions. Historically linked to apartheid-era practices, the theory hasn't fully resolved land security issues and might not be ideal for attracting investments. Moreover, the failure of land titling can be attributed to government's lack of support for community development and poor alignment with national policies (Muchechetere and Kurwakumire, 2020). Fourthly, the Systematic Theory advocates for an organized and clear land ownership system. It emphasizes replacing customary land ownership with systematic rules to enhance economic opportunities for the poor. However, this approach acknowledges the need for flexibility, as solutions that work in developed countries might not suit developing nations like South Africa. It raises important questions about whether people are willing to use their land as collateral for loans and whether banks are ready to support them. This theory requires consideration of various factors and contexts to find the right approach, much like piecing together a puzzle that fits its unique shape (Weeda and Butt, 2018).

These theories present different avenues to tackle the issue, each with its own advantages and limitations. They help us navigate the complex puzzle of land tenure security in South Africa and more specifically Ambleton and Edendale Unit H, considering historical, political, and economic factors that shape the landscape.

4 RESEARCH METHODOLOGY

This study on land tenure securityemployed a qualitative case study design, and primary and secondary data sources were utilized. Primary data collection involved the use of open-ended interviewsadministered to key stakeholders responsible for land tenure restoration. These interviews were carefully designed to elicit

detailed responses from the participants, enabling the researchers to gain insights into their perspectives and experiences. The open-ended nature of the questions allowed the stakeholders to express their insights freely, providing a nuanced understanding of the complexities surrounding land tenure security. Secondary data sources were also utilized which included relevant literature, reports, and studies that contributed tounderstanding the background of land tenure security.

5 RESULTS AND DISCUSSSIONS

The study areas were theEdendale unit H and Ambleton Townships situated within the Msunduzi Municipality (PMB), the second largest city in the KwaZulu Natal province, located near the N3 freeway. This allows it to be connected to the global economy and to Durban and Gauteng. Msunduzi is within the uMgungundlovu District bounded by Mkhambathini on the east, Mshwathi on the north, Richmond on the south, Impendle and UMngeni on the west (Msunduzi Municipality IDP 2020/2021). The Municipality has implemented a broader scope of human settlements that will require transfers and tenure restoration to be undertaken of properties constructed pre 1994 and Post 1994 which totaled a backlog of approximately 12004 in 2016.
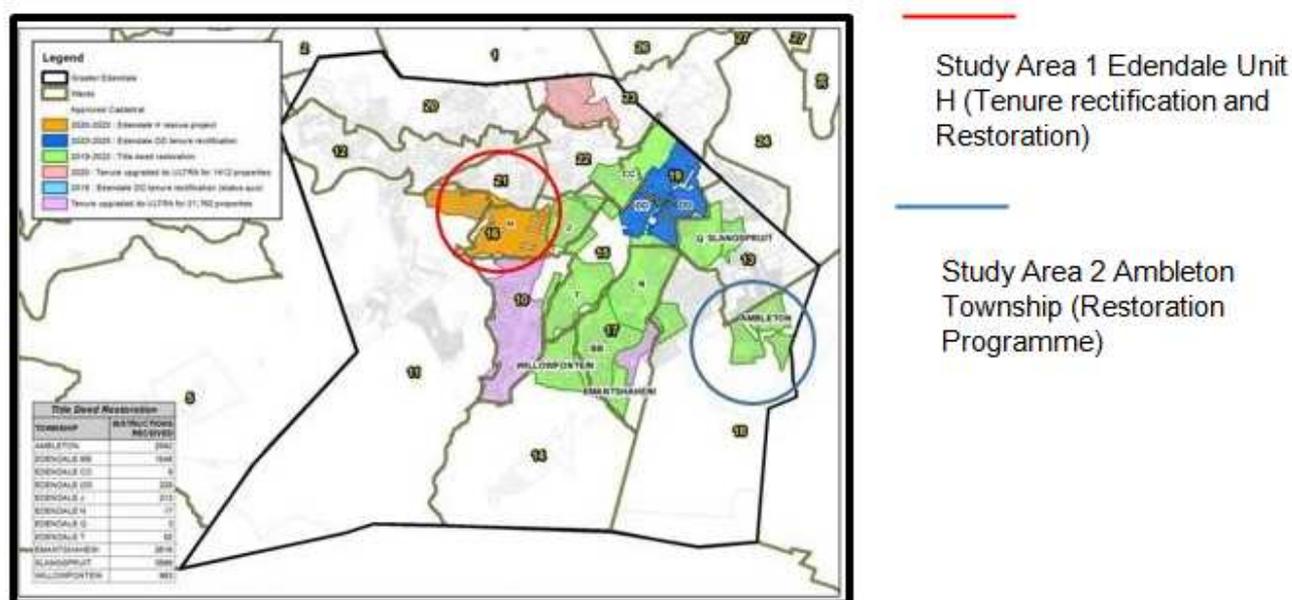
Figure 1 Edendale Unit H and Ambleton Study Area. Source: Author (2021).

Interviews were conducted with Msunduzi Municipal officials on land tenure security and restoration in Pietermaritzburg. During these interviews, they discussed their responsibilities, registration processes, policies and bylaws, stakeholders involved, financing, challenges, and the status of land tenure in Ambleton and Edendale Unit H. Their responses provided valuable insights into the implementation of the South African Urban Policy for land tenure security and restoration in the Edendale and Ambleton areas. These are addressed in the synopsis below:

Objective 1: To evaluate the effects of secure land tenure in the Edendale and Ambleton area within the framework of the South African Urban Policy for land tenure security and restoration.

The interviewee's responses reveal that they play a rolein assisting Edendale Township with its spatial transformation implementation that will promote the objective of tenure security and improve their livelihoods. The common goal of granting title deeds to communities aligns with the policy's emphasis on secure land tenure. This, through effective social facilitation, supported by local political structures, promotes community engagement and cooperation—a vital aspect of achieving tenure security. The capturing of beneficiaries through a GIS database with FICA information and the subsequent passing of titles to beneficiaries further contributes to secure land tenure. Additionally, the interviewee's emphasis on creating camaraderie from the outset through local political structures and introducing project participants to local communities speaks to the goal of ensuring social inclusion and equity. The social compact created to govern the project demonstrates a concerted effort to involve all stakeholders, disseminate information, and achieve meaningful participation, thereby aligning with the policy's objective.

Objective 2: To examine the effectiveness of government strategies used to secure land tenure rights in the Edendale and Ambleton area and identify challenges and opportunities for improvement.

The municipality's adoption of a range of policies, guidelines, and mechanisms reveals their comprehensive approach to secure land tenure rights. For example, the use of Immovable Property Market Valuation Guidelines and the Benchmark Report showcases their adaptability to diverse acquisition scenarios. This also ensures efficiency in resolving land invasion disputes within the study area and it aligns with the policy's focus on effective strategies. Furthermore, the use of the Land Title Adjustment Act and the Rates Exemption on Private Land Initiatives demonstrates the municipality's recognition of complex scenarios, such as deceased estates, and the financial challenges posed by invasions. The engagement of organizations and private firms, appointed through the Municipal Supply Chain process or funders furthermore reflects collaboration, technical support, and alignment with the policy's goal of effective implementation. However, the interviewee's mention of challengessuch as beneficiaries refusing to provide information, non-compliant properties, and conflicts arising from ownershipindicates areas that may require improvement.

In Ambleton, the information reveals that 60% of the area's properties have obtained title deeds, indicating a considerable level of achieved land tenure security. However, a notable 20% of this comprises individuals who did not originally qualify as beneficiaries, having acquired occupation through illegal sales or without the proper beneficiary claims. This aspect highlights the complex nature of tenure security, where legal and rightful ownership is challenged by unauthorized actions. Additionally, 10% of the properties are under regulation through existing policies, suggesting a structured approach to ensuring land tenure security.

In Edendale, specifically in unit H, the land tenure situation appears more challenging. Only 10% of properties have acquired title deeds, indicating a lower level of tenure security compared to Ambleton. One of the prominent challenges is encroachment over property boundaries, implying disputes over land ownership and utilization. This situation requires a comprehensive approach to rectification of illegal tenures, including an expropriation process and dispute resolution mechanisms. The need to amend the existing general plan further emphasizes the complexities of land tenure security in this area.

5.1 Integration of legal framework and theoretical components

The interview data from Edendale and Ambleton highlights the integration of the legal framework and theoretical components for land tenure security, showcasing a proactive approach to address historical land injustices. The municipality has effectively utilized policies, guidelines, and mechanisms such as valuation guidelines, benchmark reports, and the Land Title Adjustment Act of 1993 to secure land tenure. However, challenges persist in policy implementation, evidenced by cases of non-compliant properties and conflicts arising from unauthorized occupations.

Objective	Challenge	Consequence	Implementation Steps
Ambleton: Address Unauthorized Occupancy (20% properties)	Unauthorized occupants on subsidized properties	Insecurity of tenure, potential conflict among rightful beneficiaries	1. Identify properties with unauthorized occupants through GIS database and community engagement. 2. Conduct thorough beneficiary verification. 3. Utilize the Upgrading of Land Tenure Rights Act to formalize ownership for rightful beneficiaries.
Edendale: Define Clear Property Boundaries and Address Encroachment	Boundary disputes and encroachment	Insecurity of tenure, potential conflicts, lack of property value	1. Survey and demarcate property boundaries. 2. Implement a comprehensive expropriation process where necessary. 3. Utilize the Systematic Theory to establish organized land ownership system.
Community Involvement Address Perception of various stakeholders and Ensure Equitable Participation	Potential bias and, lack of community input	Discontent, mistrust, exclusion	1. Engage with community representatives to ensure their unbiased involvement. 2. Conduct awareness campaigns to educate occupants about their rights. 3. Implement community feedback mechanisms. 4. Utilize the Adaptation Theory to ensure justice and community protection.
Eviction Management: Ensure Fairness and Protection during Evictions	Eviction-related conflicts	Human rights violations, legal disputes	1. Implement the Prevention of Illegal Eviction Act for eviction procedures. 2. Establish a transparent process for eviction based on legitimate reasons. 3. Provide legal assistance to occupants during eviction procedures.
Monitoring and Evaluation: Continuous Oversight and Improvement	Implementation challenges, potential gaps	Incomplete outcomes, inefficiencies	1. Establish a monitoring and evaluation framework. 2. Regularly assess progress and challenges. 3. Make necessary adjustments based on evaluation results.

Considering that Ambleton and Edendale are not rural areas, and that the properties are government-subsidized housing, the integration of the legal framework and theoretical frameworks remains relevant but with a focus on urban contexts and subsidized housing challenges. In Ambleton, where 20% of properties have unauthorized occupants, the Upgrading of the Land Tenure Rights Act of 1991could be employed to

formalize ownership and address the issue of illegitimate occupancy. This would involve legal mechanisms to rectify property ownership, ensuring that rightful beneficiaries obtain secure tenure. The Prevention of Illegal Eviction from and Unlawful Occupation of Land Act, 1998 could be used to manage evictions while safeguarding occupants' rights. In Edendale, where boundary encroachment and disputes prevail, the Systematic Theory gains importance. By implementing an organized land ownership system, property boundaries can be clearly defined and legally enforced. The legal framework should incorporate the principles of this theory to enhance tenure security within subsidized housing projects. Additionally, the Adaptation Theory remains significant, emphasizing community involvement and rectifying perceptions of various stakeholders involved. In the context of subsidized housing, community engagement is vital to ensure that the needs and rights of occupants are upheld. Below is table 1 of integrating the legal framework into the Edendale Unit H and Ambleton security of tenure system:

6 CONCLUSION

In the context of South Africa, securing land tenure rights has emerged as a pivotal issue that intertwines historical legacies, current challenges, and aspirations for socio-economic progress. The complexities surrounding land tenure security are particularly evident in areas like Edendale and Ambleton, where a blend of legal measures and theoretical frameworks is being employed to tackle issues rooted in the apartheid era and post-apartheid land reforms.The findings reveal the hurdles faced by Msunduzi Municipality in its pursuit of securing land tenure rights in urban contexts. Despite notable advancements, issues like unauthorized occupancy and property boundary disputes persist, necessitating tailored approaches for resolution. The suggested recommendations for Ambleton and Edendale, such as using the Upgrading of Land Tenure Rights Act to address unauthorized occupants and applying the Systematic Theory for defining property boundaries highlights the importance of customized solutions. Additionally, effective management of evictions, inclusive community engagement, and consistent monitoring play pivotal roles in ensuring successful policy implementation.In conclusion, South Africa's journey towards achieving secure land tenure and facilitating restoration is a dynamic and intricate process. It calls for a careful equilibrium between acknowledging historical injustices, fostering economic growth, and providing legal safeguards. By weaving together legislative frameworks, theoretical insights, and community involvement, South Africa aspires to address the complexities of land tenure, stimulate all-encompassing development, and extend the benefits of secure land tenure to its populace.

7 REFERENCES

Adams, M. 2000. Evaluation of ODA to the LAND sector. Available: http://www.treasury.gov.za/publications/other/devco-op/section_2/08.pdf(Accessed 15 November 2021).

Aliber, M. and Popoola, O. 2018. Economic development and tenure security in South Africa. Working paper 49, October 2018. University of Cape Town.

Barnes, G. and Enemark, S. 2020. Land Tenure Security An Essential Component of Responsible Land Administration. In FIG Working Week 2020: Smart Surveyors for Land and Water Management International Federation of Surveyors. FIG Working Week, Proceedings.
Buthelezi, M. and Yeni, S. 2016. a paper on Traditional Leadership in South Africa at a Forum to be hosted by CASAC and the Nelson Mandela Foundation on 12 April 2016. Available: https://www.nelsonmandela.org/uploads/files/The_Power_of_traditional_leaders_the_politics_of_land_use_and_tenure_insecurity_in_rural_areas_What_has_law_got_to_do_with_it.pdf(Accessed 29 November 2021).

Creamer Media Reporter. 2018. The Full and Informed Consent of Informal Land Right Holders is required prior to the Grant of Mining Rights. Creamer Media's Engineering News. Available Online: https://m.engineeringnews.co.za/artcle/the-fulland-informed-consent-of-informal-land-rights-holders-is-required-prior-to-the-grantof-a-mining-right-2018-12-11/company:fasken-martineau-2016-06-29(Accessed 26 March 2021).

Department of Rural Development and Land Reform. 2017. Land Audit Report: Phase II Private Landownership by Race, Gender and Nationality. Pretoria: Department of Rural Development and Land Reform.

Holland, M.B., Masuda, Y.J. and Robinson, B.E. 2022. Land Tenure Security and Sustainable Development. Switzerland: Palgrave Macmillan imprint.

Hull, S. and Whittal, J. 2018. Addressing shortcomings of land tenure reform in customary land rights. Cape Town: EE publishers. Available online: https://www.ee.co.za/article/addressing-shortcomings-land-tenure-reform-customaryland-rights.html(Accessed 26 March 2021).

Kasimbazi, E. 2017. Land Tenure and Rights: for Improved Land Management and Sustainable Development. Global Overlook Working Paper, September.

Kingwill, R., Royston, L., Cousins, B. & Hornby, D. 2017. The Policy Context: Land Tenure Laws and Policies in Post-Apartheid South Africa. In Untitled: Securing Land Tenure in Urban and Rural South Africa. D. Hornby, R. Kingwill, L. Royston, & B. Cousins, Eds. Pietermaritzburg: University of KwaZulu-Natal Press. 44–93.

Kloppers, H. and Pienaar, G.J. 2014. The Historical Context of Land Reform in South Africa and Early Policies. PER, 17(2):677-707.

La Croix, S.J.2002. Land Tenure: An Introduction. Working Paper No. 02-13 May 2002. Department of Economics: University of Hawaii.

Lekaba, I. 2016. Land Tenure Reform in South Africa: A decolonial review. Munich, Grin Verlag. Available Online: https://www.grin.com/document/511829(Accessed 26 March 2021).

Magagula, M.E. 2017. Government Housing Subsidy: Exploring the Administration Processes in The Dispensation of Title Deeds in Kwa-Mashu. Master of Public Administration: College of Law and Management Studies.

Makhado, R.B. 2012. South Africa's land reform debate: Progress and challenges. Available: https://www.researchgate.net/publication/255724731_South_Africa's_Land_Reform_Debate_Progress_and_Challenges (Accessed 23 August 2023).

Makombe, G. 2018. Land Reform in South Africa: The Conversation That Never Took Place. The Qualitative Report, 23(6):1402-1421.

Msunduzi Municipality. 2020. Msunduzi Municipality Integrated Development Plan 2022/2021.

Muchechetere, Paul & Kurwakumire, Edward. (2020). Towards a Land Titling Framework for Improving Rural Livelihoods. Conference: FIG Working Week 2020 at Amsterdam, Netherlands. Available: https://www.researchgate.net/publication/341448161_Towards_a_Land_Titling_Framework_for_Improving_Rural_Livelihoods (Accessed 15 August 2023).

Ntsebeza, L. 1999. Land tenure reform in South Africa: An example from the eastern Cape Province. Programme for Land and Agrarian Studies: University of the Western Cape.

Pienaar, G. 2013. Land Tenure Security: The Need for Reliable Land Information. The Journal of the Helen Susman Foundation, October (70):20-27.

Republic of South Africa. 1991. Upgrading of Land Tenure Rights Act 112 of 1991. Volume 313 No. 13358. Cape Town: Government Gazette.

Republic of South Africa. 1996. Interim Protection of Informal Land Rights Act 31 of 1996. Volume 372 No. 17277. Cape Town: Government Gazette.

Republic of South Africa. 1998. Prevention of Illegal Eviction from and Unlawful Occupation of Land Act 19 of 1998. Volume 396 No. 18964. Cape Town: Government Gazette.

UN Habitat. 2014. Land Tenure Security in Selected Countries: Synthesis Report. Nairobi: UNON.

Weeda ER, Butt S. 2018. Systematic Review of Real-World Studies Evaluating Characteristics Associated With or Programs Designed to Facilitate Outpatient Management of Deep Vein Thrombosis. Clinical and Applied Thrombosis/Hemostasis, 24(9):301S-313S.

The Role of Smart Cities on Smart Healthcare Management

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1 ABSTRACT

This qualitative study examines the role of Smart Cities in smart healthcare management. Interviews with eight practitioners in the field were conducted and analyzed using qualitative content analysis. The findings highlight the significant contributions of Smart Cities in healthcare, such as improved data collection, analysis, and communication between providers and patients. Challenges include the integration of healthcare technologies within Smart City infrastructures and addressing privacy and security concerns. The research underscores the importance of robust digital infrastructures and collaborative efforts between public and private sectors to support the implementation of smart healthcare services in Smart Cities. Recommendations include enhancing adaptability to new technologies and improving communication between healthcare providers and patients.

Keywords: practitioners, Smart City, qualitative research, healthcare, management

2 INTRODUCTION

The rapid urban population growth, projected to reach 60% by 2030, presents significant challenges such as waste management, air pollution, and resource shortages (Pierce & Anderson, 2017). The healthcare industry also faces constraints in delivering patient-centered care due to limited resources. Smart healthcare management solutions have emerged as potential remedies, saving costs and improving patient access. Stakeholders recognize the benefits of smart healthcare systems (Sligo et al., 2017; Renukappa et al., 2022). The shift towards proactive health management is driven by an aging population and the rise of chronic illnesses (Touti & Tabish, 2017).

Smart cities rely on advanced technologies to streamline municipal operations, with various components contributing to their concept (Hancke et al., 2012; Khan, Algarni, and Quasim, 2021). The Internet of Things (IoT) enables innovative healthcare applications (Budida et al., 2017).

This research project aims to explore the role of smart cities in healthcare and address obstacles to their implementation (Mbunge et al., 2021). The paper's structure includes sections on relevant research, methodology, analysis, findings, and conclusions. The literature search involved using specific keywords in search engines and databases to gather relevant studies.

3 LITERATURE REVIEW

3.1 Smart City

The present research examines the state of smart cities and smart healthcare management. The literature search involved two stages. Initially, a comprehensive internet search was conducted using public search engines. In the second stage, keywords such as smart city, smart healthcare, digital healthcare, e-healthcare, and technological adaptation were used to search Google Scholar and ScienceDirect. Various AND/OR operators were used to ensure an adequate collection of studies.

Smart cities have gained significant attention due to the increasing global urbanization. This urbanization process brings forth economic, social, and demographic changes. Advances in hardware and software design have led to a revolution in information and communication technology (ICT), offering opportunities to address urbanization-related challenges. A smart city aims to improve the quality of life by utilizing ICT and other means, ensuring effective urban operations and services while considering economic, social, and environmental aspects (Mohanty, Choppali & Kougianos, 2016).

The growing population and rising living standards highlight the need for smart cities. It is predicted that by 2050, 70% of the world's population will live in cities, which currently consume 75% of resources, produce 80% of greenhouse gases, and threaten the ecosystem (Mohanty, Choppali & Kougianos, 2016). Smart cities

offer a natural approach to tackle the challenges associated with rapid urbanization and population expansion (Khan, Algarni & Quasim, 2021).

These cities leverage cutting-edge technologies to enhance living standards while addressing climate change concerns. Smart cities combine democratic governance, efficient resource management, ubiquitous computing, artificial intelligence, and the Internet of Things (IoT) to generate ambient intelligence. They collect and analyze urban big data to support decision-making, leveraging technologies like AI and machine learning (Xu & Geng, 2019). Technology acceptance plays a crucial role in smart city development, with two approaches: technology-driven method (TDM) and human-driven technique (HDM) (An, Kim & Kim, 2020).

Smart cities exhibit diverse characteristics and consist of nine components: infrastructure, networks, transportation, energy, healthcare, technology, government, education, and citizens. These cities aim to achieve sustainability, quality of life, urbanization, and intelligence, addressing societal, economic, environmental, and governance aspects (Mohanty, Choppali & Kougianos, 2016). Various definitions of smart cities exist, with Holland's definition emphasizing investments in human and social capital, sustainable economic development, and wise resource management through participatory governance (El Hilali& Azougagh, 2021). Common components proposed by Pardo and Nam are widely acknowledged as critical to the success of smart city initiatives (Pardo & Taewoo, 2011 in El Hilali& Azougagh, 2021).
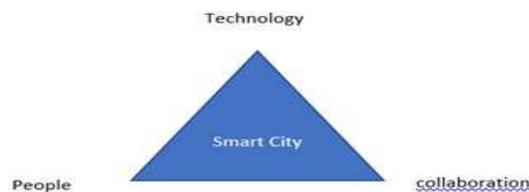
Fig. 1: Smart City Core Dimension. Source: (El Hilali& Azougagh, 2021)

Technology plays a crucial role in smart cities, serving as the foundation for rethinking various aspects. Smart cities leverage technologies such as the Internet of Things (IoT), Internet of Drones (IoD), and Internet of Vehicles (IoV) to develop sustainable urban environments. These technologies generate data that is analyzed to gain insights for enhancing the efficiency and effectiveness of smart societies and cities (Heidari, Navimipour & Unal, 2022).

While technology is important, it alone cannot create a smart city. The involvement of human resources is essential. Smart residents play a significant role in driving the smart city through their data, education, and creativity. Residents are at the core of city issues, and their input is crucial for finding solutions (El Hil, Ali& Azougagh, 2021)

Collaboration is a vital aspect of smart city governance. Smart governance, also known as smart collaboration, involves the interaction of all stakeholders, including the public sector (local government), private sector (industries), university (researchers and experts), and citizens, to design and implement smart city projects (El Hilali& Azougagh, 2021). People-centric smart city development requires governments to consider the perspectives and preferences of the residents when providing smart city services. Unfortunately, in many top-down implementations of smart city programs, the genuine needs of people are often overlooked (Wu, 2020; Ji et al., 2021).

To avoid investing in smart city projects that do not meet citizens' needs and expectations, city administrators must understand the preferences of local citizens for smart city services. This understanding can help inform decision-making on investment priorities and resource allocation for services that citizens genuinely need (Ji et al., 2021). Data warehouse technology is a critical component of smart city services, but issues such as data protection, privacy, and regulations need careful consideration (Lytras, Visvizi & Sarirete, 2019).

3.2 Smart Healthcare

In the context of smart healthcare, digital sensors, nanotechnology, fog computing, cloud computing, and telemedicine are examples of innovations that utilize the Internet of Things to generate and share data among stakeholders. These advancements in information management enable better data collection and create a foundation for "smart" healthcare platforms (Chakraborty et al., 2022). However, security and privacy in

smart healthcare systems must be addressed to prevent unwanted attacks and threats. Information security and privacy are crucial to protect against privacy violations and their potential impacts on individuals' lives (Chakraborty et al., 2022).

The healthcare industry faces various challenges due to rapid population growth, limited resources, and outdated healthcare systems. Traditional healthcare often struggles to meet the needs of the growing population, resulting in overburdened hospitals and occasional errors in treatment. In many rural areas, accessing adequate medical care remains an unattainable goal. To address these challenges, intelligent healthcare, enabled by modern technologies, has emerged as a solution (Mohanty, Choppali & Kougianos, 2016).

Smart healthcare is a system that actively accesses information, connects various stakeholders involved in healthcare, manages the needs of the medical ecosystem, and responds to those needs. It encompasses technologies such as wearables, the Internet of Things (IoT), and mobile internet, facilitating communication among all parties involved, ensuring appropriate care for patients, enabling informed decision-making, and optimizing resource utilization (Tian et al., 2019).

The year 2020, particularly with the COVID-19 pandemic, has accelerated the shift towards virtual healthcare encounters and the adoption of digital health technologies. These include shared electronic health records (EHR), remote visits, telehealth, wearable tech, and digital medicines powered by machine learning and artificial intelligence (Bergier et al., 2021). However, the digitalization of healthcare also presents significant challenges for patients, professionals, and healthcare systems.

Smart or modern technology-enabled healthcare allows people to receive medical assistance and services anytime and anywhere through digital devices such as laptops, tablets, or smartphones. The smart delivery management system enables services like emergency care, diagnostics, and monitoring. However, implementing smart healthcare solutions can be challenging, leading to a discrepancy between anticipated benefits and actual results. Factors such as resistance from healthcare practitioners, practical challenges, data security, and system vulnerabilities pose hurdles to successful adoption (Quasim et al., 2021; Renukappa et al., 2022).

To ensure the effective implementation of smart healthcare initiatives within healthcare provider organizations, it is important to understand and assess potential barriers. This can be done by identifying dilemmas and implementing proactive strategies to address them, thereby increasing the likelihood of successful adoption (Renukappa et al., 2022)

Smart healthcare relies on technologies like biotechnology, IoT, cloud computing, big data, 5G, microelectronics, and AI (Pan, 2019; Tian et al., 2019). These technologies enable disease monitoring, research, diagnosis, treatment, and patient management. Wearable devices, virtual assistants, information platforms, surgical robots, mixed reality, RFID, mobile platforms, big data, and machine learning all contribute to improving healthcare (Pan, 2019; Tian et al., 2019). Smart healthcare has the potential to reduce costs, enhance resource utilization, foster collaboration, accelerate telemedicine, and provide personalized medical services (Farahani, 2018; Tian et al., 2019).

Understanding the effective elements of IoT adoption in healthcare is crucial for maximizing its potential (Al-Rawshdeh et al., 2022). The concept of technology transfer, which examines users' adoption behavior in a connected context, is relevant in smart healthcare (Song et al., 2009; Pan et al., 2019). The Technology Acceptance Model (TAM) is often used to study users' intentions to adopt digital technologies in healthcare. TAM suggests that users' attitudes, influenced by perceived utility and ease of use, drive their intentions to use technology (Davis, 1989; Mangi et al., 2021).Factors such as gender, age, and experience have been found to influence user behavior and can modify the relationships between the components of TAM. For instance, in the healthcare context, research has shown that doctors are less likely than nurses to record incidents using an online information system (Chang and Hsu, 2012; Kingston et al., 2004). Another important factor influencing the acceptability of new technology is convenience, which comprises time and location utilities. Users are more likely to accept and adopt technology if it is easy to use and simplifies their lives (Kim, Mirusmonov & Lee, 2010; Lu et al., 2021).

Digital infrastructure refers to the technological foundation that enables the collection, storage, transmission, and analysis of healthcare data. It encompasses both public and private components, which play distinct roles in supporting the delivery of healthcare services (Buetow and Niederhuber, 2009).

Public digital infrastructure in smart healthcare involves technology and systems established and maintained by government or public entities. Examples include Health Information Exchanges (HIEs) that facilitate secure data exchange among healthcare providers, government-managed health databases for public health monitoring, and national health information networks that support interoperability between different healthcare systems (Sahay, T Sundararaman and Braa, 2017).

Private digital infrastructure in smart healthcare is implemented and managed by private healthcare organizations. Examples include Electronic Health Records (EHRs) that provide comprehensive patient health information within a healthcare organization, telehealth and remote monitoring systems for virtual care and remote patient monitoring, and patient portals/mobile apps for patient engagement and self-management (Ben Ahmed et al., 2021).

Novelty is another key factor in the adoption of smart healthcare devices. High levels of novelty indicate high innovativeness and commercial differentiation. These devices are associated with radical innovations, which can positively impact organizational outcomes and meet consumer demands. From an individual perspective, new smart healthcare devices with new services enhance customer attraction and better address their needs (Amara et al., 2008; Lu et al., 2021).

In the context of smart healthcare adoption, practitioners play a crucial role. However, previous research has indicated that practitioners face challenges in adjusting to new technologies and may not be fully enthusiastic about participating in digitalization efforts. Understanding practitioners' perceptions and uncovering the reasons behind their hesitancy is essential to promote successful adoption of digital technologies in healthcare (Pan et al., 2019).

Research Objective	Research Questions	Interview Questions	Sources
To investigate the smart city role in Smart Healthcare Management	RQ1: How does Smart Healthcare technologies ease the work for Health professionals and practitioners?	Q1-Do you think using innovative Technology in the Medical field such as IOT, AI… is Important? If yes Why and If No why Not? Q2-Why do you Trust on smart Technology or Why NOT? Q3- How do you think novel Technology would increase the patient's satisfaction?	Titan et al., 2019 Mohanty, Choppali and Kougianos, 2016). Al-Rawshdeh et al,2022 Renukappa et al., 2022
	RQ2: How do smart cities influence the perception of practitioners towards smart Health care?	Q1-Do you perceive SHCS as useful for the realization of the human needs of your patients? If yes why? If No why Not? Q2-Do you perceive working with smart Healthcare services to be easy or difficult? Please explain Q3-How do you find the role of smart cities in protecting the data in smart health care services? Q4- what additional success factor could you see for adaption of practitioners to the Technology? Q5- what kind of barriers or challenges do you see in adaption to the new technology?	Mangi et al., 2021 Tian et al, 2019 Ji et al., 2021 Lytras, Visvizi and Sarirete, 2019
	RQ3: How can smart cities motivate practitioners to accept and adopt the SHC technology?	Q1- Which beneficial influences of SHC technologies for practitioners and Healthcare organizations do you see? Q2- Which potentially negative aspects for practitioners do you see? Q3- How smart cities could increase the motivation of practitioners in using SHCS? (Educating? Workshop?)	Lu et al., 2021

Table 1: Research Table.

This study used a qualitative research approach with semi-structured interviews to explore roadblocks in smart healthcare adoption. Purposive and snowball sampling were employed to select participants. Interviews were conducted in English via video chat or phone from February 7th to 20th, 2023, with

durations of 20-35 minutes. Participants were practitioners in smart healthcare with knowledge of smart cities. The study aimed to understand their perceptions and challenges regarding digital technology adoption in healthcare.The collected material was analyzed using qualitative content analysis.(Kuckartz, 2018). This approach allows for rule-based analysis while preserving the originality of the data. A category system was developed, combining deductive and inductive approaches. Main categories were defined deductively, and subcategories were formed inductively based on the content. The coding process involved applying the category system to the entire material, facilitated by the use of MaxQDA analysis software.

Respondent	Job description	Interview Type	Interview length (Per minute)	date
R1	Pediatrician in Melbourne Royal children Hospital	Phone	25 Minuets	7/02/2023
R2	Dental Surgery Practitioner	Video chat	33 Minutes	9/02/2023
R3	Specialist in ophthalmology	Video chat	27 Minutes	9/02/20223
R4	General dentist at smart Dental clinic	phone	20 Minutes	12/02/2023
R5	General practitioner in Women's Mercy hospital	Video chat	30 Minutes	12/02/2023
R6	Medical Doctor and Director of Smart Moves Healthcare	Video chat	33 Minutes	13/02/2023
R7	Decision scientist in public Affair at Meta	Video chat	25 Minutes	19/02/2023
R8	Psychologist, researcher, Mental Health and well-being in modern working world	Video chat	35 Minutes	20/02/2023

Table 2: interview respondents.

4 PRESENTATION OF FINDINGS

This section presents the findings from the interviews, summarizing the extracted categories and providing supporting quotes from the interviewees.

4.1 Novel Technology

This main category explores the integration of smart healthcare with the technology-driven concept of a smart city, addressing the conflict between technology and resource utilization described in the literature review. The subcategories "inevitable role of innovative technology," "reliability," and "satisfaction" were created within this category.

4.1.1 Inevitable Role of Innovative Technology

The respondents unanimously identified the significant role of innovative technologies such as AI, IoT, robotics, precision medicine, 3-D printing, augmented reality/virtual reality, genomics, and telemedicine in healthcare delivery. For example, one respondent (R4) stated, "The entry of technology into the medical field is not only important but also necessary." Another respondent (R6) mentioned, "This kind of technology can help healthcare services recognize diseases with fewer failures compared to humans." Additionally, several respondents (R1, R6, R7, R8) highlighted the benefits of cost savings and efficiency. Furthermore, one respondent (R5) emphasized the critical role of technology in early illness detection, which can be a life-saving factor. The respondents also mentioned the use of technology in education to enhance learning quality and reduce the trial-and-error approach (R8).

4.1.2 Reliability

Based on the eight interviews, there is a low level of trust in innovative technology among treatment professionals. Only one respondent (R3) expressed unconditional trust, while others mentioned trusting smart technology for its efficiency (R7, R3). However, factors like lack of conclusive results, testing, assurance, technological limitations, and subject sensitivity make it difficult for practitioners to fully trust (R1, R2, R4, R5, R6, R7, R8). Respondents emphasized the need for experimental stages, patient safety, and human participation in data analysis (R6, R1, R5). Concerns about safety and security were raised,

contributing to mistrust among treatment personnel (R4, R5, R6, R7). One respondent stressed the importance of privacy in protecting patients' lives (R5).

4.1.3 Satisfaction

Patient satisfaction is crucial for evaluating care quality, and all eight respondents stressed the importance of smart healthcare technology in improving it. Time and cost savings were mentioned as significant benefits, particularly for the elderly and people with disabilities (R1, R7). Respondents also noted how revolutionary technology can enhance the patient experience, reducing discomfort and increasing satisfaction (R4, R6). The use of digital systems for data collection and storage was highlighted for improving efficiency and medical record safety (R7, R6). Furthermore, respondents recognized the impact of practitioners and treatment workers on patient care and satisfaction (R6).

4.2 Treatment staff perception

The perception of treatment staff regarding smart healthcare is influenced by smart cities, as indicated in the literature. This section focuses on the categories "human needs," "easiness and severity," "data protection/information privacy," "success factors and challenging aspects," and "adaptation motivation factors" to explore how smart cities impact the perspective of treatment staff.

4.2.1 Human needs

Patients' needs vary depending on the severity of their condition and their stage in the treatment process. The importance of addressing patients' psychological, physical, and social needs, and their interplay within larger systems such as family and society, is emphasized (R6). Five out of eight respondents agree that smart healthcare systems are effective in meeting patients' human needs (R1, R4, R6, R7, R8). Respondent 2 suggests that practitioners should provide necessary information and explain the benefits and ease of access to improve patients' understanding and positive perception of novel technologies and digitalized services. However, respondents also acknowledge that human contact cannot be replaced by smart technology (R3).

4.2.2 Easiness and severity

This section examines whether smart technology is easy for practitioners to use. All eight respondents agree that dealing with new technology can be initially difficult and challenging. However, with training, learning, and gaining expertise in innovative technology, practitioners can become more confident in using it. R6 mentions that teaching and learning new technology may be challenging at first, but it becomes easier over time. Respondents R5 and R8 highlight that persuading practitioners, especially younger ones, can be difficult due to concerns about privacy and security. Ethical and regulatory issues are also mentioned as factors that may hinder the adoption of innovative technology by practitioners (R8).

The findings indicate that while smart healthcare can meet patients' human needs and improve accessibility, there are challenges related to ease of use, privacy and security concerns, and regulatory and ethical considerations that need to be addressed to ensure the successful adoption and acceptance of smart technology by treatment staff.

4.2.3 Data Protection/Information Privacy:

Respondents emphasized the significance of data security and confidentiality in smart cities. They stressed the need for laws and regulations to protect data and information. The integration of multiple organizations in a smart city was seen as a way to enhance the healthcare system. Smart access controls, transparent regulations, and secure data platforms were identified as essential for preserving data, reducing costs, and engaging patients effectively.

4.2.4 Success Factors and Challenging Aspects:

Thorough training and understanding of new technology were seen as important for practitioners' trust and confidence. Easier communication, remote education, and therapy were mentioned as success factors. Cost, potential risks to practitioners, and the difficulty of learning new technology were identified as challenges.Sustainability was also highlighted as a factor for success

812

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4.3 Adaption Motivation Factors:

To increase practitioners' motivation to adopt new technologies, smart cities should provide appropriate infrastructure and organize seminars and workshops to enhance knowledge and trust. The positive influences of new technology include reducing the risk of failure, improving access to reliable data, and increasing practitioners' knowledge. Negative aspects include data security concerns and communication breakdown. The following figure 3 depicts the main findings.
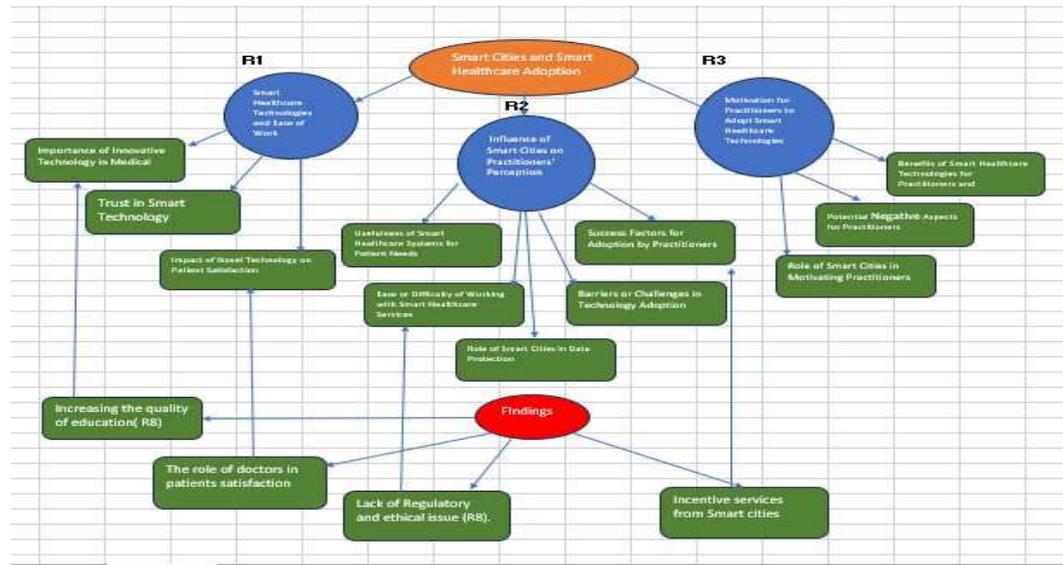
Fig. 2: Final conceptualization

5 DISCUSSION AND PRACTICAL IMPLEMENTATION:

The study highlights the significance of practitioners' perception and the role of technology in smart healthcare within smart cities (Heidari, Navimipour & Unal, 2022). While technology offers various benefits to practitioners, reservations exist regarding its limitations and the potential displacement of human roles in healthcare (R1, R2, R4, R5, R6, R7, R8). Balancing technological advancements with the essential role of human intervention is crucial. Patient satisfaction and positive experiences are also important outcomes, with patients benefiting from online services and improved treatment processes (R3). The attitude of users, influenced by anticipated benefits and ease of use, plays a significant role (Fletcher-Brown, 2020). Addressing data protection, information security concerns, and building trust are essential (R6, R8). Successful adoption requires training, improved communication, straightforward acquisition processes, post-sales support, and addressing cost-related challenges (R3, R8). The integration of technology in healthcare practices should consider practitioners' perception, human factors, patient-centric considerations, user attitudes, trust-building measures, data protection, and cost considerations (Heidari, Navimipour & Unal, 2022).

6 LIMITATION AND CONCLUSION

The study focuses on understanding how practitioners perceive smart healthcare technology within the context of smart cities. The findings emphasize the significant role of technology in advancing healthcare practices. It is evident that technology plays a crucial role in reducing human errors, aiding in various medical fields, enabling early disease diagnosis, and enhancing educational understanding. However, the study also reveals that practitioners have certain concerns and limited trust when it comes to adopting new technology. They perceive limitations and question the role of humans in smart healthcare. Factors such as user attitude, professional benefits, and ease of use influence practitioners' acceptance and adaptation to technology. On the other hand, patient experiences with smart healthcare technology are generally positive. The use of online services, diverse applications, and innovative gadgets can save time and money for patients. Patients with special needs also find smart healthcare technology to be satisfying, as it reduces discomfort and improves treatment experiences compared to traditional methods. The study highlights the importance of addressing human needs and providing patients with knowledge about revolutionary technologies to positively influence their expectations. The relationship between practitioners and patients is

considered a crucial aspect in shaping perceptions and acceptance of technology. Factors such as training, data protection, and ethical regulations are identified as key elements in building trust and confidence among practitioners. Pre-introduction training and continuous learning are identified as success factors in technology adoption. Additionally, smart cities need to invest in government regulations and ethical guidelines to ensure practitioners' confidence in data protection and information security. Cost-related challenges are recognized as barriers to technology adoption, especially in the early stages. There is also a fear among practitioners that technology might replace human involvement in healthcare processes. However, the study highlights the positive aspects, such as reduced failure rates among practitioners and improved access to integrated and accurate data, leading to time and cost savings.

In summary, the study emphasizes the central role of technology in advancing smart healthcare within smart cities. While practitioners have concerns and limited trust, patients' experiences with smart healthcare technology are positive. Addressing human needs, providing knowledge, ensuring data protection, and offering training opportunities are essential in bridging the perception gap and facilitating technology adoption in the healthcare industry.private and public infrastructure both play critical roles in the adaptation of practitioners to smart healthcare. Private sector investment drives innovation, provides training and support, and offers advanced technologies, while the public sector establishes policies, provides funding and incentives, develops infrastructure, and promotes research and knowledge dissemination. Together, these efforts create an environment conducive to practitioners' adoption and effective utilization of smart healthcare technologies.

7 REFERENCES

Al-rawashdeh, M. et al. (2022) "IoT adoption and application for smart healthcare: A systematic review," Sensors (Basel, Switzerland), 22(14), p. 5377. doi: 10.3390/s22145377.

An, S., Kim, Sungwhan and Kim, Soyeon (2020) "Necessity of the needs map in the service design for smart cities," Frontiers in psychology, 11. doi: 10.3389/fpsyg.2020.00202.

Bergier, H. et al. (2021) "Digital health, big data and smart technologies for the care of patients with systemic autoimmune diseases: Where do we stand?" Autoimmunity reviews, 20(8), p. 102864. doi: 10.1016/j.autrev.2021.102864.

Budida, D. A. M. and Mangrulkar, R. S. (2017) "Design and implementation of smart HealthCare system using IoT," in 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS). IEEE.

Buetow, K.H. and Niederhuber, J. (2009). Infrastructure For A Learning Health Care System: CaBIG. Health Affairs, 28(3), pp.923–924. doi:https://doi.org/10.1377/hlthaff.28.3.923-a.

El Hilali, S. and Azougagh, A. (2021) "A netnographic research on citizen's perception of a future smart city," Cities (London, England), 115(103233), p. 103233. doi: 10.1016/j.cities.2021.103233.

Heidari, A., Navimipour, N. J. and Unal, M. (2022) "Applications of ML/DL in the management of smart cities and societies based on new trends in information technologies: A systematic literature review," Sustainable cities and society, 85(104089), p. 104089. doi: 10.1016/j.scs.2022.104089.

Ji, T. et al. (2021) "Towards people-centric smart city development: Investigating the citizens' preferences and perceptions about smart-city services in Taiwan," Sustainable cities and society, 67(102691), p. 102691. doi: 10.1016/j.scs.2020.102691.

Khan, M. A., Algarni, F. and Quasim, M. T. (2021) Smart Cities: A Data Analytics Perspective (Lecture Notes in Intelligent Transportation and Infrastructure). Springer.

Kumar, V. (2022) Smart City Infrastructure: The Blockchain Perspective. Wiley-Scrivener.

Lu, X. et al. (2021) "Determinants of the intention to use smart healthcare devices: A framework and public policy implications," Journal of healthcare engineering, 2021, pp. 1–7. doi: 10.1155/2021/4345604.

Lytras, M., Visvizi, A. and Sarirete, A. (2019) "Clustering smart city services: Perceptions, expectations, responses," Sustainability, 11(6), p. 1669. doi: 10.3390/su11061669.

Magni, D. et al. (2021) "Employees' acceptance of wearable devices: Towards a predictive model," Technological forecasting and social change, 172(121022), p. 121022. doi: 10.1016/j.techfore.2021.121022.

Mohamed Ben Ahmed, İsmail Rakıp Karaş, Santos, D., Sergeyeva, O. and Anouar Abdelhakim Boudhir (2021). Innovations in Smart Cities Applications Volume 4. Springer Nature.

Mohanty, S. P., Choppali, U. and Kougianos, E. (2016) "Everything you wanted to know about smart cities: The Internet of things is the backbone," IEEE consumer electronics magazine, 5(3), pp. 60–70. doi: 10.1109/mce.2016.2556879.

Pan, J. et al. (2019) "Exploring behavioural intentions toward smart healthcare services among medical practitioners: a technology transfer perspective," International journal of production research, 57(18), pp. 5801–5820. doi: 10.1080/00207543.2018.1550272.

Panahi Rizi, M. H. and Hosseini Seno, S. A. (2022) "A systematic review of technologies and solutions to improve security and privacy protection of citizens in the smart city," Internet of Things, 20(100584), p. 100584. doi: 10.1016/j.iot.2022.100584.

Pierce, P. and Andersson, B. (2017) "Challenges with smart cities initiatives: A municipal decision makers   perspective," in Proceedings of the 50th Hawaii International Conference on System Sciences (2017). Hawaii International Conference on System Sciences.

Renukappa, S. et al. (2022) "Evaluation of challenges for adoption of smart healthcare strategies," Smart health, 26(100330), p. 100330. doi: 10.1016/j.smhl.2022.100330.

814

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Sahay, S., T Sundararaman and Braa, J. (2017). Public health informatics : designing for change: a developing country perspective. Oxford ; New York, Ny: Oxford University Press.

Tian, S. et al. (2019) "Smart healthcare: making medical care more intelligent," Global health journal (Amsterdam, Netherlands), 3(3), pp. 62–65. doi: 10.1016/j.glohj.2019.07.001.

Touati, F. and Tabish, R. (2013) "u-Healthcare system: state-of-the-art review and challenges," Journal of medical systems, 37(3), p. 9949. doi: 10.1007/s10916-013-9949-0.

Vidiasova, L. and Cronemberger, F. (2020) "Discrepancies in perceptions of smart city initiatives in Saint Petersburg, Russia," Sustainable cities and society, 59(102158), p. 102158. doi: 10.1016/j.scs.2020.102158.

Xu, H. and Geng, X. (2019) "People-centric service intelligence for smart cities," Smart Cities, 2(2), pp. 135–152. doi: 10.3390/smartcities2020010.

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Theoretical and Methodological Framework for the Development of Urban Climatic Planning Recommendation Maps

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1 ABSTRACT

Urban climatic analyses and planning recommendation maps are becoming increasingly important in the climate-sensitive planning of cities. Urban climatic maps typically include two main components (Ren et al. 2012): an urban climatic analysis map and an urban climatic planning recommendation map. Given the urgent need for action due to climatic changes in urban areas, planning recommendation maps are essential for introducing and locating measures that effectively increase the adaptive capacity of cities, thus increasing the resilience of urban areas and their inhabitants (Baumüller 2015). The first urban climatic maps were produced in Germany in the 1970s and currently they are used worldwide.

The aim of this contribution is to develop a theoretical and methodological framework for the development of urban climatic planning recommendation maps. The main focus is on the review of existing theories and methods that serves as a roadmap for developing these maps. The examples show that these analyses usually consist of four steps or four areas of processing: (i) an urban climatic analysis, (ii) additional in-depth analyses, (iii) the development and location of measures and (iv) the consolidation in a planning information map (Ren et al. 2011).

Within the urban climatic analysis two main approaches are common: pure static GIS (Geographic Information System) derived maps or mainly meteorologically focused maps including the calculation of regional climate simulations (and hybrid forms thereof). Supplementary in-depth analyses are often carried out, such as the intersection with socio-demographic data to identify areas that are particularly vulnerable from a social point of view, or analyses based on specific urban or spatial configurations (Reisinger et al. 2020). In the third step of the process, measures are usually developed at different levels or for different sectors of urban development. As a final step, the results are summarised in planning recommendation maps and the measures are spatially located (Baumüller 2015). Each of these individual steps has been intensively researched in the last few years; the synopsis or bringing together of these numerous research projects and approaches is a gap that this contribution seeks to fill.

The contribution demonstrates available approaches, methods and tools necessary to translate scientific climatic knowledge into urban planning recommendation maps, considering that the analyses for a particular city or municipality are strongly limited in reproducibility to other citys, even in the same country. Based on this, a theoretical and methodological framework for the development of urban climatic planning recommendation maps is elaborated that enables the creation of these.

Keywords: Urban climatic maps, Landscape planning, Urban planning, Climate change adaption, urban climatic planning recommendation maps

2 INTRODUCTION

2.1 Changes in climate signals and impacts on urban development

Urban areas are particularly affected by climate change: the ever-progressing urban development in combination with the increased occurrence of extreme weather events has resulted in a growing number of hot days and warm nights that result in increasing heat stress. In addition, more frequent and intense heavy rain events are expected (IPCC 2021).

Urban climatic maps therefore represent an important link for inter- and transdisciplinary communication and collaboration between urban climatologists, urban planners as well as decision makers and administration employees. They are as well becoming an increasingly important platform to inform planning decisions in the realm of legally binding spatial planning. There are many different approaches to cover and analyse hazards, exposure and vulnerability (see figure 1).

2.2 Hazards, exposure and vulnerability

People, ecosystems and cities and their infrastructures are differently affected or vulnerable to the impacts of climate change. Vulnerability is defined by susceptibility or sensitivity as well as response and adaptation capacity. It is a sub-component and determinant of risk together with the exposure and hazard components. Risks in the context of climate change can "only develop through linkages with exposed and vulnerable societies, cities, infrastructures or ecosystems" (Birkmann et al. 2017, 270). Since adaptive capacity is often difficult to determine and sensitivity is considered by many scientists to be the driving component of vulnerability, in practice, instead of vulnerability analyses, affectedness or climate impact analyses are often carried out (Kemper 2016).

Before the planning recommendation maps are produced, further analyses are often carried out to identify particularly affected areas or vulnerable population groups. In the preparation of planning recommendation maps, various climatic, land use or social data are usually included and combined with local planning or expert knowledge.
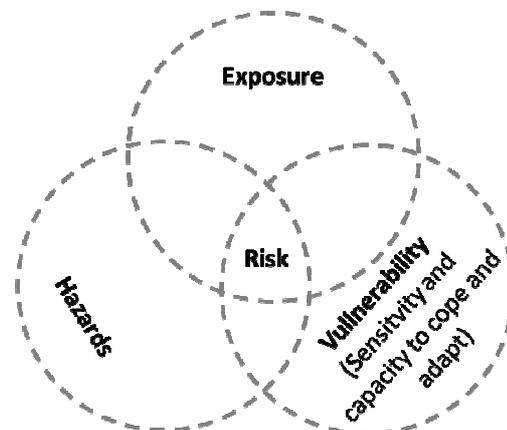
Figure 1: Incorporate hazards, exposure and vulnerability to determine risk as a basis for urban climatic analysis (IPCC 2014, Estoque et al. 2023).

2.3 Urban climate analyses and their use in urban planning

Urban climatic maps are becoming increasingly important in the everyday planning of cities. Urban climatic maps are a climatic information and evaluation instrument to inform planners and policymakers about (changing) urban climatic-environmental conditions and to assist them in urban climate adaptation and mitigation planning (Ren et al. 2012). In order to assist planners and policymakers, the urban climatic knowledge must be translated into a planning language that is actionable in regard to climate change policy (Alcoforado 2006; Alcoforado et al. 2009).

German researchers first developed the concept of urban climatic mapping in the 1970s Stuttgart (Matzarakis 2005) to mitigate air pollution during reduced airflow conditions and to apply climatic knowledge to the planning realm (Ren 2015). In the context of air pollution mitigation programs, urban areas have been identified for planning purposes according to their different climatic functions and characteristics. Based on land use information and its climatic characteristics, the different urban climatic conditions were defined as climatopes - the spatial units of the urban climatic maps (Ren 2015, see chapter 4.1.1.). In the 1990s several cities in Germany (e.g. Stuttgart, Berlin) continued to conduct climatic analyses, resulting in a series of climatic atlases that informed urban planning decisions aiming at improving the exchange of air in these urban areas (ibid). In 1993 the "VDI 3787: Part 1" was published to guide the urban climatic analysis practice in Germany (ibid). This national guideline defines symbols and representations used in UC-Map studies and recommended a rather vague method for developing urban climatic maps with the aim to create a

standard for their application (VDI 1997). Since its publication, this guideline has been used as a reference for UC-Mapping and has been adopted and developed by many countries worldwide, with Asian research teams from Japan and China in particular driving the process (Ren 2015; Jégou et al. 2022).

In Austria and Germany, many urban climatic analysis maps are based on this VDI directive, but mostly the maps are tailored to the special needs of a city and thus also differ a lot. Internationally, there are some projects which try to methodically standardise the approach such as the „Urban Climatic Map System" for Dutch spatial planning (Ren et al. 2012) which also mainly follows the German VDI directive or the "Heat Environment Map" from the Tokyo Metropolitan Government (Japan) which indicates 10 types of heat environments (Tokyo Metropolitan Government, 2005).

More and more European cities are commissioning urban climatic analyses or participating in research projects on climate change adaptation in order to generate relevant information to be able to influence their urban development towards more climate resilient structures. However, there is a lack of a strict and applicable methodology for conducting urban climatic maps both for the VDI based and the simulation based climatic analyses as well as for the development of urban climatic planning recommendation maps.

The aim of this contribution is, therefore, to develop a theoretical and methodological framework for the development of urban climatic planning recommendation maps, in order to better guide the conduction of the different steps of urban climate mapping. The main focus is on the review of existing theories and methods that serve as a roadmap for developing these maps that usually consist of four steps or four areas of processing: (i) an urban climatic analysis, (ii) additional in-depth analyses, (iii) the development and location of measures and (iv) the consolidation in a planning recommendation map (Ren et al. 2011).

3 MATERIAL AND METHOD

Since the development of urban climatic analsysis requires a thematic intersection of landscape and urban planning disciplines, meteorology and urban climate modelling and, last but not least, the involvement of planning practice and local decision-makers, an inter- and transdisciplinary approach was chosen.

The contribution is embedded in a "climate proofing framework" (Schindelegger et al. 2022). Climate proofing examines the question of adequate planning responses to climate change-related impacts on planning projects. In addition to the development and implementation of adaptation measures, effective climate change adaptation also requires an analysis and continuous improvement of the (political) decision-making basis, the capacities and competences of planning authorities, and the analysis and planning processes themselves. Following this understanding, "climate proofing" for the (Austrian) spatial planning context comprises three fields of action: (A) the overarching framework conditions and policy objectives, (B) the analysis and strengthening of capacities and competences of planning authorities, and (C) the concrete implementation of climate change adaptation through the integration of relevant steps into planning instruments and planning processes at regional and municipal level (see figure 2).

The contribution focuses on the analysis or improvement of the analysis and planning processes (Part C) by developing a theoretical and methodological concept for the development and implementation of urban climatic analysis aiming at planning recommendation maps as a basis for the adaptation of spatial planning and developments to the challenges of climate change.

The paper is based on an extensive literature review and analysis of the different methods and approaches to urban climatic analysis as well as the necessary steps described in the literature and the instruments and methods used. In addition, numerous practical examples (mainly from Austria, Germany and Switzerland) were analysed and compared to complement the (partly missing) scientific and theoretical approaches.
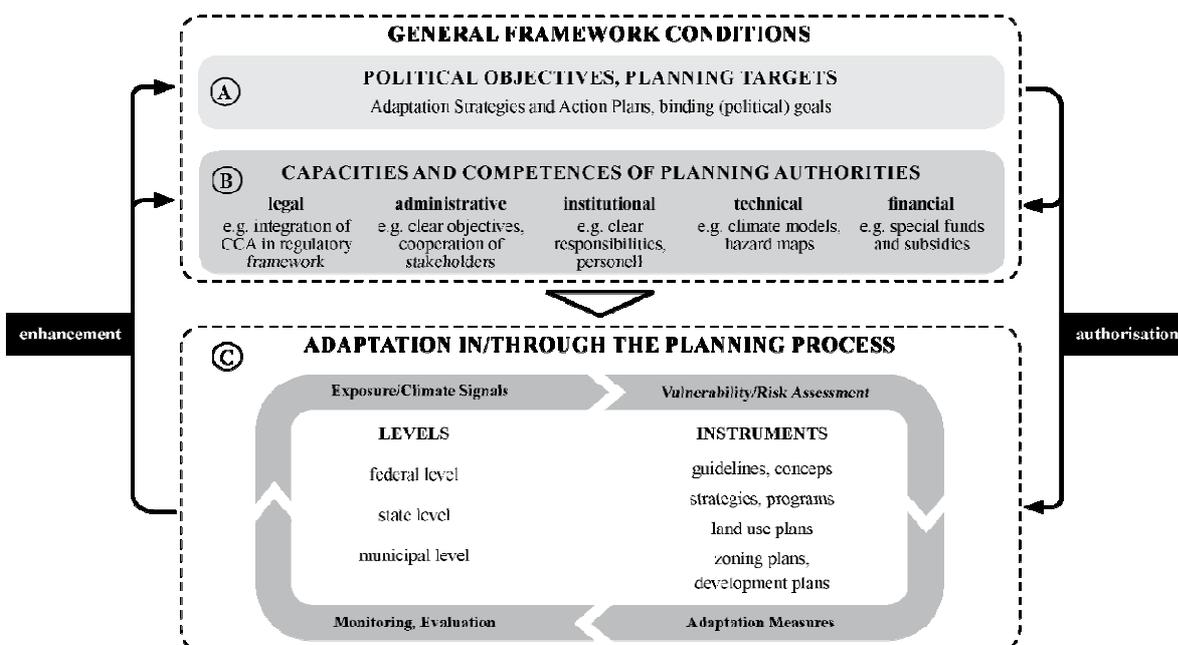
Figure 2: Climate proofing framework © Reinwald, F., Schindelegger, A. & Weichselbaumer, R.; published in: Schindelegger et al. 2021, 2022.

4 RESULTS – METHODS AND STEPS TO DEVELOP URBAN CLIMATIC PLANNING RECOMMENDATION MAPS

Urban climatic maps usually contain two main components (Ren et al. 2012): an urban climatic analysis map and an urban climatic planning recommendation map. Given the urgent need for action due to climatic changes in urban areas, planning recommendation maps are essential for introducing and locating measures that effectively increase the adaptive capacity of cities and thus increase the resilience of urban areas and their inhabitants (Baumüller, 2015). However, scientific disciplines usually develop approaches for their sectors. For urban climatic mapping, this means that the urban climate analysis maps were mostly produced by climatologists and climate impact researchers. The complementary analyses are mostly carried out by planning experts, while the development of measures is dominated by a collaboration between practitioners and researchers, and the planning recommendation maps combine these findings and also incorporate local knowledge (Ren et al., 2011). Thus, not only an interdisciplinary but also a transdisciplinary approach is needed to combine climate and planning science with the knowledge of practitioners and local administrations.
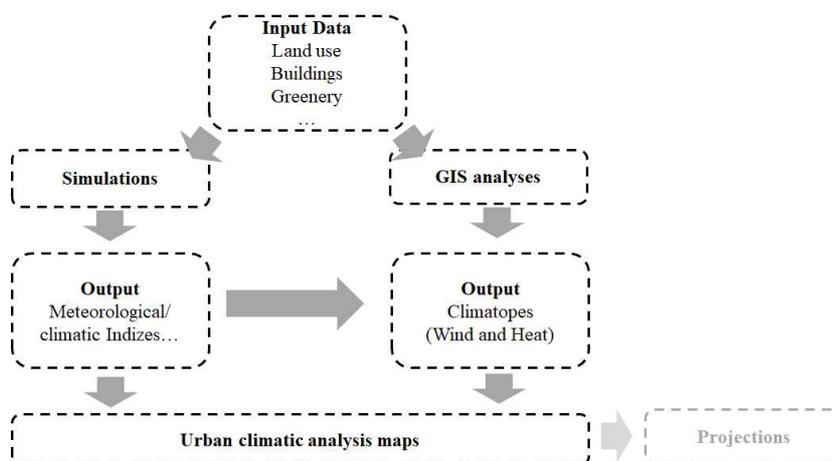
Figure 3: Climate hazard analysis using either Simulations or GIS analyses

4.1 Climate hazard analysis – urban climatic analysis

The urban climatic analysis maps provide a platform for climatic information and evaluation of cities. There are two main climatic aspects examined in urban climatic analysis maps: i) the thermal environment (UHI

and heat stress, urban bioclimatic variations) and ii) the wind environment (ventilation zones, local air circulation patterns, existing and potential air paths and the barrier effects by buildings or plants). A third aspect, iii) air pollution, is often additionally included in the analysis (Ren et al. 2011).

Within urban climatic analyses two main approaches are common: pure static GIS (Geographic Information System) derived maps or mainly meteorologically focused maps including the calculation of urban climate simulations (and hybrid forms thereof) (see figure 3). This fundamental difference in the approach affects all further steps of the analysis.

4.1.1 GIS-based analysis and Climatopes

Urban climate analysis based on GIS mapping consists of several input layers typically based on information on land use, topography, vegetation and wind (Ren 2015). Especially in the early days of urban climate map studies the types of climatopes were mainly classified by land use (VDI 1997). Climatopes are the main features of GIS-based analysis maps. Climatopes are non-parcel-specific spatial units that represent areas with similar climatic characteristics which are mainly distinguished by daily thermal variations, the surface structure and vertical roughness, the topographic situation or exposure as well as the type of land use and vegetation cover (Baumüller 2015). Their spatial scales commonly range from several tens to hundreds of metres (Ren et al. 2011). According to the VDI 3787-Part 1 there are nine climatope classes that are named after the dominant land-use type (Water body Climatope, Forest Climatope, Open land Climatope, Urban green space Climatope, Garden city Climatope, Suburban Climatope, City Climatope, Inner City Climatope, Commercial/Industry Climatope, etc.) (VDI 1997). However, climatopes are based on expert knowledge of local topography and climatology and specialized to particular urban areas. Consequently, each city exhibits a unique set of Climatopes meaning that intercity comparisons or generalizations are of limited use (Stewart & Oke 2015). In the first step, Climatopes are derived from the respective georeferenced and land-use data and are classified and allocated. The data basis should be latest digital, geo-referenced data:

- land use data
- topography (e.g. digital elevation model and information on slopes),
- data of building layer (including building height, densityand degree of sealing)
- data of vegetation type and structure
- aereal images with high spatial resolution (VDI 1997).

These data feed various GIS layers – e.g. building volume, ventilation paths, green areas, slopes, etc. – where climatopes can be delineated. This classification of climatopes should then be further improved with information on the distribution of basic climatic parameters (e.g. air temperature, humidity, wind speed and direction, radiation), cold air drainage and thermally induced wind systems, as well as information on human-biometeorological conditions (VDI 1997).

4.1.2 Urban climate simulations

Numerical urban climate models have been developed to analyse physical atmospheric processes within the urban boundary layer (e.g. Sievers et al. 2016; Maronga et al. 2020). They simulate radiation balance, energy exchange and wind flow by taking into account land use and land cover information, urban structures, surface characteristics and vegetation. Different meteorological parameters are calculated to analyse urban climatic conditions and urban heat island (UHI) effect. Combining the results with regional climate models, the models can be further used to provide long-term climate projections on urban scale, considering different greenhouse gas emission scenarios (Früh et al., 2011; Oswald et al., 2020).

In recent years, urban climate models have been extensively used to support urban planning decisions and climate adaptation strategies by providing city-specific climatic information. Covering a broad range of spatial and temporal scales, different types of models are applied to address different problems and to respond to local challenges. While urban climate models are usually applied on city scale and thus, on a level of strategic urban planning, micro-scale models have been designed to simulate the effects of (single) buildings and vegetation on their environment on a microscale, thus considering detailed building geometry and type, surface materials and vegetation properties (e.g. Bruse & Fleer 1998; Lindberg et al. 2008). Due to

their higher resolution and enhanced computational requirements, their application is usually limited to district or block level and they are often used within the framework of individual construction projects.

Within the scope of urban climatic analyses, urban climate simulations help to identify regions potentially affected by heat hazards by analysing the spatial distribution of surface or near-surface air temperature or climate indices like the mean annual number of summer days or hot days. As such, they can serve as a basis for generating urban climate analysis maps, covering the thermal component of the analysis. Model results can be further used to derive biometeorological parameters that characterise human thermal comfort like the Perceived Temperature (PT) (Jendritzky 1979), Physiological Equivalent Temperature (PET) (Höppe 1999) or the Universal Thermal Climate Index (UTCI) (Jendritzky 2012). In addition to the thermal component, cold air drainage models are applied to complement the analysis by providing information about important ventilation and cold air pathways (e.g. Sievers, 2005).

4.2 Exposure and vulnerability – in depth social and spatial analysis

People, ecosystems as well as cities and their infrastructures are affected or vulnerable to the impacts of climate change in different ways. For the analysis of exposure and vulnerability, in-depth analyses are carried out according to both social and spatial aspects (see figure 4).
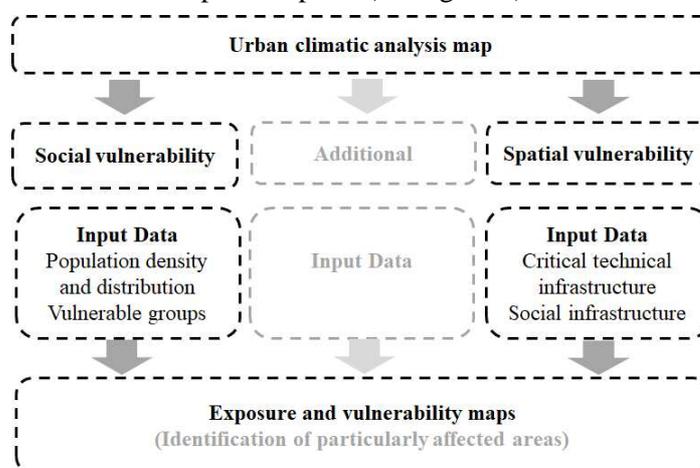
Figure 4: Exposure and vulnerability – in depth social and spatial analysis.

4.2.1 Social vulnerability

The changing temperatures and other climate signals have a strong influence on the human bioclimate. Factors like heat, cold and air humidity strongly influence people's well-being and health. It is therefore important to identify social vulnerability by analysing for example population density or the differing distribution of the most vulnerable groups. The most common demographic indicator groups are elderly residents over 65 years of age and infants and young children. Other socio-economic aspects – such as pre-existing health conditions, ethnicity, gender and income – are rarely considered, even though they influence ones vulnerability to heat and other climate signals as well (APCC 2018; BMSGPK 2021).

4.2.2 Spatial vulnerabillity

For a spatial vulnerability analysis, sensitive facilities such as hospitals or childcare centres can be presented in combination with climatic indicators such as, for example, the average number of hot days. The sensitive infrastructure facilities include facilities that are particularly relevant for the previously mentioned age groups that are especially affected (children, elderly people) as well as other vulnerable groups such as people with care needs (e.g. due to pre-existing health-conditions).

4.3 Vulnerability and adaptive capacity – measures and effects

There are numerous measures that support urban adaptation to climate change. Climate resilient measures can be implemented in existing structures, driven by factors such as heat hotspots or the need for renovations. They can also be incorporated into the development of new climate-adapted buildings and infrastructure. These measures can be categorized into the following groups (Jiricka-Pürrer et al. 2021):

- Strategic measures, such as preserving ventilation pathways and increasing albedo.

- Green infrastructure, including initiatives like tree plantations.
- Blue infrastructure, encompassing approaches like the sponge city principle for roadside trees.
- Technical measures, such as the use of permeable asphalt and water-bound surfaces.

Based on the previous analyses, measures are developed and discussed with local stakeholders. Simulations can then be used to test the impact of the various measures. In this way, their efficiency is assessed and the different locations and their effects are captured (see figure 5).
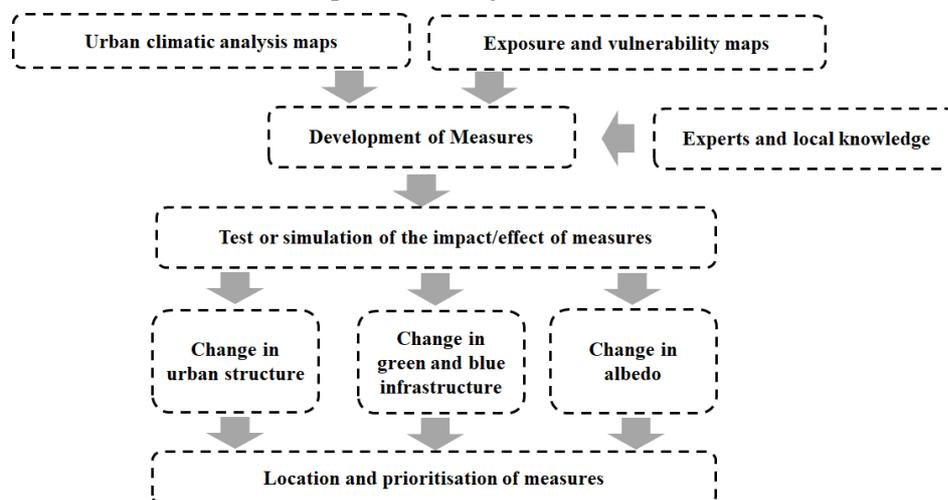
Figure 5: Vulnerability and adaptive capacity – measures and effects

4.3.1 Development of measures

The overarching goal of these measures is to combat heat islands by promoting shaded and green surfaces, reduce the impact of drought through improved local water management and the sponge city principle for roadside trees, and mitigate the consequences of heavy rainfall events through retention spaces like sponge city structures. Changes of the urban structure can also help, for example, to improve ventilation or to make better use of the shading provided by the buildings (MA 22, 2015).

It is crucial for public administrations and businesses to possess climate competence. This includes acquiring the necessary knowledge and skills to implement climate-responsive measures and to prioritise their implementation based on climate fact-based information – a crucial step for which urban climate maps are an aid.

4.3.2 Sensitivity analyses

Not all adaptation measures can be implemented everywhere in a city. Depending on the location or urban typology, only certain measures are suitable or their effectiveness varies.

Urban climate models have been used to evaluate the cooling efficiency of climate adaptation measures by carrying out sensitivity simulations. The potential of different adaptation measures (e.g. implementation of green and blue infrastructure, unsealing or a change in albedo) to reduce thermal heat load can be assessed by the model and the results can be used to support urban planning and climate adaptation strategies (e.g. Oswald et. al., 2020, Zuvela-Aloise et al., 2017).

Depending on the urban context, type of application and considering the model's resolution and planning level, adaptation measures are evaluated on a city scale, as well as on a district or block scale. The measure's efficiency can be expressed in terms of a reduction in local air temperature or heat-related climate indices in comparison to the current situation. Sensitivity analyses have shown that adaptation measures on urban scale are most effective when applied extensively and that a combination of different measures can lead to strong cooling effects (Zuvela-Aloise et al., 2016).

Moreover, sensitivity analyses using urban climate simulations are performed to evaluate impacts of densification and urban sprawl on urban heat load, based on future urbanization scenarios. Depending on the type of model and planning level, the effects of single buildings or entire new development areas on urban temperature can be assessed (e.g. Reinwald et al., 2021).

4.4 Planning recommendations and planning recommendation maps – guidance to reduce the risk

Deriving planning recommendations from the urban climate analysis map is a crucial step to assist planners, policy-makers and decision-makers towards a stronger consideration of climatic criteria. As such, a map with recommendations for planning should contain an integrated assessment of the materials represented in the urban climatic planning recommendations map (Baumüller 2015).

In the final step of creating the planning recommendation maps, the results of the previous analyses are combined and the measures are explicitly spatially located. These maps are an important basis for both strategic planning and zoning and development planning at municipal and regional level.

Planning recommendation maps summarise the analyses obtained and usually combine them with local knowledge on the current situation and possible adaptation options for different urban structures to a varying degree (see figure 6).
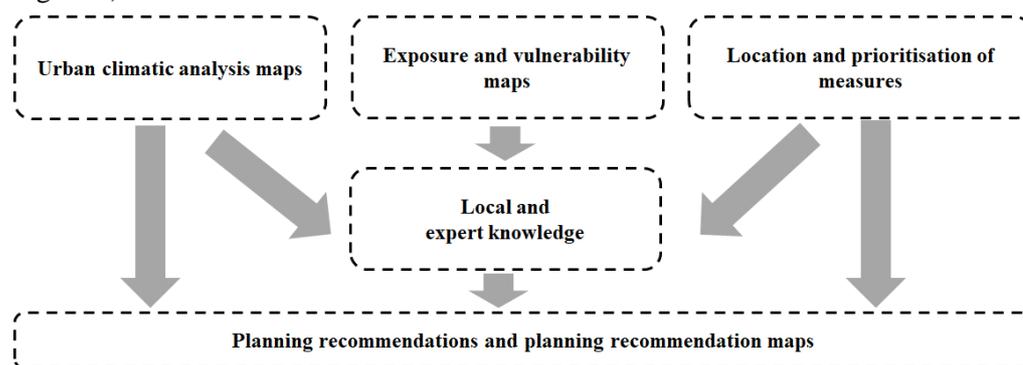
Figure 6: Planning recommendations and planning recommendation maps – guidance to reduce the risk

4.4.1 Combining analysis and local knowledge

Based on the urban climatic analysis maps, an integrated assessment of current climatic spatial characteristics needs to be carried out in order to identify climate-sensitive urban areas that require strategic attention and development. Therefore, at this stage, urban climatologists, planners and policy makers need to work closely together to combine their different perspectives on local knowledge. Different cities have different urban planning systems and climatic challenges, which means that different aspects need to be emphasised when it comes to deriving planning recommendations (Ren et al 2010).

Furthermore, a decision tree can play a crucial role in assisting administrations by providing important guidance for the selection and evaluation of the effectiveness of measures.

4.4.2 Planning recommendation maps

The urban climatic planning recommendation map is an integrated, planning-action-oriented assessment base that can be applied at the regional, city or neighborhood level (Ren et al. 2011). Planning recommendation maps provide general planning advices for sub-areas of the city in order to improve the urban climate in those areas through urban and landscape planning.

Planning recommendation maps usually contain information on two central topics: adaptation measures depending on the thermal load and the urban structure as well as on securing the production of cold air and cold air conduction. A distinction is usually made between "green" areas or areas that have an urban climatic function (cold air production and conduction) and those in which urban overheating occurs – to varying degrees. Recent urban climatic planning recommendation map examples from Germany usually distinguish between three main spatial assessment units:

- Settlement area
- Green and open spaces
- Public roads, paths and squares (e.g. the urban climatic planning recommendation map from Berlin 2015, or Leipzig 2019).

Often, particularly "sensitive" areas are designated where there is a special need for action due to the presence of vulnerable infrastructure or vulnerable populations.

Planning recommendation maps introduce and locate measures that enable urban areas to strengthen their adaptive capacity, respond to a changing climate and thus increase the resilience of cities to adverse climate impacts (VDI 1997).

5 CONCLUSION – THEORETICAL AND METHODOLOGICAL FRAMEWORK FOR THE DEVELOPMENT OF URBAN CLIMATIC PLANNING RECOMMENDATION MAPS

The analysis and descriptions showed that four steps or four areas of processing to develop a sophisticated urban climatic recommendation map are used and necessary (see figure 7):

Step 1: An urban climate hazard analysis is the first step. Two main approaches are visible: GIS-based analysis which result in climatopes which separate a city into different affected areas and urban climate simulations which deliver different climatic indicators to show the different affectedness of urban areas

Step 2: Additional exposure and vulnerability analysis are carried out to analyse in depth the effects on different population groups and their distribution in a city as well as the analysis of exposure and vulnerability regarding infrastructure.

Step 3: Based on the exposure and vulnerability, measures are developed and in many cases their effects are analysed using simulations to verify the adaptive capacities.

Step 4: As a last step, planning recommendation are explicitly spatially located and planning recommendation maps are developed which build a guidance to reduce the risk.
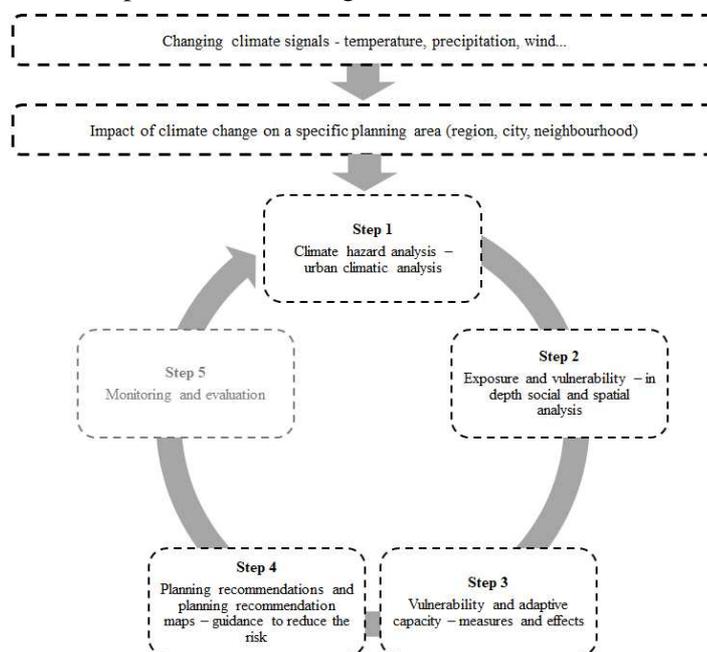
Figure 7: Theoretical and methodological framework for the development of urban climatic planning recommendation maps

The total spectrum of urban climatic analysis maps ranges from purely static GIS (Geographic Information System) derived maps to mainly meteorological maps including urban climate simulations. A thorough analysis that supports subsequent climate-responsive urban planning processes requires the combination of static data and urban climate simulation results, potentially complemented by microclimate simulation results. Therefore, a synopsis of GIS-based and simulation-based analyses is necessary. Alternative approaches to urban climatic maps include evaluation of individual parameters from various data sources and the derivation of conclusions:

- Surface temperature from earth observation data (e.g., Landsat-8) may provide information about overheated areas in a city.

- Vegetation data offers information about cold air production areas.

- In-situ measurements can provide point data of several parameters of interest for a required time range or selected days. For further verification of urban climate analysis maps, these measurements are often used in a complementary way.

- Calculation of sun hours in a 3D city model allows to draw conclusions about thermal comfort.

While each of the above-mentioned alternatives (and others) provide information on individual aspects, the holistic synopsis of urban climatic maps provides a more complete picture and allows to explain the interrelationship and impacts of various parameters.

An in-depth analysis of exposure and vulnerability is only carried out in a few projects. However, these analyses help to identify particularly affected groups and areas. This can also be used to better target or prioritise measures for adaptation and/or mitigation – both critically needed in urban planning to react to urban climatic changes as well as demographic changes.

The preparation of catalogues of measures is a common step in the preparation of planning recomendation maps. Whereas few examples and projects explicitly test the impact of these measures to demonstrate the adaptive capacity. However, this is a particularly important step, as the measures can have different effects depending on the urban fabric and the mesoclimatic conditions.

In the area of urban climatic planning recommendation maps, the research gap is even larger and the practice is far less extensive than in the area of urban climatic analysis maps. Only a few Austrian cities – the situation is comparable internationally – have their own climatic analysis map. The urban climatic planning recommendation maps currently available in Austria do not differentiate according to urban structure, use or function. For example, an industrial area can fall into the same category of climatic stress as an inner-city area – with the same recommendations for adaptation. In the planning reality, however, there are different administrative responsibilities for different areas, different policy and control instruments are required, and the possible measures for climate change adaptation and their effects vary depending on the urban planning situation.

Further research is needed to standardise the internationally diverging procedures for generating urban climatic maps, including urban climatic recommendation maps. Most analyses consider only urban warming and the wind field, changes in other climate signals or consequences (increase in heavy rainfall events, increase in drought, etc.) are mostly not considered, which is especially important for urban climate adaptation planning. Further research is also needed on standardisation for the inclusion of other important climate signals. But the biggest gap is in monitoring and evaluation. There are few cases to support an assessment of objective achievement.

6 ACKNOWLEDGEMENT

7 REFERENCES

Alcoforado M.J.: Planning procedures towards high climatic quality cities: Example referring to Lisbon. Finisterra, 41 (82): 49-64, 2006.

Alcoforado M.J., Andrade H., Lopes A., Vasconcelos J.: Application of climatic guidelines to urban planning – example of Lisbon (Portugal). Landscape and Urban Planning, 90(1-2): 56-65, 2009.

APCC – Austrian Panel on Climate Change: Österreichischer Special Report Gesundheit, Demographie und Klimawandel (ASR18). Wien: Verlag der OAW 2018.

Baumüller J.: A summary of key methodologies. In: The Urban Climatic Map for Sustainable Urban Planning, pp.35-44, London and New York, Routledge, 2015.

BMSGPK - Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz: Soziale Folgen des Klimawandels in Österreich. Wien, 2021. (Federal Ministry of Social Affairs, Health, Care and Consumer Protection: "Social Consequences of Climate Change in Austria")

Bruse, M., and Fleer, H. Simulating surface–plant–air interactions inside urban environments with a three dimensional numerical model. Environmental modelling & software, 13(3-4), 373-384, 1998

Früh, B., Becker, P., Deutschländer, T., Hessel, J. D., Kossmann, M., Mieskes, I., ... & Wienert, U.: Estimation of climate-change impacts on the urban heat load using an urban climate model and regional climate projections. Journal of Applied Meteorology and Climatology, 50(1), 167-184, 2011

Hidalgo J., Lemonsu A., Masson V.: Between progress and obstacles in urban climate interdisciplinary studies and knowledge transfer to society. New York, 2018. Ann N Y Acad Sci. 2019 Jan;1436(1):5-18, 2019.

Höppe, P.: The physiological equivalent temperature – a universal index for the biometeorological assessment of the thermal environment. Int J Biometeorol 43, 71–75. https://doi.org/10.1007/s004840050118, 1999

Jiricka-Pürrer, A.; Reinwald, F.; Weichselbaumer, R.; Juschten, M.: Endbericht zur Studie CLIP-OST Climate Proofing – Ostregion Check der Planungssysteme im Burgenland, in Niederösterreich und in Wien zur besseren Bewältigung der Klimawandelfolgen. PGO – Planungsgemeinschaft Ost, Land Burgenland, Land Niederösterreich, Vienna, 2021.

Jendritzky, G., Sönning, W., & Swantes, H. J.: Ein objektives Bewertungsverfahren zur Beschreibung des thermischen Milieus in der Stadt- und Landschaftsplanung (" Klima-Michel-Modell"). Schroedel, 1979

Jendritzky, G., de Dear, R., Havenith, G. (2012). UTCI—why another thermal index?. International journal of biometeorology, 56, 421-428, 2012

Lindberg, F., Holmer, B., Thorsson, S.: SOLWEIG 1.0–Modelling spatial variations of 3D radiant fluxes and mean radiant temperature in complex urban settings. International journal of biometeorology, 52, 697-713, 2008

MA 22 – Environmental Protection Department: Urban Heat Island Strategy, City of Vienna, Vienna, 2015.

Maronga, B. et al.: Overview of the PALM model system 6.0. Geoscientific Model Development, 13(3), 1335-1372, 2020

Oswald, S. M., Hollosi, B., Žuvela-Aloise, M., See, L., Guggenberger, S., Hafner, W., Prokop, G., Storch, A., Schieder, W.:Using urban climate modelling and improved land use classifications to support climate change adaptation in urban environments: A case study for the city of Klagenfurt, Austria. Urban Climate, 31, 100582, 2020

Reinwald, F., Brandenburg, C., Gabor, A., Hinterkörner, P., Kainz, A., Kraus, F., Ring, Z., Scharf, B., Tötzer, T., Damyanovic, D.: Multi-Level Toolset for Steering Urban Green Infrastructure to Support the Development of Climate-Proofed Cities. Sustainability, 13(21), 12111, 2021

Reisinger A., Mark H., Carolina V., et al.: The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions. Intergovernmental Panel on Climate Change, Geneva, Switzerland. pp15, 2020.

Ren C., Ng E., Katzschner, L.: Urban climatic map studies: A review. International Journal of Climatology. 31. 2213 - 2233. 10.1002/joc.2237, 2011.

Ren C., Spit T., Lenzholzer S., Yim H. L. S., Heusinkveld B., van Hove B., Chen L., Kupski S., Burghardt R., Katzschner, L.: Urban Climate Map System for Dutch spatial planning. International Journal of Applied Earth Observation and Geoinformation, Vol. 18, pp. 207-221. doi:10.1016/j.jag, 2012.

Ren C.: A review of the historical development of urban climatic map study. In: The Urban Climatic Map for Sustainable Urban Planning, pp. 11-34, London and New York, Routledge, 2015.

Sievers, U.: Das Kaltluftabflussmodell KLAM_21: Theoretische Grundlagen, Anwendung und Handhabung des PC-Modells, 2005

Sievers, U.: Das kleinskalige Strömungsmodell MUKLIMO_3. Teil 2: Thermodynamische Erweiterungen, 2016

Stewart, I.D.; Oke, T.R.: Local Climate Zones and Urban Climatic Mapping. In: The Urban Climatic Map for Sustainable Urban Planning, pp.397-401, London and New York, Routledge, 2015.

Tokyo Metropolitan Government: Guidelines for Heat Island Control Measures. Retrieved on March 23, 2022 from https://www.kankyo.metro.tokyo.lg.jp/en/about_us/videos_documents/documents_1.files/heat_island.pdf

VDI-Guideline 3787, Part 1, Environmental Meteorology – Climate and Air Pollution Maps for Cities and Regions. VDI, Beuth Verlag, Berlin, 1997/2015.

Žuvela-Aloise, M., Koch, R., Buchholz, S., Früh, B.:. Modelling the potential of green and blue infrastructure to reduce urban heat load in the city of Vienna. Climatic Change, 135, 425-438., 2016

Žuvela-Aloise, M., Andre, K., Kaltenegger, I., Lettmayer, G., Schwaiger, H., Bird, D. N.: Developing Effective Measures for Reduction of the Urban Heat Island based on Urban Climate Model Simulations and Stakeholder Cooperation. In REAL CORP 2017–PANTA RHEI–A World in Constant Motion. Proceedings of 22nd International Conference on Urban Planning, Regional Development and Information Society (pp. 131-137), 2017

Thermal Variation and Socio-Environmental Inequality in Taipei Basin

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1 ABSTRACT

This study assesses the coupling features of socio-environmental depriviation for heat adaptation through the case study of urbanised areas within Taipei Basin. Multiple data including weather, green space features and socio-economic attributes are used to understand their interplay across urban neighbourhoods. Using the weather records from 28 weather stations located inside Taipei Basin and its surrounding hills, this study maps spatial variation of wind dynamic and temeprature at daytime and night-time in summer months between 2011 and 2020. Spatial statistical analysis was conducted between this climatological information, green spaces, and socio-economic status of aging, household income, and education levels.

The result shows that summer temperature is unevenly distributed and has diurnal difference. Downwind areas tend to be warmer both during the day and night, even though the development in these areas might be less intensive and have more green and blue spaces. Further analysis with socio-economic status of these areas finds that some downwind communities are also socio-economically more disadvantaged. This spatial pattern suggests an unfair consequance due to past urbanisation, which put vulnerable commnties at higher heat risk. Nature-based interventions should therefore prioritise the reduction of such impacts through a more systematic consideration of land use zoning, wind path, and mechenism for compensation.

Keywords: socio-ecological system, urban planning, spatial inequality, heat risk, nature-based solutions

2 INTRODUCTION

Conserving and reintroducing nature into built enviornments for rehabilitating ecosystem functions and natural process of cities is urged by the latest global agendas on climate chagne for buffering impacts and for adapting to extreme weather. It is increasingly recognised that climate impacts, vulnerability, and resources for responses are unevenly distributed across space in cities, leading to climate injustice. The spatial inequality to climate risk is particularly manifested in heatwave events. Some neighourhoods are subjected to higher heat exposure and less adaptive capacity than the others. This inequality is socio-ecologically bonded, and is often produced by past urban planning and development decisions. Studies based on USA cities often found an association between higher heat risk at socio-economically deprived areas due to its lack of green spaces. Whilst studies in Paris and Taipei demonstrated a different result, suggesting socio-economically disadvantages are are not necessarily to expose to higher temperature in summer (Shih, 2022).

Nevertheless, increasing green and blue spaces for cooling and ventilation is one of the strategies to reduce urban heat. Delivering effective and justice cooling outcomes via this nature-based strategy requires understanding of not only city's natrual ventilation, but also the socio-economic variations across its neighbourhoods. To this end, this study adopted weather infromation of air temperature, wind speed, and wind direction together with geographical features of Taipei basin to understand the specific local climate with socio-economic variation. It is expected to identify areas subjected to higher heat risk in summer.

3 CASE STUDY AREA

This study took the urbanised areas of Taipei Basin as a case study area, including parts of the juristition of Taipei City and New Taipei City (Fig. 1). This includes 991 urban neighbourhoods in the basin area, which is surrounded by hills and forested mountains. The area covers approximately 2,726 km2 and has population estimated to 6.67 million by 2014. The basin sitting in the Northern Taiwan is connected to the sea on the north via the Tamshui river and on the East via the Keelong river. The Da-han River running from the central to the south-west of the basin is another main river corridor of the basin. Due to its specific geographical features that keep heat inside the basin and intensive urbanisation in the past, urban heat island effect has

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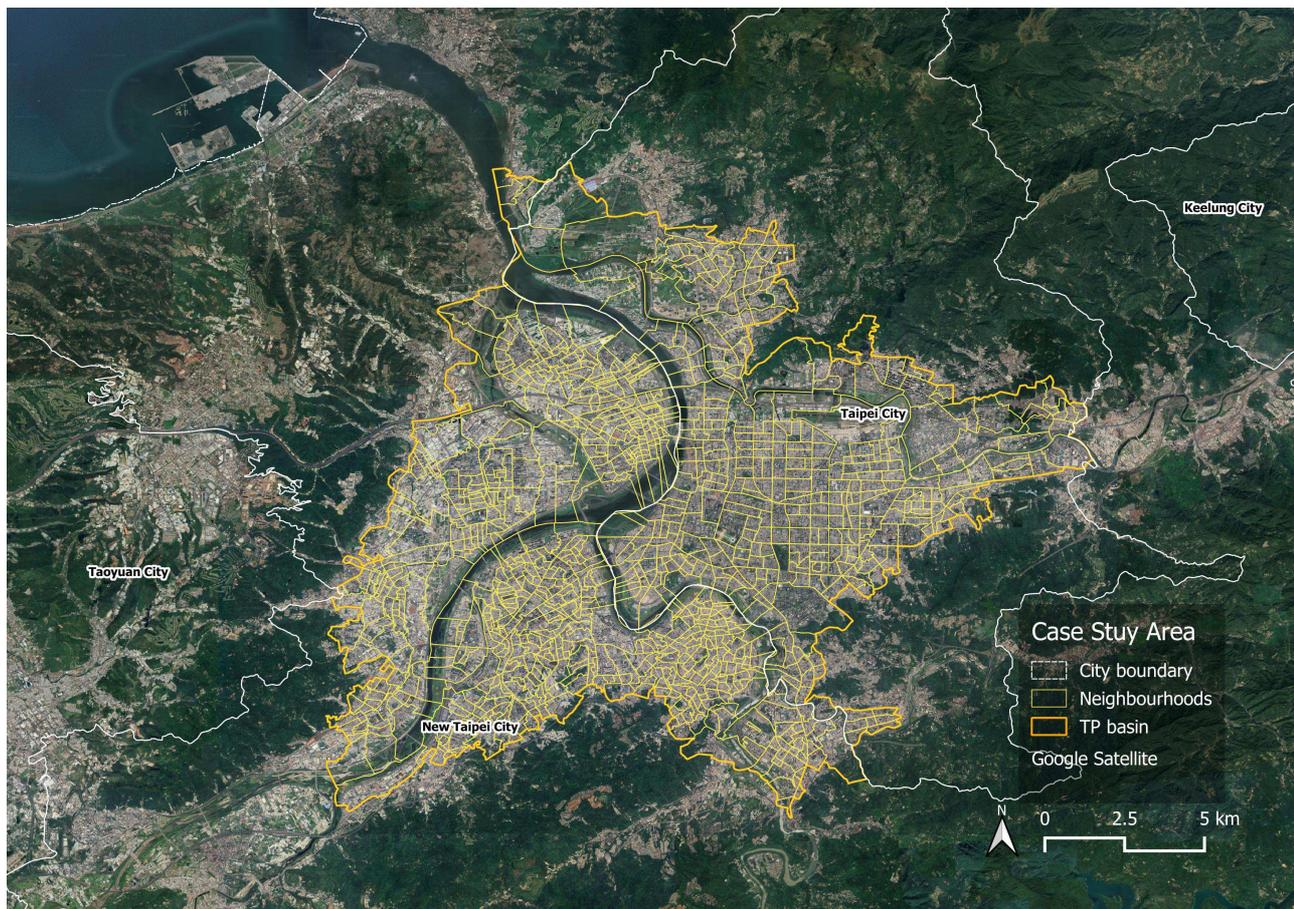
Fig. 1: The Location of Case Study Area.

4 DATA AND METHODS

4.1 Weather Data and Compilation

Weather information used for analyses was collected from 28 weather stations located either in the basin or on surrounding hills by the Central Weather Bureau in Taiwan. Daily records during June to September between 2011 and 2020 were retrieved in hourly basis. Twenty-one stations have completed data for ten-years, wereas 7 stations have less information spaning from 2 to 9 years. Data were aggregated to represent daytime (from 07:00 to 18:00) and night-time (from 19:00 to 06:00). Descriptive statistics were computed to produce mean temperature, average wind speed and major wind direction for further analysis and mapping.

4.2 Socio-economic Data

For understanding socio-economic conditions of across urban neighbourhoods, this study adopted aging index, education level and household income in 2020, which were gained from the Socio-Economic GIS platform of Ministry of the Interior in Taiwan Government. Aging index was calculated by the ratio of the elderly population (aged 65 years and over) to the younger population below 14 years old per hundred people. Education level is defined as the percentage of population holding a bacheloar degree and above. Household income was measured by median value of income within a given neioghourhood.

4.3 Green Space Interpretation

This study utilised high resolution satellite imagery from Sentinel 2 to interpretate the distribution of green spaces of the case study areas. The Sentinel imagery was acquired at 7:41am on 12 March 2019 from U.S. Geological Survey. Using the near-infrared and red bands, this study calculated the Normalized Difference Vegetation Index with equition of (NIR-R)/(NIR+ R) to identify the degree of greenness.

830

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4.4 Spatial Statistics Analysis

In order to gain a spatially contineous weather information, spatial interpolation was used to generate mean temperature and average wind speed of unobserved areas between stations. Co-Kriging was applied for interpolation via Quantum GIS software, using the elevation of stations as an additional variable to refine the predition of average wind speed and temperature. Accordingly, both daytime and nighttime wind speed and temperature were visualised and extracted to be combined with the socio-economic attributes of each neighbouhood via the zonal statistic methods. These two sets of data were initially computed by IBM SPSS to assess the weight and the direction of their linear relationship using the Pearson correlation coefficient.

5 RESULT

5.1 Temperature variation of the cities

The highest average air temperature was observed around Shipai (30.92°C), followed by Shezih (30.82°C), Lujhou (30.72°C), Taipei (30.63°C), and Shihlin (30.62°C) during the day-time of June to Septemper. At night-time, higher temperature was found in Lujhou (28.48°C), Sanchong (28.20°C), Shipai (28.17°C), Sinzhuang (28.13°C) and Shihlin (28.13°C). Obviously, Shipai, Lujhou, Shihlin, which are located to the north of the basin, was covered by higher air temperature regardless of day- or night- time in summer.
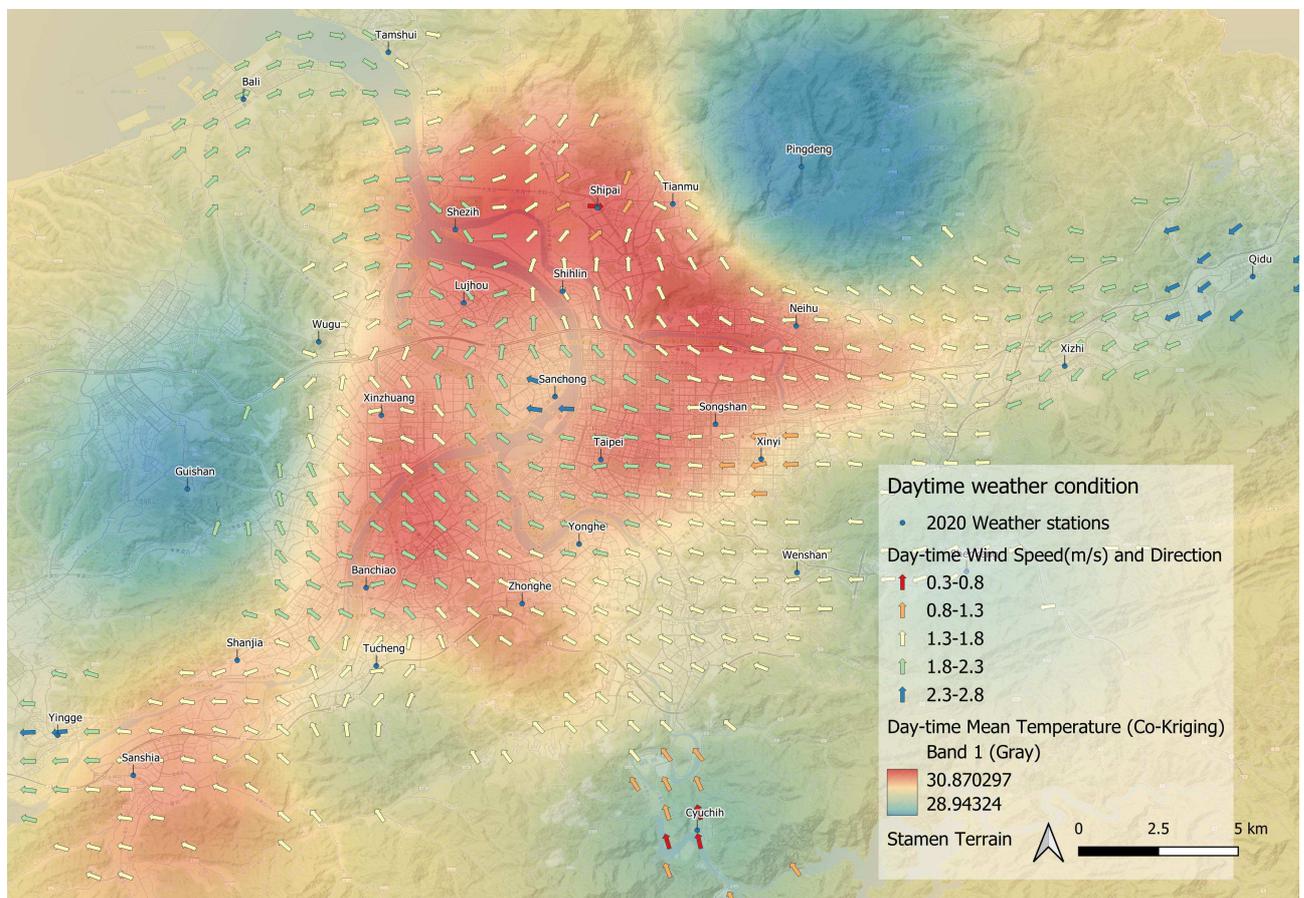
Fig. 2: Average air temperature and wind speed at day-time of Taipei Basin.

5.2 Spatial association between green infrastructure and air temperature

The correlation analysis between daily temperature and NDVI against urban neighbourhoods suggested a weak negative relationship between the degree of greenery and mean air temperature ($r(889)=-.24$, $p<0.001$) at a significant level in summer. However, the visualisation of the distribution of green spaces and mean air temperature showed that some suburban areas are subjected to higher temperature despite of greater green coverage. This is particularly obvious in Shezih, where has measured with the second highest temperature during the day. This phenomenon might be related to downwind heating as described below.
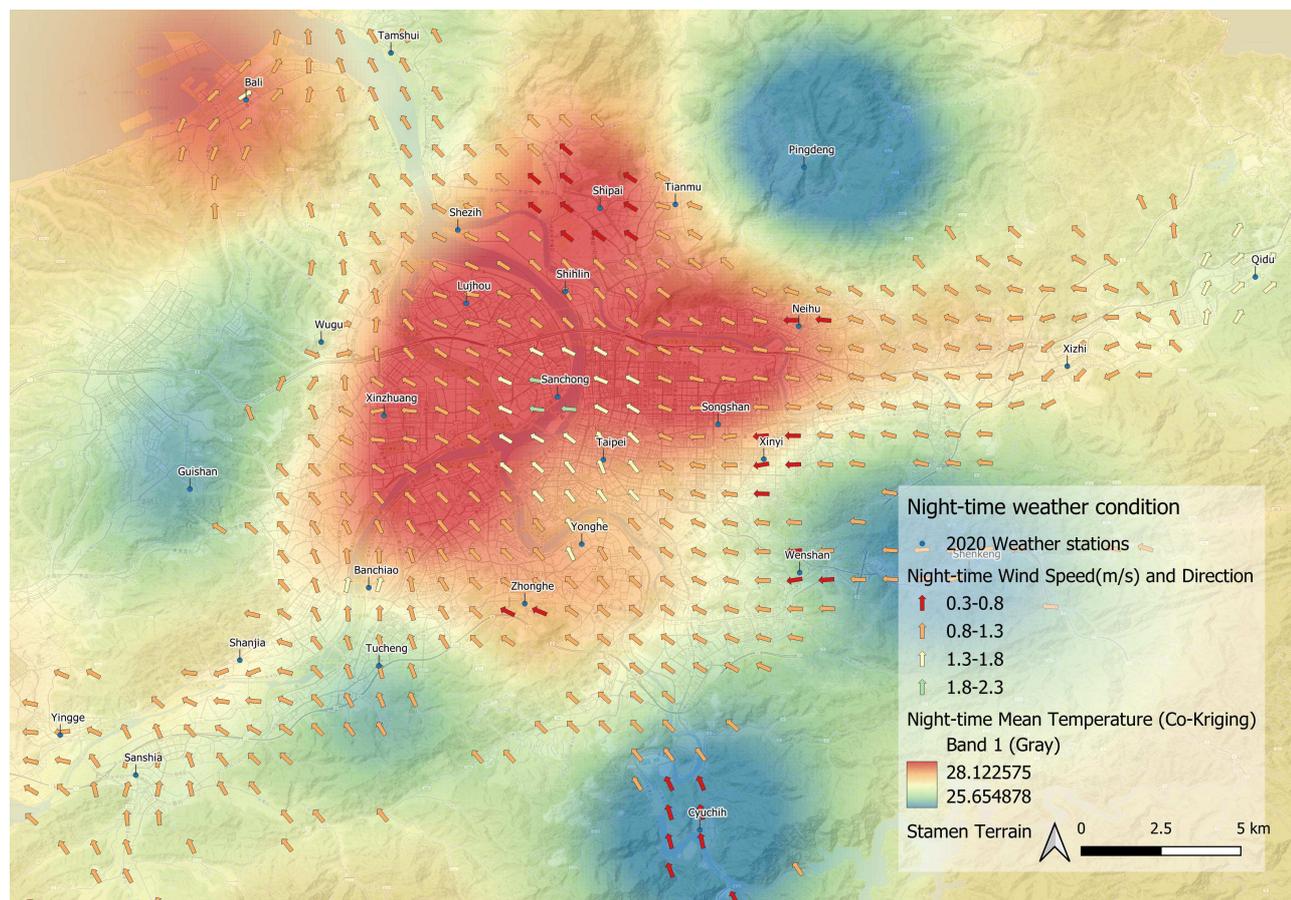
Fig. 3: Average air temperature and wind speed at nighttime of Taipei Basin.

5.3 Wind flows and influences on air temperature

The wind pattern showed a diurnal difference. Due to its closeness to the sea, a sea-land circulation was observed. Sea breeze from the North entred the basin through the Tamshui River and can reach Sanchong. According to the geogrpaphyical features of Taipei Basin and the analysis of prevailing wind in summer, the east side of the basin is strongly influenced by the wind coming from the Keelong River all day, whereas west side of the basin subjected to higher frequency of southeast wind.

The major downwind areas were identified as the Northern region of the basin, including Shihpai, Shezi, Shihlin, and Luzhou areas (Figures 2 and 3). During the day, the incoming sea-breaze from Tamshui River tended to encounter hot air from the city at this region (Fig. 2). This wind dynamic as well as the mountain barriers on the north may cause wind turbulence and stop hot air to be quickly discharged from the river valley. At the nighttime, land breeze from the south of mountains was more prevailing (Fig. 3). Yet the wind speed at night is relatively weak and might not be able to effectively bring hot air out of the basin from Tamshui River either.

Coversely, despite being the main air exit of the South-West side of the basin, areas around Shanjia, Sanshia, and Yingge along the Da-han river valley showed relatively low temperature. The air path displayed in Fig. 2 and 3 suggested that hot air from New Taipei City might turn northward and hence imposed less influence on this region. The fresh and cooler air joined from the southern hills might further cool down the valley. Overall, upwind areas are mostly cooler in summer.

5.4 Socio-economic association with weather conditions

Mean air temperature was negatively correlated with aging index, average household income, and education level at a weak but significant level. Mean wind speed showed a moderate and negative relationship with average household income and education level. This suggests socio-economic more deprived areas tended to live in environments that subjected to poor ventilisation. Some of them could be also hotter.

	Aging Index	Average Household Income	Education level

Mean Air Temperature	Pearson Correlation	-.109**	-.085**	-.179**
	Sig. (2-tailed)	.001	.007	.000
	N	991	991	991
Mean Wind Speed	Pearson Correlation	.064*	-.384**	-.409**
	Sig. (2-tailed)	.045	.000	.000
	N	991	991	991

Table 1: Correlation between weather conditions and socio-economic attributes. (**Correlation is significant at the 0.01 level (2-tailed; *Correlation is significant at the 0.05 level (2-tailed)).

The spatial distribution aging, average household income and education levels of neighghourhoods further showed that the downwind areas of Shezih is subjected to both higher summer temperature and lower socioeconomic status. Yet, although upwind area of Xinyi tended to be weathier, more educated, cooler, but have lower average wind speed. This complicated socio-environmental association might further connected to development characteristics of the areas.

6 CONCLUSION

This study spatially interpolated air temperature, wind speed, and prevailing wind direction to observe weather variation accross spaces of Taipei Basin. One of the findings from this assessment suggests upwind areas tended to be cooler whereas downwind areas of Northern basin were hotter in summer. This temperature distribution is attributeable to the specific topography of the basin which is more difficult to discharge hot air. The wind coming from city centre further brought hot air to the downwind areas and increase their temperature even they might be located in less developed suburban areas. The findings on temperature, greenery, and socio-economic association is to some extent consistent to previous studies suggesting socioeconomic disadvantaged areas are hotter. However, such socio-enviornmental relationship tended to be weak. It is noteworthy that poor ventilisation might be a more prominant factor in summer for socio-economically deprived areas.

7 REFERENCES

CHANG, Hsiao-Tung: A temporal and spatial analysis of urban heat island in basin city, utilizing remote sensing techniques. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, Prague, Czech Republic. 2016.

SHIH, Wan-Yu. Socio-ecological inequality in heat: The role of green infrastructure in a subtropical city context. Landscape and Urban Planning, 2022, 226: 104506.

Time-based Solutions for Gender Just Low Carbon, Sustainable Urban Transformation – Learning from European Time-Planning Practises

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1 ABSTRACT

The European feminist planning community (including the authors) has been addressing the challenge of a gender-just transition to climate neutral cities offering high quality living conditions for all users for decades. The planning model of a "City of proximity" – originally postulated by feminist planners– has recently evolved to the model of the "15-Minute-City". It is time to revisit 50 years of European urban time policies underlying this planning model and the theoretical ground for a temporal just city ("zeitgerechte Stadt"). The research project "DraussenDaheim" (=At Home Outside) puts this into practice.

The project aims to develop a methodology and toolbox which not only serves the participatory assessment of urban public spaces and their complex spatio-temporal use patterns, but also the co-creative simulation-based design of different planning scenarios. Taking into account a gender- and group-specific perspective, the focus is particularly on the development of less "gender-blind" participation tools that serve the analysis, assessment and co-planning of public open spaces. The target group-specific application of a digitally supported tool mix is described on the basis of two use cases and its added value for the key elements of a temporal just city, procedural and distributional justice, is shown. By making public spaces and vulnerable user groups a focus for the participatory implementation of temporally and spatially just urban transition, this will help to ensure that the transformation is inclusive, responsive to community needs, environmentally sustainable and socially just.

As the core of this paper, examples from European city-regions on time-planning practices as well as from the use cases of the DraussenDaheim project are presented with the purpose of informing gender-responsive participation and planning tools.

The conclusions highlight both the potentials and pitfalls of time-planning approaches in collaboratively assessing urban public spaces. Moreover, they anticipate a crucial endeavor: enhancing the adaptability and usability of these spaces for care-givers and care dependents. This task is a crucial step towards a more inclusive and gender just urban transformation.

Keywords: spatio-temporal use patterns, digital participation, planning tools, gender, public space

2 INTRODUCTION

The European feminist planning community (including the authors) has been addressing the challenge of a gender-just urban transition to climate neutral cities, offering high quality living conditions for all users for decades. The planning model of a "City of proximity" – originally postulated by feminist planners (Dörhofer/Terlinden 1985) – has recently evolved to the time based model of the "15-Minute-City" (Moreno et al. 2021). The ongoing research project "DraussenDaheim" (=At Home Outside[1]) addresses the urban time policies underlying this planning model and the theoretical ground for a temporal just city (Henckel/Kramer 1999).

DraussenDaheim applies different concepts of spatial justice to support equal access to planning processes and data generation. It aims to raise awareness within a neighbourhood and amongst policy makers of the diversity of daily routines and on different accessibility of public spaces. The goal is to improve fair and equitable access to public spaces with a special focus on care-givers and care dependant people. For these purposes, the project DraussenDaheim is developing a methodology and toolbox which not only serves the participatory assessment of urban public spaces and their possible uses (simultaneous, overlapping, etc.), but also the co-creative simulation-based design of different planning scenarios. Taking into account a gender- and group-specific perspective, the project puts special emphasis on the use and development of digitally

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supported tools that are less inclined to overlook gender-related factors in the analysis, assessment and co-planning of public open spaces. DraussenDaheim also gives the opportunity to revisit plannning strategies and implementations of European cities with up to 40 years of experience in time planning by transferring selected methods, theories and practices to the challenges of two use cases: an urban square in a dense fin de siecle quarter (Aumannplatz, Vienna), and a newly built housing area in a peri-urban location south of the town of Zell am See (Sonnengarten Limberg, Salzburg). In particular, a mix of analogue and of digitally supported tools is used and adapted to the application context. While in both use cases a special focus is placed on gender-relevant groups (e.g. their needs in relation to the studied focus area, their requirements for handling the tools or their equal inclusion in the workshops), the tools are individually combined and adapted depending on the specific research question and local context (see chapter 4 in corp paper Fessler et al 2023).

This paper reports on the preliminary findings of the applied research as well as its theoretical basis, particularly addressing the subquestion: What can we learn from European time practices? One key lesson learned from the examined time-planning approaches is the understanding of time and space as resource, and as an indicator of inequalities. This understanding brings to light a new set of values for the planning community in finding time-based solutions for gender-just, low carbon and sustainable urban transformation: time and gender justice in goals definition and in the selection of design criteria.

The paper is structured as follows: first, we clarify the background on gender in urban planning, introduce key-concepts for a temporal just city and present methods used to evaluate time-space policies and co-creation processes. Next, in section 4, we discuss urban time-policies with focus on time-space patterns in a brief literature review to investigate how the diversity of tempo-spatial use patterns is theorised and implemented. Furthermore, selected examples from European time-planning practice are presented, which are able to inform the DraussenDaheim use cases with a gendered lens. Section 6 then shows selected transfer applications from two Austrian use cases. Finally, section 7 summarises the findings from European time-space planning practice, proposes some recommendations identified for a just urban transformation and highlights open research questions.

3   BACKGROUND, KEY-CONCEPTS AND METHODS

3.1 Background: Gender in Urban Planning

Various guiding principles fundamental to urban development, such as the United Nations Sustainable Development Goals (SDGs), cite equality and the reduction of inequality and discrimination as the basis for inclusive and resilient urban development and social cohesion. The gender mainstreaming strategy (EC 1999) anchored in the Austrian legal system, which includes elements such as gender budgeting, is also oriented towards these goals, especially SDG 5 "Gender Equality". In accordance with gender-equitable budgeting, the federal government, the provinces and the municipalities commit themselves to strive for the actual equality of women and men in budget management and thus to take the needs of both genders equally into account. This applies, for example, to the construction of public buildings and the design of public parks. Such strategy papers, which aim at the right to participation and equal opportunities, regardless of gender and sexual orientation, always include basic principles of good urban development. It is no longer appropriate to imagine guiding documents for integrated and sustainable urban development policy in Europe, such as the New Leipzig Charter, without addressing gender. There, for example, it is stated that the transformative power of cities must ensure equal opportunities and environmental justice for all, regardless of gender, socio-economic status, age and origin. All social groups should have equal access to open space and services of general interest. This is now widely recognised in the planning community, but has not always been taken for granted. Today's visible remains of (car-centred) spatial planning, almost exclusively from an economic breadwinner perspective, driven by speed and efficiency thinking, are evidence that diversity and needs outside the norm (traditionally assumed to be healthy and full-time working men) have long been disregarded. More than 40 years after the famous envisioning of a feminist city (Hayden 1980), there is still great inequality in our cities, which promotes a rethinking towards traffic calming and improving sustainable accessibility for all. The critical debate driven by representatives of feminist urban development has not only paved the way away from a dualistic view (man vs. woman) towards gender-just urban development (all genders) and a general gender-responsive planning approach, but has also created

836

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awareness for the complex interplay of different forms of inequalities. These mutually reinforce each other and increase the vulnerability of already disadvantaged groups even more (intersectionality).

In this context, models such as the "15-Minute-City" have great potential insofar as they focus, besides traffic avoidance, on the integration of different needs in terms of sustainable accessibility. The model potentially offers easy and time-saving access to services, as well as attractive mobility options for accessing opportunities that are affordable, usable and non-discriminatory. Finally, gender and other diversity factors have a decisive influence on the quality of life in cities and municipalities and must therefore be considered in urban planning to ensure social and spatial justice (Terazza et al. 2020, Kempin Reuter 2019, De Siqueira et al. 2022). For example, at the neighbourhood level, requirements for lighting, pavement width, furniture and surface materials differ by gender, but also by other social categories such as age (Brüchert et al. 2022; Krishnamurthy, 2019) and physical or cognitive impairments (Kempin Reuter 2019). So, if one wants to know for whom our cities and (transport) systems are designed, one only has to look at how different needs are captured and whose (time) constraints are taken into account. The authors of this paper advocate for climate-friendly urban planning that incorporates diverse needs and is temporally adapted to include, rather than exclude urban residents.

A sexist city is not a sustainable city, because of its social and economic inequalities. Until recently gender equality focussed on the redivision of income and particularly unwaged care (see for example Zibell, 2022). Reconciliation between paid and unpaid care work, productive and reproductive work, child friendly and fair shared cities as planning and design tasks are one answer to the dysfunctionalities of urban spaces. Now we know that reducing CO_2 emissions needs more than a new deal for unpaid care work: it requires a gender-just transformation. This brings the need to rethink time-based planning strategies undelying the 15-Minute-City planning model, i.e. rethink how we reorganise cities, balancing waged and care work through services, mobility and housing.

3.2 Key-concepts for a temporal just city

For defining the key conception of a temporal just city, we follow Henckel & Kramer (2019). In their comprehensive reader they introduce the following key elements for a temporal just city:

(1) procedural justice, the question who has a say and whose voice is heard in planning and design decisions,

(2) distributional justice, who has access to which urban resources.

In order to achieve a temporal just city, procedural justice - i.e. fair participation and equal distribution of power in planning processes and beyond - is a prerequisite.

All forms of tempo-spatial justice suggest that a just urban transition cannot be thought nor realised without gender equality. In planning terms, equitable access to spatial infrastructures and resources as indicated in SDG 11 involves access to adequate housing, basic services (11.1), universal access to green spaces (11.7) and barrier-free access to sustainable transport offers (11.2). Special attention shall be given to include care givers (majority women), care dependants (children), persons with disabilities and older people who are more likely to be 'in vulnerable situations' (11.2). Putting care-work in focus immediately links the distributional and procedural justice to time: Fair/equitable access to spatial resources depends on distance, transport and mobility offers as well as on the autonomy of the users. Especially daily routines depend on the accessibility and availability of infrastructures of everyday life including opening hours and location (Horelli 2006, Wien 2013). Furthermore, the temporal design of participation processes (who can participate at what time and under what conditions?) determines plurivocality and thus the (more or less pronounced) representation of diverse spatio-temporal patterns of use. This is an essential component of procedural justice in urban planning and design.

Inspired by these concepts, the following main-research questions linked to spatio-temporal justice in planning have been identified.

For distributional justice: Which different time-space patterns and daily routines of urban users are addressed and is there a gender bias? Which analytical methods for analysing and mapping inequalities can be found in Euroepan time plannning documents? How equal or unequal is availability of and access to spatial ressources (=everyday life infrastructures including public space) and to temporal ressources (personal time and time poverty).

For procedural justice: How do different time-space patterns inform the design and (barrier-free) access to all steps of a planning process? Which actors are identified and how are these different actors adressed to have a say in the planning cycle (context based analysis, visioning, co-planning etc.).

3.3 Research methods: developing a model of care-profile, evaluating time-space policies and co-creation processes

To overcome stereotyping and 'sex counting', the authors have developed a model of care-profile which characterises residents and other urban users according to their care responsibility (Tummers & Wankiewicz 2021). This model differentiates from the habitual definitions of 'target' or 'user' groups, in that it does not put the personal characteristics on the foreground, but looks at the determining conditions for the use of (semi-)public urban space. Key conditions which influence stongly the temporal and spatial flexibility or rigidity and the autonomy or dependency of persons in accessing urban ressources are care responsibilities (e.g. perceived by parents) and care dependency (e.g. of children). Persons with care responsibility have little flexibility in their daily time-space-trip-chains. For example, the schedule of a part time employed single parent depends on working-hours and the availability, costs and opening hours of child care facilities.

Besides care responsibility and care dependency tempo-spatial autonomy and flexibility is related to a persons' gender, age; physical and cognitive ability (barreer-free accessibility). Last but not least, a person's occupation (employment, education, volunteering) determines their respective time-schedules and autonomy. This knowledge, bundled in care profiles[2], was applied in various online surveys (including questions about care responsibilities or dependencies) and co-creative workshop formats of the two use cases Aumannplatz (Vienna) and Sonnengarten Limberg (Zell am See), which focused in particular on group-specific spatio-temporal patterns of use. One of the main intentions is to contribute not only to equitable participation in participatory processes, but also to the spatio-temporal organisation of open spaces so that they are accessible to vulnerable groups without displacing others.Gender is at the centre of this debate and is reflected in both the use of space and time. From statistics and available data (Trapez 2020, Gender Equality Index 2022)[3], we know that in current European societies the following typical gender roles and care-related responsibilities are not equally divided between women and men. Particularly women in general perform more (unpaid) care-tasks (taking care of children, elderly and impaired persons as well as participating in cooking and housework) while they have less income. Men, by contrast, tend to have more free and leisure time, as time-use studies in Austria and Germany show (Panova et al. 2017, Statistik Austria 2009).

Building on this background knowledge, the authors' task within the research project DraussenDaheim was to select and present key topics, methods and tools for territorial and spatio-temporal analysis and to report back to the project team. For this purpose, the policies of European time planning frontrunner city-regions were analysed, which address different daily routines and rhythms of urban user groups. Further, desktop research and document analysis were carried out to investigate planning documents (time plans, urban strategies) to see to what extent and how tempo-spatial planning strategies and design criteria are reflected in them. Finally, an iterative approach was adopted in dialogue with the research partners to explore how these strategies were implemented in collaborative and co-creative planning processes. Moreover, following and participating in online discussions about the concepts and state of the art of implementing the 15-Minute-City enabled the project team to cross-check its findings. On this basis, the knowledge gathered was incorporated into the use cases of the DraussenDaheim project, in which two participation processes were carried out using digitally supported tools, taking into account the gender and time planning perspective.

4   TIME AND SPACE PATTERNS IN URBAN PLANNING AND GEOGRAPHY

This section gives a brief introduction on the history of temporal just plannning and highlights the links between time planning, sustainable and inclusive human settlements (SDG 11), followed by an overview on how the diversity of tempo-spatial use patterns and daily routines are addressed and mobilised to advance gender equality and inclusion.

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[2] More about the transfer of these care profiles jn the DraußenDaheim project see chapter 5 in Fessler et al 2023

[3] Trapez – Transparente Pensionszukunft (2020): BKA-(https://www.trapez-frauen-pensionen.at/trapez-analyse.html), Austria | Time | 2022 | Gender Equality Index | European Institute for Gender Equality (europa.eu)(access 20.10.20)

4.1 Theorising diversification of time-space patterns

Time in planning theory and practice started about 50 years ago with Hägerstrands time geography (1970). The current revival of time-based urban strategies includes the 15-Minute-City and the Superblock model (Paris, Barcelona, Vienna), as well as the 2021 Barcelona Declaration and work programme on Time policy 2.0[4] by the European network of regional and local authorities.

The Swedish Lund school on time geography around Hägerstrand, theorized the concept of space time cube. Using 3D visualisation of time paths (=trajectories) and bundles, the diversity of time-space patterns and the different constraints which influence the choices of people became visible (Hägerstrand 1970).

Feminist researchers and practitioners have criticised the time-geography approach, but also used and further developed it with gender and diversity issues (Rose 1993, Kwan 2000, Ellegard & Karlsson 2009). The US-time geographer Kwan for example looked at the impact of time-space constraints on time-space patterns (1999), visualizing these use patterns in GIS with layers of networks, settlement structure and the daily movement of time-paths from different user /gender+-groups (e.g. Afro-American women in Portland) (

(Kwan: http://meipokwan.org/Gallery/STPaths.htm) based on a great number of time diaries.

Action research like Eurofem (2000) introduced female everyday life use patterns and rhythms and placed the related infrastructures into the centre of planning and design.

For the Dutch planning culture, Tummers (2009) and van Schaick (2011) looked at the implications of this tempo-spatial diversity for planning and design innovation in the network city. Tummers proposes a set of flexible and adaptable planning and design criteria which enable user friendly and high quality urban environments for the variety of users and life situations. Further she proposes collaborative and participatory planning processes addressing the diverse users and their daily routines adequately. Schajck pursues the possibilities of tracking to understand time-space patterns (2011).

Thus, a body of knowledge about complex (female) trip chaining of part-time care-givers vs. simple full-time 9-5' commuting tempo-spatial use patterns has entered traffic and mobility planning. It inspired many projects in gendered infrastructure and open space planning. Horelli (2006, 2013) and Damyanovic et al. (2013) argued that managing time and space as a challenge for residents as well as the accessibility and availability of everyday-infrastructures (including open spaces, care-facilities and meeting points) ought to become a main planning task for sustainable urban living environments.

4.2 Collecting data on time and space patterns

Italian time policy gives the most comprehensive and inspiring answer to meet inequality and reconciliation challenges at local level. It was strongly supported by academic action research from Politecnico di Milano and Torino (Bonfiglioli, Stabilini & Zedda etc.) as well as embedded into a legal framework prescribing and obliging local and regional authorities to develop and implement a local time plan. Cities like Bolzano, Bergamo, Pesaro and Genova experimented with cooperative processes including surveys, with innovative spatio-temporal analysis and co-diagnosis as well as with integrated time and development plans (e.g. Time plan Bergamo 2004, Bolzano 2006). The mapping of urban rhythms, the harmonisation of collective and private time schedules, the mismatch between needs and opening hours of shops and services, the urban night time and the lack of personal free time are in the centre of these time planning processes (Zedda et al, Bolzano 2006). Some cities show a remarkable continuity and long soufflé in time planning: Bolzano started in the mid nineties and is part of the time policy 2.0 movement of 2021, committed with a work programme on 15-Minute-City implementation (Barcelona declaration).

In terms of data gathering, nowadays, we still face the lack of empirical data on gender+[5] differentiated time-use, daily routines and time space patterns. In Austria, the last statistical survey data from 2008 (!) only gives geographical differences at province level. In Germany, since 1992 each 10 years a state-wide survey on time use gives information on gender, age, household and care-responsibilities for children (Zeitverwendung

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[4] See the "Barcelona Declaration of a European cities network of cities promoting the 2nd generation of time policies. https://www.gemeinde.bozen.it/UploadDocs/31421_DECLARATION_BARCELONA_ON_TIME_POLICIES_EN.pdf 14.01.2023)

[5] Gender+ indicates theory the complex interplay of different forms of inequalities (intersectionality) placing gender at the core.

Deutschland). However, no data evaluation for cities nor regions is possible. In 2017, Panova et al. have published a study based on the 2013 data which gives detailed data on time use and constraints of mothers and fathers in the 'rush-hour of life' (care givers of children younger than 15 years old) and compared it to other age groups. A more detailed picture of gendered time space use patterns concerns the scale of districts and may be generated from regular mobility surveys. In Austria, the most recent data on mobility patterns date from 2013/14 (Österreich unterwegs) with a special evaluation on gender differences of these data (Knoll et al. 2016).

5 LEARNING FROM TIME SPACE PLANNING PRACTICE

From the literature review, we derive four types of time-space approaches in urban planning: time as a resource; time space patterns and public space; analysis based on time-space patterns and co-planning strategies.

5.1 Understanding Time and space as a resource

5.1.1 Bolzano Integrated Time Plan (2005 – today)

The initial aim of the Bolzano Time Plan 2005 was a better distribution of care work to improve access to the labour market for care-givers (mostly women). During more than 10 years of a collaborative co-creation process accompanied by action research and evaluation by Politecnico di Milano, this time plan evolved to a fundamental shift in planning visions, goals, planning tasks and instruments to achieve a time and gender just sustainable urban transformation. Already in 2005, Bolzano has postulated the 10-Minute-City with sustainable and inclusive public transport, a compact city model and a high quality public space for a diversity of users. Time is a key indicator and success factor for justice and wellbeing in the Urban Time Plan of the city of Bolzano (Stadt Bozen 2005, 7). It is one of the most comprehensive time planning documents and results from long-term experience with a very pronounced gender equality priority aiming to alleviate women's everyday life. Defining the increase of personal time as success indicator for the time plan goes beyond and redefines the task of planning and design. By this, Bolzano strives for distributional justice in the access of personal time as a resource. Further, Bolzano has been experimenting with co-creation, pop-up workshops, temporal use change and co-diagnosis to raise awareness of the diversity of time-space-patterns. A few practical examples are: Time diaries, pop-up workshops, street art, temporary closure of public spaces for sport and play, opening of school courts for a broader public as co-creation and discussion places. Collaborative service development for lunch meals, new infrastructures and opening hours of childcare facilities, shops, municipal and health services react to the diversity of daily routines of citizens, clients as well as employees. These planning processes are conceived to achieve more procedural justice. Implementing the vision of the 15-Minute-City in Paris

The City of Paris is a frontrunner in envisioning and implementing „la ville de quart d'heure"/the 15-Minute-City at district level. "15-Minutes-Paris" strives for urban districts suitable for everyday life: neighbourhoods which provide accessible infrastructures for the diversity of tempo-spatial daily routines, with a focus on care givers and care dependants. This includes accessible shops and services, a network of high quality and safe streets and roads, a multifunctional new infrastructure, a citizen kiosk as indoor place to meet, and high quality public spaces as outdoor meeting and activity points. This vision asks for a creative transformation in the use of existing infrastructures (e.g. school yards), the development of new public infrastructures and a revised management of public services. In short, Paris strives for distributional justice in the built environment.

Both Paris and Bolzano provide many inspiring answers to the questions 'how will life be organised in a time just city?' and how a co-creation process towards non sexist, gender equal and low carbon cities could look like.

5.2 Diversity of time space patterns and public space

The next examples propose a shift in norms and values as well. They are facilitating the autonomous mobility of children in urban public space, at the same time alleviating their care givers, giving them more personal time. If young children and older people move autonomously in their city, they do not need another person (care giver) as companion, so the care givers gain personal time.

5.2.1 Network of child-routes - Kindlint (NL/BE):

The main interest of these "Child-routes" is to give children as pedestrians access to urban resources. In a co-creation process, the child routes are selected and visualised with colours and other signs in the streets and squares. The relevance for care givers is high: if children are able to move autonomously in their city, the care givers do not need to walk with them and will have time for other things. This instrument comes from the Netherlands and Belgium. Experiences show that older people also use these routes very much. They are attractive and easy for orientation.

This strategy also reverses the planning approach: adapting the city for children as a safe walkable space all day long instead of protecting and 'fencing' children when walking to school and back.

Fig 1: Network of child route in Middelburg, NL (Online: https://www.pzc.nl/overig/middelburg-heeft-veilig-kindlint~a5194ec0/?referrer=https%3A%2F%2Fwww.google.com%2F) – (access on 18.03.22)

5.2.2 Temporal change of use - Hackney-Play-Streets (UK)

Based on a cooperative implementation of a public health progamme in east of London, a temporal change of use of public and semi-public streets and squares has been established (Hackney Play Association 2015). Public spaces are closed for traffic circulation regularly for an afternoon or a weekend, to give children and their parents temporal access to streets as playground and exercise area. This example also changes the rules of the planning game: instead of monofunctional traffic lanes, public space is used as playground, sports field and meeting place for the local community from time to time. People of all ages, genders and colour are treated as actors, especially giving groups in vulnerable situations access to sport and play facilities. This example also gives answers to our reseach question of how life will be organised and co-planned in a time-just, non-sexist, low-carbon city.

5.3 Contextual (territorial) analysis based on time-space use patterns

Understanding time-space patterns in the local context is crucial for developing strategies. Several methods of analysing, data-harvesting, mapping and visualising diverse patterns of use of time and space have been developed, some of which we present here.

5.3.1 Diversity of tempo-spatial use pattern in Nantes metropole (F)

Based on surveys or time diaries of typical week-days and weekend-days, Nantes has developed an infographic which shows the variety of time-space-patterns and the activities over 24 hours of four members of a family. This easy understandable visualisation of different time-space-patterns within four family members of both sexes is based on qualitative interviews. It can be used to start a collaborative territorial diagnosis andplanning towards more tempo-spatial just and sustainable city regions.

5.3.2 Time-use survey in Germany (2002/2012/2022)

This Germany-wide survey shows the differences in time use of people of all genders, age, occupation and family situation (with and without care-responsibilites). The data give a detailed idea of gender differences in care work and the burden of women with children under 15 years of age (Panova et al 2017). These data are unfortunately not availabe for Austria (last data from 2008).

As a very comprehensive and periodic survey it is an excellent source for comparing time use patterns of male and female inhabitants in different family situation, age or living environment over decades. Comparing local differences (for cities, urban quarters or regions) is not possible though.

5.3.3   Mapping urban rhythms: Chronotopes of shops and services in Lyon (F)

This spatio-temporal mapping method has been developed by a French research team and is called "Chronotope"[6]. For the Gerland-Quarter in Lyon, the location and the opening hours of shops and services are mapped in hourly intervals. A video performance of the different maps shows the quality and accessibility of shops and services within 24 hours. It highlights daily rhythms, local and temporal differences in access to shops and services. By doing so, this mapping method can focus on reconciliation and supply deficits of residents and workers. The topics may be extended to child-care facilities, day care centres for senior citizens etc. to highlight distributional injustice in cities.

5.4 Co-Planning Strategies committed to procedural justice

Female and feminist scholars looked for more gender balanced planning processes and broader representation of female lives and interests. Both digital and analogue tools and methods are needed for this step towards procedural justice. Widely practised is walking to share and exchange everyday life experiences and different trajectories of residents. Walking has been established as a method that is published and incorporated in planning processes.

5.4.1   LENA-the Nordic approach for redefining co-planning in time and space

This LEarning-based Network Approach to participatory urban planning and action research has been developed since 2000 by Scandinavian planners who form part of the tradition of feminist critique on mainstream planning. Beyond these infrastructures and the challenge to manage time and space, the digital tools supporting the everyday are also relevant for this paper, as well as the LENA-planning cycle with contextual analysis, visioning, co-planning, implementation, maintenance and evaluation (Horelli 2006, Wallin 2013,15).
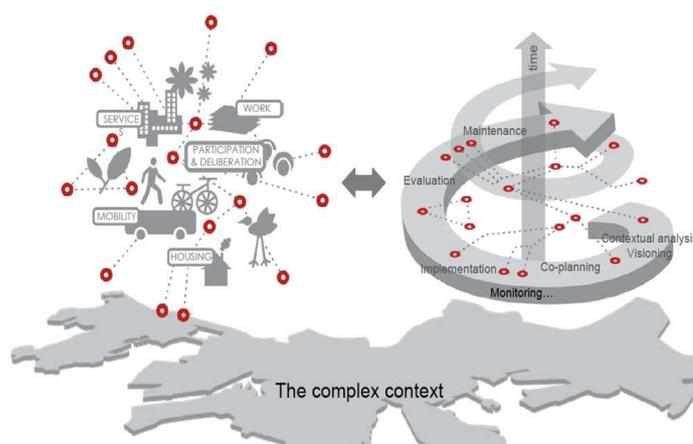
Fig 2: The Learning-based network approach to participatory urban planning and action research. (Wallin 2013, 15 – Fig. 1.1 by courtesy of the author) The red ellipses symbolise the use of digital tools

LENA systematically integrates the accessibility and the co-development of infrastructures of everyday lives and the diversity of spatio-temporal use patterns (distributional justice) into a collaborative 'co-planning' arena, with strong focus on digitalisation as well as on deliberative and self-organised processes (procedural justice).

5.4.2   Walking as a method for co-planning – Paris and Barcelona

The City of Paris (Guide Réferentielle 2017) and the Barcelona based private urbanist collective "Collectiu Punt 6" (2017) have elaborated manuals with Gender Walks methods building on the long-term experiences of the bottom-up organised Jane's walks.[7] Paris has professionalised this Gender Walking method from "top-down" to assess and co-develop an urban quarter from the perspective of (mostly) female users (Ville de Paris 2022). For the bottom-up driven and implemented approach of the Catalonian group "Col-lectiu Punt 6" walks are followed by a great variety of co-creation and participatory methods and procedures for a

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[6] More details in Equipe Chronotopies – Alain Guez – Laboratoire Architecture-Anthropologie Paris (2003bxx): https://www.laa.archi.fr/+-Chronotopies-+ (access on 21.03.22).
[7] Lets get walking (2022): Janes Walks Festval. https://janeswalk.org/ (access on 25.04.2022)

'gendered urbanism' (Col-lectiu Punt 6, 2017). The crucial role of public services, the quality and usability of public space at day and night-time and the visibility of female lives and contributions to local, urban economy is in focus (distributional, procedural justice and representation (Gutiérez-Valdivia 2021)).

Walking as a method is one of the most successful collaboration instruments for bringing into the planning process the experiences and user perspective of the (normally unheard) urban users. This instrument may be applied both for diagnosis and analysing spatial qualities and disfunctionalities, as well as for proposing new spatial and temporal organisation at local level (arrondissement, neighbourhood). In this way, walking empowers women and contributes to more procedural justice.

The following section shows how these findings have informed the DraussenDaheim case-studies.

6 TRANSFER AND TEST IN LOCAL USE CASES

Based on the practical examples of space-time planning in European practice outlined here, recommendations were derived on how insights gained from them could be usefully applied to the DraussenDaheim use cases. Regarding the collection and evaluation of data (e.g. on the daily use of a public space in Vienna or the recreational use of open spaces in and outside a settlement in Zell am See), it was decided that the specific analysis of diverse mobility and use patterns should not only be differentiated according to age, but also to gender and care responsibilities. The differentiated interpretation of the use case results would thus facilitate the setting of group-specific incentives for a time- and emission-saving qualitative stay in open spaces close to home.

In general, the findings from the analysis of European time-planning approaches could contribute to specify requirements for researching gender+ differentiated spatio-temporal patterns of use and daily routines. This includes the precise recording, analysing and visualising of data. Adapting the methodological approach from a user-sensitive perspective and carefully embedding the developed tool chain (as a mix of analogue and digitally supported tools)[8] in participatory formats ensured that gender- and care-relevant information was collected in preliminary surveys and linked to other participation and simulation tools in the further process. In addition, the design of participatory involvement (in data collection and co-creation process) could thus be adapted to specific target groups (e.g., their requirements regarding the toolset and their time availabilities). This ultimately benefits both procedural and distributive justice.

6.1 Use case Aumannplatz in Vienna's 18th district

Due to traffic issues and inadequate design, Vienna's 18th district central square no longer serves its users' diverse needs. In a broad participation process based on a functional and socio-spatial analysis, a redesign of the square is being sought, supported by the DraussenDaheim project. It contributes to the identification of the spatial qualities of the square as well as the current and future possibilities of use for specific target groups, taking into account temporal components (times of use and personal time resources).
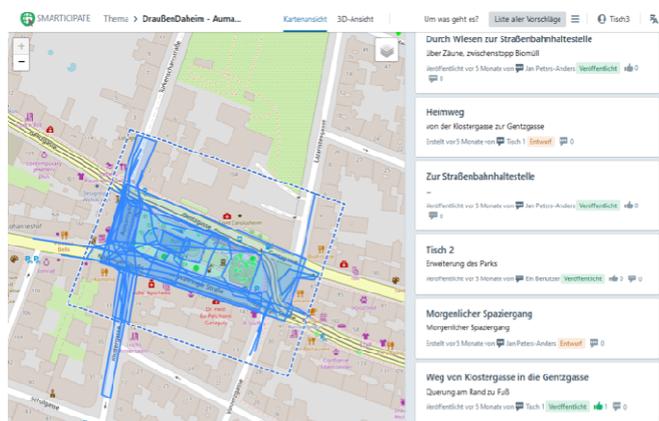

Fig. 3: Overview of all mapped pedestrian pathways (blue lines) including comments on temporal use (e.g. "morning walk") resulting from the tool workshop using "Smarticipate"

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[8] more about combined (digital) tools and methods used in DraußenDaheim see chapter 3 Fessler et.al (2023)

The initial results from the online survey (n=47) offer insights into the spatio-temporal patterns of use on weekdays and weekends as well as at different times of the day. They also shed light on respondents' socio-demographics and caregiving commitments. Analyzing these complexities from a gender perspective reveals that although nearly 70% of respondents have care-giving responsibilities, they rarely use the space with children or older people. The survey, a vital research element, connected personal attributes (e.g. gender, age or employment) and usage preferences, engaging the local community and encouraging participation in follow-up workshops. To be considerate of the valuable time resources of different groups and to increase the reach of the survey, it was offered via digital devices (smartphones, tablets) as well as for analogue completion. For seniors, visually impaired and people with language difficulties, personal assistance was offered on the spot. This also applied to the actual workshop with the digital participation tool "Smarticipate", where the focus was on the possibilities of crossing the square and using it as a place to stay and play. By jointly mapping footpaths walked at different times in mixed-age and gender groups, complex temporalities and rhythms of different users became visible and negotiable.

In addition to proposing new paths, participants had the chance to make new design proposals for the square. Using the "Simulate" tool, a real-time pedestrian simulation illustrated the impact of these designs on movement throughout the day. This highlighted everyday activities like commuting (to work or school), offering insight into the square dynamics at different times (morning, midday, evening). The outcome showcased scenarios with new design elements, altering spatial boundaries and influencing path-time dynamics.

6.2 Use case Sonnengarten Limberg in Zell am See

Unlike the Aumannplatz use case, the Sonnengarten Limberg research didn't begin within a redesign process. Instead, it offered the chance to monitor gender-specific spatio-temporal patterns of use inside and outside the freshly developed housing estate. Using a diverse method mix, similar to Aumannplatz, enabled wide participation through various channels (e.g. a WhatsApp group for residents). Housing management, played a major role, acting as a bridge to residents and amplifying individual engagement.

While the Aumannplatz workshop was held in a nearby shop bordering the square, the participation in Sonnengarten Limberg was organised directly in the housing management's premises. This communal space served to introduce participants to the "Smarticipate" tool for creating an online open space use diary. Participation requirements included completing an online survey (n=59) on leisure and mobility habits, spread through emails, the WhatsApp group, and personal conversations. Collecting details on social background (including care responsibilities) and housing situation as well as mobility habits provided insight into the participating group, which finally (partly) took part in the workshop with the digital tool (remaining persons were provided with a handout) and the creation of the diary. Both steps of participation were compensated. By analyzing the preliminary survey and categorizing participants by specific mobility behaviour types, diverse focus groups emerged. These groups included people such as a digitally savvy young mother, an environmentally conscious childless couple, and an older lady with limited technical skills. During the workshop, participants reconstructed their typical weekday and weekend routines (open space use and destinations inside and outside the neighbourhood, additional information on time, duration and purpose of use as well as means of transport) and entered these details into the "Smarticipate" tool.
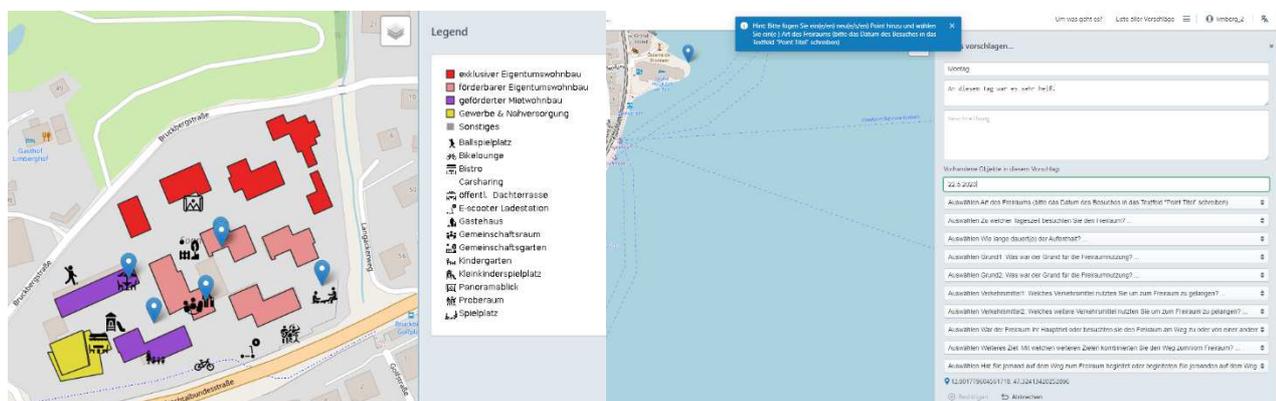

Fig. 4: Mapping of leisure destinations inside and outside the settlement at different times using Smarticipate.

14 of the approximately 60 people who participated in the first survey committed to keeping the space use diary over the period of several weeks and thus sharing personal data on the temporal use of points of interest with the research team. The analysis of the diaries and thus of all collected entries, which can be assigned to group profiles previously collected in the survey, makes different individual and group-specific use patterns and rhythms comprehensible and representable. In addition, possible temporal overlaps of user groups in certain open spaces can be identified. Subsequently, the results can provide far-reaching indications for the (spatial and temporal) optimisation of (semi-)public open spaces in the neighbourhood and thus contribute to an inclusive, gender-just and CO_2-avoiding urban redevelopment.

6.3 Lessons and possible transfers from the goal the DraussenDaheim study

Preliminary results show that collaboration and consultation processes that promote shared decision-making, low-threshold design, participation, and careful selection of digital participation tools to take account of gender- and group-specific needs and ideas are crucial for inclusive and gender-just space-time planning.

Based on practice analysis and findings we have identified the following factors to operationalise time-just urban transformation:

- Put time on top of the planning agenda as core indicator of access to personal leisure and flexible time, and its fair distribution as a core value.

- Strive for distributional justice (equal access to tempo-spatial resources) as well as for procedural justice (who has a say and whom do we reach and how)

We suggest to add representational justice (Gutiérrez-Valdivia 2021) which asks if female lives and their contributions to urban life and economy are appreciated and reflected in public spaces (e.g. name of streets), in planning methods and data generation.

7 TOWARDS TIME-BASED USER-FRIENDLY TOOLS FOR GENDER-JUST URBAN TRANSITION (CONCLUSIONS)

7.1 Findings from European time-space planning practice

One key lesson and inspiration from European time planning practice for our approach was to understanding time and space as resource and indicator to analyse inequalities. This implies a new set of values: goals definition and design criteria. Space-time-policy is a field where values and norms matter. Nevertheless, EU or state-wide representative surveys of time use and activity patterns are rare and there is no or little spatial aggregation of statistics. Cities and regions make their own surveys and are creative in visualising the different daily routines where gender, age, household situation and other sociodemographic categories are widely considered. These qualitative data are used for awareness raising in participatory planning processes. They can be incorporated in the form of innovative presentation methods such as maps and infographics like Chronotopes, spatio-temporal diagrams of the activities of individuals or a population.

Distributional justice is not mentioned explicitly, but on top of the agenda are the following planning tasks: fair/equitable and barrier-free access to high quality public spaces, user-friendly mobility (walkable city), new services and infrastructures (lunch meals for teenagers, citizen kiosk), extension of opening hours and mobility offers.

Most of the practice examples have integrated gender issues in all process-phases, sometimes implicitly by addressing reconciliation challenges or dysfunctionalities and mismatch of opening hours. Specific attention is given to women, families, children and teenagers (not gender differentiated).

Procedural justice is not mentioned explicitly, but is visible as value. A variety of user groups together with schools, public and private service providers and civil society are integrated in all phases and in some cases strongly supported for self-organisation and autonomous implementation. From context based territorial analysis and interpretation to data generation, visioning, planning and design to implementation, a wide range of collaborative methods are applied: co-diagnosis, walking interviews, pop-up workshops, pop-up concerts and discussions as well as time diaries. However, research about the inclusive or exclusive effects of digital tools in collaborative planning process is project-related and cannot be generalised.

Even if the repertoire of methods was not fully exhausted in the context of the DraussenDaheim project, it is clear that in both use cases a wide variety of efforts were made to contribute to procedural justice. Different

communication strategies and a mix of methods were used to involve diverse groups of people of different ages, with and without care responsibilities, as well as people with (mobility) impairments. In this way, new perspectives on their use of time and space could be gained and group-specific requirement for the multifunctional use of time and space could be identified. This made it possible to reflect and represent different life conditions in the development and design of diverse and gender-just public spaces and to incorporate the resulting outcomes into the underlying space-time policy. This approach could in turn benefit the well-informed creation of a time management concept for urban open spaces, such as Aumannplatz, and thus strengthen distributive justice.

7.2 Implementing time-space planning in practice

For distributional justice

- Investigate, analyse and map the diversity of time-space use patterns with special attention to care tasks and care dependencies is an eye-opener for residents, employees and other everyday- life-planning experts.
  - o Putting on the gender+ lenses to assess spatial qualities and dysfunctionalities of urban resources and how accessible they are for different users. Put a special focus on how this accessibility changes at different hours of a day, on weekends, at night, during holidays etc.
  - o This core planning task can only be realised as a horizontal task in cooperation with many other disciplines/departments (social work, labour market regime, opening hours, etc).

For procedural justice

- Co-creation and co-planning start with stakeholder-mapping (who is the most concerned and interested) and the question how these groups can be included into the planning process.
- Digital participation tools can support the collection of gender- and group specific needs, requirements and ideas, as the outlined use cases show. The quality and equity of their results is influenced by the (low-threshold) design, the (inclusive) design of the participation formats
  - o Digital tools combined with face to face workshops and qualitative surveys support the collaborative generation of data (e.g. diversity of time-space use patterns with time diaries).
  - o There is still much to do for improving the usability of the tools and the co-design with residents, which has a great potential for increasing easy accessibility to the planning process.

Further research is needed on the following questions:

How to investigate the diversity of time-space patterns at community and neighbourhood level and the distribution of unwaged work between genders, age groups etc.?

Under which conditions (inclusive process design and cooperative tool selection, usability e.g. smartphone-app, settings etc.) can digital tools enhance or hinder (exclusion of digital illiterates) residents and other user groups from participation in a planning process.

8 ACKNOWLEDGEMENTS

9 REFERENCES

BRÜCHERT, T., Baumgart, S., & Bolte, G. (2022). Social determinants of older adults' urban design preference: A cross-sectional study. Cities & Health, 6(2), 360–374.
BM-INNEREN (2020): Neue Leipzig Charta. Die transformative Kraft der Städte für das Gemeinwohl. Berlin, 5.

COL-LECTIU PUNT 6 (2017) Women working, urban assessment guide from a gender. http://issuu.com/punt6/ docs/mujerestrabajando (acces on 10/128/2018).

DAMYANOVIC, D., FINK, T., GEBETSROITHER-GERINGER, E., GRIMM-PRETNER, D., KOZLOWSKA, A., REINWALD, F., STOLLNBERGER, R., TUMMERS, L., UNTNER, S., WANKIEWICZ, H., WEICHSELBAUMER, R.: Ein Tool-Set zur Unterstützung einer Gender+-gerechten Stadtplanung. Ergebnisbericht des Forschungsprojekts SmartThroughGender+ – Integration von Gender+ in digitale Stadtplanungs-Tools und Entwicklung eines Tool-Sets für Gender+-gerechte Stadtplanung, Wien, 2021.

DÖRRHOFER, K. & U. TERLINDEN (1985): Verbaute Räume. Auswirkungen von Architektur und Städtebau auf das Leben vonFrauen. Köln, 1985.

EUROFEM (2000): The Eurofem Toolkit for mobilizing women's participation in local development. Helsinki.

FESSLER, F., GEBETSROITHER F. & F. REINWALD (2023). Gender-sensitive use and development of (digital) participation andanalysis tools for equal access to open spaces. Proceedings of the Real-corp- conference Ljubljana 2023.

HÄGERSTRAND T. (1970): What about people in regional science?". Papers of the Regional Science Association. 24 (1): 6–21. doi:10.1007/BF01936872

HACKNEY PLAY STREET ASS. (2015): Hackney Play Streets Evaluation Report. T. Gil – Author. London. (http://www.hackneyplay.org/playstreets/home/ access on18/10/2021)

HAYDEN, D. (1980): What Would a Non-Sexist City Be Like? Speculations on Housing, Urban De-sign, and Human Work. Signs, Vol. 5 (3), Supplement (Women and the American City), S. 170- 187.Terraza, H., Orlando, M. B., Lakovits, C., Lopes Janik, V., & Kalashyan, A. (2020). Handbook for gender-inclusive urbanplanning and design. HENCKEL D., KRAMER C. (2019): Zeitgerechte Stadt – Eine Einführung. IN: Henckel D., Kramer, C. (HG) (2019): Zeitgerechte Stadt: Konzepte und Perspektiven für die Planungspraxis. Hannover: Forschungsberichte der ARL 09: SS 5 – 24

HORELLi L. (Ed)(2013): New Approaches to Urban Planning. Aalto University, Helsinki 2013.

HORELLI L. (2006): Managing Time and Space for Everyday Life with a focus on health promotion. Paper for the 19th IABS Knoll B., Fitz B., Schwaninger T., Spreitzer G, Deimel A. (2016): Mobilität von Menschen mit Betreuungsaufgaben - Qualitative Studie (Gender Modul) zur österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014", Forschungsbericht im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, Wien, 2016

KEMPIN REUTER, T. (2019). Human rights and the city: Including marginalized communities in urban development and smart cities. Journal of Human Rights, 18(4), 382–402.

KNOLL B., Fitz B., Schwaninger T., Spreitzer G, Deimel A.: Mobilität von Menschen mit Betreuungsaufgaben - Qualitative Studie (Gender Modul) zur österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014", nd Technologie, Wien, 2016

KRISHNAMURTHY, S. (2019). Reclaiming spaces: Child inclusive urban design. Cities & Health, 3(1–2), 86–98.

KWAN M.-P (2000): Gender differences in space-time constraints. Area (2000) 32.2, 145-1 56

MORENO C., ALLAM Z., CHABAUD D., GALL C., PRATLONG F. (2021): Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. IN: Smart Cities 2021, 4 (1): 93–111

NANTES Métropole (2013): La ville a mille temps. Une affaire publique. Cahier de Connaissances. Nantes, 14. https://dialoguecitoyen.metropole.nantes.fr/media/default/0001/01/afc647499c27fbb79eec4c5917e05451f1cfd2bd.pdf (access on 12/09/2021)

PANOVA R, Sulak H., Buland M. & L. Wolf (2017): Die Rushhour des Lebens im Familienzyklus: Zeitverwendung von Männern und Frauen. IN: Statisitsche Bundesamt (Hg.): Wie die Zeit vergeht. Analysen zur Zeitverwendung in Deutschland. Ergebniskonferenz der Zeitverwendungserhebung 2012/2013 am 5./6. Oktober 2016 in Wiesbaden. S. 45 bis 64.

ROSE, G. (1993). Feminism and geography: the limits of geographical knowledge. Minneapolis.

van SCHAICK J. (2011): Timespace matters. Exploring the gap between knowing about activity patterns of people and knowing how to design and plan urban areas and regions. Phd TU-Delft. Amsterdam, Delft

van SCHAICK, J. (2009) European policy practices in time-space planning. In: Background articles for the exposition Space For (Every)Day (provisional title). Delft: Faculty of Architecture, TUDelf

DE SIQUEIRA G., Malaj, S., & Hamdani, M. (2022). Digitalization, Participation and Interaction: Towards More Inclusive Tools in Urban Design—A Literature Review. Sustainability, 14(8), 4514.

STABILINI, S, Zedda, R. L. Zanettichii (2013). Accessibility of Public Spaces and Services: Theoretical Remarks, Practices and Instruments from Urban Time Planning. In. Henckel, Thomeier et al: Space–Time Design of the Public City.Dordrecht, London, New York 119 119-136

STADT BOZEN (2005). Zeitplan für die Stadt Bozen. Teil2: Die Zeiten der Stadt: Ausrichtung und strategische Zielsetzungen. Der strategische Entwicklungsplan https://www.gemeinde.bozen.it/-UploadDocs/974_StrategischesDokument.pdf (access on 13/01/2022)

STADT WIEN (2013): Manual Gender Mainstreaming in Plannnign Werkstattbericht 130. Vienna.

STATISTIK AUSTRIA (2009): Zeitverwendungsstudie 2008/09. Ein Überblick über geschlechtsspezifische Unterschiede. Wien.

TEMPO TERRITORIAL (2022b). Guide Prendre en compte le temps dans les mobilité. (https://tempoterritorial.fr/prendre-en-compte-le-temps-dans-les-mobilites-rennes-23-et-24-mai-2019/ (access on 20/01/22)

TUMMERS L (2009): Room for every(one's) day. Design criteria for the everyday. Self publishing. Rotterdam, Delft

TUMMERS L., WANKIEWICZ H. (2021): Rethinking planning and spatial assessment from a care- perspective. Incorporating diversity of use-patterns in planning instruments. In: REAL CORP 2021 Proceedings/ 2021 Online: https://archive.corp.at/cdrom2021/papers2021/CORP2021_101.pdf (access on 09/09/2021)

VILLE DE PARIS (2022a). Guide Référentielle Genre & espace public. https://www.paris.fr/pages/un-nouveau-guide-pour-mieux-integrer-le-genre-dans-l-espace-public-1762 (access on 25/04/22)

VILLE DE PARIS (2022b): Paris ville du quart d'heure, ou le pari de la proximité. https://www.paris.fr/dos-siers/paris-ville-du-quart-d-heure-ou-le-pari-de-la-proximite-37 (access on 22/03/22)

WALLIN S., HORELLI L. (2010): Methodology a usersensitive service design within urban planning (Journal of Environmental Planning B (EPB 135-130): DOI: 10.1068/b35130

ZIBELL B (2022): Care Arbeit räumlich denken. Wettingen, 2022.

EC-1999 – Treaty of Amsterdam (http://data.europa.eu/eli/treaty/ams/sign)

EC 2020: New Leipzig Charter- The transformative power of cities for the common good
https://ec.europa.eu/regional_policy/en/information/publications/brochures/2020/new-leipzig-charter-the-transformative-power-of-cities-for-the-common-good
SDG - UN-Agenda 2030 (https://sdgs.un.org/2030agenda - access on 02/02/2020)
Gender Equality Index (EIGE 2022): https://eige.europa.eu/gender-equality-index/2022/domain/time/AT

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REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Towards a Conceptual Framework for Sustainable Municipal Free Wi-Fi Interventions in South Africa: a City of Tshwane Case Study

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1 ABSTRACT

The Fourth Industrial Revolution is a reality to be reckoned with in cities. Many cities across the world have ventured into various technological innovations to keep up with the demands of the need for free and/or affordable data in the context of data drive smart cities. However, in the African context, there are valid concerns that such interventions are often not sustainable. This paper provides an attempt to contribute a conceptual framework for a sustainable municipal technological innovations in municipalities, using the municipals free Wi-Fi as an example. Currently, there is no framework model, and many municipalities are implementing free Wi-Fi in rather uncoordinated ways, leading to unsustainable outcomes. The paper was based on literature review and empirically gathered views of key local government stakeholders in South Africa.

Keywords: City of Tshwane, Fourth Industrial Revolution, Spatial Planning, Free municipal Wi-Fi, Smart City

2 INTRODUCTION

This paper proposes a conceptual framework model for sustainable free municipal Wi-Fi programmes for consideration by cities in South Africa. This conceptual framework model can be used utilized as a broad framework to design and/or evaluate the sustainability of municipal technological innovations by municipalities in South Africa. The target potential users of this conceptual framework model include city managers, heads of departments responsible for designing free Wi-Fi programmes, local government practitioners, councillors (politicians), scholars and academics, civil society organizations, the private sector, NGOs, and organized local government formations/associations, such as South African Local Government Association (SALGA) and the South African Cities Network (SACN).

3 WHY SHOULDN'T DATA BE SEEN AS A FREE BASIC SERVICE?

The first key element of the framework tackles the question of data as a free basic service to be provided by municipalities. Scholars such as Ramokgopa (2018) support the notion that free Wi-Fi be designated as a basic municipal service in South Africa. However, other scholars such as Nalla (2021) argue that South Africa should first focus on basic needs such as shelter, water, food, etc. This study aligns with the views of Ramokgopa (2018), and other scholars, i.e. that free Wi-Fi be designated as a basic municipal service in South Africa. This study supports the view that data should be designated as a basic municipal service in South Africa, especially where some of the basic services in the 21st century can be provided digitally. In such instances, lack of access to data can become a hindrance.).

4 KEY ELEMENTS OF THE CONCEPTUAL FRAMEWORK MODEL

The key elements of the conceptual framework model for sustainable free Wi-Fi programs in municipalities (cities) are discussed below.

4.1 Data-driven Smart City

The second key element of the framework tackles the question of smart cities embracing the use of data for decision-making (Mazzei and Noble, 2017). Many 'big' metros in South Africa profess to be working toward being smart cities (Das, 2020). The reality is that smart cities employ the Internet of Things (IoT) and big data analytics (Bassoo, et al., 2018); and use sensors to generate data (Gohar et al., 2018). So data management systems are one of the major imperatives for smart cities (Tang et al., 2015). In addition, smart cities are required to have a proper appreciation of the strategic implications of data (Wang et al., 2018). The capability to capture and analyze data to generate value is highly important (George et al., 2014). Digital transformation cannot be achieved in organizations which do not employ a digital-savvy workforce (Warner

and Wager, 2019) because these workers shape the organizational digital capabilities of an organization (Felin et al., 2012). Some of the key skills needed include data analysts, who handle data flow management and deploy data analytics tools (Mikalef et al., 2018). Meanwhile, data scientists assist organizations to derive insights from data (Ho et al., 2019). The appointment of competent key C-suite functionaries such as the Chief Information Officer (CIO) and Chief Data Officer can assist organizations to build capabilities to use data for decision-making purposes (Vogelsang et al., 2019). A CDO, for instance, can lead digital transformation (Singh et al., 2020), and the development of a "digital" strategy for an organization (Tumbas et al., 2018). The implications of all these for smart cities is that cities should appreciate that communities are using the Internet of Things more than ever before. So, cities need to develop strong capabilities to handle data-savvy communities. Importantly for this study, cities need to find ways of assisting communities, especially the poorest of the poor, to access data, due to cost or data restrictions (Golub, et al., 2019). This matter is discussed further below.
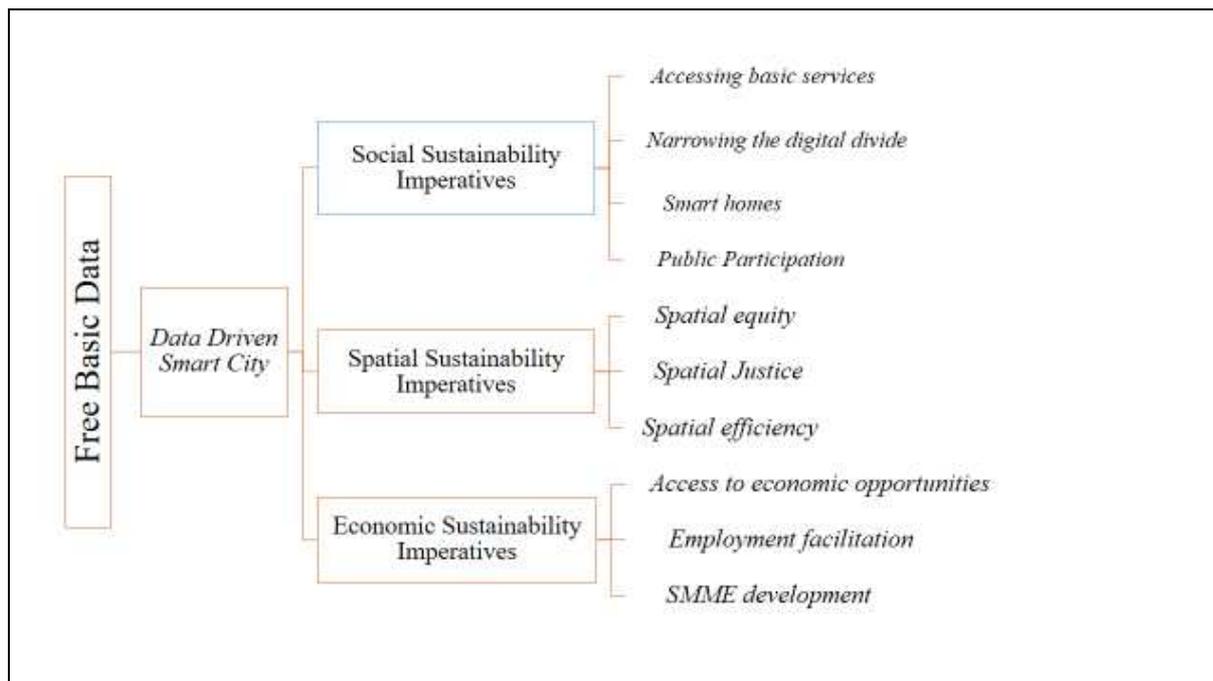
Figure 1: Key elements of the conceptual framework model for sustainable free Wi-Fi programs in municipalities, Source: Author (2023).

4.2 Social sustainability imperatives

Under the social sustainability imperative, the first motivation is that the actual reality is that some of the basic services in the 21st century can be provided digitally. So, access to data as a free service would have multiplier effects for accessing other basic services as well. For instance, Robertson, et al (2019) found that the provision of free Wi-Fi contributes to narrowing the digital divide and assisting residents to view their utility bills online. In addition, many scholars (Vigil-Hayes, et al. (2018); Zarocostas (2020); Hanson, et al. (2020), Kroese et al., (2021); Ullah, et al., (2021); Gibbs, et al., (2022) found that Internet access is one of the means through which communities access health-related services. It has been found that since the advent of the COVID-19 epidemic, the delivery of education services has changed, and embraced digital methods (Joffe, 2021; Vigil-Hayes, et al., 2018). So, internet access is one of the most prominent means to access education services (Cobo et al., 2020; Antoni, 2020; Mondal, 2020). Libraries in most parts of the world utilize free Wi-Fi (Vigil-Hayes, et al., 2018; Mersand, et al., 2019; Lenstra and Campana, 2022).

Scholars such as Castells (2000:442), we are living in the days of an "information society", characterised by "flows of capital, flows of information, flows of technology, flows of organizational interaction, flows of images, sounds, and symbols". This "information society" further creates network societies between the virtual and real worlds; thus creating social capital (Claridge, 2018; Colbjørnsen 2021). So, internet access is no longer a luxury, as it is needed by all communities to share information and content-related data (Vigil-Hayes, et al., 2018). From this perspective, the provision of free data can enhance societal transformation (Crowdy and Horst, 2022). Free data can enhance the application of smart homes (Nettikadan, and Raj,

2018). For many poorer households, this will never become a reality without the assistance of free municipal Wi-Fi. Free municipal Wi-Fi can assist greatly in youth development efforts. Young people spent at least 20% of their daily time on the Internet, for various reasons (Agbawe, 2018; Fab-Ukozor and Ojiakor, 2020: 24); including skills development (Ojeleye, et al., 2018); and wealth creation in the world of self-employment and entrepreneurship (Agbawe, 2018). Free municipal Wi-Fi can assist municipalities to enhance their informational right to the city. The informational right to a city can be seen as a "sub-set" of the concept of the right to a city. On its own, the right to the city is seen as an agenda for social change (Vergara-Perucich, and Arias-Loyola, 2019), especially in the context of smart cities (Van der Graaf, 2020). So, Free Wi-Fi possess the potential to promote informational access for the citizens because today, networks are based on borderless informational networks, powered by the internet (Yang and Saffer, 2019). In South Africa, Section 32 (1) (a) of the Constitution provides that everyone has the right of access to information. Similarly, the Promotion of Access to Information Act (2000) advocates for the informational rights of citizens.

In this study, a majority (68%) of the free Wi-Fi users who participated in the online survey believe that the Tshwane Free Wi-Fi made either lot or modest contribution to the residents exercising their informational rights in the City of Tshwane. It is encouraging that the users express a positive affirmation about the contribution of free Wi-Fi in advancing informational rights in the context of the fourth industrial revolution.

Equally, the majority of stakeholders who participated in the interviews believe that the free Wi-Fi's making a lot of contribution (60% plus) in terms of promoting informational rights to the city. However, one of the independent experts points out that sometimes information asymmetries negatively affect the informational right of the city. These findings seem to align with the findings of other scholars. For example, Robertson, et al. (2019) posit, among others, that the provision of free Wi-Fi can contribute to narrowing the digital divide. Similarly, Vigil-Hayes, et al. (2018) found that where data is 'effectively free', informational right to a city can easily take place (Crowdy and Horst, 2022). The information right to the city can be pertinent to the youth, who use a lot of data for a variety of informational purposes (Umeogu and Ojiakor, 2014). From a policy perspective, if achieved, the South African government's ambitious target of achieving 100% broadband access to everyone by 2030 could lead to better informational rights in the city. International research by the United Nations (2020) found that the deployment of ICTs can facilitate digital interaction and public participation. The informational right to a city can be seen as a "sub-set" of the concept of the right to a city. On its own, the right to the city is seen as an agenda for social change (Vergara-Perucich, and Arias-Loyola, 2019), especially in the context of smart cities (Van der Graaf, 2020). Free Wi-Fi can positively contribute to social networking created through digital technologies. So, they possess the potential to promote informational access for the citizens. Today, networks are based on borderless informational networks, powered by the internet (Yang and Saffer, 2019).

In South Africa, Section 32 (1) (a) of the Constitution provides that everyone has the right of access to information. Similarly, the Promotion of Access to Information Act (2000) advocates for the informational rights of citizens. In this study, the results showed that a majority (68%) of the free Wi-Fi users who participated in the online survey believe that the Tshwane Free Wi-Fi made either lot or modest contribution to the residents exercising their informational rights in the City of Tshwane. It is encouraging that the users express a positive affirmation about the contribution of free Wi-Fi in advancing informational rights in the context of the fourth industrial revolution. Various scholars confirm that in South Africa, prohibitive costs, and access to data remain some of the key challenges (Lorini et al., 2019; Tshishonga, 2020, and Muridzi, et al., 2021). Free data can enhance the application of smart homes (Nettikadan, and Raj, 2018). For many poorer households, this will never become a reality without the assistance of free municipal Wi-Fi. Sixthly, free municipal Wi-Fi can assist greatly in youth development efforts. Young people spent at least 20% of their daily time on the Internet, for various reasons (Agbawe, 2018; Fab-Ukozor and Ojiakor, 2020: 24); including skills development (Ojeleye, et al., 2018); and wealth creation in the world of self-employment and entrepreneurship (Agbawe, 2018).

4.3 Spatial sustainability imperatives

This framework model posits that a sustainable free Wi-Fi programmes should assist municipalities to address issues of spatial injustice in cities. Spatial inequality is one of the strongest predictors of disparities in the digital inequality stack. In countries such as India, just over 20% of people in rural have access to

internet connectivity. Taiwan has managed to address this through the provision of good-quality internet access and computer training in rural areas. The introduction of free Wi-Fi technologies can go a long way to halting the widening of the gap between rural and urban residents. Such efforts should be accompanied by skill-building opportunities, along with investment in infrastructure, and improvement of information services (Robinson, et al., 2020). In South Africa, the municipalities are required by law to consider principles of spatial justice, efficiency, and sustainability (RSA, 2013). This implies that when municipalities consider investment decisions on free Wi-Fi, they must consciously and deliberately ensure that such investments will have the effect of building inclusive cities and communities (spatial justice). In other words, municipalities must not use free Wi-Fi technologies to entrench and reinforce apartheid spatial injustice in South Africa.

In this study, the results showed that a majority (92%) of the free Wi-Fi users who participated in the online survey believe that the Tshwane Free Wi-Fi is making a lot of contributions in terms of enhancing spatial justice. Equally, the majority of stakeholders who participated in the interviews believe that free Wi-Fi's making a lot of contribution in terms of addressing the question of spatial justice. Some of the stakeholders believe that some people wouldn't have to travel if the township economies were strong and vibrant. However, others believe that free Wi-Fi is only beneficial to those living in closer range of the Wi-Fi. However, as a matter of principle, the free Wi-Fi users who participated in the online survey believe that free-Wi-Fi should serve everyone irrespective of their location. A majority of these participants (52%) value the importance of free Wi-Fi to address spatial inequalities. In addition, even though the majority of stakeholders who participated in the interviews believe that free-Wi-Fi should serve everyone irrespective of their location, from a practical point of view, a majority of these respondents either disagree or strongly disagree that the current modus operandi is one where the free Wi-Fi benefits everyone irrespective of their geographic locations. They believe that the free Wi-Fi tends to benefit those that are located in cities and urban areas. They argue that the Wi-Fi's are accessible to, and favours the rich, whereas the poor can't access them due to locational disadvantages. This is a spatial justice matter that cities should give close attention when they design their free Wi-Fi programmes.

There is a need to take an integrative approach in tackling pertinent questions about the use of municipal technologies to address spatiality questions in cities. The views of free Wi-Fi users and stakeholders regarding their perspectives on the extent, and whether or not the free Wi-Fi is advancing goals of spatial justice, access and equity need to be engaged. The use of Geographic Information System (GIS) tools to show the extent to which the spatial allocation of the free Wi-Fi in different regions and/or areas in cities is promoting principles of spatial justice, access and equity is also important. Municipalities need to have transparent and objective tool/criterion for allocating free Wi-Fi sites per region and/or area. For instance, in the case of the City of Tshwane, it is not clear if the city uses data on the population size, digital literacy, community needs, and data usage trends. In the absence of such an objective and transparent data-based process, key decisions about allocating free WiFi infrastructure could be based on political considerations, thus threatening the sustainability of the programme. The spatial planning principles of equity, efficiency, good governance, and spatial justice could be useful in this regard. Another interesting observation is the possibility of cross-border usage by residents between wards and between regions. In addition, cities need to consider strategies to allocate free Wi-Fi infrastructure in rural and/or agricultural areas. These are critical questions worth investigating further.

It should be mentioned that geographic universal provision of WiFi encounters the same problem as supplying other services throughout remote and low density areas (e.g. public transport, health care provision, etc). Other spatial policies would need too be considered simultaneously, as well as fiscal arrangements which would cross subsidise consumption services in remote low density areas. It is also a matter of finding the funding for universal provision of wifi at municipal level. By their nature poorer communities have more restricted budgets to spend on public services. Installing WiFi masts throughout the vast country of South Africa may be beyond municipal budgets. Perhaps experimenting with, and adopting alternative, cheaper, more efficient technologies like light driven 'LiFy' could be an option (see BBC radio 4, The Life Scientific (interview of Harald Haas by Jim Al'Khalili, 230627, 9am on optical wireless communication technology to access the internet, BBS sounds – a simple desk lamp was used to stream a video on 2011).

4.4 Economic sustainability imperatives

This framework model posits that a sustainable free Wi-Fi programmes should assist municipalities to address issues of economic disparities in cities. In South Africa, cities like Cape Town have high levels of economic inequality (Enqvist and Ziervogel, 2019). It means the rich are getting richer and the poor getting poorer. So, municipalities can use free Wi-Fi to address some of the intricate issues about economic injustices. Admittedly, often, there is an overlap between social and economic and/or distributive justice (Moroni, 2020). In this regard, it is argued that cities should find innovative ways to use free Wi-Fi platforms to foster environments where access to opportunities which can better the economic and/or financial position or status of community members can be constructed. So, free Wi-Fi can be deliberately used by cities to serve redistributive intentions of addressing some of the economic dimensions of justice within a city, especially in cities where the rich are getting richer and the poor getting poorer.

As cities go through periods of economic decline, the issue of economic justice becomes even more prominently important (Rodrigues and Franco, 2020). Free Wi-Fi should be used to reverse all forms of marginalisation and exclusion of people, whether based on gender, creed, class, etc can be a norm in cities. When justice is delivered to people, this can have positive economic outcomes on people in cities (Baars, et al., 2021). In the context of the "right to the city", free data should be seen as one of the foundational basis for smart city endeavours. As scholars such as Ragnedda et al. (2020) correctly posit, the economic class does affect the accumulation of digital assets and capital. This means that those who have access to economic opportunities and higher incomes are more likely to acquire digital tools than low-income groups.

So, the free Wi-Fi interventions can be designed from a policy perspective with an inherent agenda to redress such inequalities and imbalances. The reality is that access to the Internet access is one of the potent means through which communities access economic activities/services (Vigil-Hayes et al., 2018); and lack thereof can lead to a state of poor income, or financial instability (Lau, et al., 2022). So, the relationship between access to income and access to data remains (Smith, 2020). In countries such as Indonesia, free Wi-Fi interventions have been used successfully to assist village entrepreneurs to improve online marketing; thus promoting their products to the wider market (Kania, Anggadwita, and Alamanda, 2021). Such efforts of using free Wi-Fi as an economic tool of redress are needed, especially in African cities, where economic inequalities are growing. In this study, the results showed that a majority (79%) of the free Wi-Fi users who participated in the online survey agree that many residents in Tshwane rely on the Tshwane Free Wi-Fi for economic opportunities such as job application and business transactions. Equally, the majority of stakeholders who participated in the interviews believe that the free Wi-Fi's making is making a modest contribution (40%-59%) in terms of enhancing access to economic opportunities.

In South Africa, many municipalities talk about developing the local township economy. So, the free Wi-Fi data can be used to enhance the implementation of this strategy, through focussed attention to local small bsuinesses such as grocery food stores, spaza shops, shisanyama, pubs, hair salons, car wash businesses, internet cafes. The free Wi-Fi data can be used to empower local small businesses for a variety of things, including, to communicate with clients and suppliers, promoting and market local businesses, participating in social media platforms, accessing financial opportunities, doing financial transactions, etc. So, municipalities need to design their free Wi-Fi programmes with the small business operators in mind, with a view to assist them to improve sales; and income/profits. However, for that to happen effectively, municipalities need to overcome challenges such as distance, poor network, poor reliability, and load shedding, etc.

5 CONCLUSION

This paper makes some contribution on the discourse regarding whether free data should be seen as a basic service to be provided by municipalities in South Africa. This contribution is made in the context of data driven smart cities. The study does not endeavour to set a fixed amount of data as minimum free service. A one size fits all approach is not advocated. So, this is left for each individual municipal council to make policy choices in this regard. Inadvertently, some municipalities would afford to make a certain amount of data free; others could afford to offer more. This would depend on various contextual factors, including: budgets, affordability, and the ability of municipalities to embark on crowdfunding and partnerships with other stakeholders, etc. Significantly, the paper presents a conceptual framework model for sustainable municipal technological innovations in municipalities, using the free Wi-Fi in South African municipalities as an example. Currently, there is no framework model, and many municipalities are implementing free Wi-

Fi in rather uncoordinated ways, leading to unsustainable outcomes. This is one of the areas where this study is making some modest original contribution to the academic and practical discourse on sustainable municipal free Wi-Fi. In this regard, the paper presents three imperatives for a sustainable free municipal Wi-Fi programme, to cater for social sustainability imperatives, spatial sustainability imperatives, as well as economic sustainability imperatives. The conceptual framework model is flexible enough to be adapted for a variety of municipal technological innovations in municipalities, not just free Wi-Fi.

6 REFERENCES

Agbawe, M. (2018). "Challenges and Prospects of Social Media on Digital Natives: The Case of Nigeria." Journal of Information and Knowledge Management 9(3): 18-32.

Antoni, J. (2020). Disengaged and nearing departure: Students at risk for dropping out in the age of COVID-19. Faculty/Researcher Works.

Baars, S., van Hove, B. B., de Bruin, K. K., & Barkved, L. L. (2021). Storm Water Management and Environmental Justice in Cities.

Bassoo, V., Ramnarain-Seetohul, V., Hurbungs, V., Fowdur, T. P., & Beeharry, Y. (2018). Big data analytics for smart cities. Internet of things and big data analytics toward next-generation intelligence, 359-379.

Castells, M. (2000). The rise of the network society. Malden, MA: Blackwell.

Claridge, T. (2018). Functions of social capital–bonding, bridging, linking. Social capital research, 20, 1-7.

Cobo, C., Hawkins, R., and Rovner, H. (2020). How countries across Latin America use technology during COVID19-driven school closures. World Bank Blogs. Retrieved From: https://blogs.worldbank.org/education/how-countriesacross-latin-america-use-technology-during-covid19-driven-school-closures

Colbjørnsen, T. (2021). The streaming network: Conceptualizing distribution economy, technology, and power in streaming media services. Convergence, 27(5), 1264-1287.

Crowdy, D., and Horst, H. A. (2022). We just 'SHAREit': Smartphones, data and music sharing in urban Papua New Guinea. The Australian Journal of Anthropology, 33(2), 247-262.

Das, D. K. (2020). Perspectives of smart cities in South Africa through applied systems analysis approach: A case of Bloemfontein. Construction Economics and Building, 20(2), 65-88.

Enqvist, J. P., & Ziervogel, G. (2019). Water governance and justice in Cape Town: An overview. Wiley Interdisciplinary Reviews: Water, 6(4), 1354.

Fab-Ukozor, N., & Ojiakor, I. C. (2020, March). Social Media and Youth Empowerment: An Empirical Inquiry. In Proceedings of the 16th International RAIS Conference, March 30-31, 2020 (No. 003nfu). Research Association for Interdisciplinary Studies.

Felin, T., Foss, N.J., Heimeriks, K.H. and Madsen, T.L. (2012), "Microfoundations of routines and capabilities: individuals, processes, and structure", Journal of Management Studies, Vol. 49 No. 8, pp. 1351-1374.

George, G., Haas, M. R. and Pentland, A., (2014). Big data and management. Academy of Management Journal, 57(2), pp.321–326.

Gibbs, J., Solomon, D., Jackson, L., Mullick, S., Burns, F., & Shahmanesh, M. (2022). Measuring and evaluating sexual health in the era of digital health: challenges and opportunities. Sexual Health.

Gohar, M., Muzammal, M., & Rahman, A. U. (2018). SMART TSS: Defining transportation system behavior using big data analytics in smart cities. Sustainable cities and society, 41, 114-119.

Golub, A., Satterfield, V., Serritella, M., Singh, J., & Phillips, S. (2019). Assessing the barriers to equity in smart mobility systems: A case study of Portland, Oregon. Case studies on transport policy, 7(4), 689-697.

Hanson, J. D., Weber, T. L., Shrestha, U., Bares, V. J., Seiber, M., and Ingersoll, K. (2020). Acceptability of an eHealth Intervention to Prevent Alcohol-Exposed Pregnancy among American Indian/Alaska Native Teens. Alcoholism: Clinical and Experimental Research, 44(1), 196-202.

Ho, A., Nguyen, A., Pafford, J. L., & Slater, R. (2019). A data science approach to defining a data scientist. SMU Data Science Review, 2(3), 4.

Joffe, A. (2021). Covid-19 and the African cultural economy: an opportunity to reimagine and reinvigorate?. Cultural Trends, 30(1), 28-39.

Kroese, K., Porter, K., Surridge, H., and Tembo, D. (2021). Challenges and solutions: surveying researchers on what type of community engagement and involvement activities are feasible in low and middle income countries during the COVID-19 pandemic. BMJ open, 11(10), e052135.

Lenstra, N., & Campana, K. (2022). The Emerging Role of Outdoor Public Librarianship: Understanding the Need for Strengthened Infrastructure. Journal of Library Administration, 62(5), 602-620.

Lorini, M. R., Densmore, M., Johnson, D., Hadzic, S., Mthoko, H., Manuel, G., ... & van Zyl, A. (2019). Localize-it: Co-designing a community-owned platform. In International Development Informatics Association Conference (pp. 243-257). Springer, Cham.

Mazzei, M. J. and Noble, D., (2017). Big data dreams: A framework for corporate strategy. Business Horizons, 60(3), pp.405–414.

Mersand, S., Gasco-Hernandez, M., Udoh, E., and Gil-Garcia, J. R. (2019). Public libraries as anchor institutions in smart communities: Current practices and future development. In Proceedings of the 52nd Hawaii international conference on system sciences.

Mondal, H. (2020). The Library: Changing Role and services in 21st century's information societies. ICT and Library in Higher Education: An Indian Perspective organized by Chandidas Mahavidyalaya. Birbhum.

Moroni, S. (2020). The just city. Three background issues: Institutional justice and spatial justice, social justice and distributive justice, concept of justice and conceptions of justice. Planning Theory, 19(3), 251-267.

Muridzi, G., Meyer, J. A., & Masengu, R. (2021). Urban Governance in Africa–A Perspective of E-Governance in South Africa Urban Municipalities.

Nalla. (2021). A tale of new cities. News24.Com. https://www.news24.com/fin24/finweek/a-tale-of-new-cities-20210916?msclkid=4e6c17f5b82d11ecac9737979568a9ee

854

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Nettikadan, D., & Raj, S. (2018). Smart Community Monitoring System using ThingSpeak IoT Platform. International Journal of Applied Engineering Research, 13(17), 13402-13408.

Ojeleye, Y.C., Opusunju, M.I., Ahmed, A.I and Aku, S. 2018. "Impact of Social Media on Entrepreneurship Development among Users in Zamfara smithte." Journal of Economics and Finance 2(2): 303-327.

Ragnedda, M., Ruiu, M. L., & Addeo, F. (2020). Measuring digital capital: An empirical investigation. New Media & Society, 22(5), 793-816.

Ramokgopa, K. D. (2018). Leadership in establishing the Gauteng City-Region: the case of the City of Tshwane Metropolitan Municipality (Doctoral dissertation, University of Pretoria).

Robertson, A. G., Hallinan, K., and Hoody, J. (2019). Achieving Energy Justice in Low Income Communities: Creating a Community-Driven Program for Residential Energy Savings.

Robinson, L., Schulz, J., Blank, G., Ragnedda, M., Ono, H., Hogan, B., ... & Khilnani, A. (2020). Digital inequalities 2.0: Legacy inequalities in the information age. First Monday, 25(7).

Rodrigues, M., & Franco, M. (2020). Measuring the urban sustainable development in cities through a Composite Index: The case of Portugal. Sustainable Development, 28(4), 507-520.

Republic of South Africa, (1996). The Constitution of South Africa. Government Printers, Pretoria.

Republic of South Africa, (2013). The Spatial Planning and Land use Management Act. Government Printers. Pretoria.

Singh, A., Klarner, P., & Hess, T. (2020). How do chief digital officers pursue digital transformation activities? The role of organization design parameters. Long Range Planning, 53(3), 101890.

Smith, A. (2022). Innovating Internet Connectivity in the Atlanta Westside Communities.

Tang, B., Chen, Z., Hefferman, G., Wei, T., He, H., & Yang, Q. (2015). A hierarchical distributed fog computing architecture for big data analysis in smart cities. In Proceedings of the ASE BigData & SocialInformatics 2015 (pp. 1-6).

Tshishonga, N. S. (2020). Forging Civic and Democratic Governance From Below Through Virtual State and Communities: Case Studies of Communities of Practice. In Civic Engagement Frameworks and Strategic Leadership Practices for Organization Development (pp. 67-95). IGI Global

Tumbas, S., Berente, N., & Brocke, J. V. (2018). Digital innovation and institutional entrepreneurship: Chief Digital Officer perspectives of their emerging role. Journal of Information Technology, 33(3), 188-202.

Ullah, A., Pinglu, C., Ullah, S., Abbas, H., & Khan, S. (2021). The Role of E-Governance in Combating COVID-19 and Promoting Sustainable Development: A Comparative Study of China and Pakistan. Chinese Political Science Review, 6, 86–118.

United Nations. (2020). E-Government Survey 2020 Digital Government in the Decade of Action for Sustainable Development. New York: United Nations.

Umeogu, B., & Ojiakor, I. (2014). The internet communication and the moral degradation of the Nigerian youth. International Journal of Computer and Information Technology, 3(2), 450-463.

Van der Graaf, S. (2020). The right to the city in the platform age: Child-friendly city and smart city premises in contention. Information, 11(6), 285.

Vergara-Perucich, J. F., & Arias-Loyola, M. (2019). Bread for advancing the right to the city: academia, grassroots groups and the first cooperative bakery in a Chilean informal settlement. Environment and Urbanization, 31(2), 533-551.

Vigil-Hayes, M., Matthews, J., Acker, A., and Carter, D. (2018). Reflections on alternative Internet models and how they inform more mindful connectivity. ITU Journal: ICT Discoveries.

Vogelsang, K., Liere-Netheler, K., Packmohr, S., & Hoppe, U. (2019). Barriers to digital transformation in manufacturing: development of a research agenda.

Wang, Y., Kung, L., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. Technological forecasting and social change, 126, 3-13.

Warner, K.S.R. and Wager, M. (2019), "Building dynamic capabilities for digital transformation: an ongoing process of strategic renewal", Long Range Planning, Vol. 52 No. 3, pp. 326-349.

Yang, A., & Saffer, A. J. (2019). Embracing a network perspective in the network society: The dawn of a new paradigm in strategic public relations. Public Relations Review, 45(4), 101843.

Zarocostas, J. (2020). How to fight an infodemic. The Lancet, 395.

Towards Enhancement of Alexandria City Waterfront: Quality of Life Assessment Model

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1   ABSTRACT

Coastal cities evolve in alignment with people centred development to accommodate their needs. Nevertheless, uncontrolled changes of significant elements of urban morphology such as land uses along the waterfront and respective public activities, lead to alterations in the quality of life provided. The research explores models that study the various configurations and implying the effective role of controlling urban developments guidelines in terms of environmental behavioural, social well being, health and safety.

This paper is divided into two main sections: Firstly, it focuses on Alexandria City's Urban Morphology, prospect of transformation plans and highlights the nature-based integrative solutions on its waterfront for the short and long-term plans through multiple disciplinary contributions. Secondly, the research defines the structured model to assess Quality of Life of Waterfront Settings, «QLWS» in Alexandria City, used for the analysis of selected sites. This model is used as a tool to assess the attractiveness and satisfaction of the existing spatial configurations in regard of professional observation. The discussion derives implications from the analysed data to support tracking relevant morphological mutations of social and physical parameters.

The research provides a guide to evaluate and promote natural based system integration for further transformation of sites incorporated within the city's strategic plan of 2032 to ensure sustainabillity, inclusivity, liveability and resilience.

Keywords: Coastal Cities, Natural Based Solutions, assessment indicators, Waterfront, Quality of Life

2   INTRODUCTION: URBAN DESIGN AND PLANNING DRIVEN BY NATURE-BASED SOLUTIONS

Coastal cities evolve in alignment with people centred development to accommodate their needs. Nevertheless, uncontrolled changes of significant elements of urban morphology such as land uses along the waterfront and respective public activities, lead to alterations in the quality of life provided. The research explores models that study the various configurations and implying the effective role of controlling urban developments guidelines in terms of environmental behavioural, social well being, health and safety. Urban design and planning driven by nature-based solutions play a significant role in transforming urban waterfront areas into sustainable and resilient spaces. It offers a transformative approach to building sustainable and liveable cities and has the ability to mitigate climate change, enhance biodiversity, improve human well-being, and foster economic growth.

Alexandria's waterfront proximity to the coast and recreational areas makes it an important setting for studying the health and well-being of residents and planning aspects that contribute to residents' quality of life (AS+P, 2020). The Alexandrian waterfront has undergone significant urban development and redevelopment projects, The city's waterfront has undergone two phases of development (AFD Report, 2015). The first phase involved widening the road and adding lanes by backfilling a portion of the sea. The second phase concentrated primarily on economic factors (Tawil, Arnouty, & Fadle, 2020).

3   RESEARCH METHODOLOGY

The research is divided into two main sections. Firstly, the study focuses on Alexandria City's Urban Morphology and its prospect of transformation plans, highlighting the nature-based integrative solutions on its waterfront for the short and long-term plans through multiple disciplinary interventions. Secondly, The research introduces the details of the structured model to assess Quality of Life of Waterfront Setting "QLWS" in Alexadria city, used for the analysis of selected sites. This model is used as a tool to assess the attractiveness and satisfaction of the existing spatial configurations in regard of professional observation. Finally, The discussion derives implications from the analysed data to support tracking relevant morphological mutations of social and physical parameters.

3.1 Nature-Based Solutions

The research relies on the opportunities provided by the hybrid (or multi-actor) governance for upscaling urban nature-based solutions (referred to as urban NbS), representing a demand-driven and cost-effective realization of urban enhanced spatial quality of life. The notion of applying nature-based solutions in urban development strategies implies the integration of multiple disciplines for the adapted design amd diversity of settings along the extended waterfront of Alexandria city that sustains the transformative potentials. The policies and procedures needed by urban planners have an open approach to collaborative governance of applying nature-based solutions while learning with and about new appealing designs, perceptions and images of nature from different urban actors (Haase A., 2018).

The most relevant concepts in adopting nature-based infrastructure and engineering with nature are the two common concepts which define NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"; while the second concept states that "NbS are inspired and supported by nature and simultaneously provide environmental, social, cultural and economic benefits" (LIU, etal., 2021). Therefore from the two main approaches of NbS, the process adopted in this research enables a balanced system maintaining nature-based solutions through professional observation and analytical representation of the community and social perceptions to ensure inclusivity, liveability and resilience.

3.2 Quality of Life in the Alexandria Waterfront «QLWS» Assessment Model Indicators Setting

Contemporary lifestyle patterns have changed the meaning and scope of activities in open public spaces, shifting their focus from daytime to nighttime. In these circumstances, the vitality and liveability of these spaces depends on their ability to adapt to and support the flexibility of these changes, despite their physical limitations (Rokanjac, 2022). The principles of improvement and the criteria for assessing the public spaces of a large city, such as multifunctionality, safety, legibility, sustainability, human scale, interactivity and flexibility (Kozlova et al., 2018). Existing open spaces adhere to most of these criteria classified into two categories, physical and socio- cultural (Nayer, 2015). Finally, the urban spaces are evaluated by identification indicators associated with each criterion, and classification of it. The evaluation can determine the value of each indicator and its role in increasing the quality of life in an urban area, and in the present, spontaneously supplemented with objects and structures, expanding their boundaries and following the rhythm of urban development (Mahdzar S, et al., 2014).

To conclude the set of indicators and sub-indicators proposed in this research as a prominent tool for the assessment for the Quality of Life in Alexandria Waterfront "QLWS", they are used to analyse respective zones along the extended coastal line of the City of Alexandria. The structured model refers not only to quantitative but also qualitative dimensions related to the Nbs approaches, where the categories and indicators are derived from the Smart Urban Quality by Chiara G. et. Al., 2018. The set of indicators also supports the observation process by the research team, as the sub-indicators describe the urban context with completeness eliminating subjectivity during the evaluation process. This significant assessment is represented by the information displayed in Table 1.

"QLWS" combines traditional aspects of urban quality with smart and sustainable aspects related to quality of life, health and well-being. The observation enables the researchers to consider the perception levels of visitors of the waterfront regarding: a) Emotional wellbeing, b) Spatial and Environmental Characteristics, c) Social wellbeing, and d) Safety and security. In addition, each of these aspects is defined through the sub-categories identifying the actual status of users' experience in the visited sites presented in the case studies, such as presence of green area, attractiveness of surrounding buildings, quality of street lighting, easy mobility and others.

The overall analysis derived from the structured model indicators set supports the relevant integrated environmental services to maintain quality of life. The study extends to overlook the potential activities and their inclusivety to assure liveability and sustainable public space in terms of economic opportunity and social inclusion. The perspectives summed up by the research team describe each variable and sub-set of indicators in order to actively apply sustainable management and conservation of natural resources to meet major societal challenges. Therefore "QLWS" provides for a balanced analytical scheme carried out using

858

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this assessment model of quality rating, relative to every need, at the census area of study, while investigating potentials of liveability and sustainability in the studied public spaces along the waterfront.

Main Indicators	Emotional wellbeing	Spatial and Environmental characteristic	Social wellbeing	Safety and security
Sub - Indicators	Presence and quality of green area	Noise control (Urban traffic)	Presence of spaces, services and activities suitable for children	Security and accessibility
	Attractiveness of surrounding buildings	Air pollution Control		Endurance to natural disaster
	Easy mobility	Presence of open spaces, services and activities	Economic opportunity and social cohesion	Design elements (Preventing any crime or injuries)
	Environmental maintenance	Healthcare services	Perception of safety	

Table 1: Indicators for the structured model of Quality of Life of Alexandria Waterfront, "QLWS", by authors.

4 URBAN MORPHOLOGY AND LANDSCAPE

The morphology of Alexandria City is strongly influenced by its coastal setting. The city has a long coastline that extends about 32 km along the coast of the Mediterranean Sea. It plays a significant role in shaping the city's identity and development and offers its residents a combination of natural beauty, recreational activities, cultural experiences, economic opportunities, and community gathering spaces. According to El Tawil et al.(2020), it is one of the major touristic targets, as well as one of the major motorists roads linking the entire city due to the linearity of Alexandria as a city.

Alexandria's waterfront proximity to the coast and recreational areas makes it an important setting for studying the health and well-being of residents and planning aspects that contribute to residents' quality of life. The Alexandrian waterfront has undergone two phases of significant urban development and redevelopment projects. The first phase began in the year 2000 and involved widening the road and adding lanes by backfilling a portion of the sea. The second phase began in the year 2018 and concentrated primarily on economic factors by moving some recreation areas and positioning the Sidi-Gaber bridge, which is elevated over the main street (Tawil, Arnouty, & Fadle, 2020).

The first stage of development improved social cohesion and harmony by making the city more walkable, connecting it longitudinally and providing spaces for cycling, creating an active zone. Providing spaces for walking (leisure and exercising) and cycling played a major role in enhancing the physical activity levels and mental health of residents (Farag, Saadallah, & Ayad, 2021). However it witnessed an increase in air pollution due to increased traffic density. The second stage relied on restaurants, cafeterias, and siting zones, whereby it encountered an increase in water pollution as a result of the presence of new places built directly on the sea without leaving any buffer zones. Furthermore, the construction of new cafes and restaurants and parking areas for them resulted in the loss of some parts of the sea view (Figure 1 a&b), which is a prominent natural view for Alexandria's residents. This led to a rise in despair by the residents (Tawil, Arnouty, & Fadle, 2020).

Figure 1 (a) and (b): Cafes, restaurants and parking areas blocking parts of sea view, by authors.

5 STUDY AREA AND SELECTION CRITERIA

Since improving public spaces, revitalizing the waterfront, and promoting sustainable development practices have been the main goals of modern urban planning initiatives, six open public places are selected for this study in an attempt to assess their attractiveness and satisfaction as a contribution to making the waterfront area a desirable place to live and enjoy the benefits of coastal living. By assessing environmental behaviour and its impact on the quality of life along the Alexandria Egypt waterfront, valuable insights can be gained to inform strategies for enhancing sustainability, fostering a sense of environmental responsibility, and improving the overall well-being of the community. The findings can guide the development of targeted

interventions, policies, and educational initiatives aimed at promoting sustainable behaviours and improving the environmental quality of the waterfront area.

The selected sites for the study are public open spaces and they extend along the shoreline of Alexandria City. The selected open areas for the study are located in the following areas respectively : 1) "Qaitbay" waterfront area, 2) "Ras El Tin" area, 3)" El Selsela" park area, 4)"Cleopatra" area, 5)"Louran" area and 6)"Bir Masoud" area (Figure 2). These six study areas are selected because they are not restricted to a specific group, but rather are welcoming to individuals and families of all ages. They are accessible all year and provide the best possible sea view. Moreover, they encourage interaction and connection between residents and the waterfront. Each of these areas represents a 100 to 500 m walking buffer.

Figure 2: Base map of the Six Selected Study areas along Alexandria extended Waterfront, by authors.
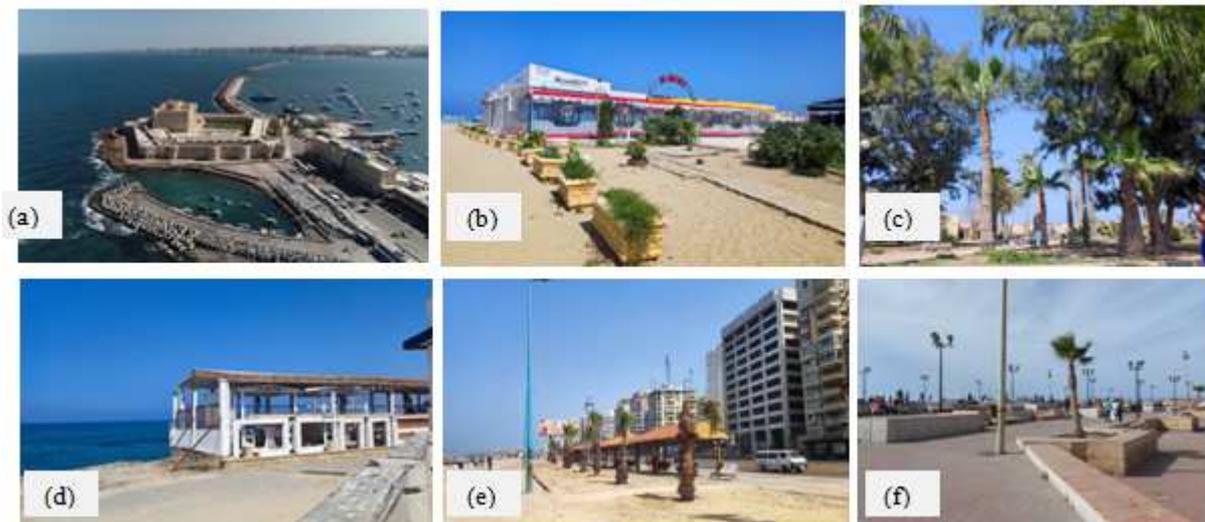
Figure (3): Six study areas (a) "Qaitbay" waterfront area. (b) "Ras El Tin" area, (c) "Selsela" park area (d) "Cleopatra" waterfront area, (e) "Louran" waterfront area and (f) "Bir Masoud" area, by authors.

5.1 "Qaitbay" Waterfront

The Citadel of Qaitbay area is situated in the Eastern Harbour of Alexandria city overlooking the sea (Figure 3a). It is known for its historical significance and is a major asset to the city and attracts citizens for gathering and tourists to enjoy its great view and enhance its monumentality. Qaitbay Citadel is a fortress built in the 15th century by Sultan Qaitbay. It offers panoramic views of the surrounding cityscape and the sea. It features cultural and recreational spaces that add to its appeal. A mix of facilities is provided along the waterfront that would appeal to visitors, and establish a specific local sense of place due to the Citadel of

860

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Qaitbay. There are also shops, cafes, and restaurants that cater for the needs of residents and visitors. The area has a lively atmosphere with a blend of local businesses and tourist-oriented establishments.

5.2 "Ras El Tin" area

Ras El Tin is situated on the eastern edge of Alexandria, along the Mediterranean Sea. Its location provides direct access to the waterfront. The Ras El Tin area features beautiful sandy beaches along the waterfront (Figure 3b). Residents and visitors can enjoy sunbathing, swimming, and beachside activities. The beaches in this area offer a space for people to unwind and enjoy the coastal environment. The Ras El Tin waterfront offers a pleasant promenade where residents and visitors can stroll and enjoy views of the sea.

5.3 "Selsela Park" area

Selsela Park is a public park located in front of the Bibliotheca Alexandrina in Alexandria City. It is a popular recreational space that serves as a gathering place for residents and visitors (Figure 3c). Its location provides convenient access for visitors to enjoy the park, relax and socialise. The park includes paved walking paths that meander through the greenery. It also provides seating areas scattered throughout the park.

5.4 "Cleopatra" waterfront area

The Cleopatra area is a well-known district. It is a bustling and vibrant part of Alexandria city. It is characterized by its wide streets, high-rise buildings, and a mix of residential, commercial, and recreational spaces. There is also a path only for pedestrians where they can walk and exercise freely. The waterfront parts of this area is home to numerous restaurants, cafes, and entertainment venues easily accessible by various means of convenient transportation options such as: public buses, taxis, and private cars. However, the presence of restaurants and cafes along the waterfront affect the sea view for the residents where some of these establishments partially obstruct the view of the sea (Figure 3d) and block parts of the walking paths made for pedestrians.

5.5 "Louran" area

Louran is a residential area in the middle of Alexandria city. The waterfront area in Louran also contains promenades that offer opportunities for leisurely walks, picnics, and gatherings to its residents. The studied area in Louran is a shaded public area constructed for pedestrians to sit and rest in the shade, socialise and enjoy the waterfront atmosphere, with restaurants and cafes beside it to provide food and beverage services. Patches of green areas and palm trees are also present but are currently under development (Figure 3e).

5.6 "Bir Masoud" area

"Bir Masoud" is an open space overlooking the sea located in the Sidi-Beshr residential area. This place has many legends revolving around it and is famous for a being a place that fulfils wishes by throwing coins into the well. The open space provides opportunities for socialising, picnicking, and enjoying the view of the sea. It also serves as valuable public resources where individuals and families can unwind, engage in leisure activities and some where residents can do some fishing. Restaurants are available around the area to provide food and beverage services to the residents (Figure 3f).

6 URBAN REGENERATION OBSERVATION AND ANALYSIS RESULTS

A site visit to the six sites under study was carried out in order to gather data, assess the attractiveness and satisfaction of the current spatial configurations, and record observations. Assessment was done using the survey mentioned above, that evaluates the following attributes: a) Emotional Wellbeing, b) Spatial and Environmental Characteristics, c) Social Wellbeing and d) Security and Safety from Natural Disaster, Crime and Injuries of each site. The following section discusses each of the mentioned indicators in the areas under study.

6.1 Emotional Wellbeing Attribute

Emotional well-being is influenced by various indicators, which are shown in table 2.

EMOTIONAL WELLBEING	INDICATORS	SUBINDICATORS
	i. Presence and Quality of green area	% of green area available
	ii. Attractiveness of surrounding buildings	Relative attractiveness
		Design : form and material
		Finishes
		Maintenance
	iii. Easy mobility	Availability of different transportation modes
	iv. Environmental maintenance	Cleanliness of space
		Condition of space
		Condition of pedestrians' area
		Quality of seating

Table 2: Indicators influencing the Emotional Wellbeing Attributes, by authors.

Figure 4: Surrounding area at (a) Qaitaby waterfront area, (b) El Selsela park area and (c) Cleopatra waterfront area, by authors.

Table 3 illustrates observations of each site under study regarding the emotional wellbeing attributes.

Indicator: (i) Presence of Green Area		
Study area	%	Actual Condition for related settings
Qaitbay waterfront area	0%	No green area
Ras El Tin area	20%	Ras El tin mainly consists of beaches along with restaurants, cafeterias and clubs. The available green space can only be found in the children's playing areas
El Selsela Park area	85%	The entire park comprises green areas with pedestrian paths flowing through them, as well as trees and palm trees to provide shade to people.
Cleopatra waterfront area	0%	No green area
Louran waterfront area	67%	The existing green areas and palm trees are between the seating area and pedestrian route, however these green spaces were still under renovation at the time of the site visit.
Bir Masoud area	0%	No green area
Indicator: (ii) Attractiveness of Surrounding Buildings		
Study area	%	Actual condition of related settings
Qaitbay waterfront area	65%	Some of the buildings there are currently under renovation
Ras El Tin area	42%	Buildings in the Ras El Tin area are not attractive and some need maintenance
El Selsela Park area	83%	The park is located in front of Bibliotheca Alexandrina. Moreover, it contains a white statue of a mermaid which is considered as a landmark of the area
Cleopatra waterfront area	67%	Consists of residential buildings overlooking the sea. Some of them are newly built, others are old and need some renovations.
Louran waterfront area	67%	
Bir Masoud area	67%	
Indicator: (iii) Presence of Easy Mobility Services		
Study area	%	Actual condition for related settings
Qaitbay waterfront area	100%	All areas are reachable and accessible via several means of transportation, including public transportation, taxis, private automobiles, and buses.
Ras El Tin area		
El Selsela Park area		
Cleopatra waterfront area		
Louran waterfront area		
Bir Masoud area		
Indicator: (iv) Environmental Maintenance Indicator		
Study area	%	Actual condition of related settings
Qaitbay waterfront area	55%	Poor condition of space and pedestrian area as a result to the current developments taking place there
Ras El Tin area	67%	Moderate condition of space in which maintenance is required to the seating areas and to the restaurants and cafeterias located there
El Selsela Park area	80%	The overall condition is due to cleanliness and good condition of the pedestrian route
Cleopatra waterfront area	75%	Some of the seating areas there need maintenance
Louran waterfront area	75%	Moderate condition of space and seating area due to the current development taking place there
Bir Masoud area	90%	Good condition of the space, pedestrian area, and seats

Table 3: Percentage and observation of the Emotional Wellbeing Attributes in each site under study, by authors.
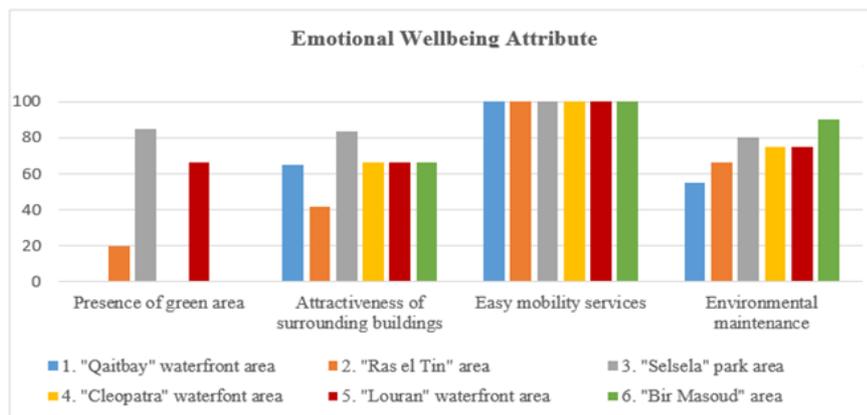
Figure 5: Percentages of Emotional Wellbeing Indicators in the six understudy areas, by authors.

6.2 Spatial and Environmental Characteristics Attribute

The assessment of Entivronmental Characteristics attribute adopted a number of indicators. They are shown in table 4.

	INDICATORS	SUB - INDICATORS
SPATIAL AND ENVIRONMENTAL CHARACTERISTICS	i. Noise control (Urban traffic)	Horns level control
		Distance from traffic, cars
	ii. Air pollution Control	Number of street lanes
		Flow of traffic
		Availability of trees
		Availability of open space
	iii. Presence of open spaces, services and activities	Percentage of open space
		Quality of services
		Presence of urban furniture
		Presence of parking areas
	iv. Healthcare services	Presence of medial office
		Quality of medical office
		Presence of ambulance

Table 4: Indicators adopted for the Environmental Characteristics Attribute, by authors.

Figure 6: Urban furniture and seating areas at (a) El Selsela Park, at (b) Louran area and at (c) Bir Masoud area, by authors.

Table 5 illustrates percentages and observation of each site understudy in Environmental characteristics attribute.

Indicator: (i) Noise Control (Urban traffic)

Study area	%	Actual Condition for related settings
Qaitbay waterfront area	95%	The furthest away from car traffic. People enter the area with their cars only to park. This results in the low levels of car horns in the area.
Ras El Tin area	50%	Beaches are considered far from the traffic, but restaurants and cafeterias there are closer to traffic
El Selsela Park area	33%	Closer to car traffic, resulting in light levels of car horns makeing the place a bit noisy during some times of the day.
Cleopatra waterfront area	33%	
Louran waterfront area	33%	
Bir Masoud area	33%	

Indicator: (ii) Air Pollution Control

Study area	%	Actual Condition for related settings
Qaitbay waterfront area	85%	Air pollution control in the six understudy areas are moderate to high. This is because they all overlook the sea and thus receive fresh air from it. However, they are near the cars traffic with wide street and high traffic flow condition.
Ras El Tin area	67%	
El Selsela Park area	83%	
Cleopatra waterfront area	67%	
Louran waterfront area	75%	
Bir Masoud area	65%	

Indicator: (iii) Presence of Open Spaces, Services and Activities

Study area	%	Actual Condition for related settings
Qaitbay waterfront area	73%	The Qaitbay waterfront has high percentage owing to the availability of vast open spaces and good quality of services available
Ras El Tin area	67%	Availability of vast open spaces but moderate quality of services
El Selsela Park area	55%	Moderate quality of services and urban furniture. Absence of parking areas
Cleopatra waterfront area	55%	Moderate condition of urban furniture where some of the seating needs maintenance as well as moderate quality of available servies
Louran waterfront area	27%	Got the lowest perentage due to the lack of parking spots, in addition to the fact that it is now under development, resulting in inferior service quality.
Bir Masoud area	67%	Lack of parking areas along with moderate services and urban furniture.

Indicator: (iv) Healthcare Services

Study area	%	Actual Condition for related settings
Qaitbay waterfront area	70%	Health care services are available as it is an important touristic attraction area
Ras El Tin area	60%	There is a healthcare medical office available near there but it needs improvements
El Selsela Park area	0%	These areas rely on mobile ambulance services
Cleopatra waterfront area	0%	
Louran waterfront area	0%	
Bir Masoud area	0%	

Table 5: Percentage and observation of Environmental Characteristics Attributes in each site under sstudy, by authors.
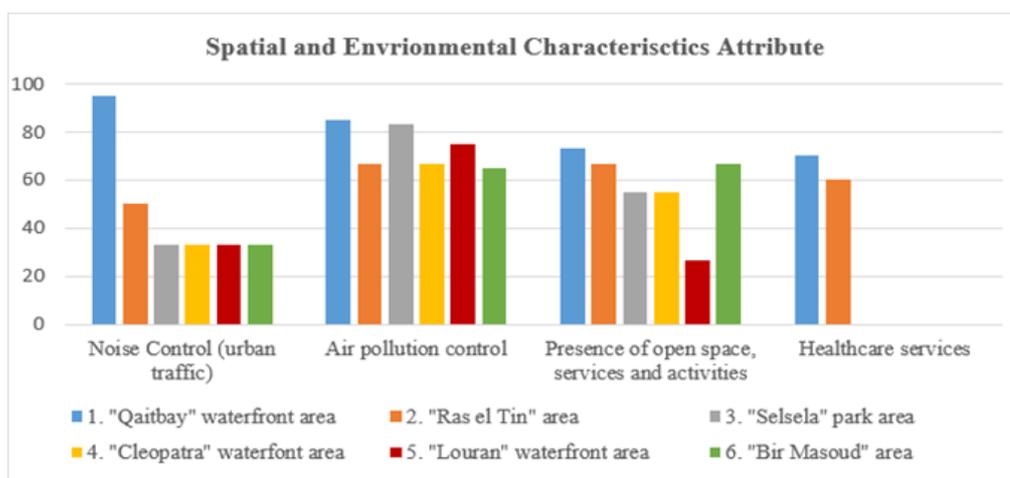
Figure 7: Percentages of Spatial Environmental Characteristics Indicators in the understudy areas, by authors.

6.3 Social Wellbeing Attribute

Social wellbeing is also assessed by evaluating and observing several indicators, they are demonstrated in table 6.

	INDICATORS	SUB - INDICATORS
SOCIAL WELLBEING	i. Presence of spaces, services and activities suitable for children	Availability of Childcare facility
		Quality of available childcare facility
		Percentage of open childcare space
	ii. Economic opportunity and social cohesion	Socio-economic level
		Social Cohesion
	iii. Perception of safety	Sense of safety
		Availability of threat
		Type of threat (if available)

Table 6: Indicators assessed in the Social Wellbeing Attribute, by authors.

Indicator: (i) Presence of Spaces, Services and Activities Suitable for Children		
Study area	%	Actual condition for related settings
Qaitbay waterfront area	0%	No playing area for children available
Ras El Tin area	60%	There is a playing area for children but of poor condition
El Selsela Park area	15%	No playing area for children available, however they can play in the green areas available
Cleopatra waterfront area	89%	There is a playing area for children alongside the cafés and restaurants situated there
Louran waterfront area	0%	No playing area for children available
Bir Masoud area	0%	No playing area for children available
Indicator: (ii) Economic Opportunity and Social Cohesion		
Study area	%	Actual condition for related settings
Qaitbay waterfront area	89%	The highest percentage, because the majority of visitors are tourists and the location provides excellent opportunities for social cohesion
Ras El Tin area	50%	It allows high social cohesion opportunities among residents, however the people are of moderate socioeconomic and economic status.
El Selsela Park area	67%	They are equal in percentages because they receive residents of similar socio-economic level. Social cohesion is high but less than that at Qaitbay waterfront area.
Cleopatra waterfront area	67%	
Louran waterfront area	67%	
Bir Masoud area	65%	It allows very high social cohesion opportunities among residents, however the people are of moderate socioeconomic and economic status specially visitors from neighbouring rural areas.
Indicator: (iii) Perception of Safety		
Study area	%	Actual condition for related settings
Qaitbay waterfront area	89%	High sense of safety as they are crowded with people during the daytime, especially on weekends. However the presence of beggars results in the slight decrease of security perception
Ras El Tin area	56%	May experience more risks than other areas because of their lower socioeconomic status. However, it is crowded with people during the daytime and at night especially on weekends and in the summer.
El Selsela Park area	56%	Sense of safety at El Selsela park area decreases at night because the street lights are inadequate, thus people avoid going there after it gets dark
Cleopatra waterfront area	89%	High sense of safety as they are crowded with people during the daytime especially on weekends. However the presence of beggars results in the slight decrease of security perception
Louran waterfront area	67%	Even though streetlights in the Louran area are also inadequate at night, but with the presence of nearby cafes, people feel safer there than they do in the El Selsela park area
Bir Masoud area	56%	May experience more risks than other areas because to their lower socioeconomic status. However, its crowded with people during the daytime and at night especially on weekends and in summer.

Table 7: Percentage and observation of Social Wellbeing Attribute in each site understudy, by authors.

Figure 8: Open Spaces at (a) Selsela park area, (b) Ras El Tin area and (c) Louran waterfront area, by authors.

Table 7 illustrates percentages and observation of each site understudy in Social wellbeing attribute.
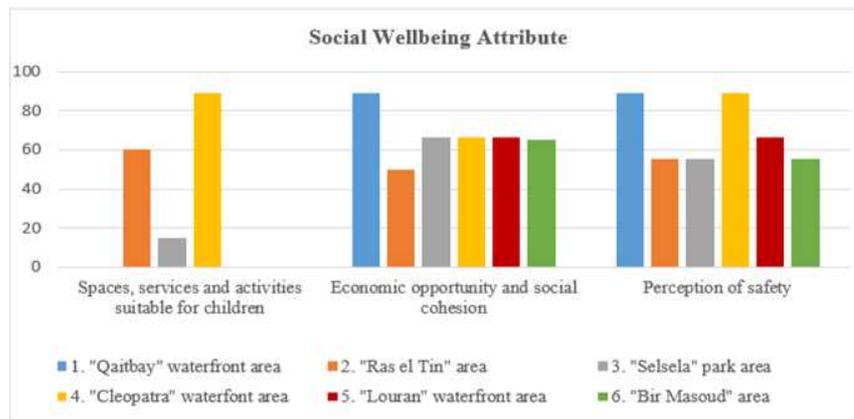
Figure 9: Percentages of Social Wellbeing indicators in the six areas understudy, by authors.

6.4 Security and Safety from Natural Disaster, Crime and Injuries

Indicators and Sub-indicators that are used to assess security and safety from natural disaster and crime are illustrated in table 8.

	INDICATORS	SUB-INDICATORS
SECURITY AND SAFETY from natural disaster, crime and injuries	i. Security and Accessibility	Surveillance
		Security presence
		Low level of crime
		Sightlines and clear visibility
		Clear access points
		Convenient access points
		Clear boundaries of space
	ii. Endurance to Natural Disaster	Endurance of space from natural disaster
	iii. Design Elements (to prevent any crime or injuries)	Quality of paving materials
		Smooth and safe pedestrian movement (no obstacles)
		Clear pedestrian routes
		Lighting levels of space
		Density of visitors

Table 8: Indicators and Sub-indicators assessed in the Security and Safety Attribute, by authors.

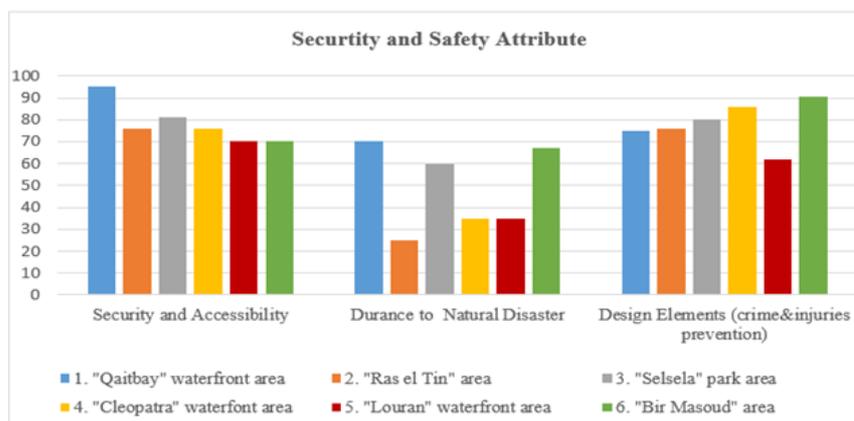Table 9 illustrates percentages and observation of each site understudy in Security and Safety Attribute

Figure 10: Percentages of Safety and Security indicators in the six areas understudy, by authors.

Indicator: (i) Security and Accessibility		
Study area	%	Actual Condition for related settings
Qaitbay waterfront area	95%	It is found to be the highest/ Due to the importance and significance of the Qaitbay waterfront area as a main attraction site for tourists in Alexandria City, there is constant surveillance and security presence to reduce the level of crime. There are also clear and convenient access points to the area. However, some buildings there are under development that slightly reduces the clear visibility of the whole area.
Ras El Tin area	76%	It is near a military base and has clear accessibility points, however these access points need improvements to be more convenient
El Selsela Park area	81%	It is near a military base and has clear and convenient accessibility points
Cleopatra waterfront area	76%	Has relative high percentage of security in addition to clear and convenient accessibility points
Louran waterfront area	70%	Has moderate percentage of security, however there are clear and convenient accessibility points
Bir Masoud area	70%	
Indicator: (ii) Endurance to Natural Disaster		
Study area	%	Actual condition for related settings
Qaitbay waterfront area	70%	Endurance is high due to water catchments installed around the area
Ras El Tin area	25%	Endurance is low because it is mainly a beach that makes it very susceptibility to any changes of the sea and some of the restaurants and cafeterias are on the beach.
El Selsela Park area	60%	Perentage is moderate because there is a military base there that has catchments installed to prevent any harm
Cleopatra waterfront area	35%	Endurance is low due to the proximity to the sea and susceptibility to its effects.
Louran waterfront area	35%	
Bir Masoud area	67%	Endurance is relatively moderate to high because its level is higher than that of the sea level and the main street as well.
Indicator: (iii) Design Elements		
Study area	%	Actual condition for related settings
Qaitbay waterfront area	75%	Design elements are affected, due to current development taking place there
Ras El Tin area	76%	Area recieves high density of residents. However, smoothness in movemenr and lighting levels of space are moderate in level
El Selsela Park area	80%	Good condition of paving materials. There is smoothness in movement and clear pedestrians paths, however the areas has low lighting levels at night
Cleopatra waterfront area	86%	Good condition of paving materials, smoothness in movement and clear pedestrians paths
Louran waterfront area	62%	Lowest in percentage due to the developments that are currently taking place there.
Bir Masoud area	90%	Good paving materials, high density of visitors, smooth movement in the area and adequate lighting levels

Table 9: Percentage and observation of Security and Safety Attribute in each site understudy, by authors.

6.5 Quality of Life in each of the areas under study

Combining the attributes evaluated above: a) Emotional Wellbeing, b) Spatial and Environmental Characteristics, c) Social Wellbeing, d) Security and Safety from Natural Disaster, e) Crime and Injuries of each site, it is possible to determine the quality of each of the areas under study, illustrated in the Table 10, below. Impact of indicators are calculated with equal weights to assure maximum value of quality of life to all study areas.

Indicators / Area understudy	Emotional wellbeing	Spatial and Environmental characteristic	Social wellbeing	Safety and security	Total score	Total Quality of life
	Out of 400	Out of 400	Out of 300	Out of 300	Out of 1400	%
Qaitbay waterfront area	220	323	178	235	956	68.3%
	The Qaitbay waterfront area has the highest quality of life, as it is one of the primary tourist destinations. Nevertheless, quality of life there is affected by lack of green areas, lack of children facilities and development taking place there. However, the percentage of its quality of life is projected to rise once the developments there are completed.					
Ras El Tin area	229	244	166	177	816	58.3%
	Quality of life in the Ras el Tin area is considered low because of the few green areas with only some trees and palm trees, low maintenance and quality of services, moderate condition of space, and is near traffic causing noise. Moreover, it has low endurance to any natural risks.					
Selsela park area	348	171	138	221	878	63%
	The Selsela Park area has moderate quality of life as it is very close to traffic, has no parking, no kid-friendly amenities, and is dark at night. However, it has a large green area and good endurance to any natural risks.					
Cleopatra waterfront area	242	155	245	197	839	60%
	The Clepatra area contains a path only for pedestrians, where they can walk and exercise freely. However, some of these paths are obstructed by cafes and restaurants. Its percentage can be considered moderate due to several factors such as: lack of green areas, some of public seating needs repair, proximity to traffic which results in loud noise from car horns, especially during the rush hours/ Moreover it has low endurance to any natural risks.					
Louran waterfront area	309	135	134	167	745	53.2%
	The Louran area has the lowest quality of life percentage, which is likely due to the ongoing development there, where green spaces are still being refurbished and finishing touches are still being added. It is also near to traffic and has no children friendly area.					
Bir Masoud area	257	165	121	227	770	55%
	Quality in the Bir Masoud area is considered aas low, due to the absence of green areas and trees and being situated near car traffic. Moreover, there is no nearby medical healthcare facilities and no security presence.					

Table 10: Quality of Life for each area understudy, by Authors.

7   DESIGN GUIDELINES AND RECOMMENDATIONS

The analytical assesment demonstrating the integrative approach is represented according to the impact of the measured aspects collectively as per Figure 11 (below). The results shows that there is always capacity for integrating solutions related to spatial configurations in order to simulate visitors experience in the selected site. However, as the analysis demonstrates, the impact varies between the areas selected due to differences in design capacities and existing infrastructure.

One of the major implications is demonstrating how a longer promenade enhances the visitors' experience such as at "Qaitbay" waterfront area and "Cleopatra" waterfront area, where visitors experience the most social well being aspects due to the variety of activities and the changing views along the waterfront. On the

866

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otherhand, the more contained sites as the "Selsela park" and the "Ras El Tin" area offer more greenery and zones of activities, however, they do need more pedestrianised continiuity in the pathways. Using the open areas as cultural hub spaces through gathering and open exhibitions areas for public art works can highlight the local identity of the, which improves the social wellness of the area with low social wellbeing attributes. Organizing seasonal festivals, and cultural events can also encourage social interaction and celebrate community diversity.

Regarding the emotional wellbing, the research recommends urban greening by increasing the landscaping features with greenery and trees as noticed on the high impact of integrated values in the "Loran" waterfront and El Selsela areas, and moderate at Ras el Teen, meanwhile sites as Qaitbay and Cleopatra lack the benefits of green covers and provided shades. Moreover, green areas and trees reduce ambient temperatures, improve air quality, and lower energy demands for cooling. Designing the waterfront area with therapeutic landscaping elements such as sensory gardens, aromatic plants, and textures can engage the senses and promote attractiveness of the space. Some retail areas promote the use of artificial plants in the last two sites, this decreses the aesthetic values as well as the environmental considerations.

Relatively all the sites require more integration of safety measures by installing well-placed lighting to illuminate pathways, seating areas, and gathering spaces, enhancing the spacial arrangements, furnishings the transitional activities, the quality of sustainable materiality of the furnishings, pavement, and fixtures. Moreover, enhancing the resilience aspects of all waterfront areas to natural disasters is crucial to improve safety and security of areas.
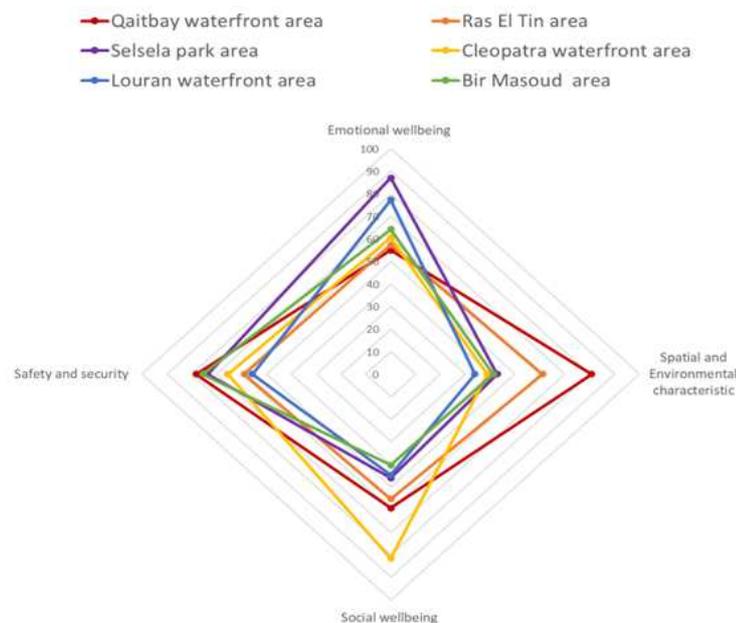
Figure 11: Integrative assesment for selected indicators, by Authors.

8 IMPACT OF URBAN POLICY REGARDING NBS IN SELECTED SITES

The researchers recommendations derived from the model verification of the quality of life in the study areas along the Alexandria waterfront support an integrative urban policy approach. The set of recommendations include socially sustainable and responsible mobility solutions.

The researchers promote the idea of "Green and Blue Infrastructure" as natural infrastructure linking the whole territory of a city by integrating green spaces, parks, and pedestrian-friendly waterfront promenades into the planning tools. Implementing green and blue infrastructure involves creating a network of interconnected natural and semi-natural features in urban waterfronts, which is also stated in the authorities' strategic planning procedures. Community responsiveness towards existing and future interventions should be integrated in the decision making process. For example, Green and Blue Infrastructure contributes to monitoring extentions of retail facilities, which takes into account spatial potentials as well as social, economic and cultural factors.

Green and Blue infrastructure attracts tourism, improves property values, and stimulates economic development, particularly in waterfront urban areas that prioritise sustainable and nature-oriented design.

Another nature-based solution is incorporating green roofs into waterfront buildings. as it can help manage the strain on urban drainage systems during rain, and improve water quality. Green roofs can also contribute to energy efficiency by insulating buildings and reducing the urban heat island effect.

Finally, the recommendations for improvements along the waterfront of Alexandria also concern the sociatal responsiveness to the deterioration of the distributional and procedural effeciency of plans, the need to provide choices, as well as incorporating public contribution into the short and long term processes of decision making.

9 CONCLUSION

The research findings support the integration of citizens' contribution in the decision making process to confirm the consistency of policies and planning processes which will maintain the characteristics of Egyptian cities, bearing in mind the need to control change and inform new development attempts along the extended waterfront.

The green and «blue» spaces in and around the city fulfil an increasingly important role in the welfare of Alexandria's inhabitants and as criteria for businesses to establish themselves in the city. Positioning itself as an international attractive city Alexandria should use its events as an occasion to foster not only the core of the metropolitan area, but also the neighbouring cities.

The findings of the Assessment Model "«QLWS»" highlight how implicit opinion of expertise in combination with bottom-up consultation procedures can impact new policy formulation. They recognise the role of current and future voices in upgrading level of services and quality of life provided on the waterfront. They recognise that accessibility, transport, joint events, communication and marketing will become priority measures to ensure the success of future regeneration of communities and overall potential of Alexandria waterfront.

10 REFERENCES

AFD (Agence Française de Développement), Alexandria: Regenerating the city A contribution based on AFD experiences, 2015. www.afd.fr

A.Nayer: Spatial Consciousness Assessment; Case Study: A responsive sense of place, Jeddah Cornice development, 12th L&T conference proceedings: "Wearable Technologies", Effat University, Jeddah, May 2015.

(AS+P) Strategic Urban Plan Alexandria 2032 Report, July 2020.

Chiara Garau and Valentina Maria Pavan, Evaluating Urban Quality: Indicators and Assessment Tools for Smart Sustainable Cities, Sustainability, vol: 10, p:575. An Open Access Journal from MDPI, 2018. doi:10.3390/su10030575.

Farag, D., Saadallah, D. M., & Ayad, H. M. (2021). Assessing the Impact of Urban Determinants on Physical Activity Engagement: An Applied Study on the Residents of Alexandria City, Egypt. CITIES 20.50–Creating Habitats for the 3rd Millennium: Smart–Sustainable–Climate Neutral. Proceedings of REAL CORP 2021, 26th International Conference on Urban Development, Regional Planning and Information Society (pp. 89-100). CORP–Competence Center of Urban and Regional Planning.

Haase A.: The Contribution of Nature-Based Solutions to Socially Inclusive Urban Development– Some Reflections from a Social-environmental Perspective. In: Kabisch, N., Korn, H., Stadler, J., Bonn, A. (eds) Nature-Based Solutions to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transitions. Springer, Cham, 2018.

https://doi.org/10.1007/978-3-319-56091-5_13Kozlova1 L., Valery Kozlov V.: Ten quality criteria of the public spaces in a large city, MATEC Web of Conferences 212, 04012 (2018) https://doi.org/10.1051/matecconf/201821204012.

LIU, Hai-Ying: The Role of Nature-Based Solutions for Improving Environmental Quality, Health and Well-Being. Sustainability, vol. 13. P:1-56, 2021. 10.3390/su131910950.

Mahdzar S., Jaberolansar S.: A Review of Effective Factors of Urban Design with an Emphasis on Pedestrian Movement, Journal of Basic and Applied Scientific Research, vol. 4(5)97-104, 2014. ISSN 2090-4304.

Ministry of Planning, Egypt, Sustainable development strategy, Egypt's vision 2030 and planning reform, 2015.

Rakonjac, I.; Zori´c, A.; Rakonjac, I.; Miloševi´c, J.; Mari´c, J.; Furundži´c, D. Increasing the Livability of Open Public Spaces during Nighttime: The Importance of Lighting in Waterfront Areas. Sustainability 2022, 14, 6058. https://doi.org/10.3390/su14106058

Riham A. Ragheb, Alexandria's Eastern Entrance: Analysis of Qaitbay Waterfront Development, International Scholarly and Scientific Research & Innovation 8(8) 2014. ISNI:0000000091950263.

Tawil, K. H., Arnouty, S. M., & Fadle, H. A.: The Social Impact and Seafront Development, Scientific Journal of the Faculty of Fine Arts Alexandria University, 2020. (Print ISSN: 2356-8038 - Online ISSN: 2535-227x).

UNDP, Egypt. Participatory Strategic Urban Planning for Alexandria City till 2032, 2016. http://www.eg.undp.org/content/egypt/en/home/presscenter/pressreleases/2016/12/26/general-organization-for-physical-planning and-the-united-nations-development-programme-sign-participatorystrategic-urban-planning-for-alexandria-city-till-2032-in-presence-of-minsters-of-international-cooperation-and-housing.html

Towards the Evaluation of Possible Indicators for the Provision of Green Spaces in Settlements to Promote Physical Activity among the Population

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1 ABSTRACT

Publicly accessible and usable green spaces in cities and smaller settlements are important for promoting physical activity and consequently for maintaining and improving public health. Adequate provision of such spaces is crucial for planning of a quality living environment. Research to date has identified different aspects in linking public health and green spaces. However, the problems of existing approaches and methods include inconsistencies in evaluating different aspects of public spaces for physical activity, lack of inclusion of social and health benefits of green spaces in green space indicators, and lack of integrated approaches towards defining the provision of green spaces to promote physical activity. Accordingly, a solid spatially explicit indicator for assessing the provision of settlements with green spaces for physical activity is non-existent. The purpose of this paper is to present the literature review and methodological framework developed within the Slovenian research project titled Development of indicators for the assessment of the provision of settlements with green spaces for outdoor physical activity that addresses aspects of public green spaces and related indicators for assessing the adequacy of the conditions provided by urban green spaces for different types of physical activity. We have defined three basic types of physical activity, namely: activities that are carried out in one place, activities that cover distance for leisure of recreation, and activities that cover distance to reach a goal (i.e., daily active mobility). Guided by this definition, we conducted a literature review to examine: (1) which spatial aspects of enabling or promoting physical activity are addressed by existing green space indicators, (2) to which spatial scale and to which spatial planning levels are indicators linked and, (3) whether indicators address different types of physical activity. Based on the findings, suggestions are made to develop a more spatially explicit indicator to assess the provision of green spaces in settlements for the three types of physical activity. Such an indicator can strengthen the long-term monitoring of the condition of publicly accessible green spaces for recreational use by the population.

Keywords: physical activity, public health, green space provision, spatial planning, spatial indicators

2 INTRODUCTION

In recent years, attention to adequate physical activity has been raised by leading health organisations and official bodies on different levels. The World Health Organisation (WHO) has been promoting increased levels of physical activity to prevent chronic non-communicable diseases and maintain a healthy lifestyle, most recently with very precise recommendations for physical activity and health, which define the recommended amount of physical activity per week for different age groups (World Health Organization, 2020). Moreover, in Europe has the European Commission (EC), beside acknowledging the importance of raising physical activity of the population, recognised the importance of supporting a cross-sectoral approach to tackle unhealthy lifestyles. The EU Guidelines on Physical Activity (2008) give an important role to spatial planning and, in the guidelines for spatial planning, highlight the importance of creating an environment in which the population can be physically active, in particularly with regard to ensuring safe and comfortable everyday mobility, interlinking of recreational areas when building new neighbourhoods, the protection of the natural environment, and taking into account the needs of different population groups.

In recent years, the importance of spatial planning to support people's physical activity has been recognised also in Slovenia, not only in research but also in policy making. The national Resolution on the National Programme on Nutrition and Physical Activity for Health 2015–2025 (ReNPPTDZ, 2015) is an important document which supports cross-sectoral cooperation to tackle the inactivity of population and, among others, stresses the importance of ensuring a healthy living environment for all population. Furthermore, the Spatial Development Strategy of Slovenia (2004) is the overarching document that defines the objectives of spatial development and is the basic strategic spatial document for the coordination of sectoral policies. The new Draft (MOP, 2020) emphasises the pursuit of a high proportion of green spaces in cities, allowing residents

and visitors to socialise and recreate outdoors. Providing opportunities for healthy lifestyles in cities through the creation of green urban systems is also listed among the priorities for achieving the Strategy's objectives. Since 2017, the Ministry of Health has been funding activities to closely integrate different aspect of physical activity into spatial planning. As a result, the authors prepared a manual and guidelines to support municipalities in planning, evaluation, improvement and monitoring of public green open spaces for the population's physical activity (Šuklje Erjavec et al., 2020b). This study continues these efforts by inspecting indicators for the provision of green spaces to promote physical activity. We suspect that despite the existence of strategic documents such as the Spatial Development Strategy of Slovenia, and legislation in the field of spatial planning (e.g., Spatial Management Act (ZUreP-3)), which emphasise the importance of green spaces for the quality of the environment and the health of the population, methods and tools for evaluating the adequacy of the planned and existing spatial conditions of municipalities for a healthy lifestyle are scarce, and sectoral transfer of knowledge is only just starting to be established. We see the potential in developing an indicator which is adjusted to Slovenian spatial characteristics. The latter relate to small settlements size in comparison to other European countries, the absence of regional planning, the tendency towards an ageing population, giving priority to tourism over the needs of the local population, and land property regulations.

Accordingly, this study aims to critically inspect the literature to set a framework for the development of a spatially explicit indicator for assessing the provision of green spaces to promote physical activity, adjusted for Slovenian circumstances. We set the following research questions:

(1) Do existing green space indicators address spatial aspects of enabling or promoting physical activity?

(2) For which spatial scale and spatial planning levels are indicators of physical activities in green spaces designed?

(3) Do these indicators address different types of activities?

To answer these questions, we performed a non-systematic review of existing aspects of green space and indicators of physical activities in green spaces. Based on the review, we set the framework for the assessment of aspects and indicators to support green space planning and management of Slovenian settlements.

3 NON-SYSTEMATIC REVIEW OF RELEVANT ASPECTS AND INDICATORS

3.1 Aspects of green space provision to promote physical activity in settlements

A growing body of research has examined how different aspects of green space, such as access, size and design features, relate to leisure and physical activities. Most of the literature highlights three aspects of provision: accessibility: proximity or coverage of a settlement based on established distance criteria; green space size and extent, which is mostly linked to population density within specific areas and the green space network; and assessment of quality, which is primarily focused on the presence of natural elements(see, for example, de la Barrera et al., 2016; Grunewald et al., 2017; Hillsdon et al., 2006).

In our review, we focused on aspects which are relevant for spatial planning. With this regard, Kaczynski and Henderson(2007) reviewed fifty quantitative studies and found that proximity to parks and recreational environments (public green spaces) is generally associated with people being more physically active. Qualitative evidence further suggests that safety, aesthetics, convenience, maintenance and proximity to public open spaces are important features that support physical activity(McCormack et al., 2010).In the Slovenian context, Šuklje Erjavec et al. (2020b)identified quality aspects of green space design to promote active lifestyles, highlighted from the perspective of urban and neighbourhood planning and partly through management. Based on these reviews, we further inspected aspects, important for the aims of this study. Each of them is briefly described and assessed in the following sub-sections.

3.1.1 Public access to green spaces

This aspects a basis to achieve equal opportunities for green space use and a key factor for assessing the green space provision of settlements. It is closely linked to the aspect of distribution, connectivity, and continuity of green spaces. Various studies have found that proximity to green spaces is crucial for its use (Cohen et al., 2007; Giles-Corti and Donovan, 2002; Harnik and Simms, n.d.). Most research methods are

based on measuring the distance of dwellings to the nearest green space. Usually they use buffers with a specific radius, most commonly a 300m for walking distance to the nearest green space(see for example Coles and Bussey, 2000; Giles-Corti and Donovan, 2002; Grahn and Stigsdotter, 2003; Nielsen and Hansen, 2007).In these studies, green spaces are often determined on the basis of land use data and their accessibility is measured with the geographic information system (GIS) tools. The problem with such approaches is that many public green spaces that are important for promoting physical activity are not included in the land use databases or are classified as some other land use (such as residential landscapes, hiking trails, urban forests, riverbanks and similar). Besides, distance radiuses quite often do not provide accurate information about accessibility due to different spatial barriers such as high traffic roads, railway lines, steep slopes but also lack of appropriate pedestrian and cycling pathways. Therefore, measurements of accessibility that use a network of existing pathways, e.g. the Network Analyst tool (Oh and Jeong, 2007) are much more accurate but less common mainly due to technical complexity of its use.

Furthermore, physical distance is just a part of the accessibility aspects. In addition to the physical distance, the time component is also important. Older people, parents with young children, or the disabled will take much longer to cover the same distance than a young, physically fit person(Biernacka et al., 2022; Kimpton, 2017). Therefore, an important factor in assessing accessibility is also the aspect of quality: universal design, safety, climatic and ambient pleasantness, attractiveness, etc.(Šuklje Erjavec et al., 2020b).

Accessibility is also strongly linked to perception of space and social inclusion, or a sense of belonging and acceptance. Some studies take into consideration the perceived accessibility of a green space and examine it by tools such as a user survey of subjective views or expert judgements based on various criteria (Sugiyama et al., 2008; Tilt et al., 2007) as well as other qualitative parameters (Giles-Corti et al., 2022).

3.1.2 Location and connectivity of green spaces

The location and connectivity of green spaces are important for the spatial distribution of green spaces in a settlement, also impacting their accessibility. The distribution of different types of green spaces is also particularly important in this context, as they allow for different forms of everyday use. The provision of multifunctional green spaces is therefore particularly important, especially in small settlements.

A balanced distribution of green spaces in settlements is key to ensuring that all residents have equal opportunities to use green spaces in their daily lives(Verma et al., 2020, Šuklje Erjavec et al., 2020). The distribution is important both at a larger scale (inter-urban, municipal) and at the local level(settlements, neighbourhoods).

Location of green spaces is often pre-defined by landscape characteristics of the settlement and its surroundings. Usually just a part of the public urban green space provision is designed and implemented completely anew. Therefore, their interconnectivity, in the form of pedestrian, cycle, and thematic routes as well as green space features, which in themselves provide stimulating settings for certain forms of physical activity, make an essential contribution to this aspect(Sander et al., 2017).

To ensure equal opportunities for all residents, green spaces need to be planned in a comprehensive and systematic way, considering population density and the distribution of existing publicly accessible green spaces. The most appropriate approach for the integrated planning of a balanced distribution and connectivity of green spaces is the design of a green system or green infrastructure. In Slovenia, as part of the comprehensive green system planning, a Green System Plan for Active Lifestyles is foreseen as a thematic concept of the green system of a settlement. It aims to provide appropriately distributed public green and other open spaces for physical activity of inhabitants(Bizjak et al., 2020).

3.1.3 Attractiveness of green spaces as support for their active use

The attractiveness of a place is a key factor in choosing open space for recreational use and the frequency of its use. Lundh (2017) notes that aesthetic experience is a primary consideration when choosing recreational places to visit, while comfort and meeting other people are important factors when spending time in outdoor spaces. The studies on urban environment attractiveness are often based on establishing indicators of the 'greenness' of a particular space, streets, neighbourhoods, cities. Despite the complex aspect of achieving quality, the quantity of natural elements is most often considered as a key parameter for the attractiveness. Attractiveness is most commonly inspected in studies through measuring natural features such as vegetation, water, animals, and the level of biodiversity (Lundh, 2017).

Methods based on satellite data have been implemented in the past to measure the presence of vegetation in specific areas(Sripada et al., 2006; Tucker, 1979), which include the ground plan representation of green areas, and methods from the perspective of the user, e.g. analyses of vegetation along streets using Google Street View, for example the greening view index(Ki and Lee, 2021). In addition to vegetation, other parameters are also used, e.g. for biodiversity including animals. Lundh (2017) used questionnaire-based and site-specific surveys for measurement of bird retention and detection in urban areas as parameter for the provision of ecosystem services. The measures for this aspect include the presence of natural elements, such as vegetation, water bodies, the evaluation of naturalness as well as potential disturbances and negative environmental effects.

Although the contact with nature is a proven factor of the attractiveness of green space for physical activity, there are some other crucial characteristics that should not be neglected when defining indicators. The biophysical characteristics of the environment such as air, water and soil quality are certainly a very important factor, but also the quality of the soundscape, and the absence of negative factors such as odour, dust, over-heating and dazzle (heat island), dereliction, etc.(Koohsari et al., 2015). Furthermore, the quality of the green space itself is also very important, reflected in its functionality for the use and its experiential and ambient quality(Francis et al., 2012; Pazhouhanfar, 2018).

3.1.4 Size of an individual green space and a total green space quantity in a settlement

This aspect is important in relation to the users' activities in green spaces and satisfying capacity. The determination of the quantity or extent of green spaces depends on the individual characteristics of settlements and their spatial affordances. Most used method for determining the quantity of green areas is the sum of all green spaces in relation to the total population (m2/inhabitant) or to the population in a given spatial unit. However, this method does not provide information either on the distribution of green spaces across a city or settlement, nor on their capacity for everyday use of or number of envisaged users (de la Barrera et al., 2016).

The WHO defined a standard of 9-11 m2 of green spaces per capita, without specifying the spatial extent used to make calculations. Gupta et al.(2012)questioned the relevance of the information on urban green space per capita data, as it provides an imprecise and insufficient answer to the question of distribution and quality of green spaces in urban areas. In addition, the decision on where to set the boundary between the urban area and the hinterland can strongly influence the outcome of the calculation and the comparison of settlements. Increasingly popular are methods which rely on extracting the percent of green space from different land use databases, such as CORINE, EnviroAtlas or Urban Land Cover (ULC). The calculations are based on the proportion of green spaces in the area (Oh and Jeong, 2007; Van Herzele and Wiedemann, 2003; Wood et al., 2017), green spaces per one thousand inhabitants and ratio of green spaces to built-up area (so called green space factors).

Findings from a health-oriented study examining epidemiological aspects (Mitchell et al., 2011) showed that larger green spaces may be more important for health benefits than smaller spaces. The results also highlight that physical activity is one of the 'mechanisms' of health and that the quality of open space is difficult to measure, as perceptions are likely to vary according to the type of the user and their preferences. For example, a relatively wild space suitable for deep contact with nature may be rated as high quality by a lone walker, but low quality by a parent wishing to visit nature with young children(Mitchell et al., 2011).

The aspect of size is very relevant for Slovenian circumstances due to the dominance of small settlements. In Slovenia, only two cities have more than 100,000 inhabitants and the majority of urban settlements are very small. A commonly used size criterion of at least 1 ha or even 2 ha of green space may be suitable for very large cities, but is questionable for the use in smaller cities and settlements where small green spaces may be of great importance for the daily needs of the local population. Slovenian studies therefore suggest to use 250m2 as the minimum size of green spaces that are taken into consideration when evaluating or analysing green space provision (Bizjak et al., 2020; Šuklje Erjavec et al., 2020b).

3.1.5 Variety of green spaces to ensure uses - types of green spaces

Akpinar (2016)researched different types of green spaces in terms of their health impacts on people. They found that not all green spaces should be treated equally and stressed the importance of having a variety of types of public green space rather than just a quantity of green spaces.

In general, all green spaces share very specific characteristics, which distinguishes them decisively from other open spaces, i.e., the presence of natural elements and thus their subordination to natural processes. However, they are very different from each other in other respects. That is in terms of their dominant characteristics (location, function, size and accessibility), nature (natural, urban, residential, connective, introverted, mass-visitor, private) and origin (natural, created). In planning practice, they can be classified according to their purpose such as ownership, predominant use (sport, recreation, rest, multifunctionality, etc.), and public accessibility (Šuklje Erjavec et al., 2020b), among others. According to their role, purpose and function, green spaces can be divided into individual green spaces (parks, recreation areas, etc.), green spaces, adjacent to buildings (e.g. schoolyards, kindergarten playgrounds, residential green spaces), green spaces that are part of buildings (green roofs and vertical greening), green spaces within other land uses (e.g. paths between meadows, urban forests), green spaces linked to transportation uses (avenues, car parks, pedestrian and cycle paths), and other open spaces incorporating natural features and green areas of special natural or cultural value (Šuklje Erjavec et al., 2020b).

We examined Slovenian legislation and national documents related to green spatial planning to understand whether an existing typology could support the aim of our study. We concluded that the existing approaches to land use planning are not adequate because they do not include all relevant types of green spaces that contribute to green space provision. For example, the Handbook on the Green System of Towns and Cities(Šuklje Erjavec et al., 2020a), which is part of the national spatial planning rules of the nearly adopted new National Spatial Order("National Spatial Order," 2023), offers a very comprehensive typology of green spaces which should support a variety of purposes and aims regarding green space planning. Based on reviewed aspects and aims of our study, we assessed it as not being fit for the purpose of this study. Accordingly, a specific approach was developed that adequately reflects the spatial requirements for the implementation of the important groups or types of the physical activity for health, while at the same time representing a suitable base for the guidelines to be used by the Ministry of Health as a National Spatial Planning Authority in the role of the monitoring and guiding spatial planning from the point of view of public health. With this objective in mind, we have identified three basic types of green spaces that are examined when defining green space provision. These are(1) Green spaces providing conditions forspatially concentrated physical activities, (2)linear green spaces providing conditions for distancerelated physical activities and (3) open spaces providing conditions for physical activities as a means of travel– active mobility(Šuklje Erjavec et al., 2020a).

3.1.6   Equipment, safety and maintenance for the use of green spaces

The use of public open spaces is influenced by their equipment, safety, and maintenance. Different spaces require different levels of equipment and maintenance, depending on the type of space, the expected use, the intensity of natural processes in the area, etc. The safety aspect is usually achieved through the criteria as defined by the society, but it has also a subjective component related to an individual's perception. Safety aspects relate to safety from injury and accidents, from violence, from negative influences from the environment and traffic safety(Šuklje Erjavec et al., 2020b). For the study and evaluation of all these aspects, qualitative methods that reflect the (dis)satisfaction of users with a particular space are usually needed, but there are also some more objective data available from evidence and records of the utility company or the service that maintains public green areas.

Research on the use of spaces in relation to user characteristics addresses the time component or duration of use of a green space and user characteristics, e.g., age, gender, education, income. Methods are usually based on the use of GPS technologies to detect spatial-temporal mobility patterns of the population. The use of GPS technologies on smartphones can provide information on how often and for how long people use green spaces for active use (Lachowycz et al., 2012; Nieuwenhuijsen et al., 2014). Conversely, surveys are often conducted through questionnaires and field visits. Questionnaires are mainly used to examine certain characteristics of the specific case studies design, and behavioural maps to examine how they are used. Lundh(2017), for example, identifies the key spatial characteristics for seating are a pleasant microclimate, an attractive view, an appropriate layout with a back screen and a sufficiently low noise level to allow conversation.

3.2 Green space indicators and promoting physical activity

Indicators are important tools of evaluation, monitoring and/or planning suitable green space provision of different settlements and other areas. To address the spatial component through the perspective of different types of activities in green space, the development of spatially explicit indicator for assessing the provision of green spaces to promote physical activity requires a review of existing indicators used for green spaces and the determination of physical activities in green spaces. In line with the objective of this study, we divided the review of indicators in three groups:(1) health indicators, which are important to inform the public and decision makers about the state of public health and to define objectives for improvement;(2) spatial quality indicators, which measure suitability of the spatial factors, and (3) environmental indicators measuring the quality of the environment for healthy active use. However, it is important to point out that these groups of indicators are intertwined.

Health indicators have been widely studied from different perspectives, including quality of life, well-being, walkability and physical activity. A review of health indicators by Pineo et al.(2018)emphasizes the importance of local measures and adapting indicators to local needs. With regard to physical activity, they found that it comprises 75.1% of environmental indicators, the most common being transportation, habits, living conditions, safety, land use, food, environment, demography, leisure and culture, and urban design. An important finding of their research is that data measured at the neighbourhood or individual levels are more suitable for identifying health inequalities and environmental characteristics that contribute to poor health. Indicators at this level can be used to inform development policies in these areas and monitor their impact over time (Pineo et al., 2018).The importance of the local level is one of the starting points for the development of the indicator for green spaces to promote physical activity.

From the point of view of spatial planning, including the provision of green spaces in settlements, indicators of spatial quality are of course particularly important. We have focused on the indicators that assess the suitability of spatial factors related to green spaces and health and thus consider aspects such as socio-economic benefits of green spaces, climate change mitigation, and improvements in urban quality of life. Although not so widely used as health and environmental indicators, there are some interesting research studies and cases related to green space indicators. Koohsari et al.(2015)for example identified criteria such as proximity, number, size, and attractiveness of these spaces. The findings of the study indicated also that the size and attractiveness of local public open spaces played a significant role in residents' preferences. Interestingly, the study revealed that having access to a larger and more attractive public open space, even if it required a greater walking distance, was often more important to residents than having access to a smaller public open space in close proximity to their home (Koohsari et al., 2015). This highlights the importance of considering not only proximity but also the size and attractiveness of public open spaces when evaluating their impact on residents' preferences and usage patterns.

To promote equal access of public green spaces, it is common to establish a "minimum standard for parks."Such standards typically outline the minimum amount of green space per person and the maximum distance to the nearest green space. However, Kimpton (2017)suggests that these standards lack precision when it comes to considering factors like frequency of use, diversity of green space types, and proximity to such spaces. To address this, indicators can be defined at different levels, such as plot, parts of settlements, city/town, and municipal levels. For assessing physical activity provision, both municipal and local level indicators are important. Municipal indicators allow for comparisons over time and between different cities or settlements, while local indicators help identify inequalities within cities or settlements that are not evident when using municipal level indicators (de la Barrera et al., 2016).

Indicators that emphasize measuring the quality of the environment have been identified through a review of existing indicators for green spaces. Several cities, including Berlin, Malmö, Seattle, Helsinki, London, Stockholm, North West England, Washington DC, Singapore, Toronto, and Vancouver, have developed indicators that assess the environmental impact and the proportion of green space in new projects, particularly in urban areas. These indicators are based on the adaptation of existing Green Space Factors (GSFs) used in Berlin and Malmö(Kruuse, 2011; Ring et al., 2021).They consider the ratio of green areas to plot size and take into account various types of greenery such as green roofs and walls, permeable pavements, water, trees, and rainwater systems such as rain gardens. They also consider the presence of different ground types regarding the relation to subsoils. The focus of these indicators is on the

874

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environmental and ecological aspects of sustainable urban development. They not only assess the presence of natural elements but also serve as a qualitative measure of the attractiveness of outdoor spaces. According to Ring et al.(2021),the urban green space index promotes urban sustainability by addressing ecological and socio-economic benefits.

The urban green spaces indicator holds a significant role supported by research and international commitments. The European Green Deal places strong emphasis on the importance of green spaces and nature in cities, particularly public green spaces. Urban Greening Plans are instrumental in achieving these objectives by creating additional green spaces, improving connections between them, and protecting biodiversity (European Commission. Directorate General for Environment, 2021).The Green Deal recognizes the ecological and social aspect of urban green spaces, which includes also providing green spaces for the population and fostering interconnectedness among these spaces. These social aspects are further elaborated and specified in documents such as the Green System in Slovenia(Šuklje Erjavec et al., 2020a). The Green System in Slovenia outlines detailed guidelines and strategies for ensuring the provision of green spaces and enhancing their connectivity, thereby addressing the dimensions of the Green Deal. To align with the European Green Deal and the EU Biodiversity Strategy, Urban Greening Plans need to incorporate specific indicators, including the proportion of urban green spaces (public and private), tree canopy cover, newly planted trees, and protected natural areas in public spaces. These indicators are crucial for monitoring and guiding the development of green spaces in cities and municipalities. The Urban Greening Plan Guidance provides guidelines for mapping the land use types of municipalities, utilizing the official Corine land cover classification system("Urban Greening Plan Guidance draft," 2022).

To develop a spatially explicit indicator for assessing the role of green spaces in promoting physical activity, the review highlighted the importance of spatial indicators in general public health assessments. It also identified different approaches to defining indicators for green spaces, depending on their intended purpose. However, it is important to emphasize that international documents primarily focus on the provision of green spaces in urban areas also for the benefit and use of the population. These documents provide guidance and frameworks that prioritize the establishment of green spaces as a means to enhance public health and overall well-being.

4 SETTING A FRAMEWORK FOR GREEN SPACE PROVISION ASSESMENT

Section 3 inspected the spatial aspects of indicators to address the provision of green spaces to promote physical activity. The next step is to identify the physical activities that relate to green spaces and their characteristics. Accordingly, we reviewed the literature on how each of the measured aspects of green space provision is addressed and combined in different indicators according to their purpose and specific criteria for each of the included aspects of green space provisioning.

4.1 Linking green spaces with physical activities

Due to the interlinking of spatial factors, local spatial and social characteristics, research generally neither determines the appropriate size of green space to increase physical activity, nor the quantity of amenity provision to encourage the use of public open space. Typically, research examining the links between attributes of public open space and physical activity are tied to individual case studies. Depending on the purpose of the physical activity provision indicators, the criteria can be adapted according to the type of activity, which leads towards considering types of activities.

Koohsari (2015)underlined the influence of green space on a variety of activities that share certain common characteristics in terms of (mainly daily) use of urban space. Public open spaces can influence physical activity in at least three ways: a public open space can be an environment where people engage in physical activity; a public open space can be a destination where people travel to be active or simply to socialise; a public open space can be used as part of a route to get to another destination (e.g., a shop) or as part of a recreational route for walking or jogging. Accordingly, green space can contribute to different types of physical activity. For example, green space as a thoroughfare is associated with active travel, as a destination with active travel or recreational physical activity, and public open space as an environment can be associated with recreational walking or cycling, jogging, dog walking, formal or informal sports or active play for children. Šuklje Erjavec et al. (2020b) made a step forward and set simple criteria of green space provision for active lifestyle. They specified three types of physical activity in terms of a design approach to

addressing physical activity: (1) space-specific or spatially concentrated activities, (2)distance-specific or long-distance activities, and (3) daily mobility activities or physical activities as a means of travel.

An adopted approach defined types of physical activity regarding the use of different spatial types. Certain outdoor activities can be tied to certain types of outdoor space. The types of spaces can be defined according to the generally defined typology of green spaces(Šuklje Erjavec et al., 2020a) and linked to the land use classes in spatial planning categories, as defined in Slovenian Spatial Management Act (ZUreP-3, RS). Figure 1 shows the activities, sorted in three main groups, and their relation to the spatial context, classified in types of green spaces and in land use classes as defined by the ZUreP-3. Linking types of green spaces to land use classes is important since it eases the transfer of knowledge from research to spatial planning practice which needs to work within legal frames of defining the land use classes. Accordingly, it is crucial also in the development of spatial indicators.

Fig. 1: Overview on the aspect "variety of green space types for different active uses"- the types of public open green spaces and their suitability for different activities(Original table translated from Šuklje Erjavec et al.(2020b)

4.2 Combining provision aspects in green space indicators

Next, a literature review and analysis of indicators were conducted to determine whether the level of emphasis on spatial qualities for promoting physical activity. Content analysis on existing indicators reviewed the combination of methods or measurements in their addressing of physical activity. We focused on the following parameters: the provision aspects addressed (aspects of the quality of green spaces to promote physical activity), spatial level considered (small urban area, city level, region or wider areas), parameters to be measured, a way of addressing physical activity, and data sources for the calculation of the indicator. The summary is presented in Table 1.

As can be seen from Table 1, most indicators of green spaces refer to three aspects of green space provision: quantity (amount), accessibility(distance, distribution) and naturalness(vegetation, natural elements, permeability)of green spaces. For developing the indicator of the provision of green areas for physical activity, combined indicators are certainly more comprehensive and a better starting point than an individual one. A doubt remains whether the presented indicators cover all important aspects of green spaces and useful for municipalities in their assessment, planning and monitoring of the provision of settlements for promoting physical activity. It can be seen from Table 1 that most frequently, combined indicators included aspects of quantity and accessibility. Only one of the reviewed indicators combines three aspects and includes a quality aspect. However, this quality aspect takes into consideration the naturalness of a green space as a main factor for the equality. Aspects of accessibility as well as quantity are certainly important for dealing with the provision but based on the review and the aim of our study, they are not sufficient. For an adequately comprehensive indicator of the green space provision for physical activity (or several of them), the quality aspect should also be added. Such an aspect should reflect quantity and diversity of vegetation but also social

functions, usability, values, and perception of place. This means including the typology of green spaces, quality of setting and equipment, management level and similar.

From theTable1 it is also evident that most of the reviewed indicators have been set to be used on a local level. This is an important step forward from the quantity indicators for a municipality or even regional and national level, however none of the indicators has directly addressed a physical activity for health. An exception are spatial indicators of urban design and transport features (Boeing et al., 2022), but they do not explicitly address green spaces.

Addressed/combined aspects in indicator	Level	Measures	A way of addressing physical activity	Selected sources
Quantity Accessibility	city level	distance variable on household level; coverage of green space (500m buffer), and household social characteristics	Through selection of open space type: addressing green urban areas and forests	Green space provision indicator in relation to the equality (Wüstemann and Kalisch, 2016)
Quantity Natural elements	Urban built plot/parcel	modelling the climatic characteristics of open space elements	Not directly; possible inclusion for activities addressed on individual plots	Green and open space factor (Ring et al., 2021)
Permeable soil Natural elements / greenery and water	Urban built plot/parcel or smaller urban unit - neighbourhood	Surface type (permeability), surface construction, soil depth, water infiltration, water surfaces, vegetation type	Not directly; on ecological and climatic environmental quality for sites	Green space factor (Kruuse, 2011); Biotope area factor – ecological value("Der Biotopflächenfaktor - Ihr ökologisches Planungsinstrument," 2021)
Quantity	smaller urban unit - neighbourhood	Combining large scale and small-scale data (existing land use); including all GS (public and private)	Not directly; addressed as wellbeing and health; not focused on public GS	Green space indicator (Mitchell et al., 2011)
Quantity	part of the city; city level	proportion of green spaces (general), built-up area and population density in each part of the city	Not directly; proportions in different the areas on all green spaces, not focused on public GS	Green space indicators in a social-ecological system (Verma et al., 2020)
Quantity (size) Accessibility (distance)	smaller urban unit - neighbourhood	Use of 2 size categories of public open space (smaller and larger than 1,5ha); Distances to points (stations, services, GS etc.) in relation to the existing network	Addresses walkability to all public spaces; not directly on location/planning adoptable results	Spatial indicators of urban design and transport features (Boeing et al., 2022)
Quantity Accessibility / distribution Quality	General and local level	Combining land use, quality of space (high vegetation and soil permeability); accessibility and shapes of GS	Addresses green spaces in general; different aspects and focused on public GS	Indicators for GS in contrasting urban settings (de la Barrera et al., 2016)
Natural elements / vegetation	Adaptable scale	vegetation cover layers by area, water bodies excluded	Not directly; can be used as a complementary measure of spatial quality	Vegetation indicators NDVI (Tucker, 1979); GRVI (Sripada et al., 2006); SAVI (Huete, 1988)
Natural elements	smaller urban unit - neighbourhood	amount of vegetation and its characterization and neighbourhood types also on height of buildings	Study indirectly addresses social aspects	Urban Neighbourhood Green Index (Gupta et al., 2012)

Table 1: An overview of studied indicators for green spaces in relation to the provision aspects addressing green spaces to promote physical activity.

5 DISCUSSION AND CONCLUSION

The performed reviews of selected literature indicate that criteria for determining appropriate and feasible green space provision indicators is inconsistent, which is also reflected in the practical implementation of indicators, as some of the inspected practical examples have shown. Guided by our objective to develop a spatially explicit indicator, useful for the assessment of green space provision for physical activity in Slovenian settlements, we discuss the two most important findings for our forthcoming work. First is the importance of integrating a variety of parameters in an indicator, second is paying attention to the performance of an indicator at different scales. This also relates to appropriateness of an indicator to be implemented at different spatial planning levels.

With regard to integration of different parameters, existing green space indicators are based on both research and international commitments, but the focus is mostly on environmentally and ecologically measurable

parameters of green spaces, with less attention paid to their social and health benefits that are more difficult to measure, as already highlighted in a 2012 study (Gupta et al., 2012). Often, data is derived from remote sensing imagery and has been used in various studies to differentiate between areas with vegetation and areas without vegetation. Such an approach, however, does not provide any information on accessibility, density of built-up areas and other characteristics of green spaces. It is important to take into consideration that only a fraction of green spaces in cities are publicly accessible and available for active use. We contend that it is due to the complexity by which spatial quality is defined and should be considered, that the existing methods of assessing quality of green spaces for diverse forms of physical activity tend to focus on single parameters, lacking integrated approach towards defining the provision of green spaces to promote physical activity. Accordingly, a solid spatially explicit indicator for assessing the provision of settlements with green spaces for physical activity is non-existent.

With regard to scale, the local level is of particular importance for the calculation of the provision of public green spaces to support physical activity. In general, not enough indicators are developed for small-scale areas such as cities and neighbourhoods, in comparison to large areas such as nations or states, which was also highlighted in a review by Rothenberg et al.(2015).However, locally developed tool which takes into account local conditions and local needs may increase its acceptability(E. Innes and Booher, 2000; Rothenberg et al., 2015).We contend that a spatially explicit indicator should address the provision of a sufficiently generalized yet locally applicable level. The development of providing an indicator further emphasizes the importance of spatially explicit conditions for physical activity. However, it is essential to incorporate relevant, reliable, and verifiable data at the local level to address the specific characteristics of each area. With this in mind, we developed the baseline criteria for each aspect of providing and interconnecting different aspects in evaluating public open spaces, as follows:

(1) Public accessibility: The criteria include proximity, with the requirement of having a public green space of over 500 m2 within a walking distance of 300 m or 5 minutes, and an urban park within a walking distance of 900 m or 15 minutes in cities. Design considerations should ensure universal access, while taking into account public accessibility and the impact of topography.

(2) Quantity: The criteria focus on the size of urban parks, which should be a minimum of 1 hectare and located within 900 m of residential areas. The provision should also offer a variety of choices and typologies to cater for diverse user preferences.

(3) Distribution, coherence, and continuity: These criteria consider the spatial arrangement of green spaces in relation to larger and smaller spatial units. The distribution should ensure a coherent and connected network of green spaces, allowing for continuity and seamless access throughout the area.

(4) Attractiveness: The criteria highlight the importance of greenery and canopy cover, aiming to create visually appealing and inviting spaces for the public.

These baseline criteria will serve as a foundation for evaluating and planning the provision of green spaces in the continuation of the project.

We can summarise that the criteria for examining each aspect shall be defined in relation to the desired achievement of the objective of green space provision to promote physical activity of the population and their applicability. The criteria can be qualitative or quantitative. In our study, we took the spatial-planning approach to provision, grouped in three physical activity types according to the way and purpose of space use. As a result, we developed a framework for a green space provision indicator that is spatially explicit and enables the comparison between settlements. This indicator allows for the identification and assessment of green spaces within settlements which comprise three types of physical activities: space-specific activities, distance-specific/long-distance activities, and physical activities as a means of travel.

6 ACKNOWLEDGEMENT

7 REFERENCES

Akpinar, A., Barbosa-Leiker, C., Brooks, K.R., 2016. Does green space matter? Exploring relationships between green space type and health indicators. Urban For. Urban Green. 20, 407–418. https://doi.org/10.1016/j.ufug.2016.10.013

878

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REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Biernacka, M., Łaszkiewicz, E., Kronenberg, J., 2022. Park availability, accessibility, and attractiveness in relation to the least and most vulnerable inhabitants. Urban For. Urban Green. 73, 127585. https://doi.org/10.1016/j.ufug.2022.127585

Bizjak, I., Mušič, B., Nikšič, M., Dražič, B., Repič Vogelnik, K., Kozamernik, J., Koblar, S., Cotič, B., 2020. Priporočila za izdelavo urbanistične zasnove: priporočila za izdelavo urbanistične zasnove in krajinske zasnove na podlagi določil Zakona o urejanju prostora (ZUreP-2). Urbanistični inštitut Republike Slovenije, Ljubljana.

Boeing, G., Higgs, C., Liu, S., Giles-Corti, B., Sallis, J.F., Cerin, E., Lowe, M., Adlakha, D., Hinckson, E., Moudon, A.V., Salvo, D., Adams, M.A., Barrozo, L.V., Bozovic, T., Delclòs-Alió, X., Dygrýn, J., Ferguson, S., Gebel, K., Ho, T.P., Lai, P.-C., Martori, J.C., Nitvimol, K., Queralt, A., Roberts, J.D., Sambo, G.H., Schipperijn, J., Vale, D., Weghe, N.V. de, Vich, G., Arundel, J., 2022. Using open data and open-source software to develop spatial indicators of urban design and transport features for achieving healthy and sustainable cities. Lancet Glob. Health 10, e907–e918. https://doi.org/10.1016/S2214-109X(22)00072-9

Cohen, D.A., McKenzie, T.L., Sehgal, A., Williamson, S., Golinelli, D., Lurie, N., 2007. Contribution of Public Parks to Physical Activity. Am. J. Public Health 97, 509–514. https://doi.org/10.2105/AJPH.2005.072447

Coles, R.W., Bussey, S.C., 2000. Urban forest landscapes in the UK — progressing the social agenda. Landsc. Urban Plan. 52, 181–188. https://doi.org/10.1016/S0169-2046(00)00132-8

de la Barrera, F., Reyes-Paecke, S., Banzhaf, E., 2016. Indicators for green spaces in contrasting urban settings. Ecol. Indic. 62, 212–219. https://doi.org/10.1016/j.ecolind.2015.10.027

Der Biotopflächenfaktor - Ihr ökologisches Planungsinstrument, 2021.

E. Innes, J., Booher, D.E., 2000. Indicators for Sustainable Communities: A Strategy Building on Complexity Theory and Distributed Intelligence. Plan. Theory Pract. 1, 173–186. https://doi.org/10.1080/14649350020008378

Francis, J., Wood, L.J., Knuiman, M., Giles-Corti, B., 2012. Quality or quantity? Exploring the relationship between Public Open Space attributes and mental health in Perth, Western Australia. Soc. Sci. Med. 74, 1570–1577. https://doi.org/10.1016/j.socscimed.2012.01.032

Giles-Corti, B., Donovan, R.J., 2002. The relative influence of individual, social and physical environment determinants of physical activity. Soc. Sci. Med. 54, 1793–1812. https://doi.org/10.1016/S0277-9536(01)00150-2

Giles-Corti, B., Moudon, A.V., Lowe, M., Adlakha, D., Cerin, E., Boeing, G., Higgs, C., Arundel, J., Liu, S., Hinckson, E., Salvo, D., Adams, M.A., Badland, H., Florindo, A.A., Gebel, K., Hunter, R.F., Mitáš, J., Oyeyemi, A.L., Puig-Ribera, A., Queralt, A., Santos, M.P., Schipperijn, J., Stevenson, M., Dyck, D.V., Vich, G., Sallis, J.F., 2022. Creating healthy and sustainable cities: what gets measured, gets done. Lancet Glob. Health 10, e782–e785. https://doi.org/10.1016/S2214-109X(22)00070-5

Grahn, P., Stigsdotter, U.A., 2003. Landscape planning and stress. Urban For. Urban Green. 2, 1–18. https://doi.org/10.1078/1618-8667-00019

Grunewald, K., Richter, B., Meinel, G., Herold, H., Syrbe, R.-U., 2017. Proposal of indicators regarding the provision and accessibility of green spaces for assessing the ecosystem service "recreation in the city" in Germany. Int. J. Biodivers. Sci. Ecosyst. Serv. Manag. 13, 26–39. https://doi.org/10.1080/21513732.2017.1283361

Gupta, K., Kumar, P., Pathan, S.K., Sharma, K.P., 2012. Urban Neighborhood Green Index – A measure of green spaces in urban areas. Landsc. Urban Plan. 105, 325–335. https://doi.org/10.1016/j.landurbplan.2012.01.003

Harnik, P., Simms, J., n.d. Parks: How Far Is Too Far? 8.

Hillsdon, M., Panter, J., Foster, C., Jones, A., 2006. The relationship between access and quality of urban green space with population physical activity. Public Health 120, 1127–1132. https://doi.org/10.1016/j.puhe.2006.10.007

Huete, A.R., 1988. A soil-adjusted vegetation index (SAVI). Remote Sens. Environ. 25, 295–309. https://doi.org/10.1016/0034-4257(88)90106-X

Kaczynski, A.T., Henderson, K.A., 2007. Environmental Correlates of Physical Activity: A Review of Evidence about Parks and Recreation. Leis. Sci. 29, 315–354. https://doi.org/10.1080/01490400701394865

Ki, D., Lee, S., 2021. Analyzing the effects of Green View Index of neighborhood streets on walking time using Google Street View and deep learning. Landsc. Urban Plan. 205, 103920. https://doi.org/10.1016/j.landurbplan.2020.103920

Kimpton, A., 2017. A spatial analytic approach for classifying greenspace and comparing greenspace social equity. Appl. Geogr. 82, 129–142. https://doi.org/10.1016/j.apgeog.2017.03.016

Koohsari, M.J., Mavoa, S., Villanueva, K., Sugiyama, T., Badland, H., Kaczynski, A.T., Owen, N., Giles-Corti, B., 2015. Public open space, physical activity, urban design and public health: Concepts, methods and research agenda. Health Place 33, 75–82. https://doi.org/10.1016/j.healthplace.2015.02.009

Kruuse, A., 2011. The green space factor and the green points system.

Lachowycz, K., Jones, A.P., Page, A.S., Wheeler, B.W., Cooper, A.R., 2012. What can global positioning systems tell us about the contribution of different types of urban greenspace to children's physical activity? Health Place, Using scale to think about HIV/AIDS interventions: local and global dimensions 18, 586–594. https://doi.org/10.1016/j.healthplace.2012.01.006

Lundh, J., 2017. Indicators for ecosystem services in urban green space management. Uppsala University.

McCormack, G.R., Rock, M., Toohey, A.M., Hignell, D., 2010. Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. Health Place 16, 712–726. https://doi.org/10.1016/j.healthplace.2010.03.003

Mitchell, R., Astell-Burt, T., Richardson, E.A., 2011. A comparison of green space indicators for epidemiological research. J. Epidemiol. Community Health 65, 853–858. https://doi.org/10.1136/jech.2010.119172

MOP (Ministrstvo za okolje in prostor RS), 2020. Strategija prostorskega razvoja Slovenije 2050. Osnutek dokumenta v javni razpravi od 15. januarja 2020 do 15. marca 2020.

Nielsen, T.S., Hansen, K.B., 2007. Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. Health Place 13, 839–850. https://doi.org/10.1016/j.healthplace.2007.02.001

Nieuwenhuijsen, M.J., Kruize, H., Gidlow, C., Andrusaityte, S., Antó, J.M., Basagaña, X., Cirach, M., Dadvand, P., Danileviciute, A., Donaire-Gonzalez, D., Garcia, J., Jerrett, M., Jones, M., Julvez, J., Kempen, E. van, Kamp, I. van, Maas, J., Seto, E., Smith, G., Triguero, M., Wendel-Vos, W., Wright, J., Zufferey, J., Hazel, P.J. van den, Lawrence, R., Grazuleviciene, R., 2014. Positive health effects of the natural outdoor environment in typical populations in different

regions in Europe (PHENOTYPE): a study programme protocol. BMJ Open 4, e004951. https://doi.org/10.1136/bmjopen-2014-004951

Oh, K., Jeong, S., 2007. Assessing the spatial distribution of urban parks using GIS. Landsc. Urban Plan. 82, 25–32. https://doi.org/10.1016/j.landurbplan.2007.01.014

Pazhouhanfar, M., 2018. Role of Space Qualities of Urban Parks on Mood Change. Psychol. Stud. 63, 25–31. https://doi.org/10.1007/s12646-017-0434-6

Pineo, H., Glonti, K., Rutter, H., Zimmermann, N., Wilkinson, P., Davies, M., 2018. Urban Health Indicator Tools of the Physical Environment: a Systematic Review. J. Urban Health 95, 613–646. https://doi.org/10.1007/s11524-018-0228-8

Resolucija o nacionalnem programu o prehrani in telesni dejavnosti za zdravje 2015–2025 (ReNPPTDZ), 2015.

Ring, Z., Damyanovic, D., Reinwald, F., 2021. Green and open space factor Vienna: A steering and evaluation tool for urban green infrastructure. Urban For. Urban Green. 62, 127131. https://doi.org/10.1016/j.ufug.2021.127131

Rothenberg, R., Stauber, C., Weaver, S., Dai, D., Prasad, A., Kano, M., 2015. Urban health indicators and indices—current status. BMC Public Health 15, 494. https://doi.org/10.1186/s12889-015-1827-x

Sander, H.A., Ghosh, D., Hodson, C.B., 2017. Varying age-gender associations between body mass index and urban greenspace. Urban For. Urban Green., Special feature:TURFGRASS 26, 1–10. https://doi.org/10.1016/j.ufug.2017.05.016

Sripada, R.P., Heiniger, R.W., White, J.G., Meijer, A.D., 2006. Aerial Color Infrared Photography for Determining Early In-Season Nitrogen Requirements in Corn. Agron. J. 98, 968–977. https://doi.org/10.2134/agronj2005.0200

Sugiyama, T., Murabayashi, N., Umekawa, T., Nagao, K., Kamimoto, Y., Sugihara, T., Sagawa, N., 2008. Rapid overgrowth of a fetus after interruption of insulin therapy in a diabetic woman. Diabetes Res. Clin. Pract. 80, e9–e11. https://doi.org/10.1016/j.diabres.2008.01.020

Šuklje Erjavec, I., Kozamernik, J., Balant, M., Nikšič, M., 2020a. Zeleni sistem v mestih in naseljih: usmerjanje razvoja zelenih površin: priročnik, Državni prostorski red. Ministrstvo za okolje in prostor, Direktorat za prostor, graditev in stanovanja, Ljubljana.

Šuklje Erjavec, I., Kozamernik, J., Žlender, V., 2020b. Ven za zdravje: priročnik za načrtovanje zelenih površin za spodbujanje telesne dejavnosti in zdravega življenjskega sloga, 1. ponatis. ed, Zbirka Urbani izziv - publikacije. Urbanistični inštitut Republike Slovenije, Ljubljana.

Tilt, J.H., Unfried, T.M., Roca, B., 2007. Using Objective and Subjective Measures of Neighborhood Greenness and Accessible Destinations for Understanding Walking Trips and BMI in Seattle, Washington. Am. J. Health Promot. 21, 371–379. https://doi.org/10.4278/0890-1171-21.4s.371

Tucker, C.J., 1979. Red and photographic infrared linear combinations for monitoring vegetation. Remote Sens. Environ. 8, 127–150. https://doi.org/10.1016/0034-4257(79)90013-0

Urad za prostorski razvoj, Direktorat z aprostor, MOPE, 2004. Strategija prostorskega razvoja Slovenije (SPRS 2004) [WWW Document]. URL https://www.gov.si/assets/ministrstva/MOP/Publikacije/0e22a8ed69/sprs_slo.pdf (accessed 2.14.23).

Urban Greening Plan Guidance draft, 2022.

Van Herzele, A., Wiedemann, T., 2003. A monitoring tool for the provision of accessible and attractive urban green spaces. Landsc. Urban Plan. 63, 109–126.

Verma, P., Singh, R., Bryant, C., Raghubanshi, A.S., 2020. Green space indicators in a social-ecological system: A case study of Varanasi, India. Sustain. Cities Soc. 60, 102261. https://doi.org/10.1016/j.scs.2020.102261

Wood, L., Hooper, P., Foster, S., Bull, F., 2017. Public green spaces and positive mental health – investigating the relationship between access, quantity and types of parks and mental wellbeing. Health Place 48, 63–71. https://doi.org/10.1016/j.healthplace.2017.09.002

World Health Organization, 2020. WHO guidelines on physical activity and sedentary behaviour: at a glance. World Health Organization.

Wüstemann, H., Kalisch, D., 2016. Towards a national indicator for urban green space provision and environmental inequalities in Germany: Method and findings 40.

Zakon o urejanju prostora (Uradni list RS, št. 199/21) (ZUreP-3), http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO8249.

Understanding Spatio-Temporal Usage Patterns of Cargo Bike Sharing to Foster Market Diffusion

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1 ABSTRACT

Cargo bikes promote urban resilience as they ensure a local supply of goods, can be used flexibly, are reliable and require low energy, and can even be driven by muscle power. Further, they contribute to socially inclusive mobility. Although driving cargo bikes may require some training, they do not require a driving licence and can be available for different income ranges (e.g. in the form of cargo bike sharing). Thus, they also contribute to health-promoting mobility. Cargo bike sharing is a relevant solution to offer households a practical, environmentally friendly and cheaper mode of transport.

According to public welfare-oriented goals, cargo bike sharing is often provided on behalf of, or with (financial) public sector support, in cooperation with residential developers or based on voluntary work in Austria and Germany. However, peer-to-peer cargo bike sharing offers and host-based sharing systems often do not meet all the criteria attributed to shared mobility services. In order to reach the full potential of cargo bike sharing, a better understanding of spatio-temporal usage patterns is needed to foster a shift towards higher quality service provision, especially regarding tailor-made services for different user groups.

The following article investigates the role of availability and type of service provision by evaluating booking data and spatio-temporal data in three case studies. GPS tracking is rarely used to better understand cargo bike usage, but it reveals further knowledge of the characteristics of users and their spatial usage patterns.

Based on three use cases, usage, users and spatial patterns of cargo bike sharing usage are analysed, the respective potentials are shown, and the added value of spatial data collection is discussed.

Keywords: mobility planning, resilience, spatio-temporal data, sharing, cargo bike

2 INTRODUCTION

The chapter discusses the basics of cargo bike use as part of socially inclusive and resilient mobility, provides an outline of cargo bike sharing systems, and highlights the possibilities of evaluating usage patterns.

2.1 Socially inclusive and resilient mobility

2.1.1 Potentials and fields of use

Existing studies show that cargo bikes are gaining importance in larger cities in the forms of (commercial) cargo transport, for CEP services or privately used for transporting goods and children by private ownership or cargo bike sharing. Up to 51% of all motorised trips in urban areas could be replaced by cargo bikes(FGM-AMOR et al. 2014). This is also reflected in the increase of sales of cargo bikes in Austria by more than 80%(VSSÖ 2021) and Europe by 66%(Statista 2022). However, cargo bikes are rarely seen in smaller cities and rural areas and could still be considered novel transport modes.

2.1.2 Cargo bikes contribute to sustainable and resilient mobility

E-cargo bikes are a sustainable transport mode as they produce nearly no emissions compared to fuel transporters (Fontaine et al. 2021) and reduce traffic noise(Shaheen, Cohen, and Martin 2013). By promoting cargo bikes and cargo bike sharing, municipalities can reduce their dependence on fossil fuels and improve air quality. This primarily benefits people who are vulnerable to health problems (associated with air quality). Cargo bikes as an active mobility mode also promote an active lifestyle and contribute positively to users' physical health.(Kammerhofer et al. 2021; Rabenstein 2015; European Cyclists" Federation 2018; Masterson 2017)

Cargo bikes are less vulnerable to fuel shortages or road closures than motorised vehicles. They can also be used in densely populated urban areas where a lack of space and traffic restrictions can be problematic. By that, cargo bikes help build community resilience by providing alternative transport options, especially in times of crisis or emergency, as they are less affected by traffic congestion and fuel shortages and provide a local supply of goods in the sense of "The City of Short Distances". During high traffic periods, natural disasters or other unforeseen events, cargo bikes can help alleviate traffic congestion and maintain the smooth transport of goods and people. (Randelhoff 2013; Thoma 2014; Kammerhofer et al. 2021)

2.1.3   (E-)Cargo Bikes are socially inclusive

Currently, typical cargo bike users only represent a narrow segment of a diverse population. Cargo bikes, especially in the form of shared mobility offers however, have the potential to enable people of different ages, abilities and financial backgrounds to participate in sustainable transport(Grasso, Barnes, and Chavis 2020; Kammerhofer et al. 2021). Unlike motorised vehicles, cargo bikes are easily accessible and do not require any special skills or a driving licence. They offer an environmentally friendly and cost-effective transport option(Shaheen, Cohen, and Martin 2013) for people who cannot afford or do not want to own a car and who do not have a driver's license. However, by now, cargo bikes are rather used by an exclusive group of citizens (Berger et al. 2019). By promoting cargo bike sharing, municipalities can make their transport infrastructure more inclusive and enable all citizens to get around, regardless of income or mobility.

2.2 Cargo bike sharing

2.2.1   Diffusion and operating models of cargo bike sharing

Cargo bike sharing is a relevant solution to offer a practical, environmentally friendly and cheaper mode of transport to households who do not have access to a car (e.g. affordability, driving rights) or do not want to use a car (e.g. due to environmental concerns). Regarding the potential to further replace privately owned cars, cargo bike sharing contributes to a healthier environment (e.g. by fewer exhaust fumes) (Shaheen, Cohen, and Martin 2013)and frees public space from cars, enabling a redistribution of public spaces and a redesign towards climate-smart public spaces.

Cargo bike sharing schemes can be found in many cities worldwide, especially in urban areas with high cycling infrastructure and a strong demand for sustainable transport options. Germany, the Netherlands, Denmark and many other European countries are pioneers in improving cargo bike sharing services. Concerning the early stage of diffusion, the field of actors and operators is currently rather heterogenous (European Cyclists" Federation 2018). The main actors in cargo bike sharing are often (local) public authorities, non-profit organisations, bicycle cooperatives or private companies. However, only a few bike sharing operators engage in the cargo bike sharing market(European Cyclists" Federation 2018). Recent developments show that private companies struggle with successful operation and feasibility (e.g. GLEAM, SIGO) and that public financial participation is necessary to sustain cargo bike sharing services.

While cargo bike sharing is already widely established in German cities, it is still in its infancy in Austria. For example, the city of Regensburg (approx. 150,000 inhabitants) has approximately the same number of shared cargo bikes as are available in the entire Austria (Radkompetenz Österreich 2023).This might be related to the fact, that, in Austria, most cargo bike sharing offers are peer-to-peer or host-based services.

Peer-to-peer sharing depicts sharing between private persons as clients and providers, who can set user fees independently. In comparison, host-based sharing systems have an organisation which provides the vehicles and sets the terms of use. The vehicles are hosted by small enterprises or private persons, and these hosts are responsible for maintaining the bikes and completing loan processing. In return, they can access vehicles more easily and cheaper. (Dorner 2020) Both peer-2-peer and host-based sharing services are often digitally provided by sharing platforms and in the case of "radverteiler.at", are provided through the same platform.

Most cargo bikes (90 of approximately 130 in total) in Austria are available via the platform „radverteiler.at", which enables peer-to-peer sharing of cargo bikes and is used for host-based sharing systems such as in Graz, St. Pölten or Mattersburg (Radkompetenz Österreich 2023). „radverteiler.at" is not the only initiative to foster peer-to-peer and host-based sharing of cargo bikes in Austria. Other initiatives and platforms inlcude „Grätzlrad" for free cargo bike sharing provided by the city of Vienna, „ListNRide" with mainly fee-based offers and „fairvelo" in the region Vorarlberg.

Public authorities can provide incentives and support for setting up and promoting cargo bike sharing schemes, further to what they provide in general infrastructure for active mobility. Non-profit organisations and bicycle cooperatives are often involved in providing the sharing infrastructure and managing the fleet.

Peer-to-peer cargo bike sharing offers and host-based sharing systems in particular, often do not meet all the criteria attributed to shared mobility services, as they often only have limited rental and availability times and cannot usually be booked or rented independently. Seestadtflotte, for example, was the first fully automated cargo bike sharing worldwide in 2015 (VCÖ 2016), using RFID cards to organise the loaning process.

2.3 Cargo Bike Usage Patterns

2.3.1 Usage Purposes

Cargo bikes are used in both the private and commercial sectors. In the commercial sector, the main areas of use are delivery services (e.g. in the CEP sector). However, hardly any data is available on the use in other types of commercial traffic such as service traffic. Commercial transport accounts for around 49% of journeys made by motorised vehicles in European cities. Commercial traffic distinguishes freight transport ("Güterverkehr" – commercial freight transport, factory traffic) and passenger traffic ("Personenwirtschaftsverkehr" – service traffic, business traffic), of which service traffic accounts for about 20% of commercial traffic. Wrighton and Reiter (2016) estimate that about 50% of service trips could be replaced by cargo bikes.

In the private sector, cargo bike usage covers all areas of everyday life - from leisure rides such as shopping and transporting children as well as transporting larger, bulkier objects and waste disposal trips (e.g. green waste, bulky waste)(Becker and Rudolf 2018; Dorner 2020; Berger, Dorner, and Brugger 2019; Kostka 2020). As shared cargo bikes are mainly used for private purposes, the article concentrates on these in the following sections.

2.3.2 Target Group

As mentioned above, regular cargo bike users are still represented by a narrow field of the population – mainly male persons aged 25-40, with higher levels of formal education(Kostka 2020; Berger, Dorner, and Brugger 2019; Becker and Rudolf 2018; Dorner 2020). However, studies show that by reducing target group specific barriers such as safety perception, infrastructural aspects or family role models, there is a high potential for a more diverse and comprehensive user group(Riggs and Schwartz 2018).

Thus, to reach the full potential of cargo bike sharing, knowledge about and consideration of barriers of non-users is needed. On the other hand, a shift towards higher quality cargo bike sharing services is also needed. Therefore, a better understanding of spatio-temporal usage patterns is needed to foster a shift towards higher quality in the service provision, especially regarding tailor-made services for different user groups.

2.3.3 Spatial Patterns of Cargo Bikes and Cargo Bike Sharing

With the availability of detailed GPS tracks of cargo bike usage, it becomes possible to delve deeper into the spatial patterns associated with their use. This information can reveal the preferred pathways taken by cargo bike users, showcasing the most efficient and convenient routes for different purposes. It can also help identify areas with high demand for cargo bike services, indicating potential areas for infrastructure improvements or service expansions (Romanillos et al. 2016).

GPS data can also be used to identify hotspots such as areas with a high concentration of cargo bike activity. These hotspots could include commercial areas with numerous deliveries, residential neighbourhoods with high cargo bike usage for personal transportation, or specific locations where cargo bikes are utilised for business purposes. Identifying hotspots allows for targeted interventions and infrastructure planning, such as providing dedicated cargo bike parking areas or optimising delivery systems(Li et al. 2020).

In addition, combining GPS tracks with temporal information provides insights into how cargo bike usage varies across different times of the day or days of the week. This analysis helps identify peak usage periods and to better understand temporal variations in spatial patterns. For example, the routes and hotspots may differ during morning and evening rush hours compared to off-peak hours. Such information can be valuable for optimising logistics operations, planning infrastructure, and managing resources effectively(Zhou 2015).

GPS tracks can be used to analyse cargo bike trip origin and destination points of cargo bike trips. This analysis provides valuable information about the origins of cargo bike journeys, such as residential areas or commercial centres, and the destinations, such as specific businesses or delivery points. Understanding the origin-destination patterns helps identify areas with high demand for cargo bike services, supporting urban planners and policymakers in making informed decisions regarding infrastructure development and service provision(Levy, Golani, and Ben-Elia 2019).

By leveraging the detailed GPS tracks of cargo bike usage, research and planning can gain a comprehensive understanding of the spatial patterns associated with these vehicles. This knowledge can guide the development of targeted policies, infrastructure improvements, and service expansion to enhance the integration of cargo bikes into urban transportation systems.

There is a large amount of literature on the spatial patterns of bicycle use (including bike sharing) - but there still needs to be a more explicit focus on cargo bikes in the literature. This paper shows user and usage patterns as well as spatial patterns and discusses the potential of spatial analysis in the context of cargo bike usage.

3 CASE STUDIES

3.1 Methodology

As case studies, cargo bike sharing within „Seestadtflotte" in aspernSeestadt (Vienna) and „KlimaEntLaster" in Mattersburg and St. Pölten will be investigated. In aspernSeestadt, an automated cargo bike sharing was implemented and integrated into the bike sharing system Seestadtflotte. Within the research project „KlimaEntLaster", host-based cargo bike sharing was implemented in small and medium-sized cities such as Mattersburg, accompanied by intensive information and test campaigns. The „KlimaEntLaster" services were further developed into an automated sharing service, e.g. in Mattersburg and St. Pölten. The higher availability of the cargo bike sharing service led to an enormous rise in bookings in Mattersburg.

Available data sources	Case Study Mattersburg	Case Study St. Pölten	Case Study AspernSeestadt
GPS-Data	No GPS-data available	GPS-tracking (via Radland Niederöstereich) of 380 trips from August 2022 to June 2023	GPS-tracking of 29 trips in May and June 2020 (Kostka 2020)
Reservation Data	Data of 161valid reservations from September 2019 to October 2021 via radverteiler.at	Data of 148valid reservations from June 2022 to June 2023 via radverteiler.at	Data of 670 valid loans in 2019 via SeestadtFlotte
Survey Data	99 valid responses to an on-going online survey in 2020and 2021 in all KlimaEntLasterpilot locations	18 valid responses to an on-going online survey from June 2022 to February 2023 within eTransport 24/7	48 valid responses to an online user survey in spring 2020 (Kostka 2020)

Table 1: Available data sources per Use Case

The spatial analysis involved several steps, which are as follows. Initially, the raw data consisted of multiple GPX files for each use case. These GPX files were imported and merged in ArcGIS Pro to create a comprehensive dataset. Subsequently, the "Reconstruct Tracks" tool was utilised to identify connected trips within the dataset. A split value of 15 minutes was chosen, meaning that if the dwell time at a location exceeded 15 minutes, the track was split. This process helped ensure an accurate representation of individual trips. The resulting trip IDs were then appended to the raw point data through a spatio-temporal join. To enhance the analysis, a map-matching algorithm was employed to snap the GPS data to a street graph (GIP). This step allowed for inferences regarding the utilised infrastructure and road network load. Finally, the "Calculate Motion Statistics" tool was utilised to derive additional information such as speed, duration, and other relevant trip attributes.

3.2 Seestadtflotte

3.2.1 Project Background

"Seestadtflotte" is the station-based bike sharing system in Vienna's urban development area "aspernSeestadt". It is part of the mobility concept in aspernSeestadt that focuses on encouraging public transport, active mobility and reducing private motorised traffic. The bike sharing system is open to everyone having a "Seestadtcard" but has a focus on the local population and is not connected to the other Vienna-wide bike sharing-system such as "WienMobil-Rad" and the Vienna-wide host-based cargo bike sharing

"Grätzlrad". Seestadtflotte currently offers 56 bicycles and e-bikes at eight stations and four e-cargo bikes at one station. Further expansion of the offer is planned in conjunction with the on-going development of aspernSeestadt and according to its own statements, it is the first automatically operated station-based bike sharing that offers e-cargo bikes(Wien 3420 aspern Development AG 2023b). Seestadtflotte was evaluated in the context of a master thesis(Kostka 2020).

3.2.2   Spatial Context

AspernSeestadt is an urban development project located in the 22nd district in the northeast of Vienna, the capital city of Austria. With about 10.000 current residents, the aim is to reach about 25.000 residents and 20.000 employees in aspernSeestadt by the 2030s, making it one of Europe's largest urban development projects (Wien 3420 aspern Development AG 2023a). Even though there is a subway connection to the city centre, aspernSeestadt is almost its own city in the city of Vienna due to its remote location in the Viennese outskirts. AspernSeestadt was designed as a multifunctional city quarter and is part of Vienna's smart-city concept, where it is highlighted as a test space for innovative ideas.

3.2.3   Operating Model

Seestadtflotte is operated and maintained by Wien Work, a publicly funded non-profit company that provides jobs for people disadvantaged in the labour market (Knapp 2021). Wien Work has a workshop on site where they can maintain the bikes. Seestadtflotte is financed by the Seestadt mobility fund, fed from charges levied for collective garage operation and construction in exchange for less parking space requirements (Wien 3420 aspern Development AG 2023c). The original idea was that users can ride the bikes 30 minutes for free and have to pay a small amount for longer rentals. However, this is not in place yet, so rentals are still free for at maximum 12 hours.

3.3 Mattersburg

3.3.1   Project Background

In September 2019, three shared cargo bikes were established in Mattersburg, Austria. Cargo bike sharing in Mattersburg was implemented within the research project „KlimaEntLaster (KEL)" using a sharing platform developed within the research project LARA-Share. KEL aimed to implement cargo bike sharing in small and medium-sized Austrian cities, while developing cooperative, feasible concepts for cargo bike sharing. Thus, the central aspect was to identify barriers to implementation as well as barriers to usage. The KEL project was led by Energy Changes in cooperation with Die Radvokaten, Quadratic, Factum and the TU Wien.

3.3.2   Spatial Context

As a small-sized city of approximately 7.500 inhabitants(Statistik Austria 2022b), Mattersburg is considered a regional centre in Burgenland according to the urban-rural typology(Statistik Austria 2022a). Further, Mattersburg has very good public transport accessibility (Statistik Austria 2023).; with a third of Mattersburg's inhabitants being commuters, primarily working in the metropolitan area of Vienna(Statistik Austria 2020), which is easily accessible by public transport.

The cargo bikes were located according to their hosts; the location of the cargo bikes was changed several times within the runtime of the project „KlimaEntLaster". Today, only one cargo bike is available in the centre of Mattersburg, 800m walking distance from the central train station. The other two cargo bikes are use in other municipalities in Burgenland.

3.3.3   Operating Model

Within KlimaEntLaster, a host-based sharing system was chosen. This means the municipality and the mobility centre of the county Burgenland financed the cargo bikes, which were then available for free loan at volunteering local businesses or private persons (the hosts). The hosts specify opening hours when other users can book and use the bike. Apart from these opening hours, the cargo bike is fully available to the hosts. The hosts are responsible for checking the cargo bike regularly for safety reasons. Local workshops act as partners for repairs.

In 2020, project partner QUADRATIC developed a solution to provide shared cargo bikes around the clock, independently based on the availability of the hosts. After successfully booking the cargo bike, the user receives a code to unlock the „SmarteVerleihbox" wall box via SMS. The key for the cargo bike and the charged battery is stored in the box. This wall box was installed for one of the cargo bikes in Mattersburg in May 2020.

The project team set up the sharing service, including legal and technical issues, the search for and training of the hosts, and the allocation of the bikes.

3.4 St. Pölten

3.4.1 Project Background

Since June 2022, a shared cargo bike is offered by Radland Niederösterreich in St. Pölten. The cargo bike was implemented within the project „eTransport 24/7" together with a smart wall box for 24/7 cargo bike sharing in the city centre of St. Pölten. „eTransport 24/7" is a follow-up project of „KlimaEntLaster" aiming to roll out and further test cargo bike sharing based on smart wall boxes for sharing around the clock in small and medium-sized towns and municipalities. QUADRATIC led the project with Die Radvokaten, Energy Changes, Factum and the TU Wien.

3.4.2 Spatial Context

St. Pölten, the capital of Lower Austria, is an urban centre (Statistik Austria 2022a)within close proximity to Vienna and with approximately 56.000 inhabitants(Statistik Austria 2022b). On average, St. Pölten has good public transport access (Statistik Austria 2023) and a high rate of in-commuters (commuting to St. Pölten for work or education) and relatively few out-commuters, most of whom commute to Vienna's metropolitan area for work or education (Statistik Austria 2020).

The offered cargo bike is located in the historic city centre, within a traffic-calmed area within 400m walking distance of the central train station.

3.4.3 Operating Model

Radland Niederösterreich is hosting the cargo bike. Thus, they are responsible for regular check-ups and customer support. Besides that, the cargo bike can be booked via the platform radverteiler.at and is accessible for free via the „Smarte Verleihbox".

4 DISCUSSION

4.1 User Patterns – Who uses cargo bikes?

Having a closer look at the question of who the users of the analysed cargo bike sharings are (Figure 1), it becomes clear that in all cases, male users dominate. In Seestadtflotte, the gender ratio appears to be a little more balanced, however, users may share one SeestadtCard or one account on radverteiler.at, so this data maybe inaccurate. Qualitative interviews within KlimaEntLaster showed that male members tend to carry out the booking process in some households, although male and female members both use the cargo bikes. In most cases users are between 25 and 54 years old, whereby the ones in aspernSeestadt and St. Pölten tend to be younger than the ones in Mattersburg. In Mattersburg, compared to the local population, the age group 35-54 is strongly overrepresented amongst users, while persons under 25, are strongly underrepresented. Furthermore, there are only a few users in Mattersburg (28), who use cargo bikes frequently. Finally, it should be noted that the data for Seestadtflotte is based on the online user survey, whereas the data for the KlimaEntLaster projects is based on user and reservation statistics.

Additionally, the number of loans per user is relatively constant between the three cargo bike systems. About 40 % used the cargo bikes only once in the period under review, while another 40% used them two to five times. Very few users loaned cargo bikes more than ten times, and there were hardly any heavy users. Mattersburg's number of loans per user was slightly higher than in the other systems. The intentions for using the cargo bikes also showed similarities in aspernSeestadt, St. Pölten and Mattersburg. The highest ranked motives for usage were the following: fun for children (as a passenger) and riders (parents); testing a cargo bike; environmental-friendly transport possibility; simple and practical as well as being inexpensive.

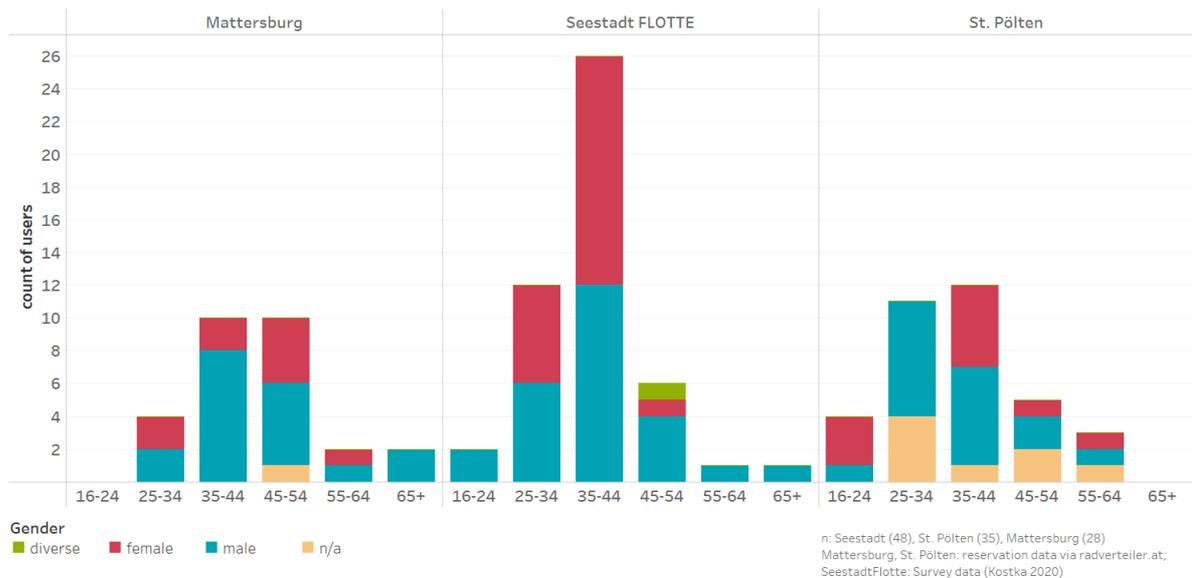## Age and Gender of users

Figure 1: Age and gender of users

4.2 Usage Patterns– How and When are cargo bikes used?

Coming to the usage-related data, we see that most of the bike loan periods begin between 8 am and 8 pm, which is a time span when also host-based services could offer their services. This time span is also related to the purpose of the cargo bike use (see below), where transport of purchases is one of the main issues. Looking at the loans over the course of the day and week in detail, further similarities and differences between the three analysed systems can be revealed. For analysing loans within the course of the week, Fridays were analysed separately from the other working days and weekends, as Friday can be seen neither as a typical working day nor as Weekend. In aspernSeestadt, loans on Fridays and weekends tend to occur earlier than from Monday to Thursday, likely related to users working times. A similar observation can be made in St. Pölten, where users also tend to loan bikes on Fridays earlier than on other days.

On the contrary, some users in St. Pölten reserve bikes also for late Sunday evenings, probably so that they can more easily begin their Monday morning travel from home. Users in Mattersburg behave differently, and the trend to later loans on Fridays/weekends was not observed. While users in Mattersburg took bikes more likely after work too, they also made some loans on working days very early, which was less the case in St. Pölten and rarely so in aspernSeestadt(Figure 2).

Having a look at the loan duration during the course of the week also revealed some interesting aspects. Firstly, loan durations differ significantly between the systems. While users of Seestadtflotte largely loaned the cargo bikes for a very short duration, this was not the case in St. Pölten and Mattersburg.

Even having in mind that the maximum loan duration in Seestadtflotte is only 12h, there are some loans lasting longer. In the other two systems, longer loans are allowed with even whole weekends being possible. It is possible that the very central location of the cargo bikes in aspernSeestadt is a reason for the comparatively short loans because users can easily take a cargo bike again if they need it more times per day. Also, a different purpose of use could be a factor here such as small purchases in the local area and fun rides around the lake for example. While the loan duration in aspernSeestadt is quite constant through the course of the week, this is not the case in St. Pölten, where loans starting on Friday tend to be of longer duration (over the weekend). In Mattersburg, another issue can be observed: While loans on the Weekends last mostly for several hours, loans during the week were either much shorter or longer (more than one day) compared to the other days, whereby longer rentals were rather the case from Monday to Thursday (Figure 3). Reasons for the described usage patterns in Mattersburg and St. Pölten may lie in the bigger spatial expansion of the municipalities compared to aspernSeestadt as an urban neighbourhood of short distances. Further, qualitative and quantitative surveys, as well as GPS-data analysis, reveal longer leisure trips by cargo bike as one of the main usage purposes in Mattersburg and St. Pölten.
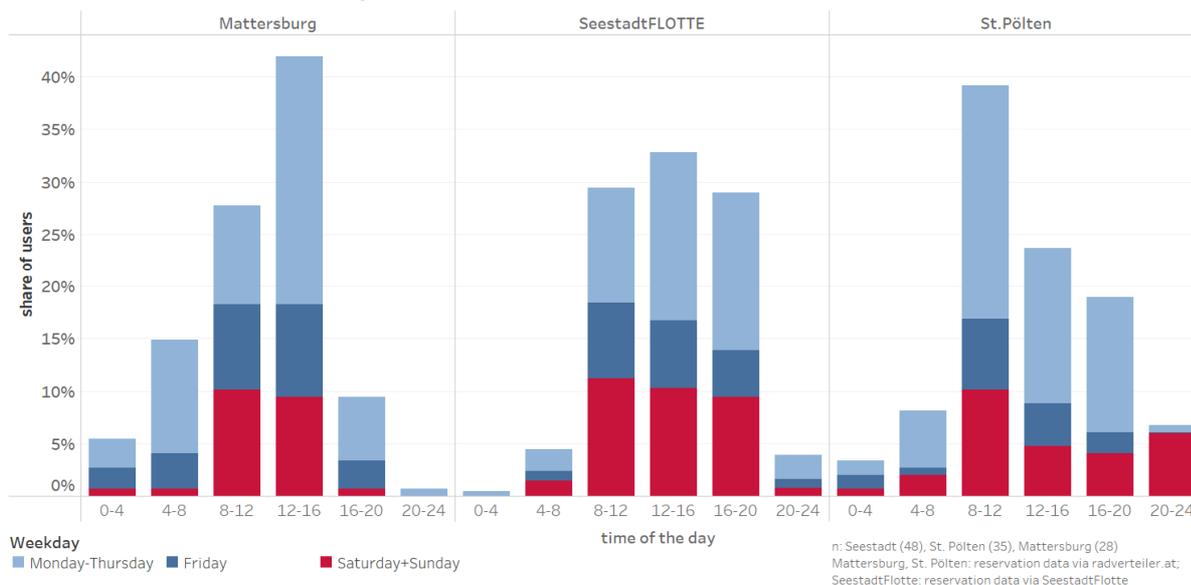
Loans in course of the day and week

Figure 2: Loans in course of the day and week

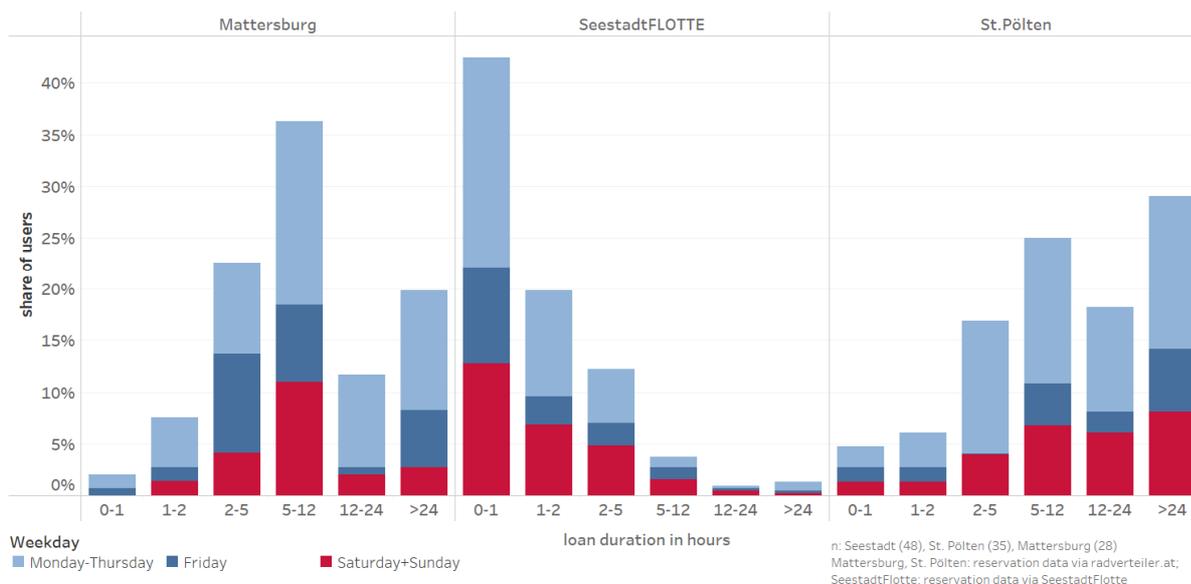## Loan duration in course of the week

Figure 3: Loan duration in course of the week

In addition to the information presented in the figures, the loan and reservation data analysis revealed that the loans are relatively constant during the week, and there is hardly a difference between the three systems. On Fridays there is a peak in loans in Seestadtflotte and Mattersburg, representing between 15 and 25% of all loans, whereas it is 10-15% on other days. Similarities can also be found regarding transported goods and persons. Cargo bike sharing users primarily transported children, purchases of different kinds, heavy, bulky goods, and equipment for leisure trips to surrounding recreational areas.

4.3 Spatial Patterns – Where are cargo bikes used?

Heat maps are powerful visual representations that provide valuable insights into spatial patterns and distributions based on quantitative data. They are particularly useful in analysing and interpreting the spatial characteristics of various phenomena, including the usage patterns of cargo bikes. Heat maps employ a colour gradient to depict the intensity or density of a particular variable across a geographic area. By visually displaying the concentration and distribution of trips, heat maps enable a first insight into cargo bike usage's spatial dynamics and identify possible key areas for intervention and infrastructure development.

Most trips in St. Pölten are concentrated around the city centre, as the cargo bike station is located at the town hall. This concentration is expected as many trips naturally start and end in this central area. Additionally, the heat map reveals a preference for utilising the dedicated cycling infrastructure along the Traisen River, indicating the importance of well-developed cycling paths in promoting cargo bike usage. Furthermore, the heat map shows that many trips extend beyond the city limits, indicating the potential for cargo bike utilisation in the surrounding, more rural areas, probably for longer leisure trips.
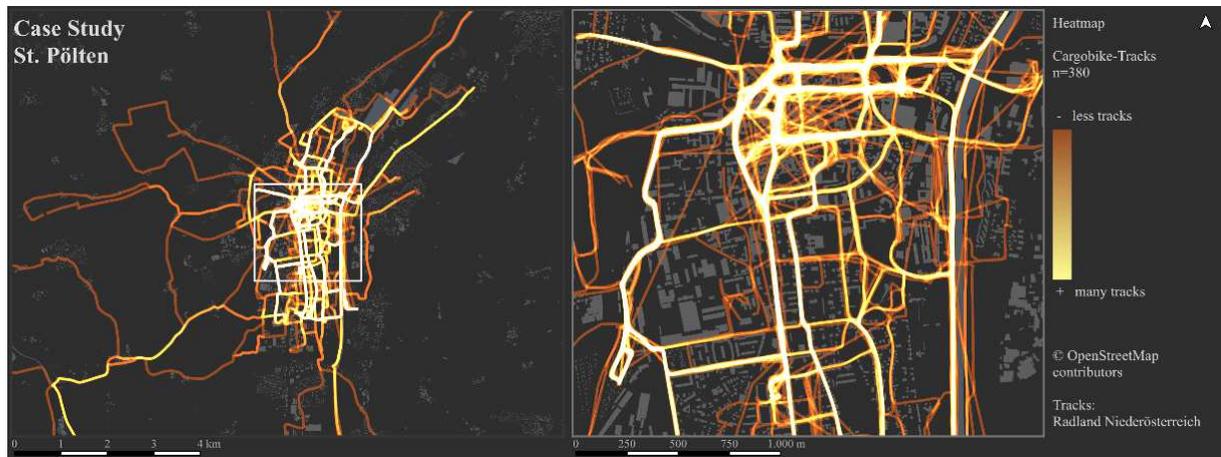

Figure 4: Heat map Case Study St. Pölten.

The heat map of aspernSeestadt illustrates a different spatial pattern characterised by a relatively homogeneous distribution of cargo bike trips. This uniformity can be attributed to the Cargo bike-friendly infrastructure provided throughout aspernSeestadt. The availability of dedicated cycling paths, safe routes, and ample cargo bike parking spaces contributes to a widespread usage pattern. Moreover, the heat map reveals that a significant portion of trips within aspernSeestadt is relatively short, emphasising the suitability of cargo bikes for local trips and the accessibility of amenities within the community, as aspernSeestadt is planned as an urban neighbourhood of short distances. However, it seems that users in aspernSeestadt have not yet recognised the cargo bike for longer leisure trips (e.g., to the surrounding recreational areas).

Figure 5: Heat map Case Study aspern Seestadt

The analysis of speed indicators based on track-level data, considering at least a 15-minute break between each track (see chapter methodology), revealed the following results for the St. Pölten and aspernSeestadt use cases.

These findings indicate notable differences in the average speeds of cargo bike trips between the two locations. In St. Pölten, where the mean and median speeds are higher, suggests a tendency for faster and potentially more direct or longer routes. Conversely, aspernSeestadt, where the mean and median speeds are lower, suggests a preference for slower and possibly more leisurely trips within the neighbourhood.

Speed indicator	St. Pölten	AspernSeestadt
Mean	17,5 km/h	10,1 km/h
Median	18,0 km/h	10,7 km/h

Table 2: Speed indicators.

The track length indicators provide insights into the variability of trip lengths. St. Pölten's longer mean and median track lengths indicate a tendency for relatively more extensive journeys. This may indicate cargo bikes being employed for purposes such as deliveries, transporting goods to farther destinations, or longer (leisure) commutes. Conversely, aspernSeestadt's shorter mean and median track lengths imply a preference for shorter trips within the neighbourhood or immediate vicinity. This pattern suggests that cargo bikes are primarily used for local mobility needs, such as short-distance errands, commuting within the community, or accessing nearby amenities.

Length indicator	St. Pölten	AspernSeestadt
Mean	3164 m	2127 m
Median	4693 m	3766 m

Table 3: Length indicators.

A map-matching technique was employed to align GPS data of cargo bike trips with the GIP graph edges, a comprehensive dataset capturing detailed information about the road network in Austria. This approach enabled insights into the specific infrastructure utilised by cargo bikes, contingent upon the quality and accuracy of the GIP data. By integrating GPS traces with the GIP-edges, it is possible to identify the routes taken by cargo bikes and to analyse the characteristics of the road segments, intersections, and other relevant features along their paths. This map-matching process can provide a deeper understanding of the spatial patterns in terms of used infrastructure and is a basis for finding bottlenecks.

For the evaluation, the number of map matched cargo bike trips per GIP edge was weighted with the length of the GIP edge – the features of longer edges thus have more weight in the result than those of shorter used edges.

Cars on street allowed/not allowed	St. Pölten	aspernSeestadt
No cars allowed	30,9 %	46,1 %
Cars allowed in one direction (one-way restriction)	7,4 %	6,9 %
Cars allowed	61,7 %	47,0 %

Table 4: Map-matched cargo bike trips and used infrastructure types (cars allowed / not allowed)

In St. Pölten, approximately 30% of the cargo bike trips were recorded on streets where cars were not allowed, 7% of the cargo bike trips occurred on streets with one-way restrictions, and the majority of cargo bike trips, accounting for around 60%, took place on streets where cars were allowed in both directions.

In aspernSeestadt, a higher percentage of cargo bike trips, approximately 46%, were recorded on streets where cars were not allowed. About 47% of the cargo bike trips took place on streets where cars were allowed in both directions. These findings suggest that cargo bike users in both St. Pölten and the aspernSeestadt prefer car-free routes, indicating a potential alignment with infrastructure that prioritizes non-motorised modes of transport. The higher proportion of cargo bike trips on car-free streets in aspernSeestadt results from the fact that planning of car-free zones has already been considered in the development plans.

Biking allowed	St. Pölten	aspernSeestadt
No	3,8%	19,4 %
Yes	96,2 %	80,6 %

Table 5: Map-matched cargo bike trips and used infrastructure types (biking allowed / not allowed)

In St. Pölten only a minimal share of the recorded cargo bike trips occurred on streets where biking was not allowed due to biking restrictions. Most cargo bike trips took place on streets where biking was allowed.

In aspernSeestadt, a higher percentage of cargo bike trips occurred on streets where biking was not allowed. These findings highlight both legal and illegal routes taken by cargo bike users, particularly in the

890

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aspernSeestadt. This concerns many trips in the parks and green spaces around the lake, where cycling is officially prohibited, but residents still like to use it as a shortcut.

The GIP also includes special information for pedestrian and bicycle traffic, which can subsequently be used for bicycle routing. This information - if complete and correctly recorded - could also be used to assess infrastructure readiness for cargo bikes better.

5 CONCLUSION

This article shows in a rough attempt the relevance of reservation and GPS data analysis for implementing and improving cargo bike sharing systems in order to offer accessible, sustainable and resilient mobility alternatives. However, even further potential lies in the deeper analysis and interconnection of different data as well as in the use of further data such as qualitative and quantitative surveys of users and non-users.

The availability and suitability of cycling infrastructure for cargo bikes remain understudied and further research is needed to understand the specific infrastructure requirements and design considerations that cater to the unique needs of cargo bikes. The „cargo-bikeability" of urban areas is a crucial aspect to consider when promoting sustainable urban mobility and to that end, different forms of use of cargo bikes tailored to the different needs of various target groups should be considered. This emphasizes the need for further research on infrastructure and the suitability for different cargo bike usage patterns (see e.g. ENTLASTA project).Different user demands should also be considered when designing the operating model. The case studies illustrate that automated lending facilitates access for regular users and for shorter loans, however, an additional contact person could be particularly supportive for first-time users. To exploit the socially inclusive potential of cargo bike sharing, it is necessary to expand outside urban areas and to reach further groups of people. Thus, further research is needed (see e.g. HAUSRAD project).

Spatial data, particularly GPS data analysis, can play a vital role in identifying bottlenecks and challenges faced by cargo bike users. The integration of GPS data provides added value to understanding cargo bike usage patterns, but it is important to consider the complementarity of additional data sources. Supplementing GPS data with other relevant data, such as demographic information, land use data, and transportation demand data, would provide a more comprehensive understanding of the factors influencing cargo bike mobility.

6 REFERENCES

Becker, Sophia, and Rudolf, Clemens: Exploring the Potential of Free Cargo-Bikesharing for Sustainable Mobility. In: GAIA - Ecological Perspectives for Science and Society, Vol.27 (1): pp. 156–64.2018. https://doi.org/10.14512/gaia.27.1.11.
Berger, Martin, Dorner,Fabian and Brugger, Arno:„Evaluierung Projekt Grätzlrad. Bericht. Vienna, 2019. URL: https://publik.tuwien.ac.at/files/publik_279102.pdf.(30.06.2023)
Dorner, Fabian: Mit Dem Lastenrad Mobil: Nutzung Und Sharing Im Kontext Privater Haushalte.Dissertation, TU Wien. Vienna, 2020.
European Cyclists" Federation: Framing the Third Cycling Century. Grafl, Katharina, Bunte, Heike, Dziekan, Katrin, Haubold, Holger (eds.). German Environment Agency. 2018.
FGM-AMOR, Outspoken, ECF, and CTC:Cyclelogistics Moving Europe Foraward. Final Public Report. Austrian Mobility Research, FGM-AMOR (eds.). 2014.
Fontaine, Pirmin, Minner, Stefan, Geier, Konstantin, Rautenstrauß, Maximiliane, Rogetzer, Patricia, Moeckel, Rolf, Llorca, Carlos: Potenziale für Lastenradtransporte in der Citylogistik | RadLast Leitfaden. Katholische Universität Eichstätt-Ingolstadt, Technische Universität München (eds.). Eichstätt-Ingolstadt & Munich, 2021.
Grasso, Susan Hull, Barnes, Philip and Chavis, Celeste: Bike Share Equity for Underrepresented Groups: Analyzing Barriers to System Usage in Baltimore, Maryland. In: Sustainability (Switzerland), Vol. 12 (18). 2020. https://doi.org/10.3390/su12187600.
Kammerhofer, Aurelia, Sodl-Niederecker,Vanessa, Füssl, Elisabeth, Dörrzapf, Linda, Schmid,Julia, Ausserer, Karin, Dorner, Fabian, Raffler, Clemens, Hackl,Roland and Berger, Martin: Transportträder Als Potenzial Für Resiliente Mobilität in Der Stadt : Rahmenbedingungen , Hemmnisse Und Erfolgsfaktoren Anhand von Zwei Projektbezogenen Fallbeispielen in Österreich. In: Der öffentliche Sektor – The Public Sector, Vol 47 (2): pp. 300–303. Vienna, 2021.
Knapp, David: Mobilitätsinfo Aspern Seestadt. Vienna, 2021. URL: https://www.aspern-seestadt.at/jart/prj3/aspern/releases/de/upload/211103_Mobilitaetsinfo-Seestadt.pdf.(30.06.2023)
Kostka, Leo: Nutzung von Stationsbasiertem Lastenradsharing in der Seestadt Aspern.Usage of Station-Based Cargobike Sharing in SeestadtAspern. Masterthesis, TU Wien. Vienna, 2020.
Levy, Nadav, Golani, Chen and Ben-Elia, Eran: An Exploratory Study of Spatial Patterns of Cycling in Tel Aviv Using Passively Generated Bike-Sharing Data. Journal of Transport Geography, Vol. 76, (January 2017): pp. 325–34. 2019. https://doi.org/10.1016/j.jtrangeo.2017.10.005.
Li, Wenwen, Wang, Shaohua, Zhang, Xiaoyi, Jia, Qingren, and Tian, Yuanyuan: Understanding Intra-Urban Human Mobility through an Exploratory Spatiotemporal Analysis of Bike-Sharing Trajectories. In: International Journal of Geographical Information Science, 34 (12): pp. 2451–74. 2020. https://doi.org/10.1080/13658816.2020.1712401.

Masterson, Ali: Sustainable Urban Transportation: Examining Cargo Bike Use in Seattle.Masterthesis, University of Washington. 2017. URL: https://digital.lib.washington.edu/researchworks/handle/1773/40719.(30.06.2023)

Rabenstein, Benjamin: Öffentliche Fahrradverleihsysteme - Wirkungen Und Potenziale. Veröffentlichungen Aus Dem Institut Für Straßen- Und Verkehrswesen 45, 2015.

Radkompetenz Österreich: Österreichweite Umfrage: Großes Potenzial Fürs Transportrad. Vienna, 2023. URL: https://radkompetenz.at/9778/oesterreichweite-umfrage-grosses-potenzial-fuers-transportrad/. (30.06.2023)

Randelhoff, Martin: Resiliente Infrastrukturen Und Städte: Kritikalität Und Interdependenzen. 2013. URL: http://www.zukunft-mobilitaet.net/40882/analyse/resilienz-infrastruktur-stadt-wirtschaft-zukunft-resiliente-infrastrukturen/ (30.06.2023)

Riggs, William, and Schwartz, Jana: The Impact of Cargo Bikes on the Travel Patterns of Women. In: Urban, Planning and Transport Research, Vol. 6 (1): pp. 95–110. 2018. https://doi.org/10.1080/21650020.2018.1553628.

Romanillos, Gustavo, Austwick, Martin Zaltz, Ettema, Dick, and De Kruijf Joost: Big Data and Cycling. In: Transport Reviews, Vol. 36 (1): pp. 114–33. 2016. https://doi.org/10.1080/01441647.2015.1084067.

Shaheen, Susan A., Cohen, Adam P., and Martin, Elliot W.: Public Bikesharing in North America. In: Transportation Research Record: Journal of the Transportation Research Board, Vol. 2387 (1): pp. 83–92. 2013. https://doi.org/10.3141/2387-10.

Statistik Austria: Abgestimmte Erwerbsstatistik. Datenstand 31.10.2020.

Statistik Austria: Gemeinden Klassifiziert Nach Urban-Rural-Typologie. Datenstand 1.1.2022.

Statistik Austria: Statistik des Bevölkerungsstandes. Erstellt am: 07.09.2022.

Statistik Austria: Gemeinden Klassifiziert Nach ÖV-Güteklassen. Datenstand: 1.4.2023.

Thoma, Klaus: Resiliente Städte. In: Burmeister, Klaus, Rodenhäuser, Ben (eds): Stadt Als System. Trends Und Herausforderungen Für Die Zukunft Urbaner Räume. Oekom Verlag, München, 2014.

VCÖ: SeestadtFLOTTE - Lastenfahrradverleih in Aspern. Die Seestadt Wiens. Vienna, 2016. URL: https://mobilitaetsprojekte.vcoe.at/SeestadtFLOTTE-lastenfahrradverleih-in-aspern-die-seestadt-wiens. (30.06.2023)

Wien 3420 aspern Development AG: Leben Und Arbeiten in Der Seestadt! Vienna, 2023. URL:https://www.aspern-seestadt.at/. (30.06.2023)

Wien 3420 aspern Development AG: Mit Dem Rad. Vienna, 2023. URL: https://www.aspern-seestadt.at/lebenswelt/mobilitaet/mit_dem_rad. (30.06.2023)

Wien 3420 aspern Development AG: Mobilität. Vienna, 2023. URL: https://www.aspern-seestadt.at/wirtschaftsstandort/planung__wirklichkeit/mobilitaet. (30.06.2023)

Wrighton, Susanne, and Reiter, Karl: CycleLogistics– MovingEurope Forward! In: Transportation Research Procedia, Vol. 12 (June 2015): pp. 950–58. 2016. https://doi.org/10.1016/j.trpro.2016.02.046.

Zhou, Xiaolu: Understanding Spatiotemporal Patterns of Biking Behavior by Analyzing Massive Bike Sharing Data in Chicago. In: PLoS ONE 10 (10): pp. 1–20. 2015. https://doi.org/10.1371/journal.pone.0137922.

892

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Understanding the Significance of Urban Lingering Factor of Built Environments in the Socio-Climatic Decision-Making Process for Urban Open Spaces: Field Survey Alexandria University Campus

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1 ABSTRACT

Urban lingering is the practice of spending time in public spaces for leisure, socializing, or simply being outdoors. It is a critical urban factor that is influenced by various factors related to the built environment and climate. Urban open spaces, such as University campuses, plazas, and streetscapes, play a bilateral role with the lingering factor in promoting social and environmental sustainability. However, it is highlighted that the urban space's lingering factor understanding process is essentially affected by the aspects of the built environment especially the climatic considerations, to ensure their resilience and future adaptability.

This paper provides a literature review on urban lingering factor with the built environment and their role behind the climatic-based decision-making of urban spaces. The review is structured around several key themes that provide a comprehensive overview of urban lingering, illustrating its causes, effects, and potential solutions. It emphasizes the importance of understanding the complex and multifaceted phenomenon of urban lingering, which is shaped by a range of social, environmental, and economic factors. The research also discusses the implications of urban lingering for urban design, public policy, and community development, and identifies key areas for future research.

Overall, this review emphasizes the importance of considering the lingering factor and built environment on the climatic design and management of urban open spaces, and how this approach of design can support urban lingering behavior and promote social and environmental sustainability. The findings have implications for urban policy and well-being in urban open spaces especially on university campuses as been the focus of the research. Overall, this research review paper provides comprehensive insights into urban lingering factor and the built environment's potential impact on climatic-based decision-making. then, offers essential recommendations for addressing this crucial issue. The review research is aided by a preliminary comparative field survey that supports the research hypothesis.

Keywords: Climate-Informed Decision-making in Urban Open Spaces, Urban Personality, Urban Built Environment, Urban Lingering Factor, Urban Personality

2 URBAN LINGERING FACTOR

2.1 Lingering Factor Definitions: General Overview

Urban public spaces play a critical role in the social, economic, and cultural life of a city. However, not all public spaces are created equal, and some spaces attract more people and activities than others. The concept of the "urban lingering factor" refers to the qualities and typologies of urban public spaces that encourage people to linger and engage in activities. Understanding this factor is crucial for architects and urban planners to design public spaces that are attractive and inclusive(Wang, Liao, Brandhorst, & Clark, 2022).

Lingering is a complex phenomenon that has been studied in a variety of contexts, including urban open spaces, retail environments, and public transportation. Lingering can be defined as the act of staying in a particular location for an extended period of time, often for social or recreational purposes(UN-Habitat, 2020). Lingering can be influenced by a variety of factors, including the physical design of the space, the social and cultural context of the community, and the perceived safety and comfort of the space. Understanding the factors that influence lingering is important for designers and planners who seek to create urban spaces that are vibrant, dynamic, and well-utilized. This part provides a general overview of the lingering factor definitions that have been identified in the literature and discusses their implications for urban design and planning.

2.1.1 Definitions of Urban Lingering

Urban Lingering is a complex concept that has been defined and studied in various ways by different scholars. In this section, we will review some of the key definitions and understandings of Urban Lingering that have been put forth in the literature.The term "Urban Lingering" was first coined by the sociologist Sharon Zukin's book in 1996 "The Cultures of Cities." In this work, Zukin defines Urban Lingering as the practice of occupying in public spaces for pleasure, entertainment, or social interaction(Zukin, 1996). According to Zukin, Urban Lingering is an important aspect of urban life, as it allows individuals to engage with their surroundings and with each other in meaningful ways.

Since Zukin's initial definition, scholars have expanded the concept of Urban Lingering to include a variety of different practices and activities. For example, some researchers have focused on the importance of Urban Lingering for mental health and well-being, arguing that spending time in public spaces can help to reduce stress and increase feelings of happiness and connection (Pretty , Peacock, Sellens, & Griffin, 2005). Others have emphasized the political and social dimensions of Urban Lingering, highlighting how public spaces can be sites of resistance and contestation, particularly for marginalized groups (e.g., McFarlane, 2010).

The term "urban lingering factor" refers to the tendency of individuals to spend time in public spaces without a specific purpose or activity. The concept of urban lingering is closely related to the idea of "loitering," but generally has a more positive connotation, as it is often associated with social interaction, leisure, and community building.

On the other hand, it may refer to the impact of past decisions on the current state of the urban environment. It recognizes that the built environment of cities is a product of past decisions and that these decisions can have extended effects on the sustainability and resilience of urban areas. The urban lingering factor highlights the need forextensivecomprehensive decisions in urban planning and design (Abd Elrahman & Asaad, 2021).

Broadly, it is argued that there are several definitions of the urban lingering factor, depending on the context and perspective of the researcher. Some definitions focus on the physical presence of individuals in public spaces, while others emphasize the social and cultural dimensions of urban lingering. Here, the following table (1) summarizes several definitions of urban lingering:

Definitions	Reference
The occupying practice in public spaces for pleasure, entertainment, or social interaction	(Zukin, 1996)
It refers to the act of spending time in public spaces without a specific purpose or activity and is often associated with social interaction and community building.	(UN-Habitat, 2020)
The urban lingering factor refers to the degree to which public spaces are conducive to social interaction and leisure activities and can impact the quality of life and sense of community in urban environments.	(Wang, Liao, Brandhorst, & Clark, 2022)
Urban lingering is a form of informal social activity that occurs in public spaces and can contribute to social cohesion, community building, and cultural exchange.	(Aelbrecht & Stevens, 2019)
To describe how past choices have affected the state of the current urban environment. It acknowledges that decisions made in the past have an impact on the built environment of cities and can have a long-term impact on their sustainability and resilience.	(Asadpour, Razmara, Heidari, & Taghipour, 2022)

Table 1: Definitions of Urban Lingering. Source: authors.

Overall, the definition of the urban lingering factor depends on the specific context and research question but generally involves the concept of spending time in public spaces without a specific purpose or activity, and the potential impact of this behavior on social interaction, community building, and urban development.

2.2 Parameters of Urban Lingering

The observation of people's presence is the standard way to visualize urban lingering in existing urban open spaces. This could be considered a basic method to measure the current state of the urban linger factor for an urban space. However, this concept may not be beneficial for analyzing futuristic scenarios of urban open spaces. Urban lingering factors refer to the factors that influence people's tendency to spend time in public spaces, such as streets, parks, and squares. Therefore, measuring the urban lingering factor involves measuring the parameters of the desirable urban built environment that stimulate people to stay in urban open spaces, as well as highlighting the parameters that could affect people's eagerness to stay outside.

It is important to highlight that this research argues that the urban lingering factor should be considered both as an effective urban parameter and as a nominal numeric factor of numerator and denominator.

894

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The urban lingering factor is a complex and multifaceted concept that is influenced by various factors. Here are some parameters that could be used to measure the urban lingering factor:

- Historical and cultural significance of urban spaces (Shinbira, 2012).
- Accessibility and connectivity of urban spaces (Gehl, 2010).
- Diversity of uses and activities in urban spaces (Elshater & Abusaada, 2022).
- Sense of place and identity associated with urban spaces(Relph, 2022).
- Perception of safety and security in urban spaces (Fleming, Manning, & Ambrey, 2016).
- Environmental and sustainable qualities of urban open spaces (Beatley, 2011).

It is important to note that the parameters for measuring the urban lingering factor may vary depending on the context and location of the urban area being studied. Additionally, the selection of parameters should be based on a comprehensive understanding of the interplay between social, economic, and environmental factors in shaping the urban environment.

The table below (Table 2) provides a projection of the previously mentioned parameters on real examples of university campuses. The examples in the table illustrate the uniqueness of each campus, as well as the subsequent effect of each parameter.

Historical and cultural significance	Accessibility and connectivity of urban spaces
An evaluation has been done of the historical and cultural significance of the University of Virginia's urban open spaces. This evaluation assisted in locating campus areas that required preservation or restoration, which are more likely for people to linger in and integrated with.(Neuman, 2007)(Baldwin, 2020).	Analyzing pedestrian and bicycle traffic patterns allowed researchers at the University of California, Los Angeles (UCLA) to evaluate the connection and accessibility of urban open areas. Which was used to identify places that required upgrading accessibility and promoting amenities. (Critique Access, 2022).
Diversity of uses and activities in urban spaces	Sense of place & identity related to urban spaces
The multi-functionality of the University of Massachusetts Amherst's urban spaces was assessed by users'surveys to classify their favorite outdoor spaces and their engaged activities. The results were used to inform decision-makers in the campus's renovation process. (Sleegers, 2010) (Toom , 2022).	The sense of place and identity At the University of British Columbia was evaluated amongurban open spaces by a series of workshops with users to determinetheir unique characteristics and qualities. Comprehensive development steps have occurred to enhance this parameter (Covin, 2009).
Perception of safety and security in urban spaces	Urban Environmental and sustainable qualities
A study at the University of Melbourne conducts to investigate the perception of safety and security in various campus open spaces. The study found that spaces tended to be perceived as safer are more likely to be used for lingering and socializing.(Piroozfar,et al, 2019).	At the Arizona State University campus, the ecological function of various urban spaces was evaluated and analyzed, which helps to identify areas that require restoration. and guide developers to a comprehensive plan for sustainable campus development. (ASU, 2023)

Table 2: Examples of Urban Lingering Factor Parameters. Source: authors.

2.2.1   The Challenges & Limitations of the Urban Lingering Factor Parameters

- Subjectivity:subjective parameters, which are based on people's perceptions and experiences rather than objective data. For instance, the sense of place is extremely subjective and based on the background, experiences, and culture of the individual.

- Context-dependency:parameters are highly contextual dependent and locational for the studied urban area. As an example, the urban space'scultural significance may be differentiated between old and new cities.

- Data availability: Due to a lack of data, some parameters are more challenging to be measured than others. For instance, they may entail advanced equipment or expertise that might not be available in all contexts.

- Interdependence:they are intertwined and cannot be isolated considered. Such as the urban space's multifunctionalitycould be influenced by its historical and cultural significance, its accessibility and connectivity, and the users' perception of safety and security.

- Resource limitations:the measurement process could be time-consuming and expensive and may require interdisciplinary expertise.

Finally, it is believed to consider the challenges and limitations which are synchronized with these parameters, while interpreting the urban lingering factor results. This process can provide valuable insights intothe social, economic, and environmental factors that shape urban open spaces.

3   URBAN BUILT ENVIRONMENT

The urban built environment has a significant role in the overall aspects of areas. Urban activity, social interaction, and access to resources all could be influenced by the design and layout of the urban context. Additionally, it can associate and reinforce social and economic disparities, affecting health and opportunities for residents. A growing need for examining the relationship between the built environment and urban outcomes has appeared. Such research can support planning and designing decisions, assisting to produce more viable, equitable, and sustainable urban environments(Paudel & States, 2023). Researchers have examined the design and management of open and green spaces, as well as the health, psychological, economic, and social outcomes (Nguyen, Astell-Burt, & Rahimi-Ar, 2021).

Generally, the study of the urban built environment is crucial for understanding how the physical environment affects urban spaces, both tangily and intangibly. By examining the relationship between the built environment and urban outcomes, researchers can inform planning and design decisions that promote the desired outcomes.

3.1 The Definitions of Urban Built Environment

Several definitions could be associated with the urban built environment.However, it generally involves the tangible assets of urban areas, including buildings, transportation systems, public spaces, streets,…etc. Urban open spaces users' health and well-being are significantly impacted by the design and management of the urban built environment, which is influenced by various social, economic, and cultural elements. Table (3) is illustrating the specific definition of both built and urban built environments.

Terms	Definition	Citation
Built Environment	The human-made physical context in which people live, work and play	(Habash, 2022)
Urban Built Environment	The physical environment of cities and towns, including buildings, streets, public spaces, and transportation systems	(Roe, et al., 2020)

Table 3: Definitions of Built Environment and Urban Built Environment. Source: authors.

The interaction between the urban built environment and the climatic and natural elements is a crucial aspect. Urban spaces, such as parks and plazas, are distinctly endangered by environmental threats, including extreme temperatures, air pollution, …etc. These threats can affect the viability and vitality of urban open spaces and may negatively impact the health and well-being of their users.Urban designers and planners hold the responsibility to address these challenges and increasingly incorporate green infrastructure, such as trees, green roofs,rain gardens,etc.through their designs, as well as help relievetheir effects (Habash, 2022).

The World Health Organization (WHO) highlights the importanceof urban built environment integration with natural elements, to enhance the urban quality. WHO emphasizes through their "Urban Green Spaces and Health" report that the human association with green spaces, such as parks and gardens, can promote physical activity, reduce stress, and improve mental health(WHO Regional Office for Europe, 2022).Overall, it is considered that the urban built environment is a complex system. It is shaped by various interconnected factors. It has an essential relationship with the climate and natural elements, (Roe, et al., 2020).

3.1.1 Urban Built Environment and Urban Lingering Factor

Urban built environment has received significant concern, through research, is the role of urban open spaces, such as parks and plazas. These spaces provide important opportunities for relief and social, economic, and cultural interaction. They can also play a role in promoting their usersboth physical and psychological health. Moreover, the design of urban open spaces can have a significant impact on how they are used and perceived by users, which are generally described as urban lingering factors(WHO Regional Office for Europe, 2022).

It is believed that the overall layout of the urban built environment has an impact on its urban outcomes. For instance, high walkability neighborhoods, connectivity, and mixed land uses have been associated with high physical activity and low obesity rates(Gehl, 2010). Similarly, access to public transportation also can improve mobility for users and reduce reliance on individual vehicles(Berg & Ihlström, 2019).

In other words, exposure to air pollution, noise pollution, and other environmental hazards can create negative effects on users' mental and physical health (WHO Regional Office for Europe, 2022). Additionally, social and economic factors, such as destitution and segregation, have reflections onthe built environment, creating disparities in accessibility, security & safety, well-being...etc (Aelbrecht & Stevens, 2019).

Abdelaal (2019) proposes that the urban built environment plays a crucial role in the urban spaces users' existence and well-being, both tangibly and intangibly, directly and indirectly. Byincorporating aspects of the built environments, and climatic and sustainable parameters, urban designers and planners can create more livable, equitable, and resilient urban open spaces(Abdelaal, 2019) (Abd Elrahman & Asaad, 2021).

Thus, it is believed that the urban lingering factor is significantly impacted by the urban built environment of space. University campuses are distinctive urban settings that provide a various range of open spaces, such as courtyards, plazas, and green areas. The way that people utilize and two-way interaction with these spaces, as well as their general satisfaction and well-being, could be influenced by their design (Abdelaal, 2019).

3.2 Parameters of Built Environment in Desirable University Campuses' Urban Open Spaces

Desirable university campuses' urban open spaces are significant campuses' outdoor areas that are used as gathering locations for visitors, staff, and students (Hanan, 2013). These spaces are designed to provide a comfortable and attractive environment for relaxation, socialization, and physical activity. The success of these spaces relies on their design, which should incorporate various characteristics, that could be considered as the conceptual shape of a space's built environment parameters, including multifunctionality, accessibility, sustainability, aesthetics, and safety and security. These characteristics are essential for developing a setting that encourages well-being, stresslessness, and fosters a sense of community. Universities build open-space environments in order to improve the student experience and feeling of communityby considering these parameters (Abdelaal, 2019).

The Characteristics of Desirable University Campuses' Urban Open Spaces				
Chars.	**Multi-functionality**	**Accessibility**	**Sustainability**	**Aesthetics**	**Safety and security**
Description	Spaces which serve multiple purposes, such as providing socialization, studying, and physical activities.	Accessible spaces to all users, including people with disabilities.	Spaces which are designed or functioned with sustainable features such as green roofs, rain gardens, ...etc.	Open spaces should be visually appealing and designed in a way that reflects the campus culture and values.	These spaces should be well-lit and designed to minimize the risk of accidents and crime.
Ref.	(Hanan, 2013)	(Qurratul, Henny, & A, 2019)	(Abdelaal, 2019)	(Yu Lau, Gou, & Liu , 2014)	(Piroozfar,et al, 2019)
Examples	The University of Sydney	University of British Columbia, Canada	UCLA, Los Angeles' Sculpture Garden	The UC Berkeley Strawberry Creek Plaza	The University of Melbourne's South Lawn

Figure 1: A brief about the characteristics of desirable university campuses urban open spaces. Source: authors.

Fig. 1 illustrates a brief about the characteristics of desirable university campuses urban open spaces. The table categorizes the characteristics, supported with relevant examples of university campuses' urban open spaces.

The urban spaces characteristics of desirably university campuses are deeply related to the urban built environment parameters. Various factors should be taken into consideration through designing and planning such as shape and layout, management and system, ...etc. For instance, sustainable features such as solar lighting, green roofs, and greenery, are considered as ingredients of a built entity and can enhance spaces' sustainability and vitality. Similarly, accessibility features such as ramps, sidewalks, and seating areas can be considered through the built environment as accessibility insurance for the space. Additionally, the visually appealing welcoming environment of the space could be achieved byincorporating aesthetically pleasing design elements. By considering these factors in the design of the urban built environment, universities can create desirable urban open spaces that have positive urban impacts (ASU, 2023). Table (4)illustrates the parameters of desirable urban built environments through university campus urban spaces.

Parameter		Description	References
Form	Size	Review space size and proportions, relatedto function and surroundings	(ÇakmakMehmet & Topcu, 2018)
	Configuration& Aesthetics	Thespace'soptimal shape and layout, based on the intended use and the surrounding environment	
LandSacpe	Materials	The space-appropriate materials, considering the function and surrounding.	(Hendel, 2020)
	Vegetation	The necessary greenery ratioin the space.	(ASU, 2023)
	Lighting	Space lighting considerations, of timing, load, and intensity.	(Gokhale, 2013)
	Furniture	Considering the space's furniture availability, suitability, and sustainability.	(Allahdadi, 2017)
System Management &	Maintenance	The space maintenance schedule& degree, based on the intended function.	(UN-Habitat, 2020)
	Long-term viability / Permanence	It is the ability of urban assets, buildings, ..etc. to remain functional, safe, and aesthetically appealing over time. Resilient and sustainable design and management policies are essential to achieving long-term viability.	

Table 4: Built Environment Parameters in Desirable University Campus Urban Open Spaces . Source: authors.

It is believed that the urban built environment of open spaces plays a crucial role in shaping the university campus experience. By considering the built environment aspects and parameters of desirable urban open spaces, there is the ability to create spaces with a wide range of supported activities, enhance well-being, and the overall campus experience.Figure (2) illustrates the interrelationships between the urban built environment and the role of the characteristics of desirable urban open spaces in the formulation of the desirable built environment.
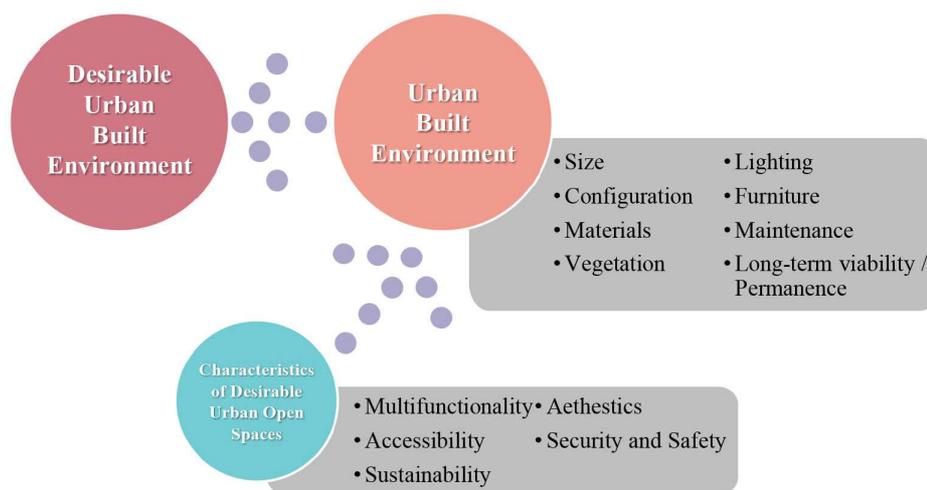

Figure 2: The Hinge Between the Urban Built Environment and the Characteristics of Desirable Urban Open Space. Source: authors.

In conclusion, the intent of desirable university campuses' urban open spaces is to promote well-being, stresslessness, and increaseusers'sense of community. Developing parameters such as multifunctionality, accessibility, sustainability, aesthetics, and safety can enhance these spaces built environmental conditions. It is thought that these parameters can also enhance the urban lingering factor of users through the urban space, and have multifaceted effects, affecting their performance, decision-making process, and overall experience

898

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of the space for both users and designers. Thus, it is proposed that the designing, controlling, or upgrading processes of these urban open spaces in a way that engages these characteristics, can significantly impact the user experience and the overall success of the space. It is believed that this process could be achieved, through the concept of a socio-climatic informed decision-making process.

4   SOCIO-CLIMATEINFORMED DECISION-MAKING PROCESS OF URBAN OPEN SPACES

Urban open spaces serve as places for recreation, social interaction, and cultural events, while also important ecological functions are provided such as air and water purification, carbon sequestration,…etc. However, with the increasing impacts of climate change, open spaces are facing new challenges that threaten their ability to provide these benefits (WHO Regional Office for Europe, 2022).Socio-climatic factors canaffect the use and accessibility of urban spaces, as well as the presence, health,and well-being of their users. To ensure that urban open spaces continue providing their intended benefits in the face of environmental changes, especially climatic changes, it is necessary to incorporate socio-climatic considerations intothe decision-making process formanaging, designing,and utilizing these spaces(Berkman, Vylegzhanin, & Young, 2023).

This part explores the socio-climate-informed decision-making process for urban open spaces. The socio-climatic factor, effects and integrated with the design and management of urban open spaces, will be investigated, through their users and decision-makers, and how this can lead to more resilient and equitable urban environments. This part will also explore the comprehensive complementary role of these elements through a bilateral bias.Overall, this part seeks to achieve a better understanding of how socio-climatic considerations can integrate with the decision-making process of urban open spaces, and how this can lead to more positive lingering urban factorsin the universities'urban environments.

4.1 Socio-Climate Informed Decision-making - General Definition

It is a theory that acknowledges the interdependence of social, economic, and environmental systems as well as how each of these systems is impacted by climate change. Support climate change-related decision-making, it entails merging scientific data and societal data. As it enables decision-makers to recognize and address the social and economic implications of climate change, this approach is particularly pertinent to public policy, sustainable development, urban planning, and business strategy.

The development of climate change adaptation plans in the agricultural sector is one practical example of the utilization of socio-climate-informed decision-making. The effects of climate change, such as altered precipitation patterns, a rise in the frequency and severity of extreme weather events, and changes to the growing season, are especially harmful to agriculture(Waldman, et al., 2020). Agricultural decision-makers can create strategies that not only address the environmental effects of climate change but also take into account the social and economic repercussions on farmers and rural communities by adopting a Socio-Climate informed decision-making strategy. For instance, to assist farmers in adapting to changing climate circumstances, decision-makers may take into account making investments in crops that are resistant to drought, creating water storage systems, and putting in place training programs for farmers. Figure (3) presents the conceptual framework for the factors affecting decisions made by American farmers in response to climate change (Chatrchyan, et al., 2017).

On the other hand,the development of climate change adaptation strategies for the transport sector is another utilization of socio-climate informed decision-making. The greenhouse gas emissions caused by transportation are an important factor in climate change. Transportation decision-makers can build plans that not only lower emissions but also consider the social and economic implications on communities by adopting a Socio-Climate informed decision-making strategy.

In general, it is proposed that the integration of social, economic, and environmental systems, as well as the climate change effects on each system is recognized as socio-climate informed decision-making theory(Manteaw, Amoah, Ayit, & Enu, 2022). It is believed that this strategy refers to the process of making decisions in an urban built environment with considering both social, environmental,and climatic factors. It is a holistic approach that allows the interplay between these factors and the need for aninclusive understanding of the urban system (Mendoza, et al., 2018).
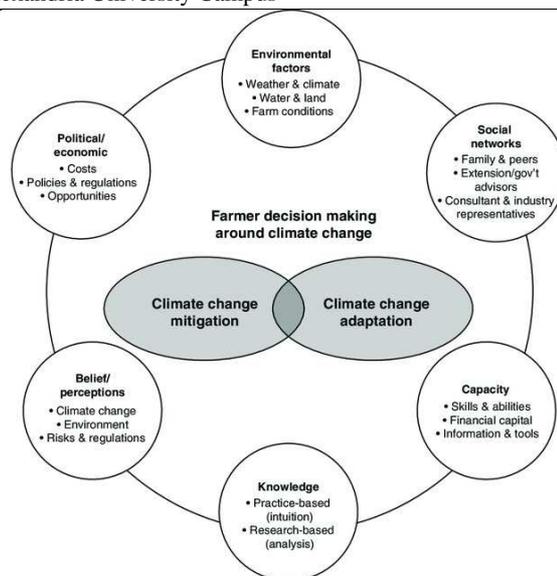
Figure 3: Conceptual framework for the elements influencing how American farmers execute climate change-related decisions. Source: Chatrchyan, et al., 2017.

Decision makers can create plans that address the social, economic, and environmental effects of climate change by adopting the socio-climate informed decision-making strategy. These actual instances show how crucial it is to consider both the environmental and social effects of climate change, as well as the necessity for a multidisciplinary approach todecision-making (Gargiulo & Zucaro, 2023).

4.2 Interdisciplinary Definitions and Viewpoints

Socio-climate informed decision-making is a complex strategy, that involves incorporating social, environmental, and climate change issues into decision-making processes. Across a range of fields, including environmental research and studies, politics, public health, community development, and engineering, the main definition of socio-climate informed decision-making is comparatively similar. Ensuring that decisions are sustainable, equitable, and resilient to the effects of climate change, is the central idea behind socio-climate informed decision-making(Orlove, Shwom, Markowitz, & Cheong, 2020). This approach is crucial for dealing with the complex issues brought on by climate change and promoting sustainable development. The procedure entails taking into account how climate change may affect social and environmental variables and using this knowledge to guide decision-making in creating policies, designing infrastructure, planning healthcare, and involving the community. Overall, making decisions based on socio-climate information is essential for reducing and adjusting the effects of climate change and promoting sustainable development(Santamouris, 2013). Table (5), summarizes the different perspectives and definitions of the Socio-Climate informed decision-making strategy. The table highlights the approached definition of each perspective that shows the fixed essence of the main concept behind this strategy.

Perspective	Definition	Ref.
Environmental Science	Process of making climate change informed decisions and its social impact.	(Koh , Loc, & Park, 2022)
Sustainable Development	The process that integrates social, economic, and environmental factors to produce sustainable decisions.	
Public Policy	Using scientific evidence and social data to, related to climate change, inform public policy decisions.	(Mendoza, et al., 2018)
General Policy Making	Process of integrating climate change considerations into policy development, implementation, and assessment to ensure policies climate change impacts resilience and support sustainable development.	(Orlove, Shwom, Markowitz, & Cheong, 2020)
Urban Planning	Considering the social and economic impacts of climate change on urban areas planning and design.	(Manteaw et al., 2022)
Business Strategy	Making business decisions that take into account the social and environmental impacts of climate change.	(Waldman, et al., 2020)
Community Development	is a participatory process that involves engaging communities in decision-making processes related to climate change adaptation and mitigation to ensure that decisions reflect the needs and priorities of the community.	(Aelbrecht,2022)
Engineering Perspective	Incorporating climate change impacts and vulnerabilities into engineering design and decision-making processes to ensure that infrastructure and buildings are resilient to climate change impacts.	(Berkman et al. 2023)

Table 5: Socio-climate informed decision-making from Different Perspectives. Source: authors.

900

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4.3 The Implementation of Socio-Climatic Informed Decision-Making Process Through the Urban Open Spaces

The concept of socio-climate informed decision-making process (SCIDM) of urban open spaces refers to the frameworkthat considers the socio-climatic factors that impact these spaces through the designing, managing, and using processes. Socio-climatic factors involve both the environmental and social aspects of a given location. To create a SCIDM process for urban open spaces, a various range of stakeholders is necessary to be engaged, including urban planners, designers, community groups, and policymakers. These stakeholders must work together to recognize the most relevant socio-climatic factors to the specific urban open space, and to develop approaches for addressing these factors.One substantial aspect of the SCIDM process is the climate data and projections incorporation into the design and management of urban open spaces(Waldman, et al., 2020). A climate model can be included to predict, for example, future temperature and precipitation patterns, and design urban open spaces that can adapt to these changes(Koh , Loc, & Park, 2022). Another key aspect of the SCIDM process is social equity and community engagement involvement. It is important to ensure that the responsiveness of design and management of urban open spaces to the needs and affinities of local communities, and the equitable distribution of these spaces benefits across different socio-economic groups. This includes the community groups'engagement in the design and management process andthe incorporation of their feedback through decision-making(Aelbrecht, 2022).

4.4 The Study Three Aspects -The Triangulated Relationship

Through this paper, it is believed that a comprehensive understanding of these factors is essential for creating sustainable, vital, and viable urban built environments.Urban open spaces are complex mechanisms that are moulded by intertwined factors, including the built environment, social & economic conditions, and climatic conditions.The interplay between these factors is critical to the vitality and viability of these urban open spaces. This parthighlights the interrelationship between the urban built environment, the SCIDMprocess, and the urban lingering factor. It is believed that the interrelationship between these three factors is simple, logical, tangled,and multifaceted. The built environment is influenced by past decisions and current and future socio-climatic projections. The SCIDMprocess recognizes the interplay between these factors and seeks to make decisions that are based on a comprehensive understanding of the urban system. The urban lingering factor is reflecting the urbanaffections of the other factors, which are represented through the innate presence of users in the urban spaces while consideringthe past decisions'impact on the sustainability and vitality of urban areas.Ideally, Urban spaces' users urban lingering critically depended on the interplay between these three variables. It is crucial to have a comprehensive understanding of them. Cities may have the ability to create built environments that suit the demands of the present and future generations while minimizing the effects of previous actions by adopting a holistic approach to urban planning and design decisions that consider the interaction between social and environmental elements, as well as, controlling the urban lingering factor of each urban open space as it is proposed by its designers through controlling the other factors.

Figure 4: The Study Three Interrelationship Aspects. Source: authors.

Overall, the interrelationship between the Urban Built Environment, Socio-Climatic Decision informed making process, and the urban lingering factor is believed to be significant. Both the urban built environment

and the socio-climatic informeddecision-making process play important roles in shaping the current and future conditions of urban open spaces. On the other hand, the urban lingering factor plays a role as a representative key value in the urban open spaces. Fig. 4 presents the interrelationship between these three factors, as well as the role of each factor as either a stimulus or an indicator.

5 FIELD SURVEY –URBAN OPEN SPACES OF THE UNIVERSITY CAMPUS, FACULTY OF ENGINEERING, ALEXANDRIA UNIVERSITY

5.1 Introduction

University campuses are often considered as microcosms of urban areas, with unique characteristics and challenges that play a crucial role in shaping the overall campus experience. The urban open spaces on these campuses have great potential for development through an updated decision-making process based on various aspects that guarantee the achievement of specific goals.

This field survey reviews the literature on the built environment of university campuses and the urban lingering factor, with a focus on urban open spaces. The survey provides an initial sensory evaluation to test the research hypothesis, which proposes a positive relationship between the implementation of built environment parameters and students' urban lingering factor. It also highlights the importance of a decision-making process that considers social and climatic factors (SCIDM).

The field survey identifies the parameters of both the built environment and the urban lingering factor while emphasizing the need for a socio-climatic informed decision-making process for existing, future, or proposed steps that would achieve a positive urban lingering factor for urban open spaces. Finally, the study summarizes the findings through a table with figures and recommendations.

5.2 Methodology

The surveys consist of, firstly, creating a social and climatic comprehensive background regarding the study-selected locations. This has involved conducting surveys or focus groups to determine how people use outdoor spaces in different day times, and weather conditions, and what their most valuable features are in these spaces.Once this data has been collected, it could be possible of creating comprehensive viewpoints of each space's urban environment, both current anddesigned ones. Next, it is important to monitor uses and effectiveness over time. This has occurred through tracking the number of users, observing how people use the space, and collecting feedback from the community about their experience.The researcher used a basic field observation method in this study. The observation process took place for three continuous days, with ninety minutes of observation each day, on the Faculty of Engineering campus at Alexandria University. Figure (5) shows the observation zone that the researcher covered on the campus. As well as, illustrates the construction locations on the campus. It is important to note that approximately 80% of the students were on summer break during the first and second days of observation, while 100% were present on the third day.

Figure 5: Campus Zones Illustration (right), Construction Location (Middle) & Green Area (left). Source: authors.

5.3 Experimental Phase

Below are the results of the field survey for six different zones. Each zone is illustrated with its urban built environment rate based on the parameters of a desirable urban environment. Additionally, the survey includes the urban lingering factor (ULF) for both the observed factor and the expected factor, taking into account the design intentions of the urban area.

Zone 01

Built Environment: 70% | Existing ULF: 60% / Expected ULF: 90%

Notes: ULF is affected by the continuity of cars among the seating areas

Zone 02

Built Environment: 10% | Existing ULF: 0% / Expected ULF: 80%

Notes: When desirable urban built environment parameters are lacking, users are discouraged from lingering.

Zone 03
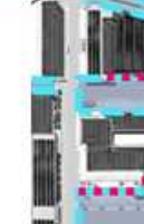
Built Environment: 80% | Existing ULF: 45% / Expected ULF: 90%

Notes: The lack of a green built environment and informed socio-climatic decisions have negatively impact the ULF

Zone 04

Built Environment: 10% | Existing ULF: 0% / Expected ULF: 20%

Notes: Despite the suitability of climatic conditions, the lack of built environment parameters has a negative impact on the ULF

Zone 05

Built Environment: 70% | Existing ULF: 55% / Expected ULF: 95%

Notes: the ULF is affected by the density of cars and the location of construction sites.

Zone 06

Built Environment: 5% | Existing ULF: 0% / Expected ULF: 80%

Notes: the absence of the characteristics of built environments have affected directly users' ULF.

5.4 Findings and Recommendations

- Provide and emphasize the reasons for users to stay in the urban open space to increase their engagement and enhance their experience.

- Acknowledge that the campus is considered as a gathering hub by some users during vacations and use this to promote lingering among the campus's urban areas.

- Prioritize greenery and climate-controlled urban areas in the development decision-making process, considering social aspects through the SCIDM process.

- Improve the condition of the urban built environment to positively impact the urban lingering factor.

- Adjust the design of the space to better meet the needs of the community in different weather conditions, such as adding sheltered areas or warming stations to encourage more use during the winter months.

- Students and users concentrate on specific areas for lingering during the construction circumstances and hard climatic conditions.

- It is believed that, by implementing these recommendations, the FOE AU can create a more desirable urban environment that promotes user engagement and enhances the overall campus experience.

- This field survey needs to be more expanded by using more advanced observation techniques in order to produce more accurate results and outcomes.

- It is important to take into consideration the aspects of social cohesion.

- The case study should highlight renowned contributions to "campus design on an international/global scale." By examining prominent examples from around the world, the study aims to identify influential approaches and principles that have shaped campus designs on a global level.

- It is important to note that the impact of the studied examples may not directly relate to the specific case used in the empirical study. The empirical study focuses on a particular campus, and it is crucial to consider similar contextual and environmental aspects when drawing conclusions and making recommendations based on the precedence study. By acknowledging these contextual differences, the research aims to provide a comprehensive understanding of campus design while tailoring the findings to the specific case under investigation.

- It is recommended to create an in-depth verification of built environment definitions through a deeper literature review.

6 CONCLUSION

In conclusion, the interrelationship between the urban lingering factor, the urban built environment, and the SCIDM process is a complex and multifaceted issue that requires a holistic approach to address. Through the field survey conducted on the FOE AU campus, it is clear that the lack of desirable urban built environment parameters can negatively impact the urban lingering factor, despite the suitability of climatic conditions. The field survey also revealed that students are more likely to linger in greenery-covered and climatic-controlled urban areas, which should be considered through the development decision-making process, in consideration of social aspects using the SCIDM process.

Overall, the socio-climatic informed decision-making process through urban open spaces involves gathering data, using that data to inform the design of the space, monitoring its use and effectiveness over time, and making adjustments as needed to better meet the needs of the community in different weather conditions. The FOE AU is recently under reconstruction or renovation, and the concepts and recommendations made through this field survey can be presented to decision-makers to inform the design of the space, in a way that guaranteesa positive impact on the users' urban lingering factor. However, it is essential to recognize that the ULF of the same place may differ from one time to another, and there is a necessity to reconsider and analyze the ULF parameters to produce more accurate ones. Future field surveys should expand the scope of the study and utilize new technologies for observation and visualization of outcomes for more accurate results.

7 REFERENCES

Abd Elrahman, A. S., & Asaad, M. (2021, March). Urban design & urban planning: A critical analysis to the theoretical relationship gap. Ain Shams Engineering Journal.
Abdelaal, M. S. (2019). Biophilic campus: An emerging planning approach for a sustainable innovation-conducive university. Journal of Cleaner Production.
Aelbrecht, P. (2022). Fourth Places Informal Social Life and Interaction in New Designed Public Spaces. Cardiff: Springer International Publishing.
Aelbrecht, P., & Stevens, Q. (Eds.). (2019). Public Space Design and Social Cohesion: An International Comparison. Routledge, Taylor & Francis Group.
Allahdadi, M. (2017). Explaining the Criteria of Designing Urban Furniture and Landscape, with a Cultural-social Design Approach. Journal of History Culture and Art Research.
Asadpour, H., Razmara, M., Heidari, A., & Taghipour, M. (2022). Privacy, patterns, and factors in urban open spaces (Case study: Jannat Park in Shiraz City). Megaron.
ASU. (2023). Sustainability goals and vision. Retrieved from Arizona State University.
Baldwin, E. (2020, July). "Style is Superficial": Alice Raucher on Social Justice and Sustainability at the University of Virginia. Retrieved from ArchDaily.
Beatley, T. (2011). Biophilic Cities: Integrating Nature into Urban Design and Planning. Springer.
Berg, J., & Ihlström, J. (2019). The Importance of Public Transport for Mobility and Everyday Activities among Rural Residents. Social Sciences.
Berkman, P. A., Vylegzhanin, A. N., & Young, O. R. (Eds.). (2023). Informed Decisionmaking for Sustainability. Springer.
ÇakmakMehmet , B. Y., & Topcu, M. (2018, October). An evaluation of urban open spaces in Historical City Center of Konya in the context of pedestrian mobility. Journal of Human sciences.
Chatrchyan, A. M., Erlebacher, R. C., Chaopricha, N. T., Chan, J., Tobin, D., & Allred, S. B. (2017, May). United States agricultural stakeholder views and decisions on climate change. WIREs Climate Change.
Covin, C. L. (2009). Cartographies of place and identity. University of British Columbia.

Critique Access. (2022). University of California Los Angeles. Retrieved from Critique Access.

Elshater , A., & Abusaada, H. (2022). Effects of nightlife activities on urban spaces and design: a case study of Cairo, Egypt. City, Territory and Architecture.

Fleming, C. M., Manning, M., & Ambrey, C. L. (2016). Crime, greenspace and life satisfaction: An evaluation of the New Zealand experience. Landscape and Urban Planning.

Gargiulo, C., & Zucaro, F. (2023). A Method Proposal to Adapt Urban Open-Built and Green Spaces to Climate Change. Sustainability.

Gehl, j. (2010). Cities for people. Island Press.

Gokhale, V. (2013). People's Perception of Urban Lighting in Public Space. The Journal of Architecture.

Habash, R. (2022). Urbanization as an intelligent system. Sustainability and Health in Intelligent Buildings.

Hanan, H. (2013). Open Space as Meaningful Place for Students in ITB Campus. Procedia - Social and Behavioral Sciences.

Hendel, M. (2020). Eco-Efficient Pavement Construction Materials. Woodhead Publishing.

Koh , Y. F., Loc, H. H., & Park, E. (2022, January). Towards a "City in Nature": Evaluating the Cultural Ecosystem Services Approach Using Online Public Participation GIS to Support Urban Green Space Management. Sustainability .

Manteaw, B. O., Amoah, A. B., Ayit, B., & Enu, K. B. (2022, April). Climate-Informed Decision-Making in Data-Poor Environments: Managing Climate Risk Through Citizen Science Networks. Frontiers in Climate.

Mendoza, G., Jeuken, A., Matthews, J., Stakhiv, E., Kucharski, J., & Gilroy, K. (2018). Climate Risk Informed Decision Analysis (CRIDA): collaborative water resources planning for an uncertain future. UNESCO & International Centre for Integrated Water Resources Management.

Neuman, D. J. (2007). University of Virginia Historic Preservation Framework Plan. Documentary.

Nguyen, P.-Y., Astell-Burt, T., & Rahimi-Ar, H. (2021). Green Space Quality and Health: A Systematic Review. International Journal of Environmental Research and Public Health.

Orlove, B., Shwom, R., Markowitz, E., & Cheong, S.-M. (2020). Climate Decision-Making. Annual Review of Environment and Resources.

Paudel, S., & States, S. L. (2023). Urban green spaces and sustainability: Exploring the ecosystem services and disservices of grassy lawns versus floral meadows. Urban Forestry & Urban Greening.

Piroozfar, P., Farr, E., Nimo, E. A., & Osei-Berchie, J. (2019, December). Crime prevention in urban spaces through environmental design: A critical UK perspective. Cities.

Pretty , J., Peacock, J., Sellens, M., & Griffin, M. (2005, October). The mental and physical health outcomes of green exercise. International Journal of Environmental Health Research.

Qurratul, A., Henny, M., & A, N. (2019). Evaluation of Accessibility for People with Disability in Public Open Space. IOP Conference Series: Materials Science and Engineering. South Aceh: IOP Publishing.

Relph, E. (2022). Place and Placelessness. SAGE Publications Ltd.

Roe, J., Mondschein, A., Neale, C., Barnes, L., Boukhechba, M., & Lopez, S. (2020). The Urban Built Environment, Walking and Mental Health Outcomes Among Older Adults: A Pilot Study. Frontier Public Health.

Santamouris, M. (Ed.). (2013). Energy and Climate in the Urban Built Environment. Routledge.

Shinbira, I. A. (2012). Conservation of the Urban Heritage to Conserve the Sense of Place, a Case Study Misurata City, Libya. American Transactions on Engineering & Applied Sciences.

Sleegers, F. (2010). University urban design centers in the planning and implementation of urban greenways. – Possible strategies for the UMass Amherst Design Center in Springfield, MA. the Fábos Conference on Landscape and Greenway Planning 2010. Scholarworks.UMASS.

Toorn , M. v. (2022). Public space and public health related to green space in urban landscape architecture. Proceedings of the Fábos Conference on Landscape and Greenway Planning. Scholarworks.UMASS.

UN-Habitat. (2020). City-Wide Public Space Strategies: A Guidebook for City Leaders. Nairobi: UN-Habitat.

UN-Habitat. (2020). Public space site-specific assessment Guidelines to achieve quality public spaces at neighbourhood level. Nairobi GPO KENYA: United Nations Human Settlements Programme.

Waldman, K. B., Todd, P. M., Omar, S., Blekking, J. P., Giroux, S. A., Attari, S. Z., . . . Evans, T. P. (2020, November). Agricultural decision making and climate uncertainty in developing countries. Environmental Research Letters - IOPscience.

Wang, X., Liao, C., Brandhorst, S. M., & Clark, P. E. (2022). Sedentarization as an adaptation to socio-environmental changes? Everyday herding practices in pastoralist communities in southern Ethiopia. Ecology & Society.

WHO Regional Office for Europe. (2022). Urban planning, design and management approaches to building resilience – an evidence review. London: World Health Organization.

Yu Lau, S. S., Gou, Z., & Liu , Y. (2014, December). Healthy campus by open space design: Approaches and guidelines. Frontiers of Architectural Research.

Zukin, S. (1996). The Cultures of Cities. Blackwell Publishers.

Urban Morphology vs. Social Cohesion: a Study of Two Neighbourhoods in New Borg Al-Arab City, Egypt

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1 ABSTRACT

Physically and socially, cities are tied together through neighbourhoods that make up their urban fabric. This research hypothesizes that the levels of Social Cohesion in a specific neighbourhood will differ based on the Neighbourhood's Physical Characteristics. This aspect is crucial for politicians responsible for new urban communities in Egypt. The main contribution of this research is to propose and test a model for comparing the levels of Social cohesion in various neighbourhoods. This is done through mixed research methods ranging from a qualitative stage including the literature review of the main neighbourhood design characteristics and social cohesion domains to a quantitative stage including statistical analysis for two neighbourhoods in New Borg Al-Arab City that differ from each other in their Morphological pattern. The data collected from the questionnaire were analyzed using the statistical package for social sciences (SPSS V26). Regarding the investigation of the main variables, this research concluded that there are significant differences in neighbourhood morphology between the two neighbourhoods, while there were no significant differences in social cohesion between the two neighbourhoods. And this result differs when investigating the subdimensions of the model, where there are significant differences in the levels of some of the subdimensions of Social Cohesion between the two neighbourhoods.

Keywords: Street system, Block system, Design Constraints, Social Cohesion, Neighbourhood Morphology

2 BACKGROUND

The term "neighbourhood" is commonly used to refer to a geographically constrained community of individuals who all make use of the same local amenities and have some degree of social cohesion with one another. The word "place" stands out among the three words "people", "location", and "cohesion" that define the neighbourhood. And in order to analyze such a place the branch of "Urban Morphology" is needed.

The study and design of "Urban Morphology" take into account the physical and spatial components of the urban structure of plots, blocks, streets, buildings, and open spaces, all of which are part of the evolutionary process of development in the specific area of the city being studied. Fundamental concepts of morphology include recognizing the evolution of urban landscapes across long time periods and being cognizant of the diverse cultural, social, economic, and political impacts of various time periods (Oliveira, 2016).

"Social Cohesion" can be affected by urban spaces since they attract large numbers of individuals. Streets, squares, parks, sidewalks, bike routes, and urban furniture tare all easily navigable and spacious and encourage people to engage with their surroundings, generate a productive use of space, and boost the vibrancy of a city. It is not enough to just think about dense metropolitan cores; the outskirts must be taken into account as well, with those living there assured of access to high-quality urban places.

The success of New Urban Communities is primarily dependent on social ties. According to our hypothesis, a connection can be drawn between Urban Morphology and Social Cohesion. In order to determine who is accountable for the development of the new urban communities in Egypt, it is essential to take into account the fact that the level of social cohesion of a neighbourhood can differ according to the physical characteristics of the neighbourhood.

3 LITERATURE REVIEW

The dilemma of Urban Morphology vs. Social Cohesion has been investigated through a limited number of research. The most prominent research in this field belongs to Wanas et al. (2014), Hossam Eldin Moustafa (2018), Aelbrecht et al. (2018), and Mouratidis and Poortinga (2020).

Wanas et al. (2014) provide new insight into how Cairo's urban design could play a part in fostering social cohesion among the city's diverse communities. It provides a comprehensive assessment and critical analysis

of the pertinent worldwide and local literature on the subject, allowing readers to gain insight into the state of our current understanding of the field and the gaps that still need to be filled.

Hossam Eldin Moustafa (2018) presents "Sense of community" as the primary strategy for achieving social sustainability on a local level, so his study aims to evaluate its constituent parts from an urban planning perspective in order to get insight into how locals feel about their neighbourhood. This is done through a literature review of the main domains of "Sense of community". By analyzing the layout design features, the researcher was able to learn about the urban characteristics of four distinct neighbourhoods in the "New Maadi" zone to the south of Cairo. Residents' perspectives on the sense of community aspects were surveyed through in-depth interviews guided by a questionnaire. Then, using SPSS, the researcher measured the correlation between these aspects and neighbourhood characteristics.

Aelbrecht et al. (2019) aim to integrate scholarly research on public space design and social cohesion in both the Global North and Global South. It aggregates research from renowned and rising researchers and practitioners from the Global North and Global South to share their knowledge and experience on these challenges. It compares case studies in different cultural and social situations with varied planning and design principles to understand their similarities and differences and to discover new theories and methods that can expand our knowledge of the topic.

Mouratidis and Poortinga (2020) are using survey and GIS data from the Greater Oslo Area. Their study proposes and tests a model in which urban vitality mediates the relationship between built environment features and neighbourhood social cohesion.

This research aims to provide a comprehensive overview of the necessary regulations, rules, priorities, and design constraints in Urban Morphology that promote greater social cohesion in local communities. The sim is to further elucidate which structural compositions lead to more effective social interaction. Furthermore, it presents a model that assesses the levels of social cohesion based on the different morphologies of neighbourhoods.

3.1 Neighbourhood Morphology

Urban morphology is characterized by factors such as the way buildings and streets are configured, as well as building properties. As the structure of cities is composed of Blocks and the Paths between them; forms of the urban fabrics could be investigated from these two aspects which are known as major components of cities (Arsiya and Mazloomi 2015). With respect to the structure of this research, the researchers present the street system and block system as the main dimensions of Neighbourhood Morphology.

3.1.1 The Street System

The main subdimensions of the Street System range from the Street Network to Street Layout, Street Type, Pedestrian Network, and Access Points.

What is meant by a "Street Network" is the way in which streets are laid out and connected in a given location. A development can benefit from having a well-thought-out structure and an efficient street network. Streets play a crucial role in the planning and layout of both structures and residential areas. It is important to establish links between various street networks (Larco 2014, Auckland Transport 2020). One definition of "street connectivity" is "the number and quality of linkages in the street network." Networks that are connected or permeable make it easier to get around on foot or bike. Similarly to considering how connectivity is concerned with outside connections, permeability looks at how people can move around and interact within a site. The permeability predetermines how easily people can travel between different areas (Bentley 1985, Partnerships 2000, Donnelley 2010, Steiner 2012, Larco 2014, Department of Human Settlements 2019,). Moreover, according to Lynch 1960, "If residents of a connected city can't get the layout of the place and what goes on there, the community will not work as intended. A readable arrangement is one in which mental representations of the content may be reliably formed. Keep in mind that the user, not the designer, forms the image; the designer is responsible only for the overall physical arrangement."

Although there is a wide range of possible "Street Layouts", the two most common network typologies are gridded and dendritic. Local streets only connect to collectors, and collectors only connect to arterials, under a Dendritic or Suburban Hierarchy. This method often encourages high speeds all the way through and concentrates traffic on the already crowded arterial system, and should be avoided. Successful urban street

network designs encourage several street types and a dense system of streets and crossings, allowing for more effective land utilization (Lahart et al. 2013, Auckland Transport 2020). Three different layouts of networks that can be tailored to specific locations are shown in Figure 1. There is a direct correlation between the permeability and legibility of a street network and how orthogonal the streets are.

Considering "Street Type", Any given street will often have what is referred to as "many personalities," which may be associated with a variety of functions or features. Each attribute of a street, such as its width, frontage type, or traffic kind, hints at a concept that may be used to categorize and rank it in relation to other kinds of streets. Table 1 presents a sampling of the subjects that were discussed (Marshall 2004).
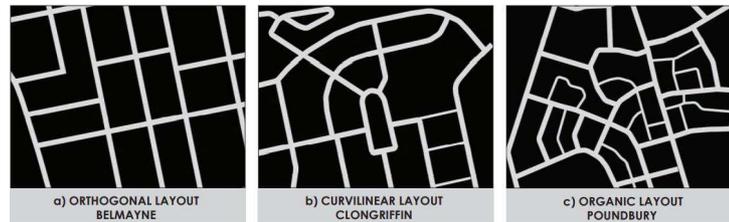
Fig. 1: Gridded Street Networks Layouts. Source: Auckland Transport (2020)

Set of road types	Classification theme	Type of theme
Square, circus, crescent, cross	Shape of space	Form
Dual 3-lane, dual 2-lane, single carriageway	Carriageway standard	
Limited access road, distributor, access road	Access control	
Street, terrace, mews, court	Built form/frontages	
Narrow street, wide street	Width	
Civic, commercial, residential, industrial	Urban building type	
Shopping street, living street, etc.	Urban uses and users	Use
High volume road, low volume road	Traffic volume	
Long distance traffic road, local traffic road	Trip length (origin and destination)	
Road type used by any mode	Transport modes	
High speed road, low speed road, etc.	Traffic speed (observed)	
Route used by tourist traffic, works traffic, etc.	Road users	
Spine road, connector street, cul-de-sac	Structural role	Relation
Strategic route, link road, local route, etc.	Strategic role	
National road, regional road, municipal road	Ownership/management	Designation
Special road, principal road, A road	Statutory designation	
70 mph, 60 mph, . . ., 20 mph road	Speed limit (designated)	
Bus only; pedestrian only, etc.	Vehicle or user permission	
'Avenue', 'Street', 'Lane', 'Mansions', etc.	Nominal	
Designated route for tourists, works traffic, etc.	Designated route	

Table 1: A taxonomy of road types, classification themes, and theme types. Source: Marshall, S. (2004)

Access to lots and connections to off-street, pedestrian-only and shared routes are all made possible by the network of footpaths and crossings that serves as the backbone of the "Pedestrian Network". When built according to the best rules, they provide easy access for all pedestrians. Figures 2 and 3 depict some suggested layout principles for them (Larco 2014).

Fig.2: Building sidewalks connecting every destination. Source: Larco et al. (2014), Fig. 3: Street crossings should be marked by painted crosswalks on internal streets. Source: Larco et al. (2014).

Promoting resident contact with the surrounding community and facilitating resident mobility to neighbouring residential or commercial areas on foot or bicycle requires an adequate number and distribution of "Access Points". Figure 4 shows how increasing the number of Access Points in a development may reduce travel times for residents by making it easier for them to walk or bike to nearby services. As a corollary, the uneven distribution of access points has consequences for site circulation as shown in Figure 5 (Larco 2014).

3.1.2 The Block System

The main subdimensions of the Block System range from the Block Type,to Density, and Mixed-land Use.

Multiple interpretations may be attributed to the land development that took place inside the block's confines. Next is a taxonomy of the most fundamental shapes that an urban block plan may take, based on the many physical configurations that could be used. "Block Types" have been broken down into the following five categories of building blocks: The Perimeter Block, The Row Block, The Point Block, The Ribbon Block, The Courtyard Block, and Other variants of the urban form (Tarbatt and Tarbatt 2020).
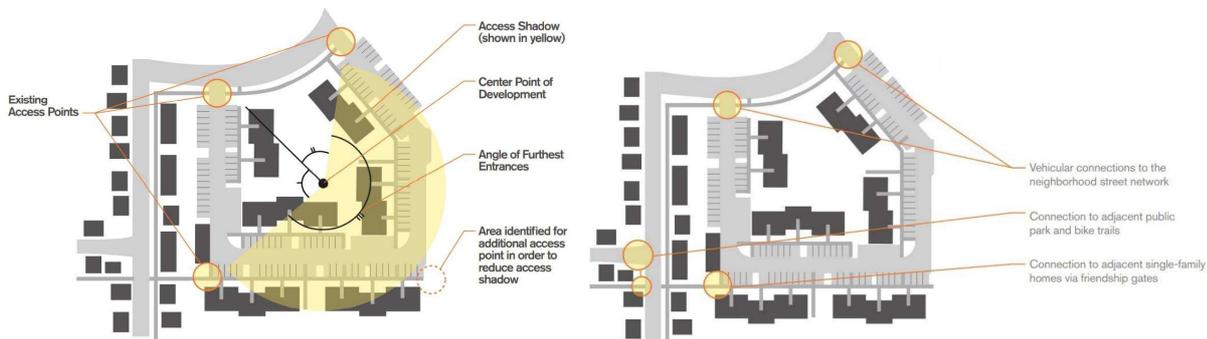

Fig. 4: Implications of Maximizing the number of Access Points.Source: Larco et al. (2014), Fig. 5: Access shadow diagram. Source: Larco et al. (2014)

Rather than viewing "Density" as the result of architectural considerations like accessibility, permeability, assembly, and proximity, it is more common to view density as a "goal". The fact that density can be tackled from a variety of angles is crucially essential. The difference between Physical and Perceived density is a key concept (Pont and Haupt 2007, Berghauser et al. 2009, Ewing and Cervero 2010, Dave 2011, Dempsey et al. 2012). For the purposes of this research, the "Perceived Density" approach is adopted in the model proposed.

The term "Mixed-land Use" is used to refer to the variation in land-related activities that can be found in specific regions. Following is a synopsis of the most important factors to think about while planning a mixed-use development: the Scale of mixed-use, Mixed-use Development Type, Location and visibility of mixed uses [Fig. 6], the critical mass of the supporting population, and the Clustering of uses at nodal points (Partnerships 2000, Barton 2003, Croucher et al. 2012).
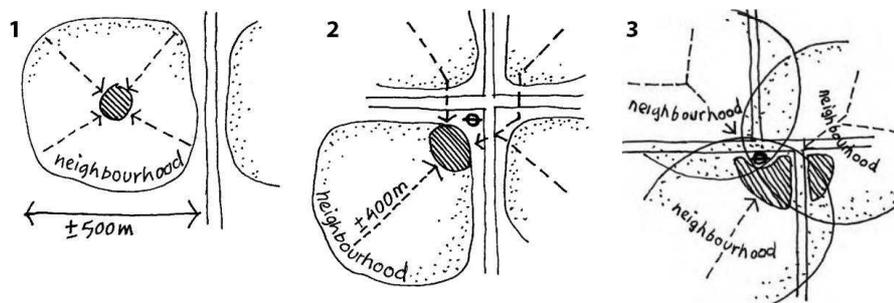

Fig. 6: Location of Mixed Use Areas and Neighbourhood Form. Source: Barton el al. (2003)

3.2 Social Cohesion

Learning what motivates a group to function as a cohesive unit is a central question at the heart of the study of social cohesion. The cooperative relationships between a group's members have their roots in early human evolution. Humans developed the ability to have healthy offspring by learning to work together. Over the

course of human history, this capacity for cooperative social conduct has been applied to situations ranging from clans to tribes to peoples to states to supranational bodies (Dragolov et al. 2016).

Surprisingly, the capacity to forge strong social relationships of cooperation is also a driving factor in the breakdown of groups. There is a natural tendency for the relationships between a subgroup and the members of the broader group to diminish or be overlooked when cooperative social bonds strengthen inside the subgroup. This strengthens or destroys the group's cohesiveness as a whole, while simultaneously creating and fostering cohesion inside the group itself (Dragolov et al. 2016).

Given that social cohesion is abstract and still being worked out in terms of operationalization, it is also multidimensional and interrelated. Its definition, measurement, and operational use are all up to debate. A singular focus on one discipline risks obscuring the importance of other factors—weak or strong—in fostering societal cohesion (Megahed 2017).

The Participation/Solidarity dimension, the Safety/Trust dimension, and the Attachment dimension are only a few examples of how academics have attempted to employ these concepts in empirical studies (Megahed 2017, Bottoni 2018, Liu et al. 2020).

4 METHODS

We have chosen two neighbourhoods for comparison; named neighbourhood two and neighbourhood three; in district one in New Borg Al-arab City, in Egypt, which differ from each other in their morphological pattern, as shown in Figure 7 and Figure 8. Then we examined the inhabitants' perception of both neighbourhood morphology and social cohesion. A random sample consisting of 193 participants was chosen for in-depth interviews using a structured questionnaire. The structured questionnaire can be divided into two main variables; Neighbourhood Morphology and Social Cohesion.

Fig. 7: Neighbourhood Two. Source: Google Earth, Fig. 8: Neighbourhood Three. Source: Google Earth.

The main variable Neighbourhood Morphology is branched out into two dimensions; Street System and Block System. The subdimensions of the street system that have been investigated in the questionnaire are Street Network (Q1:Q6), Street Type (Q7:Q10), Pedestrian Network (Q11:Q12), and Access Points (Q13:Q14). Then the main subdimensions of the Block System are Perceived Density (Q15:Q16) and Mixed-land Use (Q17:Q18).

The main Variable Social Cohesion is branched out into three dimensions: Participation/Solidarity, Safety/Trust, and Neighbourhood Attachment. The main subdimensions of Participation/Trust are Community (Q19:Q20), Political (Q21:Q22), and Solidarity (Q23:Q24). Following are the subdimensions of Safety/Trust: General Trust (Q25:Q26), and Institutional Trust (Q27:Q28). Then the subdimensions of Neighbourhood Attachment are; Identity (Q29:Q30), Ownership and Memory (Q31:Q32), and Belonging (Q33:Q34).

A five-level Likert scale with "Strongly Disagree" until "Strongly Agree", comprises the measurement level of the questionnaire. The data collected were analyzed using SPSS version 26. The Skewness and kurtosis tests were conducted to evaluate the normal distribution to choose between parametric and nonparametric tests. In comparing the two neighbourhoods, we performed the selected test on the three levels of the Questionnaire; The main Variables, the main Dimensions, and The main Subdimensions.

5 RESULTS

In terms of measuring normality, Skewness values between -2 and +2 and kurtosis values between -7 and +7 are considered acceptable in demonstrating normal distribution (Hair et al. 2014). Table 2 displays the results of the normality test, which show that the values of Skewness and kurtosis for the model's constructs fell within the acceptable range. Thus, The parametric test is the appropriate test. Since we are interested in comparing the two neighbourhoods, the appropriate parametric test is independent-samples t-test.

Construct	Notation	N	Skewness	Kurtosis
Street Network	SN	193	-0.463	1.907
Street Type	ST	193	0.354	-1.178
Pedestrian Network	PN	193	-0.574	-1.023
Access Points	AP	193	-0.489	0.187
Perceived Density	PD	193	-0.311	2.53
Mixed Land Use	MLU	193	0.052	-1.342
Community	COM	193	1.331	5.01
Political	POL	193	1.202	1.107
Solidarity	SOL	193	-0.82	0.924
General trust	GT	193	-0.037	0.657
Institutional trust	IT	193	-0.344	-0.806
Identity	IDE	193	-1.633	2.852
Ownership & Memory	OM	193	-1.042	0.596
Belonging	BEL	193	-1.023	0.86
Street System	SS	193	-0.373	-0.653
Block System	BS	193	-0.043	-1.005
Participation	PAR	193	0.416	0.932
Trust	TRU	193	-0.359	-0.503
Neighbourhood Attachment	NA	193	-1.138	0.306
Neighbourhood Morphology	NM	193	-0.128	-1.074
Social Cohesion	SC	193	-0.553	0.248
Remark: Normality assumption attained				

Table 2: Normality diagnostics. Source: Researchers.

5.1 Comparing The Main Variables

Table 3 provides some descriptive statistics that illustrate the difference between the neighbourhoods in terms of the main variables; neighbourhood morphology and social cohesiveness. Based on the data presented in the table and the graph in figure 9, it is clear that the second neighbourhood is distinctive from the third in terms of its morphology. Despite the fact that there appeared to be no visual discrepancies between the two neighbourhoods in terms of social cohesion. The results of an independent t-test are shown in table 4 to determine whether or not the observed differences are statistically significant.

Variable	Neighbourhood	N	Mean	SD
Neighbourhood Morphology	2	95	3.6794	.32241
	3	98	2.9288	.31232
Social Cohesion	2	95	2.9936	.45698
	3	98	2.9342	.46530

Table 3: Descriptive statistics of the main variables regarding the neighbourhoods. Source: Researchers.
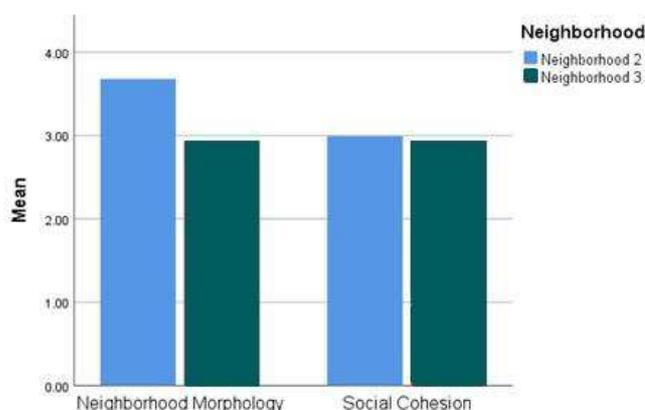

Fig. 9: Bar chart for the difference between the neighbourhoods regarding the main variables. Source: Researchers.

Variable	Levene's Test for Equality of Variances			t-test for Equality of Means		
		F	P-value	t	df	P-value
Neighbourhood Morphology	Equal variances assumed	0.348	0.556	16.429	191	0
	Equal variances not assumed			16.421	190.24	0
Social Cohesion	Equal variances assumed	0.139	0.709	0.893	191	0.373
	Equal variances not assumed			0.894	190.97	0.373

Table 4: Independent Samples t-test for the Main Variables. Source: Researchers.

According to the results of the independent-samples t-test, the morphological differences between the two neighbourhoods are statistically significant (t=16.429, p<0.01). P-value > 0.05 indicates that there is NO statistically significant difference in Social Cohesion between the two neighbourhoods. (t=0.893, p>0.05).

5.2 Comparing The Dimensions of The Main Variables

The difference between the neighbourhoods in terms of the dimensions of the main variables; Street System, Block System, Participation, Trust, and Neighbourhood Attachment; are illustrated in table 5 through some descriptive statistics. Based on the data presented in table 5, the graph in figure 10, and table 6 of the results of Independent Samples t-test, there are a statistically significant differences in the Street system, block system, and Neighbourhood attachment levels between the neighbourhoods, while there are no statistically significant differences in the levels of participation and trust.

Dimension	Neighbourhood	N	Mean	SD
Street System	2	95	3.8088	0.35971
	3	98	3.0514	0.45775
Block System	2	95	3.5500	0.52415
	3	98	2.8061	0.49939
Participation	2	95	2.4842	0.48808
	3	98	2.5782	0.51618
Trust	2	95	2.8158	0.67950
	3	98	2.7653	0.64996
Neighbourhood Attachment	2	95	3.6807	0.57100
	3	98	3.4592	0.69364

Table 5: Descriptive statistics of The Dimensions regarding the neighbourhoods. Source: Researchers.
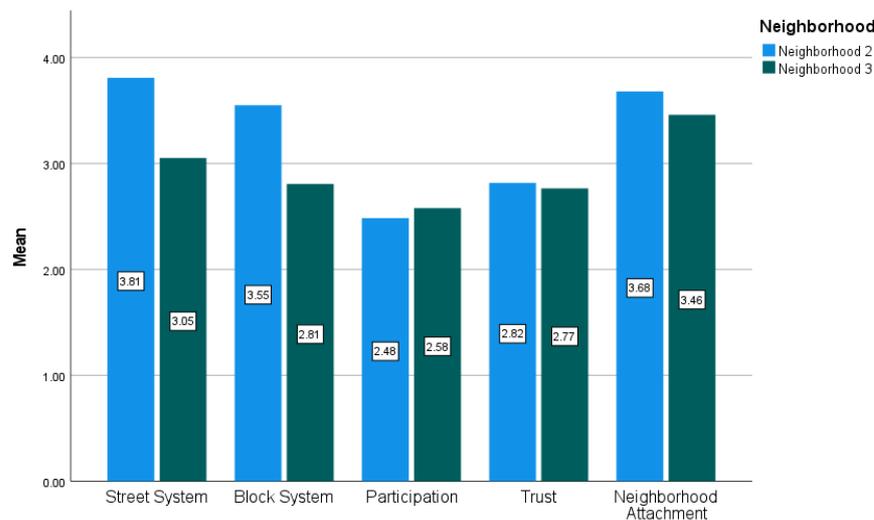
Fig. 10: Bar chart for the difference between the neighbourhoods regarding the main Dimensions. Source: Researchers.

Dimension	Levene's Test for Equality of Variances			t-test for Equality of Means		
		F	P-value	t	df	P-value
Street System	Equal variances assumed	11.389	0.001	12.754	191	0.000
	Equal variances not assumed			12.801	183.221	0.000
Block System	Equal variances assumed	0.042	0.838	10.096	191	0.000
	Equal variances not assumed			10.089	189.799	0.000
Participation	Equal variances assumed	1.581	0.210	-1.299	191	0.195
	Equal variances not assumed			-1.301	190.884	0.195
Trust	Equal variances assumed	0.000	0.999	0.528	191	0.598
	Equal variances not assumed			0.527	189.914	0.599
Neighbourhood Attachment	Equal variances assumed	5.414	0.021	2.418	191	0.017
	Equal variances not assumed			2.425	186.148	0.016

Table 6: Independent Samples t-test for the Main Dimensions. Source: Researchers.

5.3 Comparing The Subdimensions of The Main Dimensions

5.3.1 Comparing The Subdimensions of Neighbourhood Morphology

According to the data presented in the table 7, figure 11, and the results of the independent t-test in table 8; there are a statistically significant differences in the following subdimensions of Neighbourhood Mophology: Street Type, Pedestrian Networks, Access Points and Mixed-land Use levels between the two neighbourhoods, while there are no statistically significant differences in the levels of subdimensions Street Network and Perceived Density.

Subdimension	Neighbourhood	N	Mean	SD
Street Network	2	95	3.9053	0.47655
	3	98	3.9388	0.56233
Street Type	2	95	4.0456	0.52953
	3	98	2.5374	0.34058
Pedestrian Network	2	95	3.5474	0.78236
	3	98	2.3163	1.08025
Access Points	2	95	3.7368	0.55468
	3	98	3.4133	0.69618
Perceived Density	2	95	3.2842	0.48735
	3	98	3.2704	0.68175
Mixed Land Use	2	95	3.8158	0.74037
	3	98	2.3418	0.67578

Table 7: Descriptive statistics of The Subdimension of Neighbourhood Morphology. Source: Researchers.
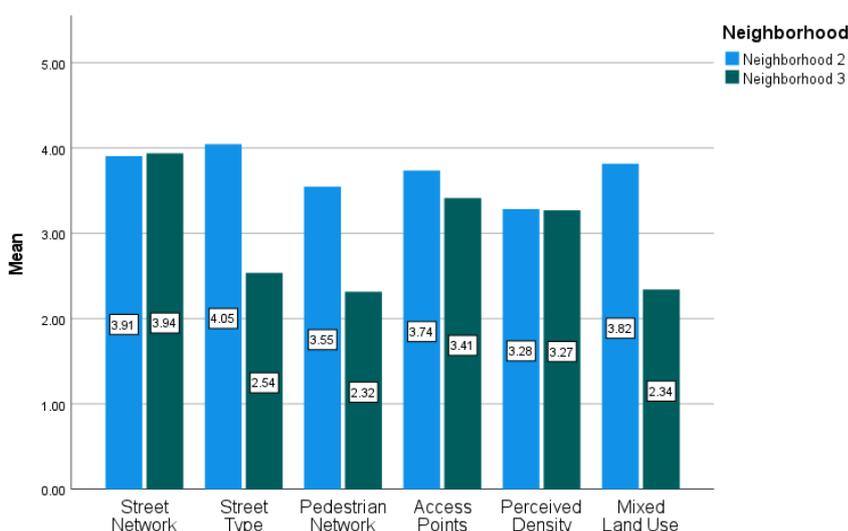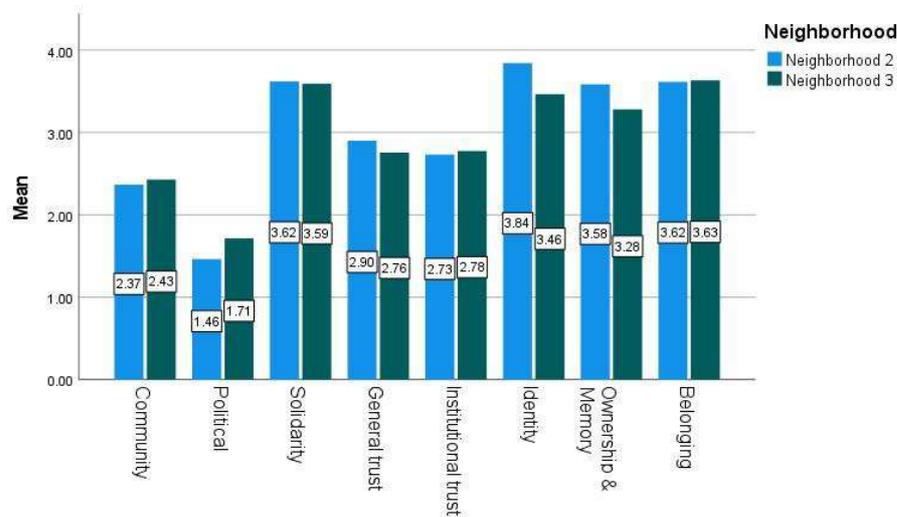

Fig. 11: Bar chart for the difference between the neighbourhoods regarding the subdimensions of Neighbourhood Morphology. Source: Researchers.

Subdimension	Levene's Test for Equality of Variances			t-test for Equality of Means		
		F	P-value	t	df	P-value
Street Network	Equal variances assumed	1.352	0.246	-0.446	191	0.656
	Equal variances not assumed			-0.447	187.672	0.655
Street Type	Equal variances assumed	68.258	0.000	23.606	191	0.000
	Equal variances not assumed			23.453	159.631	0.000
Pedestrian Network	Equal variances assumed	23.893	0.000	9.043	191	0.000
	Equal variances not assumed			9.088	176.920	0.000
Access Points	Equal variances assumed	14.522	0.000	3.564	191	0.000
	Equal variances not assumed			3.577	184.149	0.000
Perceived Density	Equal variances assumed	6.106	0.014	0.161	191	0.872
	Equal variances not assumed			0.162	175.809	0.871
Mixed Land Use	Equal variances assumed	1.007	0.317	14.453	191	0.000
	Equal variances not assumed			14.432	188.192	0.000

Table 8: Independent Samples t-test for the Subdimensions of Neighbourhood Morphology. Source: Researchers.

5.3.2 Comparing The Subdimensions of Social Cohesion

According to the data presented in the table 9, figure 12, and the results of the independent t-test in table 10; there are a statistically significant differences in the following subdimensions of Social Cohesion: Political, Identity, and Ownership and Memory levels between the two neighbourhoods, while there are no statistically

significant differences in the levels of subdimensions Community, Soldarity, General Trust, Instituational Trust, and Belonging.

Subdimension	Neighbourhood	N	Mean	SD
Community	2	95	2.3684	0.57985
	3	98	2.4286	0.48162
Political	2	95	1.4632	0.78633
	3	98	1.7143	0.78648
Solidarity	2	95	3.6211	0.58671
	3	98	3.5918	0.74039
General trust	2	95	2.9000	0.64247
	3	98	2.7551	0.49349
Institutional trust	2	95	2.7316	0.89565
	3	98	2.7755	1.08438
Identity	2	95	3.8421	0.35925
	3	98	3.4643	0.70437
Ownership & Memory	2	95	3.5842	0.72439
	3	98	3.2806	0.83748
Belonging	2	95	3.6158	0.75952
	3	98	3.6327	0.87211

Table 9: Descriptive statistics of The Subdimension of Social Cohesion. Source: Researchers.

Fig. 12: Bar chart for the difference between the neighbourhoods regarding the subdimensions of Social Cohesion. Source: Researchers.

Subdimension	Levene's Test for Equality of Variances			t-test for Equality of Means		
		F	P-value	t	df	P-value
Community	Equal variances assumed	0.934	0.335	-0.785	191	0.433
	Equal variances not assumed			-0.783	182.619	0.435
Political	Equal variances assumed	0.563	0.454	-2.218	191	0.028
	Equal variances not assumed			-2.218	190.816	0.028
Solidarity	Equal variances assumed	3.996	0.047	0.303	191	0.762
	Equal variances not assumed			0.304	183.790	0.761
General trust	Equal variances assumed	0.741	0.390	1.760	191	0.080
	Equal variances not assumed			1.753	176.366	0.081
Institutional trust	Equal variances assumed	6.233	0.013	-0.306	191	0.760
	Equal variances not assumed			-0.307	186.336	0.759
Identity	Equal variances assumed	35.496	0.000	4.672	191	0.000
	Equal variances not assumed			4.715	145.251	0.000
Ownership & Memory	Equal variances assumed	1.865	0.174	2.690	191	0.008
	Equal variances not assumed			2.696	188.588	0.008
Belonging	Equal variances assumed	3.193	0.076	-0.143	191	0.886
	Equal variances not assumed			-0.143	188.863	0.886

Table 10: Independent Samples t-test for the Subdimensions of Social Cohesion. Source: Researchers.

6 DISCUSSION AND CONCLUSION

This research was keen on comparing the levels of Social coehsion based on different morphologies of Neighbourhoods. In doing so, the research started by tackling some design constraints regarding the neighbourhood that leads to better social cohesion. Then the research presented a model that investigates social cohesion at a micro level by conducting a structured questionnaire on a random sample of the residents of two neighbourhoods in New Borg Al-arab City in Egypt that differ from each other in the morphological pattern. This model is based on comparing the two neighbourhoods and is divided into three levels.

The first level compares the main variables which are Neighbourhood Morphology and social cohesion. What turned out after conducting the statistical test using SPSS that there are differences in the neighbourhood morphology between the neighbourhoods, while there is no statistical significance difference between Social cohesion in the two neighbourhoods.

The second level of the model investigates the dimensions of the main variables, which turned out that there are differences in the street system, block system, and neighbourhood attachment.

The third level of the model is much deeper and investigates the main subdimensions of the main variables. Regarding the subdimensions of Neighbourhood Morphology, there are differences in Street type, pedestrian network, access points, and mixed land use, while there are no differences in street network and perceived density. Considering the subdimensions of social cohesion, there were differences in political identity, ownership and memory subdimensions.

Through this model, much more understanding of the main differences between social cohesion at a micro level is gained. But in general, regarding the main hypothesis, there were no differences considering social cohesion. This may be due to the following reasons that were known during the questionnaire, Neighbourhood Two is considered adjacent to Neighbourhood Three, and also although the residents of Neighbourhood Two are tenants and are not owners like the residents of Neighbourhood Three, the residents of the two neighborhoods have the same social background, and also Neighbourhood Two does not contain amenities like social cafés, which makes its residents resort to the adjacent neighbourhoods for entertainment.

7 ACKNOWLEDGEMENT

8 REFERENCES

Wanas, A.F., Moustafa, Y.M. and Murshed, S.M., 2014. Social cohesion in Cairo: toward a better understanding of the potential role of urban design. Journal of Engineering and Applied Science, 61(1), pp.1-24.
Saleh, H.E.M.E., 2018. Assessment Of Social Sustainability Values At New Communities In Cairo-A Case Study Of "New Maadi" District. Journal of Urban Research, 28(1), pp.130-152.
Aelbrecht, P. and Stevens, Q. eds., 2019. Public space design and social cohesion: An international comparison. Routledge.
Mouratidis, K. and Poortinga, W., 2020. Built environment, urban vitality and social cohesion: Do vibrant neighbourhoods foster strong communities?. Landscape and Urban Planning, 204, p.103951.
Oliveira V. (2016) The Elements of Urban Form. In: Urban Morphology. The Urban Book Series. Springer, Cham
Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). Multivariate Data Analysis. (7th Ed.) Pearson.
Arsiya Ravari, A. and Mazloomi, M., 2015. A framework for urban morphology with respect to the form, 8(14), pp.91-103.
Larco N., Kelsey K., West A. (2014). Site Design Criteria. In: Site Design for Multifamily Housing: Creating Livable, Connected Neighbourhoods (pp.11-55). Island Press, Washington, DC
Auckland Transport (2020). Urban Street and Road Design Guide. Auckland Council
Steiner, F.R., Butler, K. and American Planning Association, 2012. Planning and Urban Design Standards. John Wiley & Sons.
Donnelley, R.R. (2010). Designing Streets: A Policy Statement for Scotland. The Scottish Government
Department of Human Settlements (2019). Neighbourhood layout and structure. In: The Neighbourhood Planning and Design Guide (Red Book): Creating Sustainable Human Settlements. The South African Government
Bentley, I., 1985. Responsive Environments: A Manual for Designers. Routledge.
Partnerships, E. and HOUSING CORP. HOUSING CORP-SEE ENGLISH PARTNERSHIPS (2000). Urban design compendium (Vol. 1). London: English Partnerships.
Dempsey, N., 2008. Quality of the Built Environment in Urban Neighbouurhoods. Planning, Practice & Research, 23(2), pp.249-264.
Ewing, R. and Clemente, O., 2013. Measuring urban design: Metrics for livable places. Island Press.
Lynch, K., 1960. The Image of the City. MIT Press
Silavi, T., Hakimpour, F., Claramunt, C. and Nourian, F., 2017. The Legibility and Permeability of Cities: Examining the Role of Spatial Data and Metrics. ISPRS International Journal of Geo-Information, 6(4), p.101.

Lahart, J., Conroy, E., Curley, R., Hogan, P., McGrath, S., Molony, D., Stapleton, J., Taylor, D. and Taylor, J., 2013. Design Manual for Urban Roads and Streets. Department of Transport, Tourism and Sport and Department of Environment, Community and Local Government, Dublin.

Marshall, S., 2004. Streets and patterns. Routledge.

Tarbatt, J. and Tarbatt, C.S., 2020. The Urban Block: A Guide for Urban Designers, Architects and Town Planners. Routledge.

Ewing, R. and Cervero, R., 2010. Travel and the built environment: A meta-analysis. Journal of the American planning association, 76(3), pp.265-294.

Berghauser Pont, M.Y. and Haupt, P.A., 2009. Space, density and urban form.

Dempsey, N., Brown, C. and Bramley, G., 2012. The key to sustainable urban development in UK cities? The influence of density on social sustainability. Progress in planning, 77(3), pp.89-141.

Dave, S., 2011. Neighbouurhood density and social sustainability in cities of developing countries. Sustainable Development, 19(3), pp.189-205.

Pont, M.B. and Haupt, P., 2007. The relation between urban form and density. Urban Morphology, 11(1), p.62.

Barton, H., Grant, M. and Guise, R., 2003. Shaping Neighbouurhoods: a guide for health, sustainability and vitality. Taylor & Francis.

Croucher, K., Wallace, A. and Duffy, S., 2012. The influence of land use mix, density and urban design on health: a critical literature review. York: University of York.

Dragolov, G., Ignácz, Z.S., Lorenz, J., Delhey, J., Boehnke, K. and Unzicker, K., 2016. Theoretical Framework of the Social Cohesion Radar. In Social Cohesion in the Western World (pp. 1-13). Springer, Cham.

Megahed, A., 2017. Sustainability of Urban Community: A Social Cohesion Approach. (Master's thesis, Alexandria University)

Bottoni, G., 2018. A multilevel measurement model of social cohesion. Social Indicators Research, 136(3), pp.835-857.

Liu, Y., Wang, R., Lu, Y., Li, Z., Chen, H., Cao, M., Zhang, Y. and Song, Y., 2020. Natural outdoor environment, neighbouurhood social cohesion and mental health: Using multilevel structural equation modelling, streetscape and remote-sensing metrics. Urban Forestry & Urban Greening, 48, p.126576.

Urban Nexus: An Approach for Regenerative Urban Environments (Public Spaces Located in the Urban Fringe)

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1 ABSTRACT

The built environment is the main habitat for human beings, this makes it act as a driver for climate and biodiversity changes, with multiple potential opportunities for alteration and transition. Therefore, it may be essential for the built environment to go beyond ordinary actions not only to limit the negative impacts, but instead aim for benificial outcomes. Analysing and desigining the urban built environment from the perspective of ecosystems functions and services could help in creating cities where positive restoration of and integration with local ecosystems could be recognised. Urban regeneration could be useful in this regard as it is defined as a comprehensive integration of vision and action aimed at resolving the multi-faceted problems of urban areas in order to improve their quality of life. However, the rapid urbanisation - especially with the exploding urbanism of some cities - controlled sustainable development and carefully considered urban regeneration have not always been achieved. It is also argued that one of the strategies for successful urban regeneration is "High-Quality Architectural Design and Public Space as a Catalyst for a Better City". At a more local perspective, new urban expansions in Egypt lack one of the relevant quality-of-life pillars. Public spaces are currently losing their role in the new communities located in the urban fringe of Cairo. In such context, new urban nucleii are expanding disregarding the necessity of collective public spaces (a continuum of public realm) due to the privatization, disconnection, and introversion. Thus, the aim of this research is to introduce the Urban Nexus, a new approach merging the contemporary trends and emerging theories to design sustainable urban development solutions. The nexus approach seeks to understand risks, engage decision-makers, and enable action with the aim of attaining knowledge integration, efficiency, synergy and 'win-win' solutions. This could be achieved through bridging/ integratng Ecosystem services preserved through Nature Based Solutions (NBS), Human Centred Design (HCD) and the Star Approach, in order to reform public spaces acting as a catalyst for the urban regeneration. Ultimately the study would contribute in improving the built environment and in providing a better quality of life in new urban expansions.

Keywords: Human Centered Design, Nature Based Solutions, Ecosystem Services, Urban Nexus, Quality of life

2 INTRODUCTION

2.1 Background

Urbanization is an inevitable phenomenon expanding worldwide, predominantly changing the land use on a large scale and encompasses essential land cover change, even if it is carefully planned (Wang et al., 2021). Around 68% of the world's population will be living in urban regions by 2030 (Blanco, Pedersen Zari, Raskin, & Clergeau, 2021). The African urban population is undergoing the highest rate of urban growth in the world, at 3.3%, and most likely will double by 2050 (Julia & Andrey, 2013). The rapid or unplanned urbanization results in the risk of extreme social instability, risks to crucial infrastructure, potential water crises and the possibility for spread of diseases. If not well managed, rapid urbanisation could be a huge environmental and human health risk and a threat to sustainable cities by 2030 (Nhamo et al., 2021).

2.2 Problem Definition

Growing cities generate conflicts that need to be carefully negotiated and managed (Lehmann, 2019). In the past three decades, the Egyptian capital, Cairo, has experienced a significant boom in the urban expansions including building gated communities and new fringe cities, such as 6th of October and Sheikh zayed,

located in the west. Such trends have grown rapidly since 2010,which have made a lot of Egyptians eager to own a property in one of those well planned new cities and luxurious gated communities (Aboubakr et al., 2020). Recently, several studies discussed that those new expansions lack some of the main urban features that the old, dense and kind of informal fabrics have. Public spaces are considered one of any built environment pillars. It is the main context for social and economic activities that might happen in any community, leading to enhancing the sense of belonging. From Agora of the polis, and open marketplaces of Medieval cities to today's shopping malls, corporate plazas, atria and festival places, public spaces have been a prominent element affecting the design of cities for centuries (Naguib, Abdel-Salam, & Saadallah, 2020). However, cities are undergoing a rapid transformation of public spaces as a result of economic and cultural globalization, demographic transformations, marketing strategies, urban planning, design approaches, privatization and others (Haas & Olsson, 2014). This led to misunderstanding the concept of public spaces within the new urban expansions and communities especially in Egypt.

Figure 1: Examples for the privatized urban spaces located in Sheikh Zayed city, Cairo, Egypt (Researcher)

2.3 Public Spaces

Urban open spaces are one of the fundamental elements shaping cities, they play an important role in urban sustainability and human health (Kefale, Fetene, & Desta, 2023). Several planning researchers and pioneers like George Perkins Marsh, JohnWesley Powell, Patrick Guedes, Sir Ebenezer Howard, and Frederick Law Olmsted, have integrated urban spaces, ecosystems and their services in the process of urban design and planning since the 19th century (Blanco et al., 2021). According to (Lehmann, 2019), attractive public spaces that provide distinctive life experiences result in increasing the liveability of cities. Therefore, it could be debated that the improvement of public spaces is one of the major drivers for urban regeneration, leading to the promotion of social inclusion and creating more interesting and diverse cities (Jacobs, 1961). Urban regeneration is mainly concerned with the rejuvenation of deteriorated urban areas, through interventions such as rehabilitation of old districts, enhancement of living conditions in residential areas, revitalization of public spaces, and renovation of urban infrastructure (Abdo, Abdel-Salam, Ayad, & Taha, 2019). Consequently, the revitalization of public spaces is considered one of the main catalysts for creating regenerative urban environments according to Lehmann (2019) when he stated the ten main strategies of successful urban regeneration.

Figure 2: The 10 strategies for successful urban regeneration recommended by Lehmann (2019)
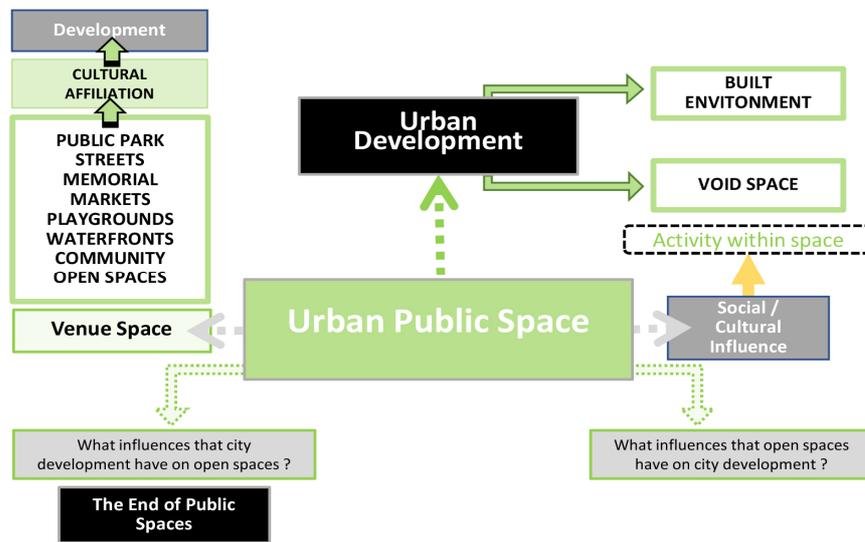
Figure 3: The relationship between urban public spaces and city's development, Adapted from (Ramlee, Omar, Yunus, & Samadi, 2015)

2.4 Urban Ecosystems

Urban ecosystems are cities, their surroundings, and social and ecological systems where citizens inhabit (Maes et al., 2016). They are the main container, including all other ecosystem types (forests, water bodies and agricultural areas) which are influenced by human activities. Urban ecosystems guarantee the provision of essential services for city dwellers (Ahern, Cilliers, & Niemelä, 2014). Those services could be objects, features and processes carried by ecosystems that secure the people's health and wellbeing (Pan, Page, Cong, Barthel, & Kalantari, 2021). It is highly debated that ecosystem services should integrate with urban planning (Ahern et al., 2014). Urban open spaces are fundamental providers of a wide range of ecosystem services in cities, consequently they are one of the main supporters of urban resilience and sustainability (Ibes, 2016). Therefore, Professionals, planners and designers need to take into consideration the preservation of those services through adopting innovative solutions and planning frameworks.

Figure 4:The services provided by the ecosystems classified to 3 main categories (https://www.euskadi.eus/)

2.5 The Urban Nexus Approach: A New Dimension

Although the new communities located in the Egyptian urban fringe are well designed aesthetically, they lack the presence of collective non-privatized open spaces that all people could use freely. The privatisation of public space is growing rapidly, the investment in the public domain is relying more on the private sector, which increases the challenges that cities face. Most of the - so called- public spaces are located within shopping malls like mall of Egypt and mall of Arabia, or business parks like Arkan Plaza and capital business park. Moreover, the lack of any sort of seating or shading elements forces the users to enter the restaurants and cafes. The only possible form of open green spaces could be found inside the luxurious gated communities. Therefore, it is time to benefit from the various urban design tools to achieve the best and most optimum solutions. Architects, urbanists, and urban design pioneers have been calling for the adoption of more integrated approaches, proclaiming that planning and design tools must be amplified as they are

considered the fundamental tools for effectively creating regenerative urban environments. Architects and urban designers play a crucial role in augmenting creative alternatives to the ordinary known forms of urban regeneration (Lehmann, 2019).

 Attempting to find solutions in a certain field can cause a problem in another. This may be due to lack of proper analysis leading to negative impacts on policies and technological choices. Therefore, the nexus approach tends to understand risks, engage decision-makers, and enable action. It investigates the different pathways that lead to sustainable development and green growth (UN(ESCAP), 2016). A dominant interpretation of the nexus approach is that it stresses knowledge integration, efficiency, synergy and 'win-win' solutions (Nhamo & Ndlela, 2021).The key of the urban nexus is designing sustainable urban development solutions, in order to guide stakeholders with the aim of creating collaborations between different sectors, authorities, and technical domains. This is with an attempt to increase the performance of institutions and optimize resource management quality (Lehmann, 2018).
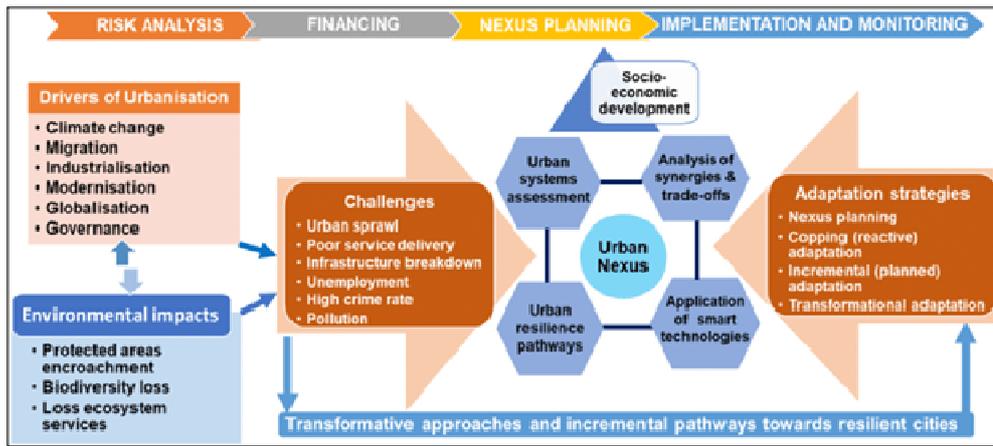
Figure 5 Key elements of urban nexus design, Lehmann (2018)

3   METHODOLOGY: INTEGRATING URBAN DESIGN TOOLS AND APPROACHES

In order to create regenerative environments, addressing the main isssues that cities undergo is more important than technological solution, while thinking of a comprehensive framework and adopting a reconstructive governance to guide the process, with appropriate indicators to monitor the progress and implementation (Lehmann, 2019).
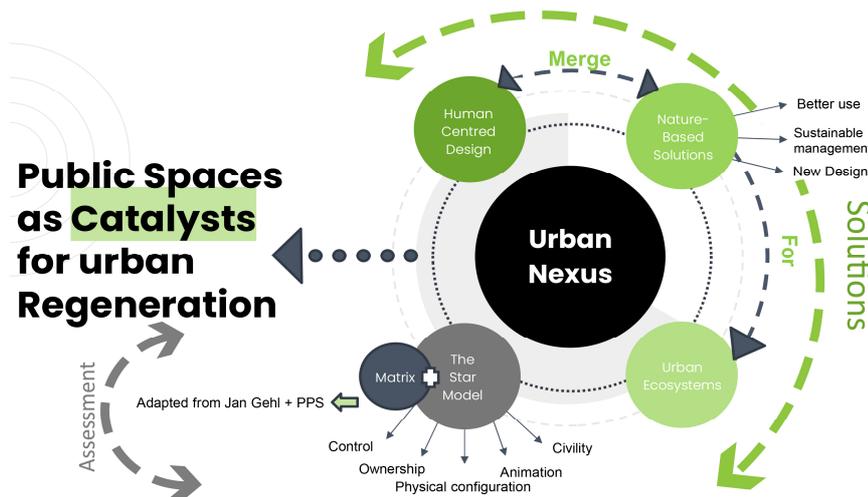

Figure 6: The proposed research hypothesis (researcher)

3.1 The Star Model

George Varna created a diagnostic model that uses simple and measurable tools to evaluate the liveability of public open spaces. It could easily be used by professionals either planners or academians as well as regular people with no experience in urban design. The model emphasizes the attributes related to the publicness of urban open spaces concerning their liveability. Five main dimensions form the star model (Meta-themes):

ownership, control, physical configuration, animation and civility. Those five themes incubate 19 indicators as shown in Table (1). Each indicator is evaluated on a measuring scale of, where 1 is the lowest and 5 is the highest.

The Star model quantifies the quality of open spaces on 3 main levels as described by Aboubakr et al. (2020) as follow:

(1) For comparative purposes: measures the degree of liveability of public places compared to each other; (2) For producing analytic and normative/perceptual stars: a more objective measure of liveability to be compared to the sense of liveability held by specific social groups and individuals; (3) For further expectations: serves as a point for future assessments of certain spaces.

Although the star model offers definite indicators, the model should be used with a certain degree of common sense, as some of the indicators should be evaluated by the researchers.
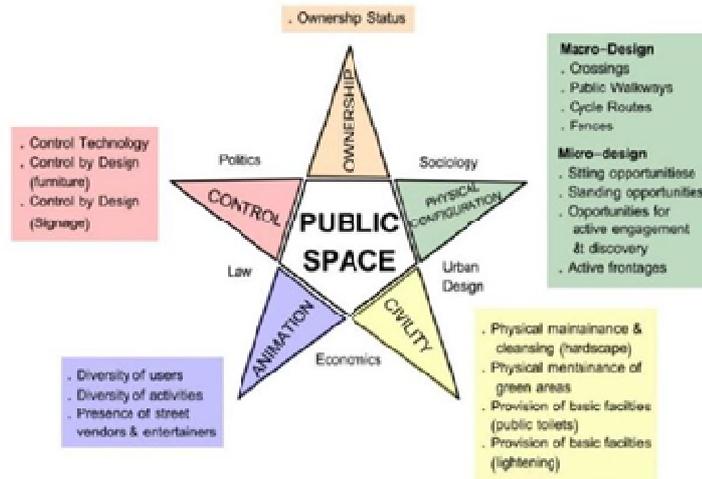
Figure 7: The Star Model (Aboubakr, Nasreldin, & Abdelfattah, 2020)

Table 1: Calculating te 19 indicators of the star model (Aboubakr et al., 2020)

3.2 The Public Space Qualities

Since it was mentioned in the previous section 3.1 that the star model has some weaknesses whereby it neglects the fact that each public place has its own identity, consequently the model should be used with a fraction of common sense. A primary matrix was created based on the studies of Jan Gehl concerning the studying of public life, Mathew Carmona's listing of public spaces qualities, the place diagram developed by

the Project for Public Spaces (PPS) and the 19 indicators measured by the star model, to act as an aiding tool for assessing the quality of public spaces.

Table 2: The 12 quality criteria for good public space by Jan Gehl, adapted from (Dietrich & Kengyel, 2016)
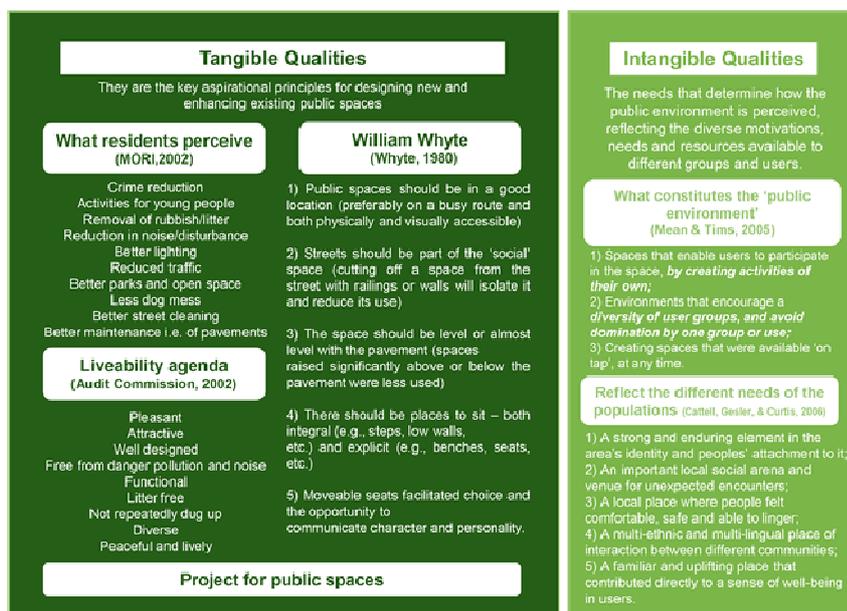
Table 3: The Tangible and Intangible qualities of public spaces reviewed by Matthew Carmona (Audit Commission, 2002; Carmona, De Magalhaes, & Hammond, 2008; Cattell, Gesler, & Curtis, 2006; Mean & Tims, 2005; Mori, 2002; Whyte, 1980)
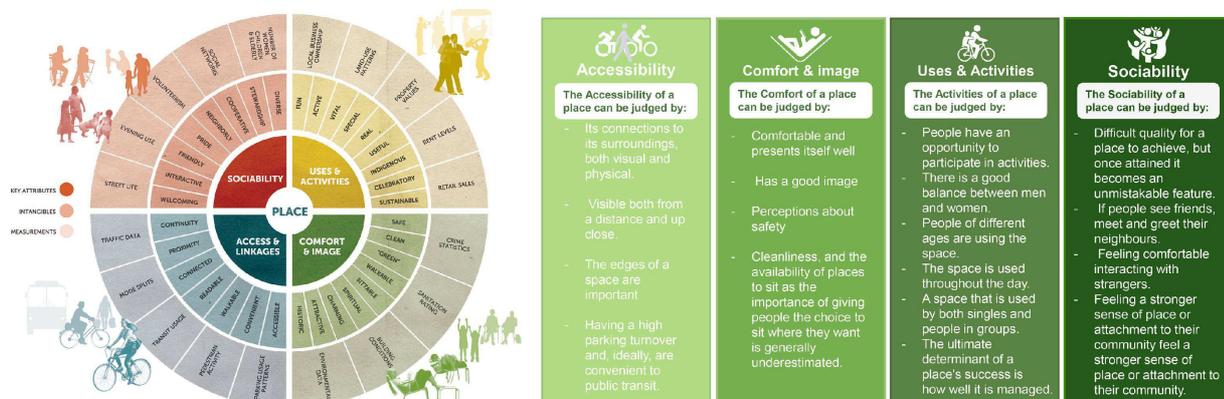
Figure 8 : What makes places succeed, adapted from (PPS, 2000)

The unstable climate variations in the 21st century put pressure on the place diagram as it does not contain a clear perception or solutions for the climatic conditions in terms of comfort. Several authors such as Marcus & Francis (1997) and Whyte (1980) stated the importance of sunlight and temperature and considering reduction strategies in case of overexposure. Also, the airflow was highlighted in studies by Jan Gehl and

924

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William Whyte due to its role in decreasing the distressing climatic conditions (Gehl, 2011; Whyte, 1980). Consequently, when evaluating the "Place Diagram," based on the currently existing public spaces as examples, several questions arise concerning the delay in the improvement of adaptation efforts in terms of urban design and climatology (Santos Nouri & Costa, 2017). The following Figure (9) illustrates the necessity for including the expected climate change consequences. Therefore, the place diagram by Santos, Nouri and Costa was enriched with new qualitative and quantitative features shown in Figure (10) in order to question the pedestrian comfort. This is achieved by examining several theories aiming to integrate the measurable data and intangible elements of the outdoor thermal environments with the design of the public open spaces to make it climatically responsive.
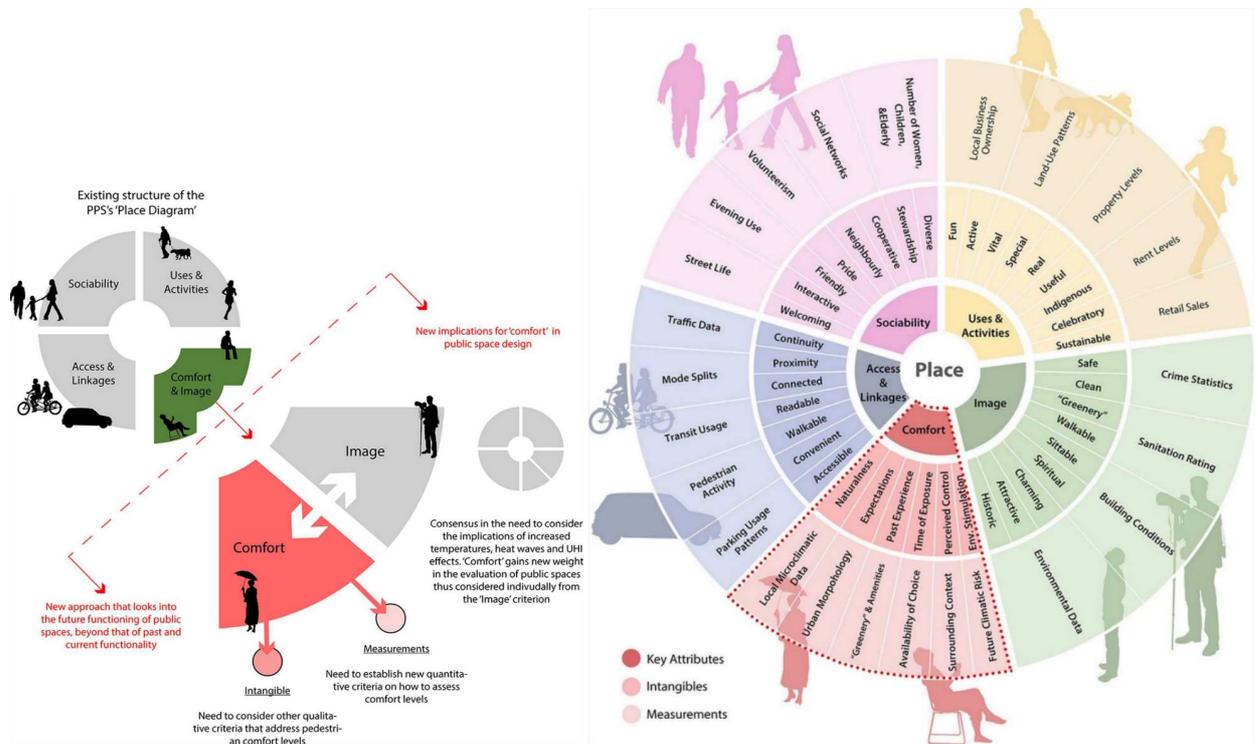
Figure 9 (left): Extending the "Place Diagram" to consider new implications on pedestrian comfort in the light of climate change (Santos Nouri & Costa, 2017). Figure 10 (right): Restructured Place Diagram by Santos Nouri & Costa (2017), the original adapted from (PPS, 2000)
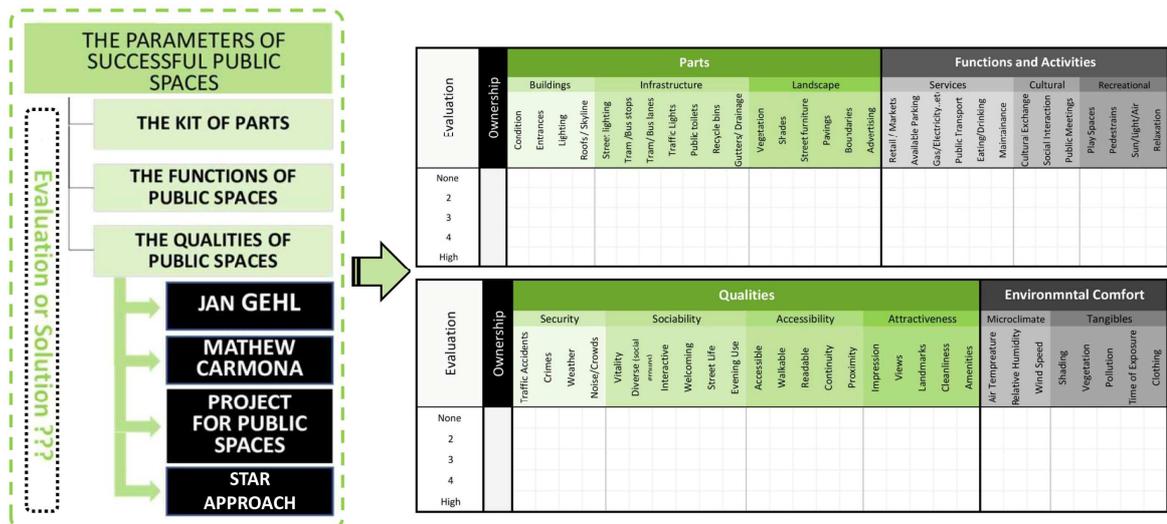
Figure 11: The initial proposed matrix for public spaces qualities (Researcher)

3.3 The Proposed Matrix for Public Spaces Assessment

The following matrix shown in figure (11) gathered the common qualities between the previously mentioned pioneers' theories and approaches shown in Tables (1), (2) ,(3) and figures (7) and (8). The matrix gathered

the common qualities between Jan Gehl, Mathew Carmona and the Project for public spaces. Also from the restructured place diagram illustrated in Figure (4 - 6) which focused on the comfort parameter. The Matrix can be used as a generic tool in assessing the quality of public space design in further studies.

The matrix was tested on two urban spaces located in the western expansion of Cairo. Americana Plaza is a public space located in district two in Sheikh Zayed city. This space accommodates several economic and social uses including shops, restaurants, cafes, cinema, and an indoor kids playing area. It represents a magnet for a wide range of social groups of Sheikh Zayed residents, along with users from all over Cairo (Aboubakr et al., 2020). The second space is the Capital business park located on the 26th of July corridor and owned by the Al-Durra group. This park allows people to escape the crowds of the capital cities (Atwa, Ibrahim, Saleh, & Murata, 2019). It provides employees with safe workspaces in the form of designed green areas surrounding the buildings in the morning, while, besides the morning it is open to the public at night. It accomodates several uses including shops, cafes, restaurants, seasonal kiosks, kids area and a medical centre.

Figure 12: The selected two open spaces in Sheikh Zayed city for evaluation (Researcher)

3.3.1 Capital Business Park

The assessment and real life observations showed more information and differences in the characteristics of the two spaces. For example, being privately owned lowered the results of Capital Business Park in many dimensions. The user of space has to pass several gates and check points at the entrance. Also, it lacked any public furnishing and shadings, which forces the pedestrians to enter the restaurants and cafes. This is a huge reason to downgrade the space's assessment, in addition to the poor vegetation and shading, although the place is well designed and maintained.

926

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Figure 13: Capital Business Park (Source: Researcher)

3.3.2 Americana Plaza

Americana Plaza received higher results due to the presence of clean, free access, and easy to find toilets. However, the physical configuration was less pleasant than Capital Business park and that is why it received slightly lower results. At Americana Plaza the other restriction is not present as it is not located in a privately owned entity, and users pass through the entrance check point easily and find several public amenities with no obligations.

Figure 14: Americana Plaza (Source: Researcher)

Table 4: Matrix adapted to evaluate the parts, functions and activities in each of the two spaces, continued in Table (5)

Evaluation	Open space	Ownership	Buildings				Infrastructure							Landscape						Services						Cultural			Recreational			
			Condition	Entrances	Lighting	Roofs/Skyline	Street lighting	Tram/Bus stops	Tram/Bus lanes	Traffic Lights	Public toilets	Recycle bins	Gutters/Drainage	Vegetation	Shades	Street furniture	Pavings	Boundaries	Advertising	Retail/Markets	Available Parking	Gas/Electricity..etc	Public Transport	Eating/Drinking	Maintainance	Cultural Exchange	Social Interaction	Public Meetings	Play Spaces	Pedestrains	Sun/Light/Air	Relaxation
None	Capital Business Park							√																								
2									√							√										√		√				
3										√				√	√	√			√													√
4					√	√	√									√							√				√		√			
High		√	√	√							√	√					√		√	√	√		√						√	√	
None	Americana Plaza							√																								
2														√																		
3			√		√				√					√		√		√			√								√		√
4			√		√	√			√		√	√		√	√				√	√		√				√	√	√	√		
High									√	√									√					√			√				

Table 5: Matrix adapted to evaluate the qualities and evironmental comfort in each of the two spaces (Source: Researcher)

Evaluation	Open space	Ownership	Security				Sociability							Accessibility					Attractiveness					Microclimate			Tangibles				
			Traffic Accidents	Crimes	Weather	Noise/Crowds	Vitality	Diverse (social group)	Interactive	Welcoming	Street Life	Evening Use	Accessible	Walkable	Readable	Continuity	Proximity	Impression	Views	Landmarks	Cleanliness	Amenities	Air Tempreature	Relative Humidity	Wind Speed	Shading	Vegetation	Pollution	Time of Exposure	Clothing
None	Capital Business Park		√	√																									√	
2						√		√																√		√	√			
3					√					√			√			√							√						√	
4						√		√		√			√	√														√		
High		√									√							√	√	√	√	√								
None	Americana Plaza			√																										
2			√																					√		√	√	√		
3		√			√										√	√							√					√	
4						√	√	√	√				√	√				√	√	√	√						√		
High						√	√																						

4 POSSIBLE SOULUTIONS AND INTERVENTIONS

4.1 Nature-Based Solutions

Nature-based solutions (NBS) is a concept that emerged attempting to integrate ecosystem-based approaches in order to achieve sustainable development goals. They are also considered as the optimum solution for preserving the ecosystems and its services (Balzan, Zulian, Maes, & Borg, 2021). Since 2010, the strong relation between NBS and mitigating the environmental challenges has been a crucial dimension in the urban regeneration mechanisms. It is preferable to apply NBS in urban design to secure the engagement in sustainable urban development. Therefore, urban planners and decision makers became more interested in exploring the evidence of the NBS potentials to cope with these challenges. In NBS, ecosystem services play vital roles in addressing urban challenges and with the potential of designing sustainable urban environments (Pan et al., 2021).

Figure 15: Steps for NBS implementation to achieve resilient urban environments (World Bank Global NBS team)

According to the UN environment programme, NBS require an important change of approach in the decision-making process at the institutional and planning level, which is summarized in three main aspects shown in figure (16). The third aspect emphasizes the importance of citizens participation which is one of the Human-Centred design approach main characteristics.

Figure 16: The aspects of change in NBS' approach in decision making (UNEP,2001)

4.1.1 Human-Centred Design (HCD)

According to the previous figure (16), HCD is one of the NBS pillars. Creating effective and sustainable products or services in developing communities, urges designers to understand the social factors, cultural context, and needs of their intended users (Donaldson, 2009). However, understanding user needs can be challenging when designers come from different cultural and socio-economic backgrounds than their targeted users. Design Thinking or Human-Centred Design (HCD) methods provide a wide range of tools that guarantee the participation of the potential users in the design process while taking into consideration their needs and generating solutions (Brown, 2008; Magidsohn, 2019). Human-centred design is an approach that begins with the end-user of a product. It has a different methodology from the commonly used ones, where the products were made first then tested by the users after being created. What is unique about this modern design process is that it analyses the experience of the end-use, assuming that understanding the

928

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roots of the problem enables the designers to come up with the most suitable user-friendly solutions (Magidsohn, 2019).
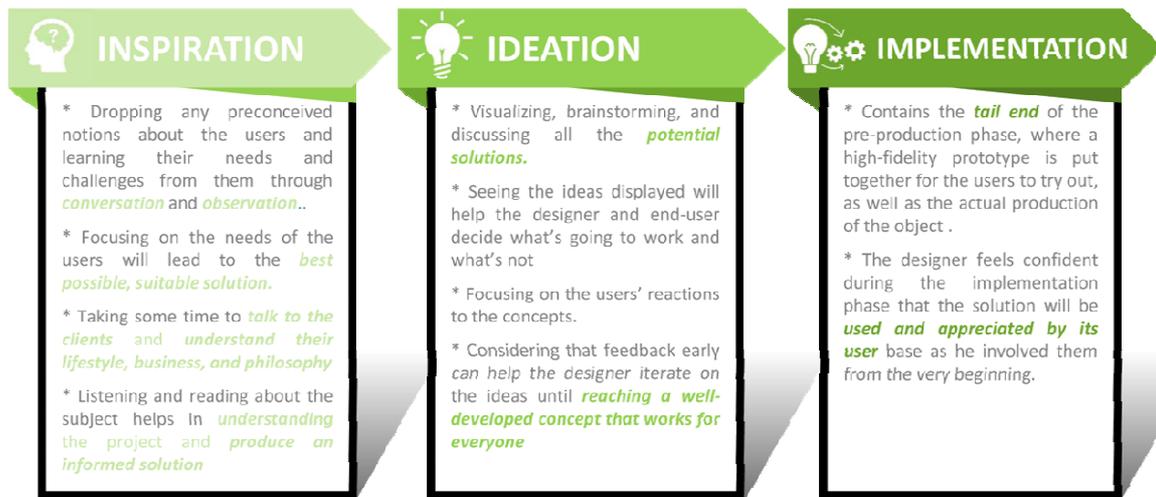

INSPIRATION

* Dropping any preconceived notions about the users and learning their needs and challenges from them through *conversation* and *observation*..

* Focusing on the needs of the users will lead to the *best possible, suitable solution.*

* Taking some time to *talk to the clients* and *understand their lifestyle, business, and philosophy*

* Listening and reading about the subject helps in *understanding the project* and *produce an informed solution*

IDEATION

* Visualizing, brainstorming, and discussing all the *potential solutions.*

* Seeing the ideas displayed will help the designer and end-user decide what's going to work and what's not

* Focusing on the users' reactions to the concepts.

* Considering that feedback early *can help the designer iterate on the ideas until reaching a well-developed concept that works for everyone*

IMPLEMENTATION

* Contains the *tail end* of the pre-production phase, where a high-fidelity prototype is put together for the users to try out, as well as the actual production of the object .

* The designer feels confident during the implementation phase that the solution will be *used and appreciated by its user* base as he involved them from the very beginning.

Figure 17: The simplified process of HCD (Keating, 2017)

5 CONCLUSION

A wide spectrum of underused, or misused spaces with different scales are distributed through the urban fabric of cities. They require a communal perception to coinjointy understand their diverse locations and practices. Several criteria and evaluations could be carried out to enable further amplification and deep analysis of the characteristics of these spaces, such as the background of their formation, their scale and shape, the surrounding context, the influence of urban planning on them, and their ownership.

Therefore, based on the study carried-out it could be argued that it has directed the attention to the complexity of parameters affecting the design of public spaces. The physical parameters have been considered through a quantitative integrated approach. An evaluation matrix was designed to assess the missing qualities and physical elements in each space. Also, the matrix could be used in further experiments studying other spaces. In addition, some transformative approaches like the preservation of ecosystems services through Nature-based solutions and the Human-centred design approach were discussed. They are all linked through nexus planning, providing solutions to transform urban areas into resilient and sustainable cities of the future. The majority of future urban developments and their imminent potential would depend on reusing the existing land and urban voids to create regenerative urban environments. This paper presents some of the accumulated key studies on urban spaces that could contribute to the provision of an integrated and comprehensive understanding for professionals and decision makers. It also proposes possible solutions that can be implemented by planners, designers, and urban policy makers in order to create regenerative urban environments leading to ecologically sustainable, economic and social development. Moreover, it visualises alternative urban scenarios, forecasts future demand and simulates the benefits of various density types to better inform policies and decision makers, by reconsidering new urban communities in terms of overall quality of urban life.

The introduction of the urban nexus approach in terms of urban design and planning could positively aid the urban regeneration process as it understands risks, engages decision-makers, and enables action. It also asks what are the different pathways that lead to resource security, sustainable development, and green growth.

6 RECOMMENDATIONS

It is highly recommended that the ownership of – the so called – public spaces in new urban expansions should be reviewed carefully, as they lack the main feature characterizing them which is "publicness " itself. Serving a specific social group does not properly aid the development process as such a community has to be homogeous. Also, urban spaces should not only be judged according to the fancy designs and facilities, but also taking into account the quality of services it provides is a must. For that reason the study adopted several asessment tools and approaches to cover all the possible aspects and details shaping the open public spaces.

7   REFERENCES

Abdo, M. M., Abdel-Salam, H. M., Ayad, H. A., & Taha, D. S. (2019). Linking Urban Regeneration to Sustainable Urban Development of Smart Cities. Paper presented at the IS THIS THE REAL WORLD? Perfect Smart Cities vs. Real Emotional Cities. Proceedings of REAL CORP 2019, 24th International Conference on Urban Development, Regional Planning and Information Society.

Aboubakr, D., Nasreldin, R., & Abdelfattah, D. (2020). Assessing livability of public spaces in gated and ungated communities using the star model. J Eng Appl Sci, 67(3), 605-624.

Ahern, J., Cilliers, S., & Niemelä, J. (2014). The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation. Landscape and Urban Planning, 125, 254-259.

Atwa, S. M. H., Ibrahim, M. G., Saleh, A. M., & Murata, R. (2019). Development of sustainable landscape design guidelines for a green business park using virtual reality. Sustainable Cities and Society, 48, 101543.

Audit Commission, L. (2002). Street scene.

Balzan, M. V., Zulian, G., Maes, J., & Borg, M. (2021). Assessing urban ecosystem services to prioritise nature-based solutions in a high-density urban area. Nature-Based Solutions, 1, 100007.

Blanco, E., Pedersen Zari, M., Raskin, K., & Clergeau, P. (2021). Urban ecosystem-level biomimicry and regenerative design: Linking ecosystem functioning and urban built environments. Sustainability, 13(1), 404.

Brown, T. (2008). Design thinking. Harvard business review, 86(6), 84.

Carmona, M., De Magalhaes, C., & Hammond, L. (2008). Public space: the management dimension: Routledge.

Cattell, V., Gesler, W. M., & Curtis, S. (2006). Public spaces, social relations and well-being in East London: Policy Press.

Dietrich, U., & Kengyel, N. (2016). What makes a public open space liveable?

Donaldson, K. (2009). The future of design for development: three questions. Information Technologies & International Development, 5(4), pp. 97-100.

Gehl, J. (2011). Life between buildings: using public space: Island press.

Haas, T., & Olsson, K. (2014). Transmutation and reinvention of public spaces through ideals of urban planning and design. Space and Culture, 17(1), 59-68.

Ibes, D. C. (2016). Integrating ecosystem services into urban park planning & design. Cities and the Environment (CATE), 9(1), 1.

Jacobs, J. (1961). The Death and Life of Great American Cities (London: Jonathon Cope).

Julia, Z., & Andrey, K. (2013). Urbanization Dynamics in Egypt: Factors, Trends, Perspectives. Arab Studies Quarterly, 35(1), 20-38. doi:10.13169/arabstudquar.35.1.0020

Keating, S. (2017). Applying Human-Centered Design Methods to Your Process.   Retrieved from https://dispatch.moonfarmer.com/applying-human-centered-design-methods-to-your-process-27b783147e8

Kefale, A., Fetene, A., & Desta, H. (2023). Users' preferences and perceptions towards urban green spaces in rapidly urbanized cities: The case of Debre Berhan and Debre Markos, Ethiopia. Heliyon, 9(4), e15262. doi:https://doi.org/10.1016/j.heliyon.2023.e15262

Lehmann, S. (2018). Implementing the Urban Nexus approach for improved resource-efficiency of developing cities in Southeast-Asia. City, Culture and Society, 13, 46-56. doi:https://doi.org/10.1016/j.ccs.2017.10.003

Lehmann, S. (2019). Urban Regeneration. A Manifesto for transforming UK Cities in the Age of Climate Change.

Maes, J., Liquete, C., Teller, A., Erhard, M., Paracchini, M. L., Barredo, J. I., . . . Petersen, J.-E. (2016). An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem services, 17, 14-23.

Magidsohn, A. (2019). Human-centered design: five lessons for urban planners.   Retrieved from https://www.bangthetable.com/blog/human-centered-design/

Marcus, C. C., & Francis, C. (1997). People places: design guidlines for urban open space: John Wiley & Sons.

Mean, M., & Tims, C. (2005). People make places: growing the public life of cities: Demos.

Mori. (2002). The Rising Prominence of Liveability: MORI London.

Naguib, N., Abdel-Salam, H., & Saadallah, D. (2020). Optimizing the Performance of Public Open Spaces by Enhancing the Human Thermal Comfort. Paper presented at the REAL CORP 2020: SHAPING URBAN CHANGE: Livable City Regions for the 21st Century, Aachen, Germany. http://realcorp.at/archive/CORP2020_2.pdf

Nhamo, L., & Ndlela, B. (2021). Nexus planning as a pathway towards sustainable environmental and human health post Covid-19. Environmental Research, 192, 110376. doi:https://doi.org/10.1016/j.envres.2020.110376

Nhamo, L., Rwizi, L., Mpandeli, S., Botai, J., Magidi, J., Tazvinga, H., . . . Mabhaudhi, T. (2021). Urban nexus and transformative pathways towards a resilient Gauteng City-Region, South Africa. Cities, 116, 103266. doi:https://doi.org/10.1016/j.cities.2021.103266

Pan, H., Page, J., Cong, C., Barthel, S., & Kalantari, Z. (2021). How ecosystems services drive urban growth: Integrating nature-based solutions. Anthropocene, 35, 100297.

PPS. (2000). Project for Public Spaces.   Retrieved from https://www.pps.org/

Ramlee, M., Omar, D., Yunus, R. M., & Samadi, Z. (2015). Revitalization of urban public spaces: An overview. Procedia-Social and Behavioral Sciences, 201, 360-367.

Santos Nouri, A., & Costa, J. P. (2017). Placemaking and climate change adaptation: New qualitative and quantitative considerations for the "Place Diagram". Journal of Urbanism: International Research on Placemaking and Urban Sustainability, 10(3), 356-382.

UN(ESCAP). (2016). The Urban Nexus: Conceptual Framework and Linkages to Global Agendas. Retrieved from

Wang, R., Bai, Y., Alatalo, J. M., Yang, Z., Yang, Z., Yang, W., & Guo, G. (2021). Impacts of rapid urbanization on ecosystem services under different scenarios – A case study in Dianchi Lake Basin, China. Ecological Indicators, 130, 108102. doi:https://doi.org/10.1016/j.ecolind.2021.108102

Whyte, W. H. (1980). The social life of small urban spaces.

930

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Urban Regeneration: Identifying Causes and Impacts of Urban Decay within the Pietermaritzburg Central Business District: South Africa

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1 ABSTRACT

Urban decay affects cities worldwide, and South African cities have not been immune to this quagmire. It is regarded as a development that negatively contributes to physical degeneration and high spatial inequality. Most integrated development plans highlight the challenges of South African cities facing environmental decay and inadequate infrastructure maintenance. Consequently, greater regeneration plans for inner cities have been the strategic focus of urban planning. The study aims to investigate the main factors influencing urban decay within the Pietermaritzburg Central Business District (CBD). It is known that urban decay in Pietermaritzburg CBD is associated with economic decline and negatively impacts the city. However, it is unknown what specific strategies or plans the Municipality of Msunduzi is pursuing to combat urban decay, the level of funding available for urban regeneration initiatives, and the role of the private sector in urban regeneration efforts. The work adopted a case study research design and applied a qualitative approach to understanding factors contributing to urban decay in the Pietermaritzburg CBD. An in-depth examination and comparison of the causes and effects of urban decay using interviews with residents and relevant stakeholders, as well as observations of buildings conducted between 1 October 2022 and 30 October 2022, mention that the causes of urban decay in Msunduzi include Urban Planning and Governance: lack of measures to encourage city growth and inconsistent service delivery. The closure of public facilities, inadequate services, and the neglect of properties by absentee landlords worsen urban decay. The research findings emphasise the significance of private investments and changing residents' negative perceptions in achieving successful urban regeneration. A comprehensive approach to urban regeneration should encompass psychological, economic, social, physical, and civic aspects, thereby fostering economic development through collaboration between the public and private sectors. Most Pietermaritzburg participants attribute urban decay to socioeconomic shifts, such as the departure of middle-class residents, the presence of absentee landlords, and the absence of necessary amenities. Proposed solutions to combat urban decay involve implementing a regeneration programs program that prioritises city cleanliness, holds landlords accountable, enforces eviction measures, and offers incentives for businesses to relocate. Effectively implementing these measures necessitates collaboration among the municipality, private sector, community, organisations, and residents to stimulate economic growth, enhance infrastructure, and promote urban regeneration. The paper's overall contribution lies in developing an urban renewal strategy that addresses the factors leading to urban decay and supports efforts toward urban regeneration.

Keywords: Urban Planning, Spatial Inequality, Urban Regeneration, Urban Decay, Governance

2 INTRODUCTION

The built environment is always changing, both physically and functionally. Urban decay is examined from the viewpoints of physical, social, and economic origins, which have detrimental effects on urban planning. Urban decay presents itself in various ways, specifically in the physical deterioration of buildings and declining quality of the environment (Lea, 1972:43). Urban decay happens everywhere in the world in particular places or geographical areas in cities. However, the UN-Habitat (2017) notes that most of the world's population is relocating to cities and is predicted to increase in the next decade. However, urban decay mostly affects cities in developing countries. Urban decay is a global issue affecting developed and developing countries, resulting in the most aggravated effects if not addressed promptly. The cause of urban decay differs in each city. However, the impacts are slightly similar (Smith, 2018). According to Amirtahmasebi, Orloff, Wahba, & Altman (2016), every city either has an underutilised, overused, or distraught parcel of land, which gradually degenerates the city's appearance, liability and production and negatively affects the overall development and economy of the city. According to Andersen (2003:23), urban

decay is the most significant process which negatively contributes to generating high spatial inequality. It should be noted that urban decay is regarded as a global phenomenon affecting both developed and developing countries. Hence, the ARCA conference (2016:382) mentions that the impact of urban decay has stimulated global cities to formulate and implement urban regeneration strategies to address this issue. This research aims to investigate the main contributing factors influencing urban decay within the Pietermaritzburg Central Business District (CBD) and develop an urban renewal plan that addresses the threats contributing to urban decline while promoting urban regeneration. By analysing international case studies, the research will examine the reasons and factors behind the decline of the Msunduzi CBD, evaluate the socioeconomic and physical effects of urban decay in the area, and assess past, current, and future interventions aimed at combating urban decay. Through this comprehensive analysis, the research aims to provide valuable insights and recommendations for sustainable urban development and revitalisation in the Msunduzi CBD.

3   SIGNPOSTING

This paper explores various case studies that offer valuable insights into urban renewal and revitalisation efforts. Specifically, examining the cases of Santiago, Chile; Washington DC; Seoul; Singapore; and Johannesburg, providing a comprehensive understanding of their respective approaches. These case studies demonstrate the importance of comprehensive planning, public-private partnerships, restoring natural and cultural assets, addressing socio-spatial segregation, and having a long-term vision adaptable to changing circumstances. The significance of effective policy frameworks and governance structures in driving successful urban renewal initiatives is also highlighted. Moving on to the study area of Pietermaritzburg, South Africa, the paper delves into the perceptions of urban decay and its impacts through interviews with municipal officials and business owners. They shed light on the causes of urban decay, including middle-class residents leaving the city, absentee landlords neglecting properties, and a lack of services. Furthermore, the paper examined the resulting impacts, such as abandoned buildings, rising criminal activity, and declining property prices. Despite these challenges, there is a sense of optimism regarding the municipality's ability to regenerate the city. Participants propose potential solutions, including implementing a rehabilitation program, holding landlords accountable, conducting eviction processes for overcrowded properties, and providing business incentives. The findings emphasise the significance of private investment, transforming negative perceptions, preserving historical and cultural heritage, creating green spaces, improving transportation infrastructure, and investing in affordable housing and job opportunities as crucial factors for effective urban renewal.

4   RESEARCH METHODOLOGY

The research approach is in line with the study's goals and objectives. Since the study's main goal is to understand other people's opinions and behaviours surrounding urban decay in the Msunduzi CBD, the interpretative paradigm is used (Rahi, 2017). Qualitative research allows for the deep observation, examination, and disclosure of human experiences and behaviour (Alzheimer Europe, 2009). An in-depth examination and comparison of the causes and effects of urban decay are provided using a case study approach, the research design employed in this work. This aligns with thoroughly comprehending how urban decay affects the Msunduzi CBD. The sampling design chosen for the study is convenience sampling, which McCombes (2019) believes involves selecting individuals who are easily accessible and located near the study area. The target population for the study includes business owners located along Upper Boom, Pietermaritz and Church Street and government officials. Data collection instruments include primary data such as interviews with residents and relevant stakeholders and observations of buildings. Interviews took place between 1 October 2022 and 30 October 2022, where participants were asked to demonstrate their understanding of contributing factors and people responsible for urban decay within Msunduzi Municipality. Participants were also encouraged to provide personal views regarding how urban decay has affected them as individuals in their daily personal experiences and provided suggestions for an effective regeneration plan. This aligns to assess the scale of impacts regarding established interventions in Msunduzi CBD. Additionally, as Kabir (2016) indicated, secondary data collection methods are used to gather existing data from peer-reviewed journals and government publications.

5 CASE STUDIES

In the case study of Santiago, Chile, Santiago followed the laws of the Indies for planning but faced socio-spatial segregation and obsolescence in buildings and public spaces. The city lost half its population in the 1940s and implemented the Repopulation Program in 1990 to attract residents and promote urban renewal. The measures included attracting private investors, rehabilitating the physical environment, and changing negative perceptions of the city (Greene et al., 2011; World Bank, 2015). The Washington, DC, case study highlighted the city's strong model of urban revitalisation through the Anacostia Waterfront Initiative (AWI). The initiative aimed to bridge the psychological, economic, social, physical, and civic divide by restoring the river, improving transportation infrastructure, creating public open spaces, and developing cultural attractions and residential areas (Amirtahmasebi et al., 2016; Government of the District of Columbia, 2003). Seoul's case study focused on restoring the Cheonggyecheon stream in the downtown area, which sparked the regeneration of the city's inner districts. Revitalisation involved tearing down an elevated expressway, restoring the stream, and collaborating with the private sector for further development (Amirtahmasebi et al., 2016; World Bank, 2015). Singapore, a highly populated metropolis, faced physical decline and overcrowding in its core section. The city implemented urban rejuvenation strategies through legislative and development action plans, including the Master Plan of 1958. Projects such as the restoration of the Singapore River and the development of the Marina Bay waterfront played a significant role in the urban renewal process (Amirtahmasebi et al., 2016; World Bank, 2015; Guo, 2016). In Johannesburg, the decline of the inner city was influenced by apartheid policies and subsequent political transitions. Urban regeneration initiatives were implemented through area-based initiatives, improved public spaces, and urban development zones, focusing on rehabilitating neighbourhoods and revitalising the inner city (Amirtahmasebi et al., 2016; Nzimande & Fabula, 2020).

6 LESSONS LEARNT

The case studies of Santiago, Washington DC, Seoul, Singapore, and Johannesburg provide valuable lessons for urban renewal and revitalisation efforts. Here are the key lessons learned from these cases:

Comprehensive planning: Effective urban renewal requires a comprehensive planning approach considering various factors such as physical infrastructure, social dynamics, economic considerations, and environmental sustainability. By addressing multiple aspects of urban development, cities can create a holistic and integrated strategy for revitalisation. Public-private partnerships: Collaborating with the private sector is crucial in urban renewal initiatives. Engaging private investors, developers, and businesses can bring expertise, funding, and innovation to support the revitalisation process expertise, funding, and innovation. Public-private partnerships can help leverage resources and ensure the sustainability of urban renewal projects. Restoring natural and cultural assets: Rehabilitating natural and cultural assets within cities, such as rivers, streams, historic sites, and public spaces, can catalyse urban renewal. These assets can attract residents, tourists, and businesses, contributing to the economic and social vitality of the city. Addressing socio-spatial segregation: Urban renewal efforts should address socio-spatial segregation and inequality within cities. Cities can promote inclusivity and social cohesion by providing equal access to quality housing, transportation, public amenities, and economic opportunities. Long-term vision and adaptability: Successful urban renewal requires a long-term vision and adaptability to changing circumstances. Cities should develop flexible plans to evolve and accommodate new challenges and opportunities. Policy and governance: Effective policy frameworks and governance structures are essential for driving urban renewal initiatives. Cities need supportive legislation, regulations, and institutional mechanisms that enable coordinated planning, implementation, and monitoring of urban renewal projects.

7 STUDY AREA

The study area is in South Africa, within the second largest city of the KwaZulu-Natal province, known as the Pietermaritzburg city. The Pietermaritzburg city was originally established in 1838 after the defeat of Dingane at the Battle of Blood River. It was named after the two Voortrekker leaders, Piet Retief and Gert (Gerrit) Maritz. Pietermaritzburg is also known as uMgungundlovu and the capital city of KwaZulu-Natal, as it falls within the uMgungundlovu district and is governed by the Msunduzi Local Municipality (see figure 1). The current Pietermaritzburg population is estimated to be over 600,000 residents (including neighbouring townships). It is deemed to have one of the largest Indian South Africans in this country

(Siyabona Africa (Pty) Ltd, 2021). Pietermaritzburg is popularly known for its history and heritage essence, as it has numerous museums, art galleries and monument sites, historical buildings, and a railway station (Siyabona Africa (Pty) Ltd, 2021). The study area covers the Pietermaritzburg Central Business District, particularly the upper Pieter Maritz Street and upper Church Street (see figures 2 and 3).
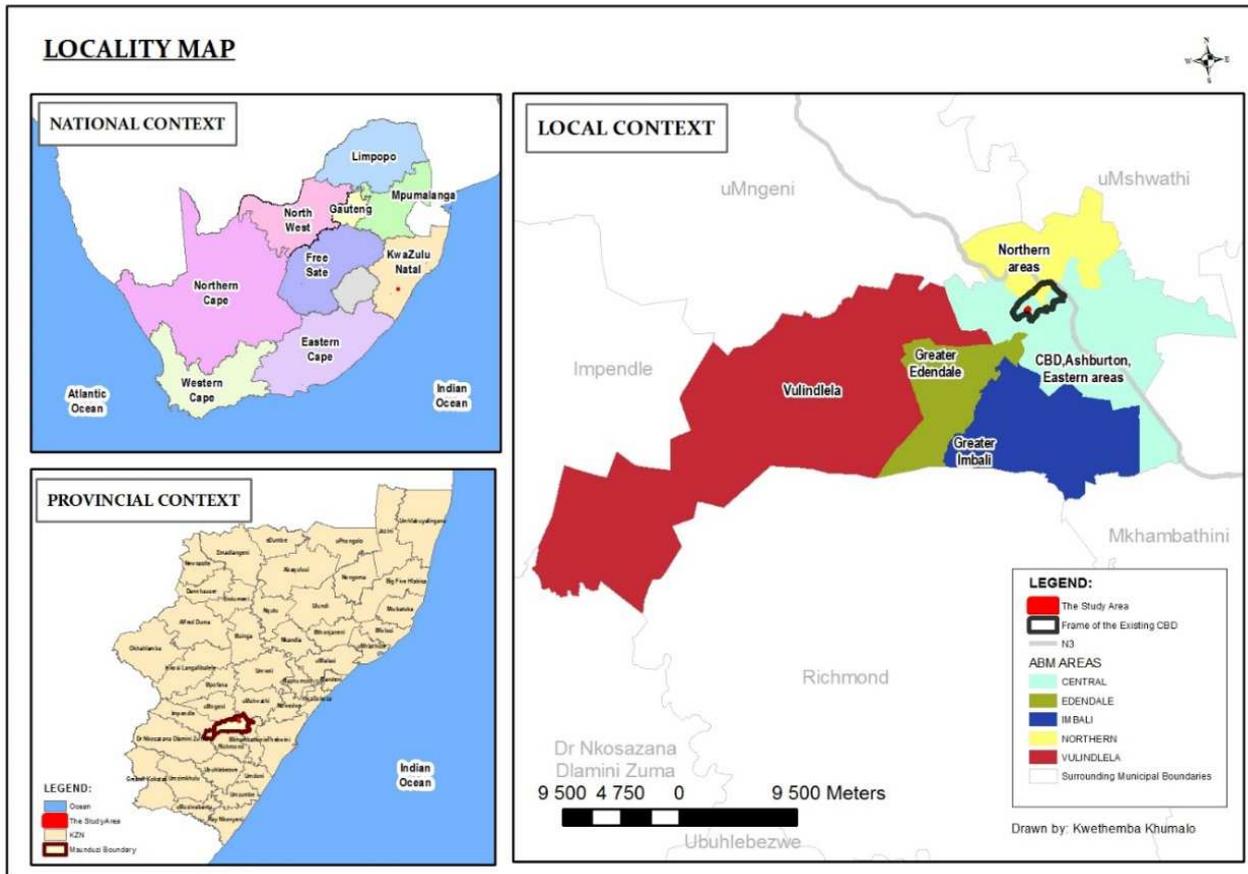

Figure 1: Locality Map. Source: Authors (2023).

Figure 2: Study Area. Source: Authors (2023)

8 RESULTS AND DISCUSSIONS

The results and discussions of the study emanate from the perceptions of municipal officials and business owners situated along Upper Boom, Pietermaritz and Church Street. The results and discussions are categorised into themes as per interview questions.

8.1 Conceptualising urban decay

Factors	Percentage
Despair	13.33%
Decline of Economy	40.00%
Decline of Status	20.00%
Unhygienic Habits	13.33%
Social Ills	13.33%

Table 1 Defining Urban Decay

Inquiring about the definition of urban decay allowed researchers to assess how well participants understood it and how it related to their own experiences. Because there are many different ways to define this term depending on the environment, it was suggested that participants think about what they observe in the city of Msunduzi. According to the diagram, most PMB participants associate urban decay with economic decline. According to the participants, urban degradation is the process by which a community gradually deteriorates through time as a result of a change in the socioeconomic circumstances of a community. Cuthbert (2017) states that the cause of urban decay varies, even though the underlying philosophy is comparable and is gradually and permanently deteriorating the city's cities-built form feature. Urban decay is a global issue that mostly affects an area's overall built environment; as such, most root causes require joint intervention from different spheres of government. Urban decay has many undesirable impacts, including a decline in a city's market economy, intensified crime and employment rates, and health effects. According to Shin and Shaban-Nejad (2018:9), various aspects of urban decay have the possibility of causing permanent health issues, especially respiratory-associated illnesses.
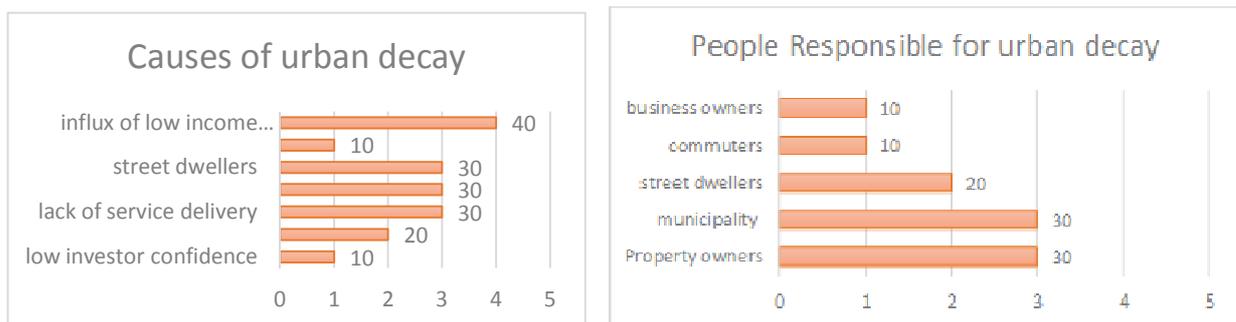
Figure 3: Causes of Urban Decay.

The participants contend that the primary causes of Pietermaritzburg's urban decline are middle-class citizens leaving the city for the suburbs, resulting in a commensurate inflow of lower-class or temporary residents. This is made worse by absentee landlords who do not check on the number of occupants or the condition of their buildings and are unable or unwilling to maintain their properties. The most underrated factor is a lack of services, namely the closure of public facilities, which forces commuters and homeless people to use open spaces like streets as restrooms when public restrooms are unavailable.

The participants continue to argue that the Municipality and property owners bear the primary blame for accelerating urban decline. The lack of consistent service delivery throughout the city with areas not being prioritised, the municipality's non-implementation of measures to encourage growth in the city and developing a favourable environment for economic and social sustainability. Most property owners neglect their homes and are not penalised, which causes the city's attractiveness to deteriorate.
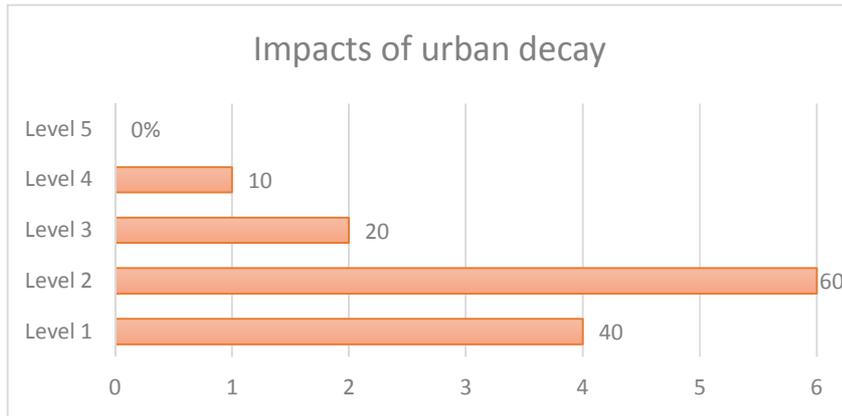
8.2 Impacts of the Urban Decay in PMB

Figure 4: Impacts of urban decay.

Participants' opinions and observations on the effects of urban decline in the Msunduzi Municipality were requested. They were asked to rank the impact level from 1 to 5 as another criterion. The objective of this study on urban decline was to determine the most urgent issue and encourage community involvement in the process. Participants said Msunduzi Municipality is in the middle of levels 1 and 2. Urban decay's Level 2 impacts, which are more obvious, include unoccupied or abandoned buildings, shattered windows, and a rise in criminal activity. These problems have decreased property prices, deterring regional growth and investment. Level 1 refers to minor issues such as peeling paint on buildings and occasional vandalism.
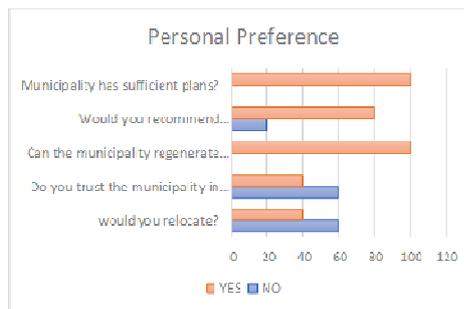
Figure 5: Personal preference.

Participants were questioned about whether they needed to leave the study's area, whether they trusted the municipality's approach to effective urban regeneration, and whether they would suggest investors in the study area based on the consequences. The findings suggest that there may be a lack of confidence in the municipality's leadership and capacity to take decisive action because 60% of participants do not believe the municipality would work relentlessly to fix the problem. However, the data also reveals that some inhabitants are hopeful and upbeat. There is a view that the problem of urban decline can be solved, as evidenced by all respondents to the question "Can the municipality regenerate the city?" agreed that the municipality can do so. Furthermore, 100% of participants who responded positively to the question "Does the municipality have sufficient plans?" agree that the municipality has adequate plans in place to address the problem of urban decay and that 80% of participants would advise the city to invest both show that residents are willing to support efforts to make the city better.

8.3 Possible solutions to urban decay in PMB

The participants engaged in discussions to suggest potential solutions for addressing urban decay in PMB. Among the participants, 40% advocated for a comprehensive rehabilitation program that adopts a multifaceted approach. This program encompasses various strategies, including initiating a cleanup campaign to reclaim public spaces from vagrants and criminal elements. Holding landlords accountable for their properties emerged as a critical step, emphasising the need for property owners to undertake reasonable maintenance. Additionally, participants highlighted the importance of enforcing eviction processes in cases of overcrowded dwellings. The municipality's role was acknowledged, with suggestions that it should play a part by condemning and demolishing abandoned structures. A proactive approach to law enforcement was

936

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emphasised to curb criminal activities, and the revival of incentives for businesses was deemed essential to rejuvenate the city's economic landscape. In response to the reviewer's comments, a comprehensive examination of these proposed measures reveals the following recommendations:

Figure 6: Possible solutions.

(1) Establish Rehabilitation Programmes: Develop and implement structured rehabilitation programs that restore deteriorating areas. These programs should involve community engagement, partnerships with local organisations, and targeted interventions to address specific challenges within each locality.

(2) Demolish Old Buildings: Identify derelict and dilapidated structures that contribute to urban decay and pose safety risks. Develop a systematic plan for demolishing and removing these buildings, ensuring proper waste disposal and adhering to environmental regulations. Old buildings listed under AMAFA (Amafa aKwaZulu-Natali) should be comprehensively preserved. This involves detailed documentation, a conservation plan that respects historical value, and adherence to heritage regulations. Stakeholder engagement and sensitivity to original design during restoration are crucial. Periodic maintenance, public access, and heritage tourism can further promote their significance.

(3) Enforce Strict By-Laws for Residents and Property Owners: Strengthen and enforce municipal by-laws that require property owners to maintain their premises in a reasonable condition. Introduce penalties for non-compliance to encourage property owners to invest in upkeep.

(4) Formalize Businesses: Facilitate formalising informal businesses operating in the affected areas. Provide support and resources to help these businesses become legal entities, contributing to the formal economy while promoting safety and regulatory compliance.

(5) Community Clean-Up Initiatives: Mobilize community members to participate in regular clean-up campaigns. Encourage ownership and responsibility for the local environment, fostering community pride and cleanliness.

(6) Business Retention and Incentives Strategy: Develop a comprehensive strategy to attract businesses back to the area and retain existing ones. This could involve offering tax incentives, streamlined licensing procedures, and support for business development.

(7) Address Parking Issues: Implement effective parking management strategies to alleviate congestion and ensure orderly parking. Consider introducing parking regulations, designated zones, and alternative transportation options.

The research focuses on an area outside the city's CBD regeneration strategy, posing challenges in sourcing funds for regenerative efforts in this location. A potential solution involves advocating for policy amendments to encompass these overlooked streets within the regeneration initiatives. A closer examination reveals that the chosen study area is primarily occupied by homeless individuals, leading to investor reluctance due to heightened nocturnal criminal activities. Addressing their inclusion in policy-making requires innovative strategies. To address this, the City of Msunduzi could develop a comprehensive mandate as part of its regeneration policy, collaborating with rehabilitation centres to relocate and support homeless individuals. This collaboration would offer them essential activities, skill development programs, and drug rehabilitation services. The study area also comprises tenants from various African countries

renting properties owned by South African landlords who don't reside there. The city could consider purchasing these properties, enhancing them through rehabilitation, and reselling them under stricter maintenance regulations. Alternatively, exploring expropriation is an option, subject to conditions that allow property owners to provide tenants with sufficient time to relocate, with the city's assistance if needed. Collaboration is key, such as utilising already-built housing programs to benefit these residents, ensuring a joint effort to prevent potential gentrification. Furthermore, part of the regeneration process should involve integrating informal street traders. This could entail reserving ground-level spaces within buildings for economic activities and providing stalls and furniture to support a regenerative economy.

9 CONCLUSION

According to the interviews, it can be inferred that most PMB participants saw urban decay as a process where an area deteriorates because of a shift in socioeconomic conditions. They also think that the outflow of middle-class residents from urban areas, absentee landlords, and a lack of amenities are major factors in urban decline. Urban deterioration is rated as having a level 1 to level 2 impact by participants in PMB, with more obvious problems such as broken windows, abandoned buildings, and increasing criminal activity. Participants don't have complete faith in the municipality to successfully combat urban deterioration, but they think it can revitalise the city. Participants suggest possible solutions, including creating a rehabilitation program that cleans up the city, holding landlords responsible for their homes, evicting extra people, and offering incentives for companies to relocate back to the city. Overall, the findings indicate that urban decline is a serious problem in PMB, but citizens are hopeful and eager to fix it. We can infer from the case study that the key components of effective urban regeneration initiatives include luring private investment and altering negative perceptions of the city, collaboration between the public and private sectors, giving top priority to historical and cultural significance, creating green spaces, putting transportation planning into practice, regenerating natural resources like rivers, and investing in affordable housing and job opportunities.

10 REFERENCES

1. Amirtahmasebi, R., Orloff, M., Wahba, S., & Altman, A. (2016). Regenerating Urban Land: A Practitioner's Guide to Leveraging Private Investment. Available from: https://elibrary.worldbank.org/doi/pdf/10.1596/978-1-4648-0473-1
2. Andersen, H. S. (2002). Can Deprived Housing Areas Be Revitalized? Efforts against Segregation and Neighborhood Decay in Denmark and Europe. Urban Studies, 39(4):767–790.
3. Andersen, H.S. (2003). Urban sores: On the interaction between segregation, urban decay, and deprived neighbourhoods. Available from: https://www.researchgate.net/publication/330771513_Urban_Sores_On_the_interaction_between_segregation_urban_decay_and_deprived_neighbourhoods
4. Anderson, C. (2010). Presenting and Evaluating Qualitative Research. American Journal of Pharmaceutical Education, 74(8):141. Available from: https://www.ajpe.org/content/ajpe/74/8/141.full.pdf
5. Andrews, A. (2018). Decline and the City: On the Urban Crisis in Liverpool, c. 1968-1986. (Doctoral thesis, University of Leicester, England). Available from: https://leicester.figshare.com/articles/thesis/Decline_and_the_City_the_Urban_Crisis_in_Liverpool_c_1968-1986/10215833
6. Andrews, A. (2019). Dereliction, decay, and the problem of de-industrialization in Britain, c. 1968-77. Creative Commons, 44(1):2-24. Available from: http://eprints.leedsbeckett.ac.uk/id/eprint/5853/
7. ARCA conference. (2016). Conference proceedings book of the 5th applied research conference in Africa 25-27 August 2016. Conducted by African Applied Researchers Association. Cape Coast: Ghana.
8. District of Columbia. 2010. Anacostia Waterfront Initiative 10 Years of Progress. Washington, D.C: District of Columbia Office of Planning. Available: awi10yearprog.pdf (ctycms.com) (Accessed 15 November 2022).
9. Fabiyi, O.O. (2011). Analysis of urban decay from low resolution satellite remote sensing data: example from organic city in Nigeria. International Journal of Development and Management Review (INJODEMAR), 6(1): 172-189. Available from African Journals online database: https://www.ajol.info/index.php/ijdmr/article/view/66993
10. Kabir, S.M.S. (2016). Methods of data collection. In Basic Guidelines for Research: An Introductory Approach for All Disciplines (Vol.1: 201-275) Available from: https://www.researchgate.net/publication/325846997_METHODS_OF_DATA_COLLECTION
11. Lea. J.P, (1972). The Quality of the Built Environment: The Problem of Urban Decay. South African Journal of Science, February (1972): 43-46.
12. McCombes, S. (2019). An introduction to sampling methods. Available from: https://www.scribbr.com/methodology/sampling-methods/
13. Miraftab, F. (2007). Governing Post-Apartheid Spatiality: Implementing City Improvement Districts in Cape Town. Antipode, 39 (4): 602–26.
14. Nzimande, T.P. and Fabula, S. (2020). Socially sustainable urban renewal in emerging economies: A comparison of Magdolna Quarter, Budapest, Hungary and Albert Park, Durban, South Africa. Hungarian Geographical Bulletin, 69(4): 383–400.
15. Rahi, S. (2017). Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues, and Instruments Development. International Journal of Economics & Management Sciences, 6 (2):1-5

938

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

16. Siyabona Africa (Pty) Ltd. (2021). Available from: http://www.siyabona.com/kwazulu-natal-pietermaritzburg.html
17. The World Bank. (2015). Available from: https://urban-regeneration.worldbank.org/Shanghai
18. UKEssays. (November 2018). Two main paradigms, namely positivist and interpretive. Retrieved from:
        https://www.ukessays.com/essays/education/two-main-paradigms-namely-positivist-and-interpretive-education-
        essay.php?vref=1
19. UN-Habitat. (2017). Trends in Urban Resilience 2017. Available: Trends in Urban Resilience 2017 | UN-Habitat (unhabitat.org)
        (accessed 15 November 2022).

Urban Revitalisation of Small Settlement in the Regional Context: Case study Kneževo in Baranja Region in Croatia

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1 ABSTRACT

Spatial, socio-economic and demographic characteristics of individual areas of the European Union define numerous specific settlements and regions, among which the peripheral areas and small settlements, are particularly interesting and challenging for both researchers and planners, thus they represent the main research problem. It is particularly important to create revitalisation strategies for such areas at the regional and local level, based on the specific characteristics of the place and set within the framework of national and European development criteria. The importance of this research for readers is to highlight the necessity of comprehensive planning and the use of the scenario method, the foundations of which can be mastered in education at the Spatial Planning Workshop, and later applied in urban and spatial planning practice. The aim of this paper is presentation of thematic workshops as education method for future spatial planners, urban planners and architects based on European sustainable development documents, which enables research, analysis and planning at the regional level through application of the scenario method, as *par excellence* tool for definition of future development. The possibility for students to choose both the subject area and the specific topic during the workshop represents an opportunity for further education and development of a visionary approach not just at the regional but also at the local level with the possibility of planning revitalisation strategy for small settlements in the following semester. The case study of Baranja region in eastern Croatia was chosen for the purpose of this research, because of its geographical isolation and depopulation, a lack of micro-regional centres, neglected industry and a relatively old population. On the other hand, its diverse natural and cultural heritage, historical agricultural significance, and the regional specificities of individual settlements, especially Kneževo, represent spatial potential which should be activated in order to stimulate its regional, and consequently, local development. On the basis of the detailed analysis, and the application of scenario method, the result of the work is definition of six possible scenarios for the Baranja region development, determined by dominant activities (smart villages, agriculture, tourism, energy, industry and livestock) which are further broken down into two basic models of space activation approach. The proposed scenarios are based on global sustainable development goals and specific possibilities of spatial revitalisation, which enables definition of an integral scenario (as a result of the valorisation of individual scenarios), further elaborated as a vision of development and revitalisation of the Baranja region with macro and micro projects acting as space activators. The special emphasis is placed on Kneževo, a small settlement with historically significant urban and industrial features which experienced a significant economic and demographic decline due to the dynamics of business and deindustrialization trends in the late 20th century. The introduction of the new function is seen as a potential activator of Kneževo settlement revitalisation, where the construction of a film studio is proposed as the most suitable scenario. It would contribute to the development of culture and media at the national level, while the development of supporting functions and an increase in the number of temporary and permanent residents would enhance the revitalisation of the settlement and the surrounding area.

Keywords: space activation, sustainable development goals, scenario method, spatial planning, revitalisation strategy

2 INTRODUCTION

Spatial, socio-economic and demographic characteristics of individual areas of the European Union define numerous specific settlements and regions, among which the peripheral areas are particularly interesting and challenging for both researchers and planners.

The term "periphery" has numerous interpretations from spatial to socio-developmental perspectives. Pénzes and Demeter (2021) stress that considerations of peripheral areas and their delimitations themselves can be

based on different approaches, and specific indicators should be considered in order to determine their level of development. The ESPON applied research PROFECY (2017) point out the inner peripherality is the result of multiple combinations of processes, features and evolutionary dynamics affecting all kinds of territories across Europe. The combined action of different processes and features on a specific territory can cause significant limitations in its development potential. Peripherality is not only determined by geography but also by non-spatial proceses and factors. Some delineations of peripheral areas are: higer travel time to regional centres, lower economic potential, poor access to services of general interest and depletion. Considered in the territorial context, the most peripheral areas in geographical terms frequently appear as inner peripheries and border regions. Regarding the future development of such areas, development policies on the regional and local level should be based on specific characteristics of peripheral areas and the characteristics of their settlements, defined by national and European criteria. Smaller settlements represent a particular challenge because dynamic processes on higher levels leave greater effects on the local level, thus more attention should be paid to direction of their development.

The main research problem are peripheral areas and small settlements, for which it is necessary to create long-term revitalisation strategies. The importance of the research to the reader is to emphasize the need for comprehensive planning and the use of scenario method in planning both at the regional and the local level, the foundations of which can be mastered in education at the Spatial Planning Workshop.

The aim of this paper is to present thematic workshops as education method for future spatial planners, urban planners and architects, which enables research, analysis and planning on the regional level through application of the scenario method as par excellence tool for definition of future development based on European sustainable development documents. The possibility for students to choose both the subject area and the specific topic during the workshop represents an opportunity for further education and development of a visionary approach on the regional and local level with the possibility of planning revitalisation strategy for small settlements, in this case Kneževo settlement in the Baranja region in eastern Croatia.

The paper will show how students at the Faculty of Architecture in Zagreb in the Spatial Planning workshop on the Master's course in Architecture and Urbanism are directed to think strategically about space through comprehensive planning, using the planning scenario tool.

As a part of Workshop 3: Spatial planning at the Faculty of Architecture of the University of Zagreb, under the mentorship of Professor Lea Petrović Krajnik, head of the workshop, student Petra Banić, created a vision for the development of the Baranja Region named "Re: Baranja: Development and Revitalisaion Scenarios" (Banić, 2023a). Afterwards, she further developed specific location and theme on the scale of urban planning project as the graduation thesis "The Revitalisation of Kneževo", under the mentorship of Professor Damir Krajnik (Banić, 2023b).

3 SPATIAL PLANNERS' EDUCATION AND SPATIAL PLANNING WORKSHOPS

Stategic visions can be considerd as the basis for creating high quality places and delivering a more sustainable future for communities as well as to achieve their long-term needs. The comprehensive planning has to be pointed out as the effective tool for enabling communities to formulate strategic visions of their future development goals. The integrative approach in spatial planning allows an evaluation of the strengths and challenges of the specific area, the definition of opportunities and scenarios, and selection of optimal vision and spatial policies for the future development. Spatial planning operates at all scales, from European, transnational, national, regional to local plans, so spatial planners must have the abilities to cope with different scales and different levels of territorial planning.

According to the Charter of European Planning (ECTP-CEU, 2013) spatial planners play the key role for changes that are needed to manage existing and create new cities and regions. They need to be leaders of change, political advisors, designers, urban managers, and scientists. This would make achievement of the Vision and application of the Charter of European Planning Principles easier.

ECTP-CEU (2017) points out that spatial planning is a distinct profession with its own areas of expertise in territorial development processes. The planners' core commitments, embodied in the Charter of European Planning, include research and analysis, advocacy and mediation, the ability to envision, evaluate and promote potential future options for urban, spatial, and territorial development. Planners need to combine scientific and creative conceptual thinking with practical approaches in order to harmonize society and

environment at various territorial levels. ECTP-CEU explains the framework of guidance based on three needs and the related eight core competences of spatial planners:

- Critical thinking and understanding of the rationale of planning and its theoretical and legal basis (The Rationale od Planing)

- An understanding of the spatial systems (Socio-economic systems, The Built Environment, Environmental systems)

- Technical and creative competence needed to engage in planning practice (Planning Techniques, Planning Instruments, Planning "Products" and Independent Research).

In the spatial planners' education, during the Undergraduate and Graduate Studies in Architecture and Urbanism at the Faculty of Architecture of the University of Zagreb, students encounter various tasks in the field of urbanism and spatial planning: from planning low-density residential areas, high-density residential areas, planning a new part of the city, designing public space, the urban-architectural project of the transformation of a specific city area, and the integral vision of development of cities and municipalities.

On the third semester of the Master Study in Architecture and Urbanism students have the opportunity to choose between fourteen workshops led by professors from the Faculty of Architecture. Workshop 3 - Spatial planning is one of three workshops led by professors of the Department of Urban Planning, Spatial Planning and Landscape Architecture. The main goal of the course is to propose a vision of the spatial development of chosen area (region or city) based on the principles of sustainability and the proposed topic depending on the academic year. The work on the course is adapted to the student, or group of students, and takes place in stages in accordance with the timetable, depending on the chosen subject coverage. The first stage of students′ work includes a consideration of theoretical starting points and a detailed analysis of the existing situation and spatial planning documentation, which ends with a SWOT analysis as a basis for the second stage.

Students are guided to perceive spatial strenghts, weaknesses, opportunities, and threats from different perspectives, that is, to immerse themselves in the different roles played by various actors in the space, in order to be able to determine possible development scenarios. In addition, in the initial stages of planning, they are encouraged to use surveys to determine the key issues and needs of residents and users of the subject area. In the second stage, students independently or in group research and conceive different scenarios for the future development of the chosen area, taking into account complex systems and numerous processes taking place in them. Based on the set criteria, students choose the most appropriate development scenario and propose a development vision and a concept for the subject area (graphics, model). In the third stage, a more detailed elaboration of the program for the selected location and the proposal of strategic and development projects are made.

The scenario method is used as a par excellence tool for determination of the future development possibilities of a certain area. Scenario methods are research subject of many authors, considering the use of scenarios, which has a special significance for spatial planning, and which encourages strategic thinking and helps to overcome thinking limitations. There are numerous definitions of scenarios depending on the authors and areas of application.

Kahn and Wiener (1967), the founders of future studies and scenario planning, define scenario as "a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points". Godet and Roubelat (1996) perceive a scenario as a description of the future state and the sequence of events leading to the future state. Shearer (2005) points out that the scenario is not a "variant of the future" but a mean to achieve the desired state.

The use of the scenario method expanded after WWII, when it was linked to military planning at the RAND Corporation. In addition, the methodology was used during the 1960s for the purposes of social forecasting, public policy analysis and decision making. In the 1970s, scenario planning gained a new dimension in the private sector thanks to the unconventional French oil director Pierre Wack. During the last decades, the use of scenario method has particularly increased, not only in the business sector but also in the field of spatial planning. (Bradfield et al., 2005)

Rothman (2008) emphasizes that scenarios can be presented in textual and graphic form (pictures, graphs, maps, etc.), which enables better perception and understanding of the future. In comparison to other future-

oriented approaches, Ljubenović et al. (2014) stress that scenario planning usually provides a more qualitative description of how the present will evolve in the future, rather than quantitative numerical accuracy which is typical for simulations. They point out that in the scenarios the range of possible outcomes resulting from uncertainty is explored, while creating a vision builds a picture of desired future together with strategies for achieving goals. Friedmann et al. (2004) believe that it is a way of questioning the future for optimal decisions in the present, which have to be based locally. He points out that a detailed investigation of strategic issues is necessary in the context of different assumptions or scenarios in order to enable the assessment of the outcomes and effects on different aspects of sustainability. Kok et al. (2006a, 2006b) point out that scenarios created for lower levels are based on scenarios from higher levels. Higher-level scenarios are usually developed by scientists and stakeholders on the regional and national levels, while local scenarios are developed by local stakeholders.

Radeljak Kaufman (2016) points out the existence of different types of scenarios such as scenarios of exploratory / normative, qualitative / quantitative, expert / participative and basic / managerial character, which indicates the significance of the selected typology in research and spatial planning. She emphasizes that the scenario method is useful in spatial planning because of the creation process during which knowledge about development trends and spatial elements is expanded, but also because of the final results that are important for management strategies and measures.

During studies in spatial planning workshops, students are directed to strategic thinking and the use of the scenario method, which presents an efficient tool to articulate concepts of an uncertain and complex future. Scenario planning serves as a basis for defining an integrated vision of development of cities and regions. The intention to stimulate students′ intuition and creativity is achieved by applying scenario planning based on Intuitive logics school which does not use any mathematical algorithms. The methodology proposed by Stanford Research Institute International (SRI) is one of the most popular and frequently used. The advantage of the SRI approach is the development of flexible, internally consistent scenarios from an intuition and logical perspective (Huss and Honton, 1987). Students are taught the importance of flexibility in the process of creation of a spatial development vision, as well as the need to create four scenarios which enable an open discussion and the combination of different interests of stakeholders in the process of defining the preferred model and creating a common development vision (Vogelij, 2010).

Urban revitalisation represents a special issue in urban and spatial planning. It′s definition according to the CEMAT Spatial development glossary (2007) is: „urban regeneration and revitalisation which aims at transforming the obsolete socio-economic base of certain urban areas into a more sustainable socio-economic base through the attraction of new activities and companies, modernisation of the urban fabric, improvement of the urban environment and diversification of the social structure.“ Urban revitalisation is a complex and long-term process that brings back to life spatial structures encompassing different dimensions such as urbanistic, architectural, technical, cultural, aesthetic, social and natural. Strezelecka (2011) points out that it is understood as a process involving spatial, social and economic transformations of towns. Urban revitalisation should be carried out systematically, in the context of environmental improvement and political and institutional development, in order to enable implementation of adopted strategies in legal frameworks and organizational conditions.

The process is associated with the concept of sustainable development since it is a comprehensive approach which considers three main aspects of urban life, the ecological, social and economic, and puts emphasis on quality of life of town residents. In the process of revitalisation, particular attention has to be paid to social, infrastructural and spatial development (preserving cultural heritage through renovation, modernization and conservation of historical monuments, buildings and public spaces and improvement of the natural environment). Zagroba and Gawryluk (2017) dealt with a revitalisation as a method of planning sustainable development of historic towns. They point out that simultaneous protection of cultural heritage and restoration and improvement of usable functions and strengthening social integration is particularly challenging in the process of revitalisation of a historic town centre.

There are various initiatives and programs for revitalisation of small settlements in Europe. The European Council for the Village and Small Town (ECOVAST) was set up in Germany in 1984 in order to further the well-being of rural communities, and safeguarding of the rural heritage throughout Europe. Its main aim is to foster the economic, social and cultural vitality and the administrative identity of rural communities in

944

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Europe, to safeguard and promote the sensitive and imaginative renewal of their built and natural environments. Nowadays ECOVAST has more than 500 members in 20 countries in East and West Europe, and it can be seen as a bridge between decision-makers and those who are active at local level, between experts and practitioners (ECOVAST, 2023). The Cittàslow movement emerged in Italy in 1999 and has spread to 33 countries during the years, connecting over 287 towns not in Europe and around the world. Bernat and Flaga (2022) stress that membership in the International Cittàslow Network can constitute an alternative development path for the revitalisation of small towns in peripheral areas. Honoré (2005) points out that the idea of slow town is a part of the so-called "slow movement", conceived as a response to the progressing globalisation and in the context of the sustainable development paradigm.

At national level specific policies and tools for small and medium-size towns have been recently developed across Europe (Gros-Balthazard & Talandier, 2020; Rauhut & da Costa, 2021). A series of initiatives have been implemented in some European countries, in order to address the challenges faced by territories defined as internal, peripheral, or lagging-behind places. For example, in France "The national policy Petites villes de demain - Territoires de cohésion au coeur de la relance" was established in 2020, "Kleinstadt Akademie (The German Small Town Academy)" in 2021 in Germany, "Piano Nazionale di Ripresa e Resilienza - Bando Borghi (Call for Villages)" in 2020 in Italy, "Estratégia Portugal 2030. Documento de Enquadramento Estratégico" in 2020in Portugal, and "Plan de Recuperación. 130 Medidas Frente al Reto Demográfico (2021-2023)" in 2020 in Spain. (ESPON, 2022)

4 CASE STUDY: BARANJA REGION AND KNEŽEVO

The Baranja region and the settlement of Kneževo were chosen because of their specific location and characteristics, i.e. as the peripheral area with special challenges of depopulation and deindustrialization, but also a great potential of natural and cultural heritage and historical industrial significance for the entire area of northeastern Slavonia and Croatia.

4.1 Specifitites of the Baranja Region

Geographically, the Baranja region covers parts of the territory of Croatia and Hungary, of which the Croatian part is 20.5% of the total region area. The Croatian part of Baranja occupies the northeastern part of the Osijek-Baranja County, territorially defined by the Drava River on the south and the Danube on the east, while the northwestern border with Hungary is defined administratively. The Croatian part of Baranja has 30,782 inhabitants, which represents 12% of the population of Osijek-Baranja County. Compared to the previous population census from 2011, Baranja recorded a loss of 8,000 inhabitants, which represents a total of 20%. (Croatian Bureau of Statistics, 2023; Banić, 2023a)

Fig. 1: Administrative Division of Croatian Part of the Baranja Region. Source: Banić, 2023a.

The A5 highway, which is an integral part of the pan-European Vc corridor (Ploče - Sarajevo - Osijek - Budapest) and the European route E73 passes through the Baranja region. The completion of he highway route to the state border with Hungary (from 5 km north of Beli Manastir to the state border) is planned in 2024. The Pan-European Corridor Vc railway route is also planned, which should become an important transport route, especially for freight traffic. The area is well connected by local road infrastructure which

connects settlements and enables daily migrations to larger regional centers, while the public transport network is insufficiently developed.

The Baranja Greenways bike path passes through the area, a multipurpose path that supports: walking, horseback riding, cycling and other forms of movement without a motor (Mecseka - Osijek). In its southern part, it passes through the municipalities of Bilje and Kopački rit, passing through Zlatna Greda, Tikveš and Kopačevo. The Pannonian Road, the bicycle path (Osijek - Sombor) passes towards Bilje to the gate of Kopačko rit - Kopačevo, passes through the wastelands of Podunavlje, Kozjak, Sokolovac and Mirkovac, continues via Suza and Zmajevac to Batina. The Danube bicycle route (EV6) has a total length of 4,450 km and passes through 10 European countries, connecting 11 UNESCO World Heritage sites and 6 European rivers. In a length of 150 km, it passes through the eastern part of Croatia through two counties (Osječko-Baranjska and Vukovarsko-Srijemska county), following the course of the Drava and Danube rivers.

The area has a rich natural heritage. A significant part of the Baranja is protected by the NATURA 2000 ecological network, the area along the Drava and the Danube (special reserve Gornje Podunavlje and nature park Kopački rit). The area has a developed network of public facilities: cultural (five museums and one library), educational (five kindergartens, 31 primary schools, one high school and three vocational high schools) and health (three health centers and seven clinics). (Banić, 2023a)

The region is also rich in cultural heritage: manors, sacral buildings and complexes, rural and industrial settlements, archaeological zones and sites. A rich industrial history is evident in numerous complexes called "pustare", which were established in the 19th century, and in the first half of the 20th century. Today, "pustare" are mostly abandoned or have maintained an exclusively productive function, while their spatial potential remains unused. (Ministry of Culture and Media, 2023; Matišić et al., 2017)

In the Croatian part of the Baranja, the main economic branches are agriculture and tourism. The main tourist zones are the Kopački rit nature park and the settlements in the zone of Bansko brdo with tourist offer based on sports and recreation.

Based on the analysis of the existing situation and spatial planning documentation, a SWOT analysis was made pointing out strengths (natural and cultural diversity, agricultural importance, rich tourist offer and numerous specific settlements), weaknesses (geographical isolation, neglected industry, older population and lack of micro-regional centers), advantages (international connection, modernization of industry, activation and attraction of population and formation of regional centers) and threats (exclusively tourism based economy, excessive industrialization, abandonment of agriculture and loss of the historical character of settlements).

4.2 Development and Revitalisation Scenarios of the Baranja Region

Based on the conducted analyses, possible development and revitalisation of the Baranja region is considered through six basic scenarios determined depending on the dominant economic activity in the area, which are further broken down into two basic models of space activation approach. In the process of creating basic scenarios, an attempt is made to investigate the current activities and their impact on the economy and population of Baranja in order to define steps for possible improvement. The proposed scenarios are based on global sustainable development goals and specific possibilities of spatial revitalisation. Evaluation of individual scenarios is carried out in order to determine an integral scenario which is later elaborated as a vision of development and revitalisation of the Baranja region with macro and micro projects as space development activators.

4.2.1   Smart villages

According to the European network for rural development (2003) smart villages are the concept of communities in rural areas that use innovative solutions to improve their resilience. In order to improve their economic, social and/or environmental conditions, they rely on a participatory approach in development and implementation of development strategies and solutions offered by digital technologies. Additional benefit can arise from the cooperation with other communities and actors in rural and urban areas. The basic prerequisite for the development of smart villages is internet networking and internet literacy. Although Croatia is largely covered by a Wi-Fi network, not all areas have broadband Internet (HAKOM, 2023). As a part of the concept of smart villages development, it would be necessary to improve the internet infrastructure and implement the digitization of health, administrative and commercial services (Pavić-

Rogošić, 2019). Since almost all settlements in Baranja, with the exception of Beli Manastir, have a rural character, their survival and development can be achieved through transformation into smart villages.
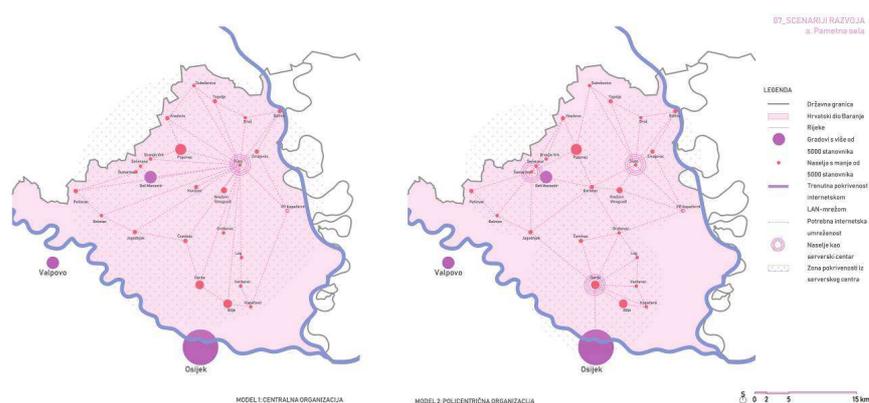

Fig. 2: Development Scenario: Smart Villages - Central Organisation Model (left) and Policentric Organisation Model (right). Source: Banić, 2023a.

The central organization model envisages concentration of digital server and administrative functions in one place, which would thus become the digital center of the Baranja region. The Suza settlement is chosen as the center, due to its undergoing revitalisation and several settlements in the vicinity with high economic potential.

The polycentric village organization model assumes division of the Baranja region into three sub- areas with centers in Darda, Suza and Šumarina, which were chosen due to their location in gravity zones of larger cities. The activation of centers is perceived through new function which ensures creation of new work places, thus improving living standard of inhabitants.

4.2.2 Agriculture

The most important economic branch of Baranja is agriculture, with production of corn, wheat, sugar beet, fodder and industrial plants. The current challenge of agriculture in Baranja is the lack of irrigated areas and the absence of processing facilities. Agricultural production is not on the technological level which would ensure production results in accordance with the quality of the soil. As a solution for improvement of agricultural production, construction of a processing plant which would ensure the export of finished products, resulting in higher revenues (Croatian Chamber of Commerce, 2023; Glas Slavonije, 2023). Two models of the organization of processing centers are proposed.

The central organization model envisages the establishment of one processing center, which is planned in the Čeminac settlement due to the good traffic connection with Osijek as a macro-regional centre. It is located along the railway corridor and is well connected to other settlements in Baranja. Farms and biogas plants are located next to it, which would ensure its supply. The construction of the processing centre would create numerous working places for the residents of Čeminac and its surroundings.
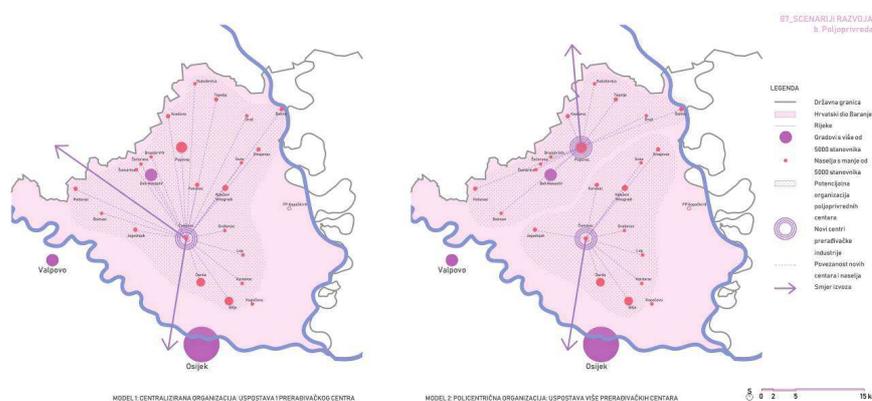

Fig. 3: Development Scenario: Agriculture - Central Organisation Model (left) and Policentric Organisation Model (right). Source: Banić, 2023a.

The polycentric organization model proposes establishment of two processing centers, one in Čeminac and the other in Popovac settlement. The processing center in Popovac would be focused primarily on the export of goods to the European Union via Hungary, and would cover the agricultural production of the settlements north of Bansko brdo. It was chosen because of its central location in northern Baranja and proximity to Beli Manastir as a regional centre. In this way, the northern settlements of Baranja region would also be activated and new working places created.

4.2.3 Tourism

The existing tourism offer in Baranja is concentrated in two zones: the nature park Kopački rit and the southern slopes of Bansko brdo. Kopački rit is the center of active tourism in nature, while the area of Bansko brdo is the center of rural tourism focused on the production of local products, mainly wine. Kopački rit is easily accessible from Osijek, and Kopačevo is the starting point for organized tourist route to the presentation and education center in newly renovated Tikveš manor in the north. The activation of new tourist zones and the integration of the tourist offer is proposed. (Baranja Tourist Board, 2023)

The model of integration of the existing tourist facilities is based on the connection of two main existing tourism assets, with minor expansions west of Beli Manastir.

The model of activation of new tourist centers is focused on the restoration and preservation of existing cultural assets and the formation of new tourist hotspots. These are cultural centers with classicist and historicist manors and parks in Bilje, Darda and Kneževo, while Topolje is a center of traditional rural architecture. Existing centers with already recognized cultural heritage, such as Zmajevac, are not included in this model.

The integration of both models and the overlap of the tourist offer is proposed.
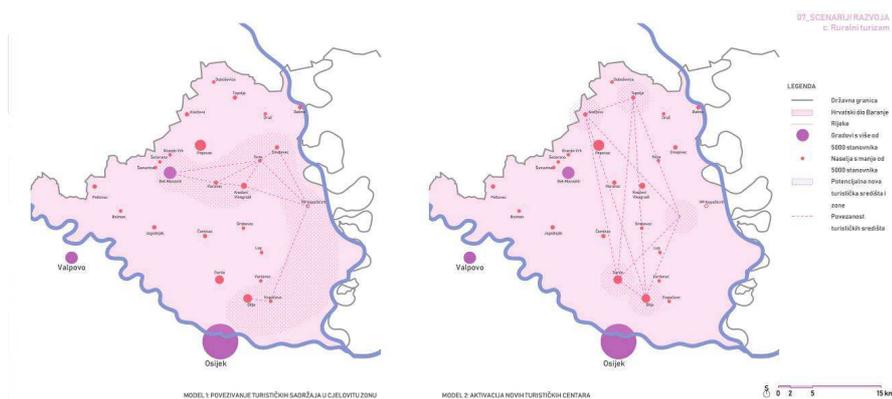

Fig. 4: Development Scenario: Tourism – Model of Connecting Tourist Facilities into a Complete Zone (left) and Model of Activation of New Tourist Facilities (right). Source: Banić, 2023a.
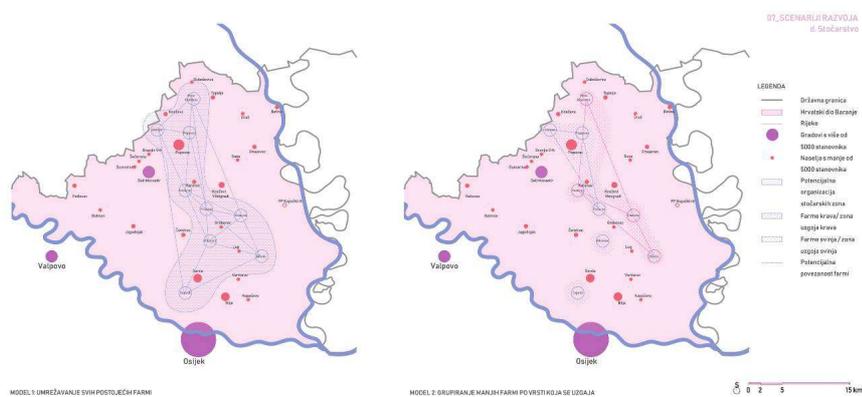

Fig. 5: Development Scenario: Livestock – Networking Model of all Existing Farms (left) and Model of Connecting Smaller Farms Depending on the Type of Livestock (right). Source: Banić, 2023a.

4.2.4 Livestock

Cattle breeding is the second most important branch of agricultural production in Baranja. It is divided into two types: small family farms and large-scale breeding on farms of the Belje industry. Cattle raised on family farms are mainly used for processing into dried meat products and for local use, while the production on Belje farms is organized according to the highest technical standards and it is quantitatively and economically dominant. Additional technological improvement and improvement of production standards on family farms are proposed. (Agroklub, 2008; Kult plave kamenice, 2016)

The model of existing farms networking assumes their digitalization and integration. Digitalization would facilitate communication and migration of experts and the exchange of knowledge, while the centralization would facilitate acess to the market and control of prices and quality. It can be assumed that this model has been partially implemented since most of the farms are managed by Belje, but there is certainly a need for additional improvement.

The model predicts the connection of small farms depending on the type of livestock. Optimization of cultivation is foreseen by connecting small farms in a network thus enabling the competition with larger farms.

4.2.5 Energy

In the Baranja region there are five larger power plants, the goal of which is self-supply of the farms they are built next to. The biogas power plants next to the Topolnik and Mitrovac farms use biomass, which is a byproduct of the farm′s production, while the solar power plant in Zmajevac is for irrigation of vineyards. As a part of the rural development project, the municipalities of Baranja plan to install solar collector panels on roofs of county and municipal buildings, which is a step towards energy self-sustainability, but larger projects are also necessary in order to achieve the best possible results. The goal of this scenario is to create an energetically self-sustainable Baranja region using the existing spatial potential - the construction of biogas power plants next to farms and the installation of solar power plants. (Lider, 2022; Savez energetičara Slavonije i Baranje, 2023)
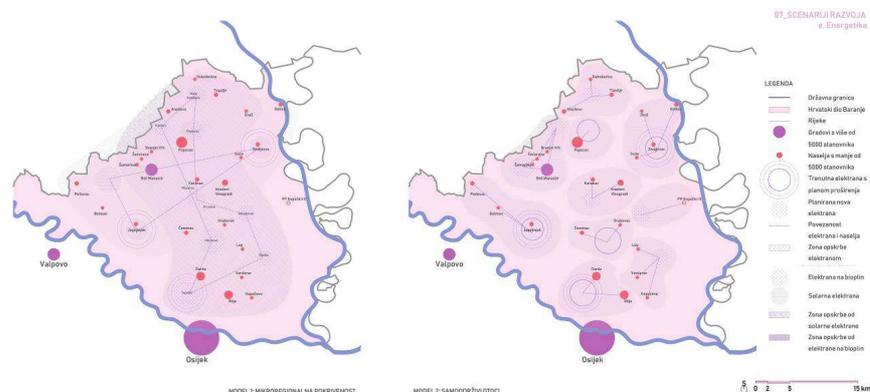

Fig. 6: Development Scenario: Energy – Microregional Coverage Model (left) and Model Self-Sustainable Islands (right). Source: Banić, 2023a.

The microregional coverage model proposes the creation of a microregional energy network that would equally supply the entire Baranja area. This model does not assume power plants next to every farm. It is based on total production which has to be equal or greater than the total energy consumption of each microregion. Two overlapped networks are shown - the network of solar power plants and the network of biomass power plants.

The self-sustainable islands model envisages the construction of power plants next to group of settlements in order to provide the source of energy for each "energy island". In this way, an even development and energy independence of all settlements would be achieved, while power plants in terms of energy production are assumed to be the same as in the previous model.

4.2.6   Industry

The Baranja region has a rich industrial history. For centuries it has been the center of the Belje agricultural estate, with seasonal migrations of workers from various regions. The process of deindustrialization led to the fact that the former industrial plants are now mostly abandoned, with the exception of a few smaller factories. Former factory workers today mostly daily migrate towards the city of Osijek. The scenario envisages the transformation of existing industrial facilities for the needs of new technologies, in accordance with global trends, which would lead to changes in migration process. (Bug, 2018)
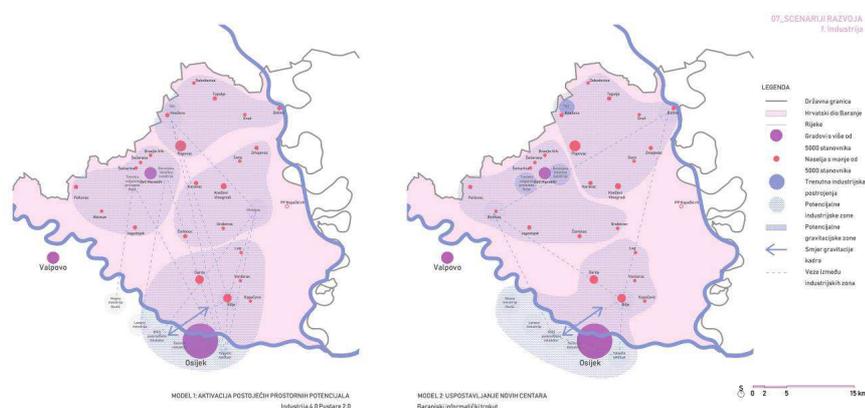
Fig. 7: Development Scenario: Spatial Potential Activation Model (left) and New Centers Model (right). Source: Banić, 2023a.

The model of activation of existing spatial potentials proposes the conversion of former "pustara" settlements and other brownfield areas for the needs of information technology. The establishment of an IT campus in one of the "pustara" settlements (e.g. Mirkovac or Kneževo) would enable a strong relationship between professional staff and students with Osijek.

The model for the establishment of new centers foresees the activation of hitherto inactive industrial areas and suggests Batina, Bolman and Bilje settlements as centers. Their peripheral location encourages activities related to international cooperation with neighboring countries. The scenario is based on smaller business incubators and the idea that IT companies are not necessarily tied to a specific location.

4.3 Vision of Development and Revitalisation of Barnja Region - Re: Baranja

The comparative analysis of six scenarios and the valorization of elements of different models according to the set criteria resulted in a combination of scenarios providing that the integral scenario has an impact on the further development of the Baranja region as positive as possible. The integral scenario represents the basis for development vision and revitalisation of the Baranja region. The proposed vision particularly activates the settlements of Suza, Šumarin, Darda, Čeminac, Bilje, Kneževo, Jagodnjak and Mirkovac, as well as farms and agricultural fields.

In order to realize the vision, macro and micro projects have been proposed, with a defined period necessary for the realization of each project.

Macro projects include various infrastructural, marketing, educational and digitization projects. Planned infrastructural projects include extending the LAN/optical network through all settlements as a prerequisite for digitalization (seven years), increasing the capacity of existing power plants as a prerequisite for the energy transition (ten years), connecting existing producers as a step in the digital transition (two years), maintenance and management of IT systems as an accompanying process to digitization projects (continuous process). Marketing projects include integration of the tourist offer and promoting new destinations as a step in the activation of tourist destinations (three years) and connecting renovated manors into a regional or international network as a step in the activation of tourist destinations (five years). Digitalization projects include digitalization of services as a prerequisite for the realization of smart villages (five years). Education projects include digital education of the population as a step in the revitalisation of the village (two years + continuous), education of farmers as a step in the improvement of agriculture (two years + continuous) and cooperation with Osijek faculties as a result of digital and industrial improvements (continuous).

950

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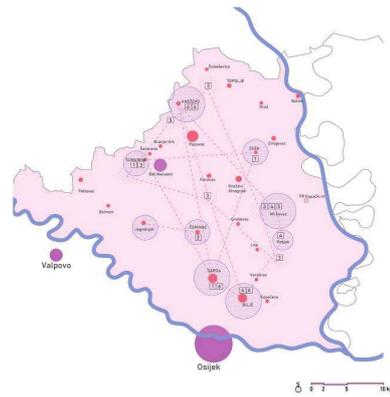
Fig. 8: Development and Revitalisation Vision of the Baranja Region. Source: Banić, 2023a.

Micro projects at specific locations were also proposed (Figure 8): 1) establishment of IT incubators with server centers, 2) establishment and construction of a processing and distribution center, 3) construction of new power plants (biogas power plants in addition to existing farms and solar power plants); 4) conversion of abandoned brownfield sites for new industry, 5) construction of the IT campus and 6) revitalisation and conversion of manors.

4.4 Kneževo

The special emphasis is on Kneževo, a small settlement with historically significant urban and industrial features (one of the main centers of the Baranja region after the WW2), which experienced a significant economic and demographic decline due to deindustrialization trends in the late 20th century.

4.4.1 "Pustare" in Croatian part of Baranja

Kneževo represents one of the seventy "pustara" settlements in Croatian part of Baranja. The basic meaning of "pustara" comes from the Hungarian word "puszta", which originally refers to a spacious plot of land intended for open-air cattle breeding. In Croatia, "pustare" represent planned industrial settlements with residential areas and public and social facilities (educational, cultural, administrative, etc.). They are located in rural areas and have a rural-urban character. Their history is connected with the manor estate, and later with the industry of Belje. In 1697, Archduke Eugene of Savoy acquired a property on the southern border of Baranja, in today's Bilje, where he builds a manor from which he manages the entire property and economy of Baranja region. In 1825, the center of Belje moved to Kneževo, when intensive industrialization and the construction of most "pustara" settlements began. After WW1 they have been adapted to new industrial conditions and additional facilities were constructed, which resulted in improved quality of life. Although located in completely rural environment, settlements gained urban characteristics which makes them unique construction complexes. (Živković and Horvat, 1986)
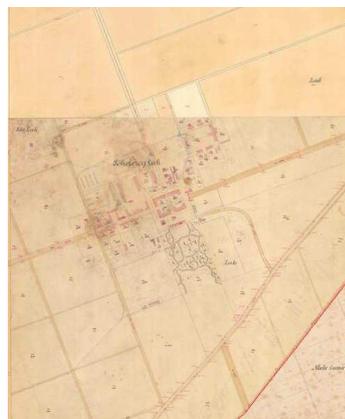

Fig.9: Kneževo on the 19th Cenutry Habsburg Empire Cadastral Map. Source: Arcanum (2023).

Settlements usually have an orthogonal urban scheme, simple rectangular buildings and a central administrative building with a landscaped park. They are characterized by division into three zones; production/agricultural, residential and administrative/social zone. Originally, they did not have the cemetery

or the church. They are low density settlements, mainly with collective one-story buildings with several apartments (6-12 housing units) and shared auxiliary buildings in the garden. The apartments of managers, administrators and doctors were located in separate buildings of a higher standard in the administrative zone. The agricultural or production zone depended on the economic branch and contained stables and warehouses, and later industrial halls and industrial facilities. (Ravas and Stober, 2017)

4.4.2 Specificities of Kneževo

The village of Kneževo is located in the very north of the Croatian part of Baranja, in Osijek-Baranja County, in the municipality of Popovac. The municipality of Popovac, which includes the settlements of Popovac, Branjina and Kneževo, is on the border with the town of Beli Manastir to the east and the municipality of Draž to the west. According to the 2021 census, the municipality of Popovac has a total of 1,446 inhabitants, and the settlement of Kneževo has 485 inhabitants.

The development of the Kneževo settlement dates back to 1818, when the construction of the manor of the Archduke Friedrich Habsburg began by the order of the Habsburg Emperor Karl Ludwig. Various commercial and administrative buildings had been built next to the manor, gradually forming the settlement. Since the end of the first third of the 19th century, Kneževo has been the seat of administration of the Belje estate. Intensive development followed the industrial revolution and construction of the railway in the 1890′s. Until 1914, the settlement was connected by a narrow-gauge railway to Beli Manastir, and from there to other pustara settlements and the river wharf on the Danube. After the collapse of the Austro-Hungarian monarchy, the property became the state property of the Kingdom of Yugoslavia. The period between two World wars was marked by production stagnation and economic decline. During the WW2, the settlement was devastated, and production stopped. With the establishment of Yugoslavia, Belje experienced a transformation into the Belje agricultural-industrial complex as a federal agricultural asset, the intensive reconstruction of settlements and production began, and in the 1950s and 1960s Kneževo had a population of around 1,600. In the 1980s, new plants were built as part of the food industry, but due to the war in 1991, production stopped on the entire Belje estate. After the war it has been only partially restored. (Kukulić, 2021)
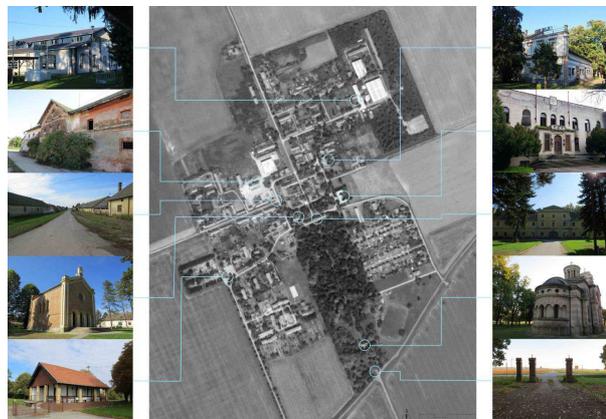

Fig. 10: Characteristic Buildings in Kneževo. Source: Banić, 2023b.

The central element of the settlement is a classicist manor with a 11 hectares park, which represents a valuable example of classicist residential architecture. It is a protected cultural heritage, enlisted in the National register of cultural assets. The transverse (NW-SE) axis of the manor forms the orthogonal axis of the entire settlement. Next to it, the oldest part of the settlement with administrative and commercial buildings that make up the block northwest of the manor and continue into the two main streets is situated. The buildings on that stretch are mostly single-story residential blocks with 4 to 10 residential units, each with separate entrances and auxiliary buildings in the garden. The apartments of clerks and coachmen were originally located in that block. In the southeastern zone, along Graničarska Street, production facilities and apartments for workers were situated, while southeast of the manor there were public facilities: school, kindergarten, teacher's apartment, clerk's apartments and a church. Northeast of the manor in the same axis there were the doctor's and dentist's apartments and the infirmary. A cemetery was built outside the rectangular base of the settlement along its western edge, and the existing railway station was converted into a morgue. The northern zone of Kneževo was a production area, with industrial production (mechanical

952

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Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

workshop for locomotives and machines, a steam mill and a brickyard) in the eastern part, and agricultural warehouses and stables in the western part. The architecture in the settlement is unusually representative, the brick buildings have numerous design details, profiled wooden beams and decorated brick fences and portals Numerous public facilities and the architecture quality of buildings clearly indicate that the conditions and quality of life in "pustara" were above the standards of the time. (See Figure 10)

The new zone of the settlement consists of two parts, with apartment buildings to the west of the park and family housing area east of the park. In the late 1980s, five multi-apartment two-story buildings were built, housing a clinic, a shop and a cafe, while a new primary school was built next to the park. Most of the residents live in the area with family houses that have been built since 1980s.

Public and social buildings and service facilities are located in the southern part of the settlement. In the old part, north of the manor, there is a local post office and the area of the local board. Most of the facilities (local general practice clinic, dentist's office, pharmacy, cafe and small shop) are located in the zone with multi-residential buildings west of the manor park. To the east of the park, there is a new community center and a soccer field. There are two churches in the settlement - the Catholic Church of St. Hildegarde northwest of the manor and the Orthodox Church of St. Gregory in the southern part of manor park. Along the eastern edge of the settlement, there is a local cemetery with a morgue.

In the northern zone of the settlement, there are remnants of the former industry and the Equipment and Machinery Factory plant, which today operates on a reduced scale. The settlement used to have a cinema, a restaurant, a hospital and a kindergarten.

Fig. 11 (left): Spatial Plan of Popovac Municipality – Land Use. Source: Banić, 2023b. Fig. 12 (right): Proposal for the Conceptual Zones of Kneževo. Source: Banić, 2023b.

The area around the settlement is surrounded by particularly valuable arable land and commercial forest. Northeast of the settlement, next to the planned business zone, there is an agricultural airport with a grass runway. In the area of Kneževo, there are three protected archaeological areas: Brickworks along the southeastern edge of the settlement (from the Roman period, dating from 1st to 3rd century BC), Buziklica - Malo Kneževo (from 5300 BC to 1400 AD) and Ćrna bara-Buziklica (from 800 CE to 1400 AD) northeast of the settlement, along the border with Hungary. The manor of Frederick II. Habsburg is a protected protected cultural heritage, enlisted in the National register of cultural assets, while the manor park is a monument of park architecture.

4.4.3 New Purpose as a Revitalisation Activator of the Settlement

Based on the proposed vision of the development and revitalisation of the Baranja region and detailed analysis of Kneževo settlement, the introduction of a new function is seen as a potential activator of its revitalisation. Based on the research and consideration of the most suitable scenario for Kneževo, the construction of a film studio is proposed, given that movies have already been filmed in the historic part of the settlement and that many of existing buildings have the potential to be transformed to be suitable for the needs of film production. The introduction of a new function would contribute to the development of culture and media at the national level, while the development of supporting functions and an increase in the number of temporary and permanent residents would contribute to the revitalisation of the settlement.

The National Development Strategy of the Republic of Croatia until 2030 (2021) states the development of culture and media as one of five priority areas of public policies, in order to achieve strategic goal 1. "Competitive and innovative economy". The strategy emphasizes that Croatia has been recently profiled as an attractive and cost-competitive location for filming series and movies of foreign production companies, thus attracting considerable foreign capital. This is supported by one of the most profitable state aid programs with a direct economic impact on the audiovisual industry, the international promotion of Croatia, but also the profitability of all related economic branches, primarily tourism. Feasibility studies for the project of a new studio complex in the Republic of Croatia sees Croatia as a possible location for international productions (Olsberg SPI, 2020). The availability of a film studio in the Republic of Croatia would generally enable a longer stay in the country and the realization of larger investments, which would have a positive economic and cultural effect not only at the local level but also at the regional and national level.

From a comparison of the European film studios Cinecitta in Rome and Studio Leavesden in London and the recommended parameters for planning, it is evident that, in terms of necessary area and existing structures, the historical part of the settlement is suitable for a film studio for international production.

4.4.4   Film studio in Kneževo

The existing organization of the settlement is based on two orthogonal axes. The concept proposes densification of the orthogonal street network in order to provide access to existing and planned buildings. The existing settlement is characterized by three zones in which specific interventions are proposed.

In the southern zone, on the area of the existing residential area, minimal interventions of new pedestrian paths are planned in order to connect residential areas east and west of the manor park. The northern zone, where remnants of former industrial complex are located, is planned for functional and structural transformation for the needs of an international film studio. The central zone is designed as a transition zone between the film studio and the residential zone. New public, social and tourist facilities are planned (facilities for film production participants, restaurant, auditorium, part of the film studio intended for educational and local needs, etc.). In the central part of the zone, preservation of the original architecture and its functional transformation according to the needs of new functions for both groups of users is planned.
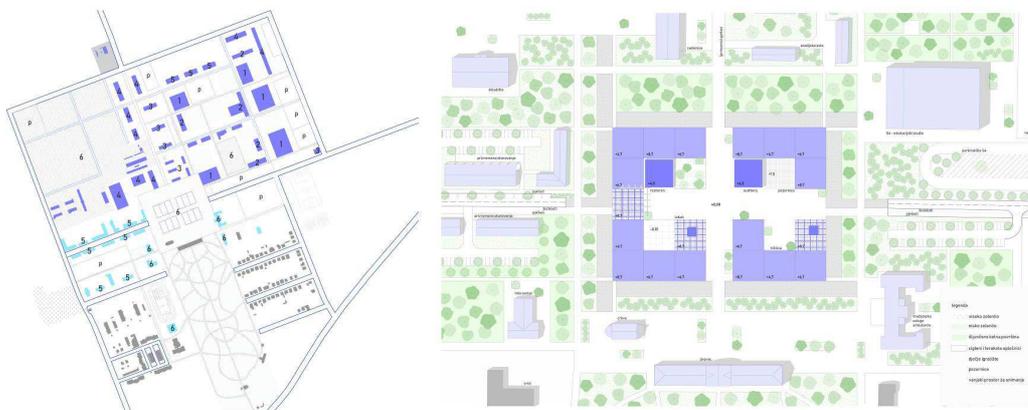

Fig. 13 (left): Planned Structure in Kneževo. Source: Banić, 2023b. Fig. 14 (right): New Central Square of Kneževo. Source: Banić, 2023b.

The system of planned public spaces together with the road network serves to connect and integrate the existing settlement and the planned film studio. The existing public spaces of the settlement (the manor park and the lawn north of the manor) are planned to be supplemented with a new, central square planned as a central public space for all users, while new squares and parks in the northern zone would have a semi-private character. The central square area is designed as a modern architectural interpretation of historical urban block, with public and commercial facilities (auditorium, market, catering facilities, etc.).

5   DISCUSSION

The spatial planning workshop is a platform where students are taught expertise in the processes of spatial / territorial development. In the last workshop before the graduation, students "practice" the application of knowledge acquired during their studies and acquire new knowledge about research and analysis, the field of

954

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advocacy and mediation, the ability to imagine, evaluate and promote potential options for urban, spatial and territorial development. Students are encouraged to think critically and understand the logic of planning and its theoretical and legal basis, learn to understand spatial systems that, in addition to the built and natural environment, include socio-economic systems, and improve the technical and creative skills necessary for their inclusion in the planning practice.

The use of the scenario method in the education process, not only as a theoretical basis but also as practical application in workshops, is particularly significant because it encourages strategic thinking, the development of intuition and helps to overcome thinking limitations. In order to enable a comprehensive overview of the needs and possibilities as well as aspirations of various stakeholders, the development of several possible scenarios is particularly important, above all for an open discussion and flexibility in the later process of creating a spatial development vision.

The result of this case study is the definition of six possible scenarios for the Baranja region development which are further broken down into two basic models of space activation approach. Various scenarios give a better overview of the spatial possibilities and create a basis for evaluation and decision-making on the direction of further development. Conceiving scenarios based on the global sustainability goals indicates an awareness of the importance of development based on global principles, which through planning and interventions at lower levels contribute to the achievement of global goals.

The possibility to choose an area or location as a task of the spatial planning workshop according to the detailed selection criteria, opens up the possibility to do planning tasks in a familiar area or an area students want to perceive better. In addition, there is the possibility of connecting the task at the spatial planning workshop and the graduation thesis, which enables a more detailed elaboration of the chosen location, and a critical reflection of planning decisions with an offset of one or two semesters.

This paper shows how the work which was focused on the regional development and revitalisation scenarios for Baranja region is in the next step focused on Kneževo, a small settlement with historically significant urban and industrial features which, due to the dynamics of business and deindustrialization trends in the late 20th century experienced a significant economic and demographic decline. The development and revitalisation vision of Baranja region set a wider framework for development planning of the Kneževo settlement, i.e., the settlement was singled out as one of the primary regional centers. On the basis of the knowledge about the specific location and consideration of the national needs defined by the National Development Strategy of the Republic of Croatia until 2030, a new urban function of the film studio was chosen as the optimal activator of the settlement′s revitalisation. The implementation of "unusual" facility in the area represents a challenge in the process of planning and design of the necessary infrastructure, while meeting the needs of film studio users and permanent residents, in terms of achieving the best possible quality of life. By introducing a new cultural and media industry in Kneževo, in addition to contributing to the revitalisation of the settlement at the local level and in the regional context, the former industrial character of the area would be preserved, and at the national level it would contribute to the realisation of one of the strategic national development goals - the establishment of a "Competitive and innovative economy".

6 CONCLUSION

In addition to the theoretical knowledge in spatial planning at the local and regional level acquired during the studies, practical application is essential in order to prepare the future planner for the roles that await him in professional practice. Spatial planning workshop is one of the platforms where strategic thinking is encouraged, research, analysis, synthesis, critical reflection and understanding of spatial systems are practiced, as well as forecasting and planning on different spatial levels. The possibility to choose a workshop according to personal affinity, respectively the possibility to choose both the subject area and specific the topic during the workshop represents an opportunity for further education and development of a visionary approach on the regional and the local level.

The scenario planning methodology is used in spatial planners' education in order to enable future planners to deal with complexity and predict the future development of cities and regions and to conceive consequences regarding specific interventions. Over and above, the scenario planning tool encourages

creativity and intuition and provides a possibility to think "outside the box" and at least one step futher in the future.

In addition to European documents on sustainable development, national, regional and local strategies and plans relevant to territorial development and existing spatial planning documentation are taken as starting points. Students are encouraged to take a comprehensive overview of the area and development process and to determine the scenarios evaluation criteria as a basis for development vision concept. Critical thinking of planning decisions, and consideration of causes and consequences through specific development projects is the basis for creation of new spatial planning documents. Flexibility in planning is a characteristic that stands out as particularly important for achieving harmonization of dynamic circumstances in space and time with the set goals of the long-term development and the legislative framework, in order to accomplish a better quality of life, i.e. sustainable development of the selected area.

7 REFERENCES

AGROKLUB (2008). Farma Topolnik – čudo u Baranji / Topolnik Farm - a miracle in Baranja. [Online] Available from: https://www.agroklub.com/stocarstvo/farma-topolnik-cudo-u-baranji/292/ Accessed [09/06/2023].

ARCANUM (2023). Cadastral maps. [Online] Available from: https://maps.arcanum.com/en/ Accessed [13/06/2023].

BARANJA TOURIST BOARD (2023) About Baranja. [Online] Available from: https://tzbaranje.hr/ Accessed [09/06/2023].

BRADFIELD, Ron, WRIGHT, George, BURT, George, CAIRNS, George, VAN DER HEIJDEN, Kees: The origins and evolution of scenario techniques in long range business planning. In: Futures, 37 (8), pp. 795–812. Elsevier, 2005.

BANIĆ, Petra: Re: Baranja: Development and Revitalisaion Scenarios. Workshop 3 – Spatial Planning. University of Zagreb, Faculty of Architecture, Zagreb, 2023a.

BANIĆ, Petra: The Revitalisation of Kneževo. Master Thesis. University of Zagreb, Faculty of Architecture, Zagreb, 2023b.

BUG (2018). HUP-ICT: Hrvatska je spremna za digitalizaciju, vrijeme je za postavljanje ambicioznih ciljeva / Croatia is ready for digitization, it is time to set ambitious goals. [Online] Available from: https://www.bug.hr/istrazivanja/hup-ict-hrvatska-je-spreman-za-digitalizaciju-vrijeme-je-za-postavljanje-5114 Accessed [09/06/2023].

CEMAT: Spatial development glossary – European Conference of Ministers responsible for Spatial/Regional Planning (CEMAT). Council of Europe Publishing, Bruxelles, 2007.

CROATIAN BUREAU OF STATISTICS (2023). Census 2021 [Online] Available from: https://popis2023.hr/ Accessed [09/06/2023].

CROATIAN CHAMBER OF COMMERCE (2023). Poljoprivreda i prehrambena industrija / Agriculture and food industry. [Online] Available from: https://hgk.hr/zupanijska-komora-osijek/poljoprivreda-i-prehrambena-industrija Accessed [08/06/2023].

ECOVAST (2023). European Council for the Village and Small Town. [Online] Available from: http://europeanheritagealliance.eu/members/ecovast/ Accessed [27/07/2023].

ECTP-CEU: Charter of Euroepan planning. ECTP-CEU, Bruxelles, 2013.

ECTP-CEU: Guidelines on professional competences in spatial planning. ECTP-CEU, Bruxelles, 2017.

ESPON: PROFECY- Processes, Features and Cycles of Inner Peripheries in Europe (Final Report). ESPON, Luxemburg, 2017.

ESPON: ESPON TOWN Spin-off Denmark - Small and medium sized towns in Denmark (Final Report). ESPON, Luxemburg, 2022.

EUROPEAN NETWORK FOR RURAL DEVELOPMENT (2023) Smart Villages Portal. [Online] Available from: https://ec.europa.eu/enrd/smart-and-competitive-rural-areas/smart-villages/smart-villages-portal_en.html Accessed [08/06/2023].

FRIEDMANN, John, BRYSON, John, HYSLOP, John, BALDUCCI, Alessandro, WIEWEL, Wim, ALBRECHTS, Louis, HEALEY, Patsy: Strategic Spatial Planning and the Longer Range. In: Planning Theory & Practice, 5(1), pp. 49-67. Taylor & Francis, Abingdon, 2004.

GLAS SLAVONIJE (2023). Bez razvitka prerađivačke industrije Slavonija i Baranja nastavit će gubiti stanovnike / Without the development of the processing industry, Slavonia and Baranja will continue to lose inhabitants [Online] Available from: https://www.glas-slavonije.hr/505022/1/Bez-razvitka-preradjivacke-industrije-Slavonija-i-BAranja-nastavit-ce-gubiti-stanovnike Accessed [08/06/2023].

GODET, Michel, ROUBELAT, Fabrice: Creating the Future: The Use and Misuse of Scenarios. In: Long Range Planning, 29 (2), pp. 164-171. Elsevier, Amsterdam, 1996.

GROS-BALTHAZARD, Marjolaine, TALANDIER, Magali: Cooperation, proximity, and social innovation: Three ingredients for industrial medium-sized towns' renewal? In: Urban Science, 4(2), 15, MDPI, 2020.

HAKOM (2023). Overview map of broadband availability and speed. [Online] Available from: http://bbzone.hakom.hr/hr-HR/InteraktivniPreglednik#sthash.sxgbUjDo.dpbs Accessed [08/06/2023].

HONORÉ, Carl: Praise of Slow - How a Worldwide Movement Is Challenging the Cult of Speed. Orion, London, 2005.

HUSS. William R., HONTON, Edward J: Scenario planning - What style should you use? In: Long Range Planning, 20 (4), pp. 21-29. Elsevier, Amsterdam, 1987.

KAHN, Herman, WIENER, Anthony J.: The Year 2000: A Framework for Speculation on the Next Thirty-Three Years. Hudson Institute, New York, 1967.

KOK, Kasper, ROTHMAN, Dale S., PATEL, Mita: Multi-scale narratives from an IA perspective: Part I. European and Mediterranean scenario development. In: Futures, 38 (3), pp. 261-284. Elsevier, Amsterdam, 2006.

KOK, Kasper, PATEL, Mita, ROTHMAN, Dale S., QUARANTA, Giovanni, 2006b: Multi-scale narratives from an IA perspective: Part II. Participatory local scenario development, Futures, 38 (3), pp. 285-311. Elsevier, Amsterdam, 2006.

KUKULIĆ, Ivan: Trenutono stanje i perspektive prenamjene brownfiled lokacija industrije Belja / The current state and perspectives of the conversion of brownfield sites of the Belje industry. Master's Thesis. University of Zagreb, Faculty of Science, Zagreb, 2021.

956

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

KULT PLAVE KAMENICE (2016). Farma Mitrovac kako funkcionira veliki kravlji sanatorij u Baranji / Mitrovac farm, how the large cow sanatorium in Baranja works [Online] Available from: https://plavakamenica.hr/2016/04/11/farma-mitrovac-kako-funkcionira-veliki-kravlji-sanatorij-u-baranji/ Accessed [09/06/2023].

LIDER (2022). Na karti solarnih elektrana u Europi Hrvatska ne stoji baš najbolje / Croatia does not do very well on the map of solar power plants in Europe. [Online] Available from: https://lidermedia.hr/zeleno-i-digitalno/na-karti-solarnih-elektrana-u-europi-hrvatska-ne-stoji-bas-najbolje-142512 Accessed [09/06/2023].

LJUBENOVIĆ, Milica, MITKOVIĆ, Petar, MITKOVIĆ, Mihailo: The scenario method in urban planning. In: Facta universistatis-series Architecture and Civil Engineering, 12(1), pp. 81-95. University of Niš, Niš, 2014.

MATIŠIĆ, Mislav, JAKOPIČIĆ, Luka, PEŠIĆ, Dinko, RICL, Jesenka: Revitalizacija Baranjskih pustara / Revitalisation of Baranja "pustare". In: Drugi hrvatski ruralni parlament - Interdisciplinarnom suradnjom do bolje kvalitete života u ruralnim prostorima. Hrvatska mreža ra ruralni razvoj: Sveti Martin na Muri, 2017.

MINISTRY OF CULTURE AND MEDIA (2023). Pretraživanje Registra kulturnih dobara Republike Hrvatske / Searching the Register of Cultural Properties of the Republic of Croatia. [Online] Available from: https://registar.kulturnadobra.hr/#/ Accessed [07/06/2023].

OFFICIAL GAZETTE (2021). Nacionalna razvojna strategija Republike Hrvatske do 2030. Godine / National Development Strategy of the Republic of Croatia until 2030 [Online] Available from: https://narodne-novine.nn.hr/clanci/sluzbeni/2021_02_13_230.html Accessed [16/05/2023].

OLSBERG SPI: Studija izvedivosti projekta novog studijskog komplaksta u Hrvatskoj / Feasibility study of the project of a new studio complex in Croatia. Ministry of Culture and Media of the Republic of Croatia, Zagreb, 2020.

PAVIĆ-ROGOŠIĆ, Lidija: Globalni ciljevi održivog razvoja i ruralni prostor / Global goals of sustainable development and rural areas. In: Treći hrvatski ruralni parliament - prezentacija. Hrvatska mreža za ruralni razvoj: Vodice/Tisno, 2019.

PÉNZES, János, DEMETER, Gábor: Peripheral areas and their distinctive characteristics: The case of Hungary. In: Moravian geographical Reports, 29(3), pp. 217–230. The Czech Academy of Sciences and Institute of Geonics, Ostrava-Poruba, 2021.

RADELJAK KAUFMAN, Petra: Metoda scenarija u istraživanju i planiranju prostora / Scenario Method in Spatial Research and Planning. In: Hrvatski geografski glasnik, 78(1), pp. 45-71. Hrvatsko geografsko društvo, Zagreb, 2016.

RAUHUT, Daniel, DA COSTA, Nuno Marques: Territorial Cohesion in Denmark, Finland, Norway and Sweden 2007 and 2017. In: Geografisk Tidsskrift - Danish Journal of Geography, 121(1), pp. 1–14. The Royal Danish Geographical Society, Taylor & Francis, Oxfordshire, 2021.

RAVAS, Mirela, STOBER, Dina. Pregled prostornograditeljskog potencijala pustar u ruralnom razvoju Baranje / Review of Spatial Building Potential of Pustara Settlement in Baranja's Rural Development. In: Urbano ruralne veze, pp. 187-195. Institute for Spatial Development, Zagreb, 2017.

ROTHMAN, Dale S.: A Survey of Environmental Scenarios. In: Environmental Futures: The Practice of Environmental Scenario Analysis (ed. Alcamo, J.), pp. 37-65. Elsevier, Amsterdam, 2008.

SAVEZ ENERGETIČARA SLAVONIJE I BARANJE (2023). Društvo energetičara Osijek u obilasku bioplinske elektrane Mitrovac-Belje / The Osijek Energy Association on a tour of the Mitrovac-Belje biogas power plant. [Online] Available from: http://www.energeticar.hr/index.php?option=com_content&task=view&id=138&Itemid=1 Accessed [09/06/2023].

SHEARER, Allan W.: Approaching Scenario-Based Studies: Three Perceptions about the Future and Considerations for Landscape Planning. In: Environment and Planning B: Urban Analytics and City Science, 32 (1), pp. 67-87. Sage Journals, Thousand Oaks, 2005.

STRZELECKA, Elzbieta: Rewitalizacja Miast w Kontekście Zrównoważonego Rozwoju / Urban revitalisation in the context of sustainable development. In: Budownictwo i Inżynieria Środowiska, 2 (4), pp. 661-668. Wydawnicza Politechniki Białostockiej, Białystok, 2011.

VOGELIJ, Jan: Fifteen Steps towards Territorial Cohesion. ECTP-CEU, Bruxelles, 2010.

ZAGROBA, Marek, GAWRYLUK, Dorota: Revitalisation as a Method of Planning Sustainable Development of Old Town Complexes in Historic Towns. In: IOP Conference Series: Earth and Environmental Science, 95 (5), 052002. IOP Publishing, Bristol, 2017.

ŽIVKOVIĆ, Zdravko, HORVAT, Manja: Pustare na Belju / "Pustare" in Belje. In: Tri stoljeća Belja, pp. 421-430. JAZU, Osijek, 1986.

Urban Stress and Bicycle Infrastructure in the City of Osnabrück – Analysing Well-Being and Infrastructure Relationships in Streetscapes through a Triangulation Approach

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1 ABSTRACT

Active mobility is a key factor in the mobility revolution and is thus elementary in combating the climate crisis. At the same time, however, much research is still needed to improve the situation of active mobility, especially regarding inhibiting factors in the choice of active modes of transport. Essential here is road users' positive and negative emotional experiences in different infrastructure settings.

Due to high volumes and speeds of motorised traffic, high noise and pollution levels and a lack of greenery urban space, today is often associated with increased stress and an excess of stress-related diseases such as cardiovascular diseases, depression, or schizophrenia (Adli, 2017). Providing data and objectifying much-discussed issues such as perceived safety in transport infrastructure is essential for decision-making at the community level (Sørensen, 2009). Such data can provide evidence to refine traffic planning guidelines and improve public space for pedestrians and cyclists. It is therefore necessary to get a differentiated picture of social and ecological considerations in the mobility sector.

The BMDV project "Emotion Sensing for (E-)Bicycle Safety and Mobility Comfort ESSEM" investigates the subjective perception of cyclists' safety in urban traffic. With the help of iterative environmental and body-related data collection, stress points in the municipal cycling network are identified and analysed in the two model cities of Ludwigsburg and Osnabrück .

The framework given in this study applies a triangulating approach that allows statements on individual "stress" utilising biological markers (skin conductivity, skin temperature) via a sensor wristband and through standardised questionnaires. In this way, vulnerable groups can be identified, which can be better taken into account in project development and planning. This study focuses on three "stress hotspots" in Osnabrück, considering different forms of bicycle infrastructure.

Keywords: Transportation Planning, Streetscapes, Bicycle Infrastructure, Well-being, Urban Stress

2 INTRODUCTION

To plan ecologically, spatially and socially sustainable and equitable cities of the future, one starting point is to move human perception to the centre. Especially in the field of active mobility, such as cycling, people are directly exposed to their environment. Projects such as the "Emotion Sensing for (E-)Bicycle Safety and Mobility Comfort ESSEM", funded by the German Ministry of Digital Affairs and Transport, focus on researching stress in cycling. On the one hand, body-related data are collected that can indicate a stress reaction in the body. These are geo-referenced and subjective data can thus be made objectively comprehensible in the form of heat maps in QGIS. The results represent an indicator of the subjective perception of safety. Spatial specifics, such as guidance forms and street intersections, have a significant role to play here. On the other hand, different people have different perceptions due to their different characteristics, which also shape the perception of stress. These can be collected through e.g. standardised questionnaires. The ESSEM project takes place in the model cities of Osnabrück and Ludwigsburg. The present study focuses on the results of the research in Osnabrück. The following research questions are guiding:

(1) Where do cyclists in Osnabrück feel stressed?

(2) To what extent do personal dispositions, such as gender, age or personality play a role in this?

(3) To what extent can statements be made about the connection between different designs of bicycle infrastructure and stress?

3 STATE OF RESEARCH

The state of research focuses on the perception of safety, measuring stress and influencing factors.

3.1 Perception of safety

One pillar of the mobility transition in Germany is to increase the share of cycling (BMDV, 2022). Obstacles to changing the mode of transport are manifold. An essential part of this is the perception of safety. On the one hand, there is objective safety. This can be quantified in the form of police accident statistics. At the same time, subjective safety must be taken into account (Johannsen, 2013). This is of great importance when choosing a means of transport. This subjective perception is determined by various factors. On the one hand, there are "exogenous" factors, i.e. external structural factors. These can lead to critical situations, near-accidents, a feeling of being squeezed or a noise-induced stress reaction. The resulting stress in cycling can therefore negatively influence the choice in favour of cycling and is, therefore, an important starting point for research (Graf, 2016). Various personal dispositions "endogenous factors" diversify the picture. For example, there are differences in people who generally use bicycles little, in gender, the purpose of travel, age and the psychological constitution of people when assessing stressors (Schmidt-Hamburger, 2022). When researching stress phenomena and their harmful effects on the human body, it is above all relevant how strongly the respective person evaluates and thus also feels the experienced stress. This subjective stress evaluation can be further specified by adding information about the mobility profile, socio-demographic and socio-psychological assumptions. The endogenous influencing factors refer to individual demographic, socio-economic and sociocultural attributes of individuals and their social environment, which significantly influence perception (Wermuth, 2005). Examples of relevant factors are gender, age, physical constitution, local knowledge or familiarity with the means of transport. Furthermore, from a biopsychological point of view, there are indications that genetic or psychological predispositions can strengthen or mitigate stress reactions. In this context, personality, control beliefs and risk tolerance are particularly important (Schandry, 2016; Kovaleva, 2012). These data are collected utilizing standardized questionnaires before the sensor measurements and included in the evaluation. It is hoped that this will identify particularly vulnerable groups in terms of stress to gain knowledge about barriers to equality for cyclists. Further insights can be gained from the increase in cycling behaviour. According to Geller (2009), cyclists can be divided into four groups: "the strong and fearless", "the enthusiastic and confident", "the interested but concerned" and "no chance, no matter what" (Geller, 2009). An overview of the characteristics is given in Table 1. The transitions between the groups should be viewed dynamically.

Group	Fearless cyclists	The enthusiastic and confident (Everyday cyclists)	The interested but concerned (Interested cyclists)	No chance, no matter what
Characteristics	• cycles always • safely, confident	• Drives daily routes, • confident, medium safety needs	• No everyday cycling • Safety concerns • open-minded towards bicycles	• No cycling in general
Riding skills	Excellent control of the bicycle	Confident, partly defensive because of security	Less sovereign	Poor control of the bicycle, lack of riding experience
Stress tolerance	high	medium	low	very low

Table 1: Types of cyclists (Geller 2009), own presentation.

In terms of cycling promotion, it is interesting in projects such as ESSEM to focus especially on the stress-ful experience of the "interested but concerned".

3.2 The construct of stress

Stress theories differ in terms of adaptability and operationalizability. Stress always arises when, depending on the theoretical underpinning, the physique (stress-as-a-reaction) or psyche (stress-as-a-stimulus or stress-as-a-transaction) has to muster resources to process environmental stimuli. The most prominent is the transactional stress model according to Lazarus (1999), but at the same time, it is also the most com-plex, since stress always arises situationally in the interaction of people and the environment. On the other hand,

there are stress-as-a-reaction models (Selye, 1956; Cannon, 1932), which examine the physical reac-tions to an external stimulus (Bercht, 2013). Critical here is the assumption that a stimulus "stresses" all people equally (Lyon, 2005). The third group of theories, which understands stress as a stimulus, focuses on the psychological effects. Here, it is assumed that there are "critical life events" (Holmes, Rahe, 1967) that are objectively trigger stress to some extent. Due to developments in emotion research in this field, the stress-theoretical basis of this paper is more in line with models from the stress-as-a-reaction perspec-tive. However, subjective components are included in the data collection and analysis.

3.3 Influence of street space on the subjective perception

Safe infrastructure can be named as one key contributor to the promotion of bike traffic in cities (Reyn-olds, 2009; Di Gioia, 2017). Here different design solutions are discussed controversially in the light of conflicts in the use of street space, and space restrictions but also about safe and qualitative bike infra-structure (Hull, 2014; Autelitano, 2021; Van Petegem, 2021). Traffic engineering, therefore, was mostly focused on objective traffic safety, focusing solution finding for certain street designs on the analysis of accident statistics and fluidity of motorized traffic. A more comprehensive evaluation of safe mobility in-frastructure and in particular bike infrastructure today discusses the aspect of subjective safety in addition to quantifiable objective traffic data (Götschi, 2018). Subjective safety among other aspects takes a look at how street users feel in certain contexts, or if they are overwhelmed by other road users, like cars. Multiple studies show the extent of research and debate on the topic (Von Stülpnagel, 2022; Aldred, 2018; Beck, 2021; Nilsen, 2004). All in all the subject takes into account the sense of security and besides positive per-ceptions like comfort, or well-being, the feeling of aforementioned stress.

Today the aspect of subjective safety, or rather safe and comfortable design solutions finds recognition in more and more design manuals of bike infrastructure like the Dutch "Crow Manual", especially consider-ing more vulnerable groups of cyclists like children or elderly people (De Groot, 2016). In Germany, the FGSV (Forschungsgesellschaft für Strassen- und Verkehrswege) addresses the topic of subjective safety, though it can be argued that it's still not implemented in the design solutions of its manual for bike infra-structure the ERA (Empfehlung für Radverkehrsanlagen) or it's manual for city streets, the RAST (in German: Richtlinien für die Anlage von Stadtstraßen/ "Guidelines for the construction of urban roads"). This shows that data and an extensive analysis of the stress experienced on certain cycleways, or rather certain street design solutions are still missing. This data and the aspect of subjective safety have to be evenly balanced with other data like accident statistics, or the capacity of street design and intersections for all street users, e.g. Here the concerns of pedestrians and other social uses of urban streets besides mo-bility have to be highlighted (Gehl, 2015).

4 DETAILS ON ESSEM

The "Emotion Sensing for (E-)Bicycle Safety and Mobility Comfort, ESSEM" project, the subjective safety perception of cyclists in urban traffic. The project aims to increase the comfort and safety of cyclists and thus contribute to sustainable and climate-neutral mobility. In a triangulation process consisting of iterative and sensor-based surveys of environmental and bio-physiological data and standardized questionnaires, stress points in the local bicycle infrastructure are being identified, analyzed and evaluated. The two model cities are Ludwigsburg and Osnabrück, in each around 350 test persons participate during the three-year project period (2022-2025).

The project data collected will be used to develop mechanisms for measuring safety, the perception of safety and mobility comfort in cycling, based on the underlying infrastructure, environmental influences, the cycling equipment used as well as the cycling accessories. The insights gained will help to identify optimization needs for (e-)bicycle infrastructures and components. This will promote modern, user-centred and data-based cycling planning and further advance environmentally sensitive traffic management (UVM) in Osnabrück. In the long term, the project aims to develop an innovative, and above all, practical tool that can be used to review and optimize urban cycling infrastructures.

5 METHODOLOGY

A triangulating procedure between methods (Flick, 2008) is used to research the stress experience of cyclists. With this method, the disadvantages of one method can be compensated for by the addition of another during

data collection, analysis and interpretation. The subjectivity and complexity of the research object require a methodological procedure that reflects these circumstances (cf. Chapter 3.2).

The following Figure 1 provides an overview of the methodological approach. Triangulation was used in the study for data collection (standardized as well as open, sensor data), analysis (spatial and statistical) and interpretation.
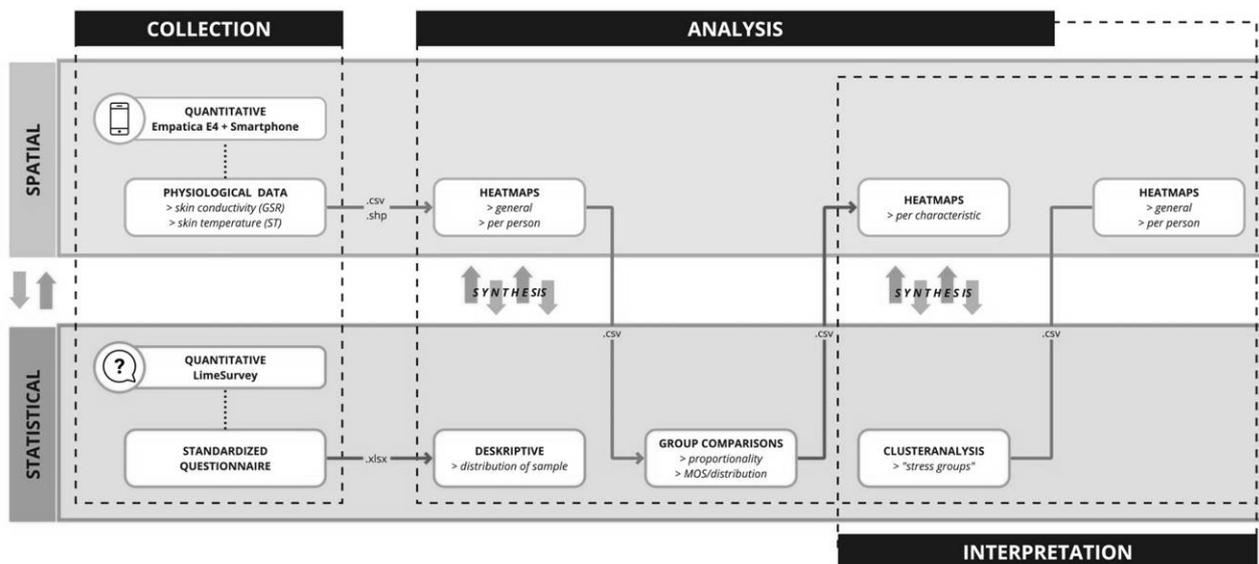

Figure 1: Scheme triangulating process, own presentation

5.1 EmoCycling

Measuring stress in terms of response is feasible, although theoretical limitations must be accepted. Biological indicators are used to identify moments of stress (MOS). When confronted with a stressor, the human organism regulates endogenous stress responses to establish homeostasis. These responses are detectable through a variety of body-related parameters and are recognized as a proven method for measuring stress from external stressors. These include an increase in electrodermal activity (EDA) and a decrease in skin temperature (Kyriakou, 2019; Schandry, 2016). Based on the functioning of these biosignals, Kyria-kou et al. (2019) developed an algorithm that can detect people's MOS using wearable biosensors. The biosensor wristband "E4" from the company Empatica was used to measure the biosignals. The data is collected in an app (e-diary) on a smartphone. The result is a database in which one line corresponds to one sec-ond of the measurement period and provides information about a MOS (yes/no) and its geographic coordi-nates, which can thus be read and visualized in a geographic information system (GIS).

The procedure of recording biostatistical data in a georeferenced manner and following the visualization in maps goes back to Christian Nold (2009). The "emotional cartography" (Nold, 2009) allowed humans and their physiological responses to serve as a kind of sensor for the first time, recording the state of stress or arousal in an urban context. Different developments in the technology itself (e.g. storing of measured EDA and ST in smartphone application) and the methodology (e.g. including ego-perspective cameras) hap-pened since then accumulate under the term "EmoCycling" (Zeile, 2016).

5.2 Standardized questionnaire

Additionally, "EmoCycling" a standardized questionnaire based on validated scales of mobility in Germany (2019) from the BMDV (Nobis, Kuhnimhof, 2018), Leibniz Institute for Social Sciences (GESIS) and Geller's (2009) types of cyclists was developed to record endogenous factors. The questionnaire was used to collect information about the person and his or her sociodemographic background as well as psychological characteristics in addition to traffic behaviours. The personality of individuals is traditionally determined based on the so-called Big Five, which consists of the characteristics of extraversion, neuroticism, openness, conscientiousness and agreeableness. The Big Five are considered to have good predictive power for certain aspects of life. The level of control beliefs describes a person's belief that he or she has control over various situations and that these are the result of his or her actions (internal) or that fate, coincidences, or powerful

962

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others are responsible for the occurrence of certain events (external) (Rammstedt, 2012; Ko-valeva, 2012; Beierlein, 2014). The degree of control belief is a relevant factor in the evaluation of a stress reaction (Brosschot, 1994).

5.3 Implementation and analysis

The data collection of ESSEM is divided into different phases in each city. This paper presents results from the first period in Osnabrück which took place in September 2022. 30 Participants were to fill in the standardized questionnaire and then were equipped with the sensor wristband and the smartphone which collected the measured EDA and ST. In the following, they collected their data on bike rides in their day-to-day life within two weeks. More detailed information on the former phases of the project can be found in Zeile et al. (2023).

For the data analysis, so-called heat maps were created based on the MOS and endogenous factors. This makes it possible to gain insight into the locations where a large number of MOSs of different individuals occurred. Further analyses focusing on the endogenous factors of the participants were performed by appropriate statistical analyses. In the first step, an overview of the distribution of the expressions was obtained. For this purpose, the distributions of the expressions and the MOS were examined (cf. Table 1).

In this paper cycleways on major streets in cities with a higher amount of motorized traffic are examined and correlations between stress levels and certain design solutions like advisory bike lanes, or "sharrows", separated and protected bike lanes are further examined. To further examine the underlying hypothesis that protected bike lanes and distance to other road users (e.g. cars and pedestrians), different designs of bike infrastructure in Osnabrück are superimposed with the data of the stress levels through the EmoCycling-methodology. Major urban roads are selected because here design solutions differ the most. On minor side streets designs mostly call for mixed traffic and generally speaking can only differ in ordinances like the Bicycle Streets, or more precisely the German "Fahrradstraße ". Major arteries in cities on the other hand are characterized by high traffic volumes, and high speeds and are oftentimes the most direct connection from A to B. Therefore, the analysis of subjective safety concerns concerning design solutions for this kind of infrastructure is of great interest. The analysis focuses on the areas in Osnabrück (cf. Figure 2). Those areas show different streetscapes which made it suitable for our analysis.

(1) Berliner Platz is located at the eastern end of the inner-city ring road "Am Wall". It is characterised by an extremely high vehicle load (evening peak with 3.633 vehicles/h and 345 bicycles/h). The bike lanes mostly show widths below standard, partly < 1.5m. In addition, bus lanes and high pedestrian volumes exacerbate the use of space (Heinke, 2022).

(2) Katharinenstraße is one of Osnabrück's "Bicycle Streets" with mixed traffic. It originates in the west outside the inner-city ring and ends at the inner-city ring. To reach the city center waiting at traffic lights is necessary. Katharinenstraße is highly frequented, but narrow for cycling volumes (pulks), overtaking is not possible. Left turners have no striping/space around to avoid possible oncoming traffic (Heinke, 2022).

(3) Lotterstraße/Am Wall: This intersection is located in the northwest of the city center. Very high traffic volume and the lack of objective safety already resulted in a temporary reconstruction (From the north). The bike lane was moved to the edge of the roadway and is now protected. Currently still under construction, which narrows the space. From the other directions the cyclists either ride on the bike lane in the middle of the road (from the west) or on the bus lane (from the south) (Heinke, 2022).

6   RESULTS, PRESENTATION AND DISCUSSION

30 persons were registered for the data collection. Three were prevented from attending at short notice and one person had not completed the questionnaire. In this context, a pseudonym to anonymously match the MOS and the information from the questionnaire was created. Table 1 provides an overview of the composition of the sample.

In the selection of participants, care was taken to ensure gender parity. This is reflected in the sample. The average age was 45 years. Of the participants, 42% had a university degree, and the educational level can be classified as fairly balanced. In terms of cycling types, there is a preponderance of everyday cyclists (70%), followed by interested cyclists. Most bicycles are powered by muscle power (60%). Overall, transportation infrastructure is rated as poor (46% find this at least poor). On average, participants were more likely to be

extraverted, neurotic, and open-minded. The characteristics of conscientiousness and agreeableness were rather low. The level of internal locus of control was more pronounced than the external locus of control. People tended to be viewed as more likely to believe that they are causally responsible for their actions rather than external forces. In addition, people are more likely to be risk averse (62%).

The 26 participants had a total of 11,996 MOS after adjustment. Average 461 MOS. The median is 443. The range is from 108 to 1205.

Variable	Description	$N_{participants}$=26 (in %)	N_{MOS}= 11996 (in %)
F1a	Age (>45)	54	61
F1b	Gender (female)	46	46
F1c	Education, high	42	
Cyclist	Cycling types		
	No chance no matter what	0	0
	Interested cyclists	27	22
	Everyday cyclists	70	68
	Fearless cyclists	3	10
Drive Type	Type of drive of the bike		
	Conventional	60	
	electronic	40	
Bike Type	Most commonly used		
	Trekking bike	42	
	City bike	31	
Situation	Evaluation of the situation for cyclists in Osnabrück		
	very good, good		
	satisfactory	0	
	sufficient	12	
	poor	42	
	insufficient	31	
		15	
F4a	Big Five personality traits		
	Extraversion (above average)	54	52
	Neuroticism (above average)	69	75
	Openness (above average)	65	68
	Conscientiousness (below average)	73	77
	Agreeableness (below average)	58	59
F4b	Conviction of Control		
	Internal (below average)	62	54
	External (below average)	81	54
F4c	Risk affine	62	59
	Statistical key figures $\bar{x}$ = 461 MOS; $\tilde{x}$ = 443 MOS; $\{min; max\}\{108; 1205\}$		

Table 2: Descriptive Analysis of the sample, own calculations

Figure 2 shows the heatmap of the MOS in downtown Osnabrück. After evaluating the interconnections of the volume and the bicycle infrastructure at the hotspots, no significant difference could be found. The underlying hypothesis that protected bike lanes have a positive impact on cyclist exposure could not be confirmed in this case. Here further research is needed as analysis of a short strip of around 150 meters at Heger-Tor-Wall did not show any MOS. Another crucial finding is the occurrence of hotspots especially at intersections, where different vehicles cross, noise is generated, and the situation is confusing. Situations like this a further examined in the following.

In further examination, the situation and potential stressors at those spots have to be observed with camera systems. Surely factors such as time of day and quantity of vehicles must be considered to obtain are more differentiated picture, especially on the effect of streetscapes, especially the design of bicycle infrastructure. Therefore, a comparison of morning or evening peaks at different cycling infrastructures would be favourable.

The analysis of the three study areas showed the following results, underlying some early findings of the research conducted concentrating on two major intersections and Katharinenstrasse a main bicycle route converted to a "Fahrradstraße" in 2011 (Martens, 2011).

964

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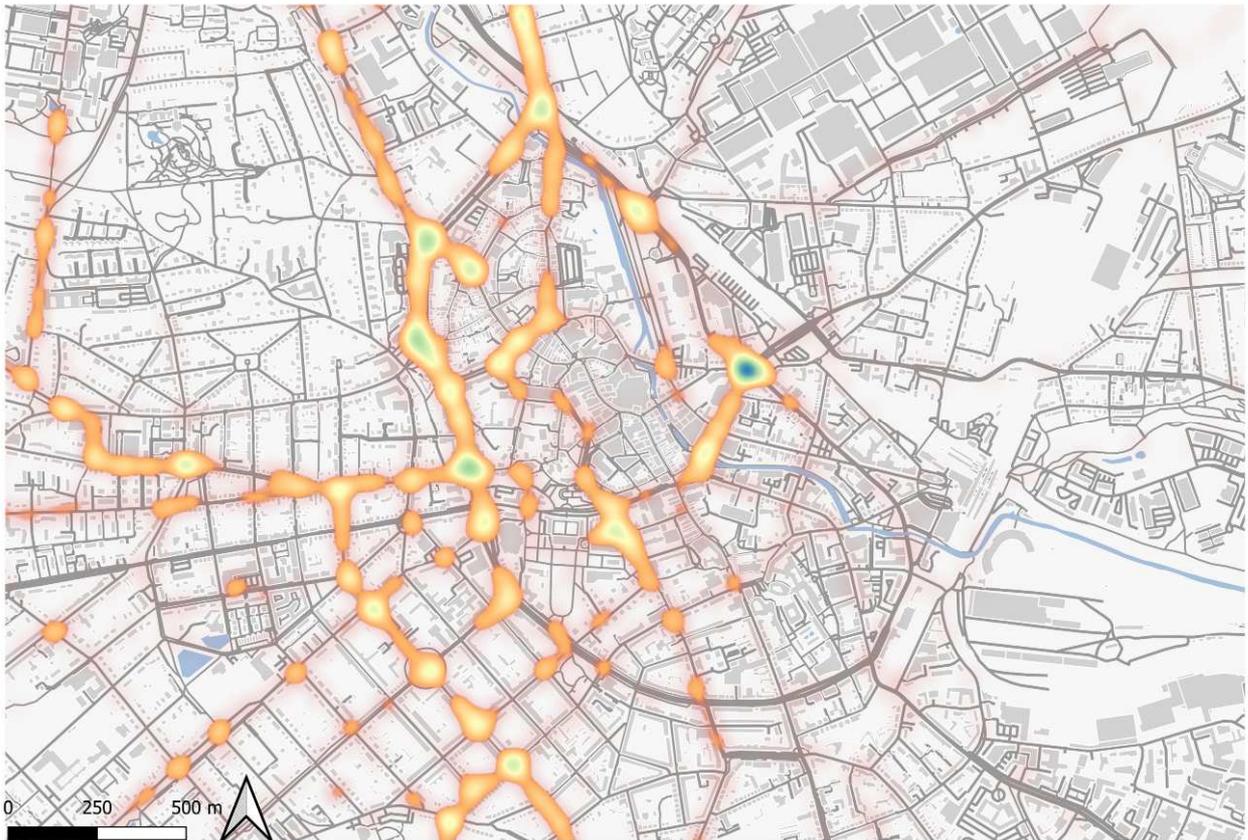
Figure 2: Heatmap of the MOS in Osnabrück with focus areas (1:20,000). Own figure based on OSM contributors. 21.06.2023

As Figure 2 shows, the Berliner Platz (1) shows the highest accumulations of MOS in the research area. This main intersection is characterized by high amounts of motorized traffic connecting the ring around the city center with one main artery leading out of the city to the east, the Wittekindstraße. Including the main bus routes the intersection also handles high amounts of bike traffic, as the data shows. Besides dedicated bus lanes, the distribution of street space is mostly dominated by 4-6 lanes, including turning lanes, for motorized individual traffic. The bike infrastructure here is characterized by painted bike lanes and no separation in construction by bollards, curbs or other measures. At the same time turning lanes for car traffic are crossing the bike lanes and cyclist turning left are expected to wait in the middle of the intersection waiting for their signal.

"Berliner Platz" (cf. Figure 3) can be named as a standard example for the design of many major intersections in German cities, including design choices standardized by main guidelines like the RAST, that are discussed in the section above (FGSV, 2006). The amount of MOS in this area shows the need to rethink design choices in the light of subjective safety and the general quality of bike traffic especially in intersections. Further analysis aims to prove the hypothesis mentioned above, questioning intersection designs mainly focused on red paint with no real protective measures, besides aspects like traffic speed and street width.

Another main intersection in Osnabrück that show similar characteristics as Berliner Platz in its spatial relationships within the city, the inner-city ring and outgoing main streets, here the Lotter Strasse. The intersection Lotter Strasse, Natruper-Tor-Wall (2) (s. figure 4) was redesigned converting one turning lane into a designated and protected lane for bike traffic.

On the other hand, the number of turning lanes and the general design of the intersection is very comparable with the situation at Berliner Platz. The research does not provide data before the redesign, but the MOS analysis shows some evidence towards improving stress levels in comparison to "Berliner Platz", which can be related to the redesign of the northern leg of the intersection. To confirm those findings further analysis is needed evaluating the questionnaires and other data comparing the findings at both intersections.

Figure 3: Photos of Berliner Platz (Maximilian Heinke)

Figure 4: Photos of Lotter Strasse – Natruper-Tor-Wall (left) and Bicycle Road Katharinenstraße (right) (Maximilian Heinke)

All in all, the data shows high amounts of stress levels or rather high accumulations of MOS. Relating problems in the design of those major intersections like this are discussed in literature and mobility panels under the aspect of subjective safety. Here protected intersections and roundabouts standardized in Dutch traffic guidelines (Rik de Groot, 2016) can be named as a possible design solution, that needs to be further examined using the methodology detailed in Chapter 5, adding quantifiable data to the discussion of road distribution objective and subjective safety of different street users, especially considering the needs of pedestrians.

Katharinenstraße (3) shows rather interesting findings. The street was redesigned as a bike street still allowing motorized traffic, but giving cyclist priority. The data shows high amounts of trips using Katharinenstrasse on different routes leading from east to west. At the same time, MOS data shows rather high amounts of stress. A closer examination of the street shows a high number of cars parking at a 45-degree angle with the street switching sides from north to south in between parking cars. In general, the street isn't characterized by high amounts of motorized traffic, so other possible stressors need to be further examined through questionnaires and further data analysis. At the same time the legal set-up of the "Bicycle Street" can be questioned concerning qualitative bike infrastructure not accompanied by real design changes including the reduction of street-side parking.

7 CONCLUSION

Contributing information to inhibiting factors of cycling was the main aim of this study. Embedded in the project "ESSEM", funded by BMDV 26 cyclists were equipped with sensor wristbands which measured their stress level whilst cycling in Osnabrück. In general, almost 12.000 so-called moments of stress (MOS) could be identified, geolocalized and visualized. The further analysis emphasized three "stress hotspots" where the

966

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cycling infrastructure differs. In doing so no mentionable results concerning the streetscape could be pointed out. Meaning MOS showed up on protected bike lines, in mixed traffic and so on. Most of the hotspots are located at intersections, where different modes of transport meet and the situation is unclear.

8 OUTLOOK ESSEM

Data analysis at this point in the project shows several limitations to significance. The study design required participants to ride bicycles in everyday life to rule out MOS associated with study participation ("study effects"). The marked variation in routes and travel times severely limits the comparability of participants' MOS patterns. Further research should focus on comparing street patterns at peak times to provide more detailed information and opportunities to restructure intersections, e.g., to make traffic signal timing more bicycle friendly. Further, after analyzing the routes taken, it seems obvious that some streets or even areas were avoided completely because participants knew in advance that it was not convenient to ride a bicycle there. An important example is "Am Wall". This assumption was substantiated by responses from participants at a workshop in July 2023. Additionally, patterns of MOS by various personal dispositions such as gender, age or bicyclist type could not be considered for the time being. In addition to the small number of participants, the ratio of MOS to the number of bicycle trips made by bicyclists must also be integrated into the evaluation in order to conduct a meaningful statistical analysis. It is worth mentioning that this study and the other studies conducted by ESSEM focus mainly on the cycling domain at this point. In future studies, it is important to consider the entire transportation system when considering emotional responses.

These limitations will now be addressed in the upcoming project phases starting in September 2023. First, more test rides will be conducted, increasing the number of participants from 26 to about 120. In addition, a study design with pedestrians is being considered. To account for the non-comparability of the results provided and to allow studies to examine the role of personal dispositions, an additional study will be designed for spring 2024 to provide reference values. This study will be conducted during rush hour, will follow a pre-designed route that includes bypassed streets such as the inner ring road, and will be representative of all participants who participated in the prior studies. In a complementary way to spatial analysis, the data analysis is carried out by means of statistical group comparisons and cluster analysis (Schmidt-Hamburger, 2022). The aim here is to conduct an in-depth analysis focusing on the quality of the perception of negative emotions as inhibiting factors for cycling in Osnabrück.

9 ACKNOWLEDGEMENTS

10 REFERENCES

ALDRED, R., Goodman, A.: Predictors of the frequency and subjective experience of cycling near misses: Findings from the first two years of the UK Near Miss Project. Accident Analysis & Prevention, 110, 161–170. 2018. https://doi.org/10.1016/j.aap.2017.09.015

ADLI, M.: Stress and the City. Warum Städte uns krank machen. Und warum sie trotzdem gut für uns sind. 2. Edition. Munich. 2017.

AUTELITANO, F., GIULIANI, F.: Colored bicycle lanes and intersection treatments: International overview and best practicees. Journal of Traffic and Transportation Engineering (English Edition), 8(3), 399–420. 2021. https://doi.org/10.1016/j.jtte.2021.03.003

BECK, B., PERKINS, M., OLIVIER, J., CHONG, D., JOHNSON, M.: Subjective experiences of bicyclists being passed by motor vehicles: The relationship to motor vehicles passing distance. Accident Analysis & Prevention, 155, 106102. 2021. https://doi.org/10.1016/j.aap.2021.106102.

BEIERLEIN, C., KOVALEVA, A, KEMPER, C., RAMMSTEDT, B.: Eine Single-Item-Skala zur Erfassung von Risikobereitschaft: Die Kurzskala Risikobereitschaft-1 (R-1). In: GESIS-Working Papers 34. 2014.

BERCHT, A.L.: Stresserleben, Emotionen und Coping in Guangzhou, China: Mensch-Umwelt-Transaktionen aus geographischer und psychologischer Perspektive, Stuttgart. 2013.

BMDV: Fahrradland Deutschland 2030 – Nationaler Radverkehrsplan 3.0. Berlin, 2022. https://bmdv.bund.de/SharedDocs/DE/Anlage/StV/nationaler-radverkehrsplan-3-0.pdf?__blob=publicationFile (28.06 2022).

BROSSCHOT, J.F., GEBHARDT, W., GODAERT, G.: Internal, powerful others and chance locus of control: relationships with personality, coping, stress and health. In: Personality and Individual Differences 16(6), pp. 839-852. 1994.

CANNON, W. B.: The wisdom of the body, New York. 1932.

DIGIOIA, J., WATKINS, K. E., XU, Y., RODGERS, M., GUENSLER, R.: Safety impacts of bicycle infrastructure: A critical review. Journal of Safety Research, 61, 105–119. 2017. https://doi.org/10.1016/j.jsr.2017.02.015

FGSV: Richtlinien für die Anlage von Stadtstraßen (RASt 06), Berlin. 2006.

FLICK, U.: Triangulation: Eine Einführung, Wiesbaden. 2019.

GEHL, J.: Städte für Menschen, Berlin. 2015.

GELLER, R.: Four Types of Cyclists. Portland Bureau of Transportation. Portland. 2009.

GÖTSCHI, T., CASTRO, A., DEFORTH, M., MIRANDA-MORENO, L., ZANGENEHPOUR, S.: Towards a comprehensive safety evaluation of cycling infrastructure including objective and subjective measures. Journal of Transport & Health, 8, 44–54. 2018. https://doi.org/10.1016/j.jth.2017.12.003

GRAF, T.: Handbuch: Radverkehr in der Kommune: Nutzertypen, Infrastruktur, Stadtplanung, Marketing: Das Hygge-Modell, Ergänzung zur ERA (1st edition). Les éditions Bruno im Hause Thiemo Graf Verlag, Röthenbach an der Pregnitz. 2016.

HEINKE, M.: Analyse Hotspots Osnabrück. Interne Projektpräsentation, Stadt Osnabrück. 2022.

HOLMES, T. H. & RAHE, R.H.: The social readjustment rating scale. In: Journal of Psychosomatic Research 11(2), pp. 213-218. 1967.

HULL, A., & O'HOLLERAN, C.: Bicycle infrastructure: Can good design encourage cycling? Urban, Planning and Transport Research, 2(1), pp. 369-406. 2014. https://doi.org/10.1080/21650020.2014.955210.

JOHANNSEN, H.: Unfallmechanik und Unfallrekonstruktion. Springer Fachmedien, Wiesbaden. 2013.

KOVALEVA, A.; BEIERLEIN, C.; KEMPER, C.J.; RAMMSTEDT, B.: Kurzskala zur Messung von Kontrollüberzeugung: Die Skala Internale-Externale-Kontrollüberzeugung-4 (IE-4). In: GESIS-Working Papers 19. 2012.

KYRIAKOU, K., RESCH, B., SAGL, G., PETUTSCHNIG, A., WERNER, C., NIEDERSEER, D., LIEDLGRUBER, M., WILHELM, F.H., OSBORNE, T., PYKETT, J.: Detecting Moments of Stress from Measurements of Wearable Physiological Sensors. Sensors, 19 (17), 3805. 2019. https://doi.org/10.3390/s19173805

LAZARUS, R.S.: Stress and emotion: A New Synthesis, New York. 1999.

LYON, B.L.: Stress, Bewältigung und Gesundheit: Konzepte im Überblick. In: Rice, V.H. (Ed.): Stress und Coping. Lehrbuch für Pflegepraxis und -wissenschaft, p. 25-47, Bern. 2005.

MARTNS, J.: Osnabrück, In der Katharinenstraße bestimmen Radler das Tempo. Neue Osnabrücker Zeitung, https://www.noz.de/lokales/osnabrueck/artikel/fahrradstrassen-osnabrueck-in-der-katharinenstrasse-bestimmen-radler-das-tempo-23933373, Osnabrück. 2011.

NILSEN, P.: Making sense of safety. Injury Prevention, 10(2), 71–73. 2004. http://dx.doi.org/10.1136/ip.2004.005322

NOBIS, C.: Mobilität in Deutschland - MiD Nutzerhandbuch: Fragenübersicht, Bonn. 2018.

NOLD, C.: Emotional Cartography: Technologies of the Self. London. 2009.

RAMMSTEDT, B., KEMPER, C.J., KLEIN, M.C., BEIERLEIN, C., KOVALEVA, A.: Eine kurze Skala zur Messung der fünf Dimensionen der Persönlichkeit: Big-Five-Inventory-10 (BFI-10). In: GESIS-Working Papers 23. 2012.

RIK DE GROOT, H. (Ed.): Design manual for bicycle traffic. Crow. 2016.

REYNOLDS, C. C., HARRIS, M. A., TESCHKE, K., CRIPTON, P. A., & WINTERS, M.: The impact of transportation infrastructure on bicycling injuries and crashes: A review of the literature. Environmental Health, 8(1), 47. 2009. https://doi.org/10.1186/1476-069X-8-47

SCHANDRY, R.: Biologische Psychologie. 4th edition. Julius Beltz, Weinheim. p.324f. 2016.

SCHMIDT-HAMBURGER, C.: Stresstest Fußverkehr: Eine Studie im Rahmen des NRVP-Projektes „Cape Reviso" zur Messung des Stressempfindens Zufußgehender in Stuttgart, Universität Bremen (Master-Thesis), p. 26f. 2022.

SELYE, H.: The stress of life, New York. 1956.

SØRENSEN, M., MOSSELEMI, M.: Subjective and Objective Safety. The Effect of Road Safety Measures on Subjective Safety among Vulnerable Road Users. TØI report 1009/2009. ISSN 0808-1190. Oslo. 2009.

VAN PETEGEM, J. H., SCHEPERS, P., WIJLHUIZEN, G. J.: The safety of physically separated cycle tracks compared to marked cycle lanes and mixed traffic conditions in Amsterdam. European Journal of Transport and Infrastructure Research, 21(3), 19–37. 2021. https://doi.org/10.18757/ejtir.2021.21.3.5283

VON STÜLPNAGEL, R., Binning, N.: How safe do you feel? – A large-scale survey concerning the subjective safety associated with different kinds of cycling lanes. Accident Analysis & Prevention, 167, 106577. 2022. https://doi.org/10.1016/j.aap.2022.106577

WERMTUH, M.: Modellvorstellungen zur Prognose. In: Steierwald, G.; Künne, H.D.; Vogt, W.: (Hrsg.): Stadtverkehrsplanung: Grundlagen, Methoden, Ziele. Issue 2, pp. 243-295. Springer, Berlin. 2005.

ZEILE, P.; RESCH, B.; LOIDL, M.; DÖRRZAPF, L.: Urban Emotions and Cycling Experience - Enriching Traffic Planning for Cyclists with Human Sensor Data. GI_Forum J. Geogr. Inf. Sci. pp. 204–216. 2016. https://doi.org/10.1553/giscience2016_01_s204

ZEILE, P., HAUG, N., SCHMIDT-HAMBURGER, C., BENGEL, S., MOTZER, N., OTTE, F., RATH, T., KLEIN, P., MOSER, M., RESCH, B.: Emotion Sensing für (E-)Fahrradsicherheit und Mobilitätskomfort – das BMDV-Projekt ESSEM. Proceedings of REAL CORP 2022, 27th International Conference on Urban Development, Regional Planning and Information Society. pp. 259-268. ISSN 2521-3938. Vienna. 2022. https://doi.org/10.48494/REALCORP2022.8029

ZEILE, P., HAUG, N., SCHMIDT-HAMBURGER, C., MOTZER, N., MOSER, M., RESCH, B.: Emotion Sensing for (E-) Bicycle Safety and Mobility Comfort. In: JoDLA – Journal of Digital Landscape Architecture, 8-2023. Dessau. 2023. https://doi.org/10.14627/537740041

968

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Vertikales Wachstum im Städtebau

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1 ABSTRACT

Der Megatrend Urbanisierung stellt Stadtplanerinnen und Architekten vor die Herausforderung, auch in Zukunft die räumliche und strukturelle Gesamtentwicklung einer Stadt anhand den drei Säulen der Nachhaltigkeit auszurichten. Immer mehr Menschen zieht es in dicht besiedelte Gebiete, die Attraktivität der Großstädte wirkt auf die jungen Generationen gar wie ein Magnet. Aus der steigenden Nachfrage einer zentralen Unterkunft im Ballungsraum resultiert jedoch ein Ungleichgewicht aus sozialer, ökologischer und ökonomischer Betrachtungsweise. Ist der Zugang teurer Innenstadtwohnungen vermehrt der oberen Einkommensschicht vorenthalten, müssen sich einkommensschwächere Haushalte mit den frisch versiegelten Wohnflächen im Agglomerationsgürtel zufriedenstellen.

Der bezahlbare Wohnraum, eine ausgewogene Bevölkerungsdichte sowie der Erhalt von Grünflächen – all diese Faktoren bedarf es folglich unter dem Deckmantel der nachhaltigen Städtebauentwicklung zu vereinen. Ein bauliches Mittel zur Reduzierung der anhaltenden Problematik bildet das vertikale Wachstum. Die Aufstockung eines bestehenden Gebäudes mindert zum einen die Flächenversiegelung in der Breite; weiterhin wird neuer Wohnraum dort geschaffen, wo er die größte Beliebtheit erfährt. Die theoretischen Voraussetzungen dieser Erweiterungsmaßnahme im Bestandsbau lassen sich über drei Instrumente charakterisieren: tragfähige Gebäudestatik, rechtliche Zulässigkeit, lokaler Wohnraumbedarf vorhanden. Zeigen Fallstudien und abgeschlossene Beispiele ein hohes Wohnraumpotenzial durch vertikales Wachstum auf, bremsen rechtliche Herausforderungen eine großflächige Praxisanwendung. Um im Interesse der nachhaltigen Städtebaupolitik jene Baumaßnahme eines flächenschonenden Wohnraums häufiger zu realisieren, bedingt es zunächst einer selbstbewussten Auseinandersetzung mit den Bestandsobjekten. In der Folge helfen vereinfachte Genehmigungsprozesse (vgl. Wien[1]), eine stärkere Aufklärung sowie finanzielle Anreize, potentielle Investorinnen und Investoren für das Bauen im Bestand zu gewinnen. Abschließend können industrielle Vorfertigungen Baukosten, Produktionszeit und das Baumaterial nachhaltig beeinflussen.

Keywords: Urbanisierung, Stadtplanung, Architektur, Wachstum, Nachhaltigkeit

2 WAS BEDEUTET VERTIKALES WACHSTUM?

Vertikales Wachstum steht im bauplanerischen Kontext für eine räumliche Erweiterung von Bestandsgebäuden und -flächen ohne zusätzliche Bodenversiegelung. Auf europäischer Ebene wird die Baumaßnahme der Gebäudeaufstockung als Nachverdichtung angesehen. Im nationalen Sprachgebrauch hingegen bezeichnet man das Äquivalent im Fachjargon als Innenentwicklung, obgleich beide Wortbedeutungen dasselbe Ziel anvisieren: auf dem bereits vorhandenen Kostenfaktor Boden weiteren Wohnraum erschaffen, sodass potenzielle Flächen im Siedlungsbestand aktiviert und im Außenbereich geschützt werden.[2] Tragfähige Bestandsgebäude, brachliegende Flächen, Baulücken sowie Flächen in minderstrukturierten Quartieren – all diese Orte weisen durch eine mögliche Verdichtung- bzw. Innenentwicklungsmaßnahme ihr Potenzial auf, neuen Wohnraum zu erzeugen.

In diesem Paper erfolgt die Betrachtung jener Maßnahmen anhand des vertikalen Wachstums auf Bestandsgebäuden. Die folgende Erläuterung des gesamten Planungs- und Bauprozesses mit den resultierenden Nutzen richtet sich in erster Linie an Architekturbüros, die mit dem Auftrag einer Bestandserweiterung vertraut werden. Mithilfe des rechtlichen Betrachtungswinkels auf Ebene der Stadtplanerinnen und Stadtplaner erfolgt am Ende die Gegenüberstellung zwischen Potenzial und Hemmnissen für das vertikale Wachstum des zukünftigen Städtebaus.

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[1] Stadt Wien (2023).
[2] BBSR (2014), S. 25.

3 INSTRUMENTE DES VERTIKALEN BAUENS

Jener Prozess ist als Schaubild unter dem Namen Instrumente des vertikalen Bauens dargestellt (vgl. Abbildung 1). Die Instrumententafel dient als Wegweiser für potenzielle Vorhaben, dessen Realisierbarkeit zu prüfen, zu planen und den Nutzen zu erkennen.
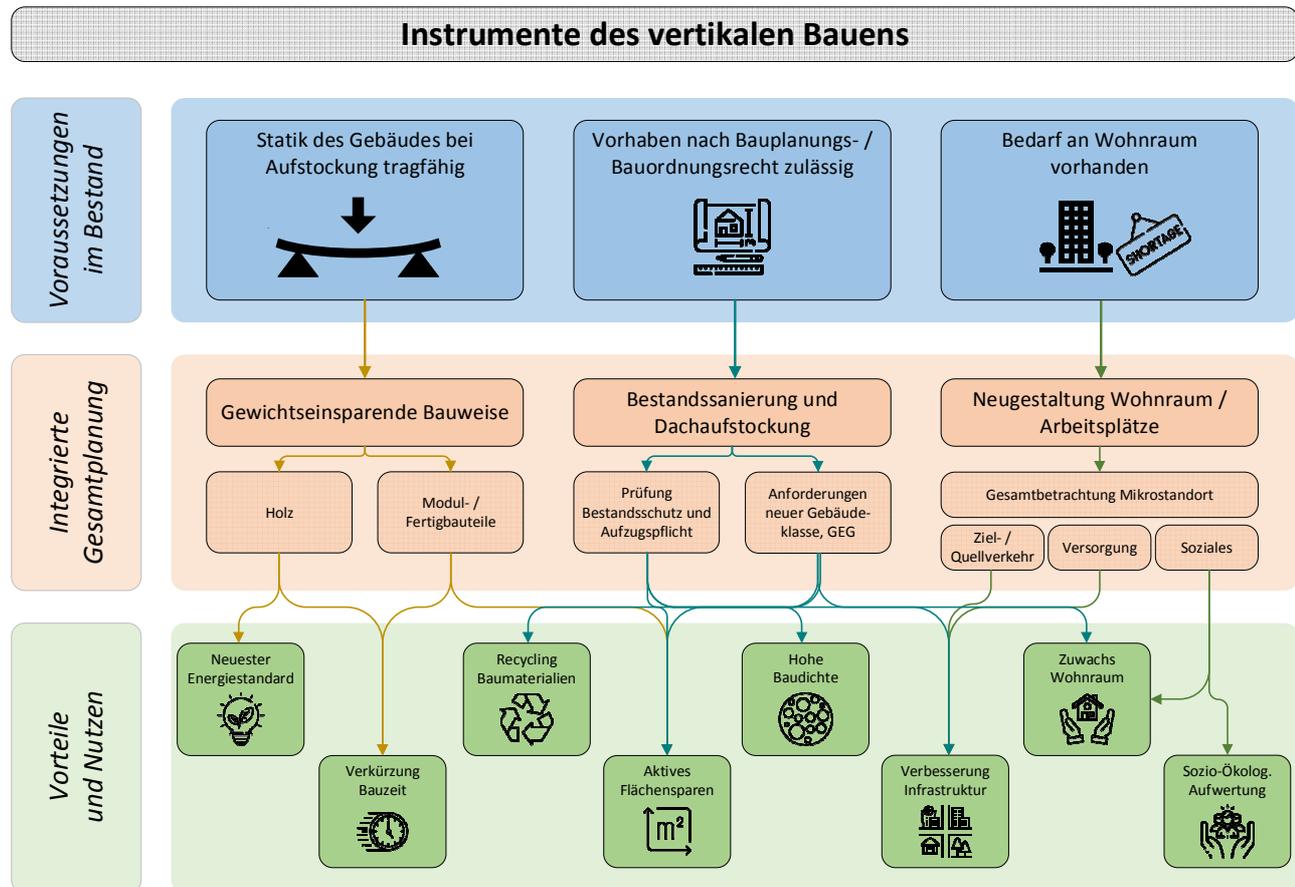

Abbildung 1: Instrumente des vertikalen Bauens.[3]

Im blau hinterlegten Feld sind die technisch-planerischen sowie rechtlichen Voraussetzungen skizziert, die für jede individuelle Dachaufstockung zu erfüllen sind. Ein stabiles Fundament legt den Grundstein für die Zusatzlast eines oder gar mehrerer Geschosse auf dem Bestandsbau. Qualitativ anspruchsvolle Bauweisen, Massen von Beton oder historisch belastbare Bausubstanzen zählen zu denjenigen Hauseigenschaften, aus denen hohe Traglastreserven resultieren. Daher charakterisiert das Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) vor allem Häuser der 1950 bis 1960er Jahre mit dem größten Potenzial für zukünftige Dachaufstockungen.[4] Der Bestand dieser Baualtersklassen beläuft sich auf insgesamt 11 Millionen Wohnungen in Deutschland.[5] Weiterhin hängt die konstruktive Rahmenbedingung der Tragfähigkeit von den berücksichtigten Verkehrslasten ab; ändert sich beispielsweise die Nutzungskategorie des Gebäudes von Gewerbe zu Wohnraum, sinkt die Nutzlast gemäß DIN 1055-3von fünf auf zwei Kilonewton pro Quadratmeter. Folglich ergeben sich anhand der geringer anzusetzenden Nutzlasthöhere Tragreserven, welche die Zusatzlasten durch ein- oder mehrfache Geschossaufstockungen aufnehmen können. Für diese Schritte sind sowohl ein qualifizierter Tragwerksplaner als auch ein Sachverständiger für die Prüfung der Standsicherheit zu beauftragen.

Das Bauplanungsrecht mit den Vorschriften des Baugesetzbuches sowie der Baunutzungsverordnung und das Bauordnungsrecht in den jeweiligen Landesbauordnungen regeln die Zulässigkeit eines Bauvorhabens. Die Genehmigung kann je nach Gebiet des Weiteren vom Denkmal-, Naturschutz- oder Wasserrecht abhängig sein. Generell wird eine Erweiterungsstrategie nach Kombination mit Sanierung der Gebäudehülle oder Durchführung der Einzelmaßnahme ohne zusätzliche Modernisierung differenziert. Im ersten Fall

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[3] Reinhard (2022).
[4] BBSR (2016), S. 34.
[5] Pestel-Institut (2023), S. 19.

erfolgt ein Eingriff in den Bestand durch eine oder mehrere Baumaßnahmen (z. B. Herstellung eines baurechtlich konformen Treppenaufgangs ins Dachgeschoss). Folglich verfällt der Bestandsschutz und das gesamte Gebäude muss mit dem aktuell geltenden Recht in Einklang stehen – es ist wie ein Neubau zu behandeln und muss somit auch die neuesten Anforderungen im Gebäudeenergiegesetz erfüllen.[6] Der zweite Fall findet sich häufig in denkmalgeschützten Gebäuden wieder, deren Außenfassade je nach Bauvolumen, Stil und Proportion einer geplanten Aufstockung nicht beeinträchtigt werden darf. Das BBSR kritisiert die rechtlichen Vorgaben bei der Zulässigkeitsprüfung einer Bauerweiterung und sieht deutliche Hemmnisse in der Realisierung von Dachaufstockungen und -ausbauten. Investoren würden vor allem durch den Wegfall des Bestandsschutzes, erhöhte Anforderungen durch die Änderung der Gebäudeklasse sowie die Einhaltung der Energieeinsparverordnung (seit 08/2020: Gebäudeenergiegesetz) für Neubauten finanziell zurückgehalten.[7]

Der Bedarf an Wohnraum lässt sich jährlich anhand der Geburten- und Sterberate, den Wanderungen über die Bundesgrenze sowie der zukünftigen Bevölkerungsentwicklung aufstellen. Das Pestel-Institut hat für das aktuelle Kalenderjahr ein Defizit von 700 Tausend Wohnungen ermittelt– welches der größten Wohnungsnot seit 20 Jahren entspricht. Die Gründe für das hohe Defizit liegen an den jüngst entstandenen Problemen: Energiekrise, Materialknappheit, Lieferkettenengpässe, steigende Baukosten und Fachkräftemangel. Der Wohnungsbau scheitert allerdings auch an langwierigen Genehmigungsverfahren, die bereits vor dem Russland-Ukraine-Konflikt publik waren.

Die integrierte Gesamtplanung im orange gefärbten Feld baut im Folgeschritt auf den zu erfüllenden Voraussetzungen auf. In Abhängigkeit von Bausubstanz, Traglastreserven und weiteren statischen Bedingungen erfolgt der Einsatz von Holzkonstruktionen oder Modul- bzw. Fertigbauteilen aus Leichtbeton. Im ersten Fall steigen Zusatzlasten infolge eines Dachausbaus nur um ein geringes Maß, da lediglich ein Austausch des Dachstuhls stattfindet – z.B. durch den Bau von Gauben und Flachdächern, deren Lasten durch neu angerichtete Holzbalken abgetragen werden(vgl. Abbildung 2, Skelettbauweise; Abbildung 3, Strategie 1). Als Alternative bietet sich der Einsatz von Modul- bzw. Fertigbauteilen an, welche auf der Baustelle vor Ort über einen Schwerlastkran an den vorgesehenen Platz gehoben und anschließend final verschraubt werden(vgl. Abbildung 2, Modulbauweise).
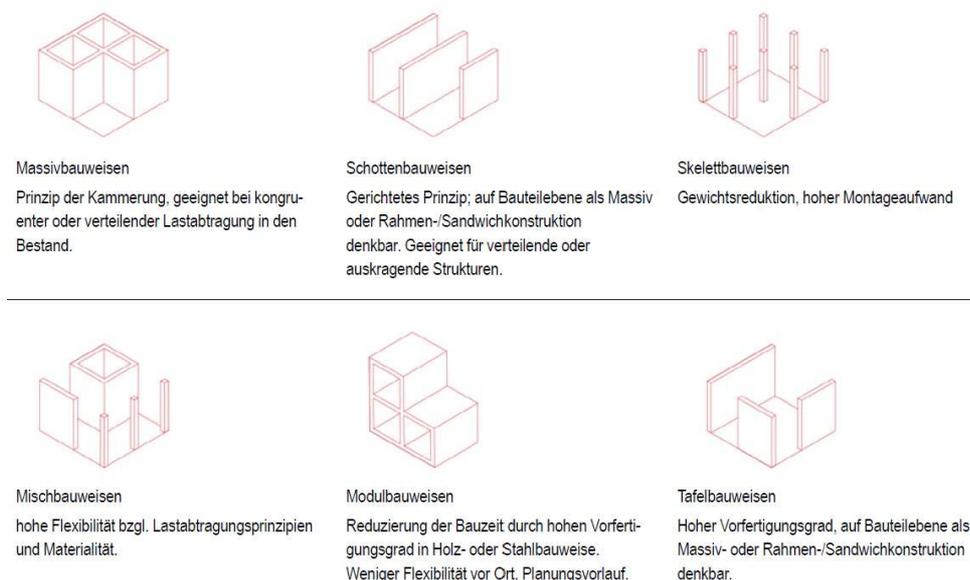

Massivbauweisen

Prinzip der Kammerung, geeignet bei kongru-enter oder verteilender Lastabtragung in den Bestand.

Schottenbauweisen

Gerichtetes Prinzip; auf Bauteilebene als Massiv oder Rahmen-/Sandwichkonstruktion denkbar. Geeignet für verteilende oder auskragende Strukturen.

Skelettbauweisen

Gewichtsreduktion, hoher Montageaufwand

Mischbauweisen

hohe Flexibilität bzgl. Lastabtragungsprinzipien und Materialität.

Modulbauweisen

Reduzierung der Bauzeit durch hohen Vorferti-gungsgrad in Holz- oder Stahlbauweise. Weniger Flexibilität vor Ort. Planungsvorlauf.

Tafelbauweisen

Hoher Vorfertigungsgrad, auf Bauteilebene als Massiv- oder Rahmen-/Sandwichkonstruktion denkbar.

Abbildung 2: Typologien zur Erweiterung von Dachgeschossen[8]

Innerhalb der zweiten Planungsstufe wird das vertikale Wachstum zwischen Bestandssanierung und Dachaufstockung differenziert. Abbildung 3 verdeutlicht den Betrachtungswinkel zwischen bestehender Gebäudehülle und der Erweiterungsstrategie, wobei die „Aufstockung als Building Envelope" eine

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[6] Weitkemper (2018), S. 1002.
[7] BBSR (2016), S. 34.
[8] ebd., S. 31.

Koinzidenz von Sanierung und Aufstockung darstellt. Die Strategien eins bis vier decken die alleinstehende Aufstockungsmaßnahme ab; sie unterscheiden sich vor allem im Ausmaß der neu erschlossenen Wohnfläche.
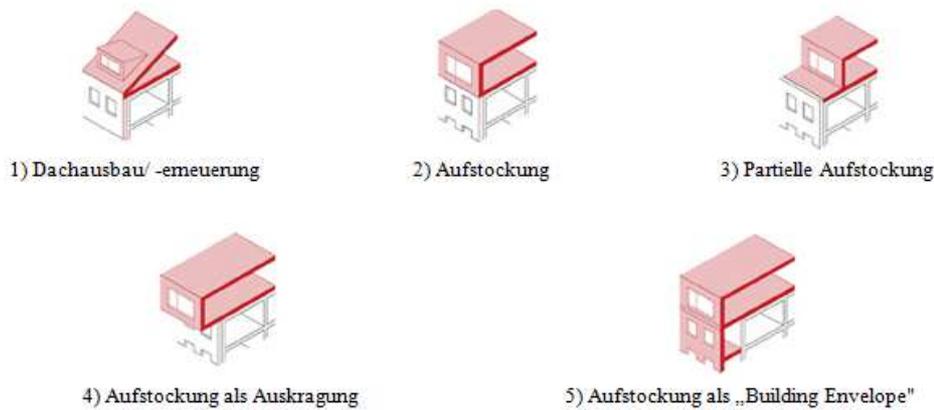

1) Dachausbau/ -erneuerung   2) Aufstockung   3) Partielle Aufstockung

4) Aufstockung als Auskragung   5) Aufstockung als „Building Envelope"

Abbildung 3: Strategien der Bestandserweiterung (Bestandsbau weiß, Neubau rot markiert)[9]

Überschreitet das gesamte Gebäude nach der geplanten Erweiterungsmaßnahme eine Gebäudehöhe von sieben Metern, ändert sich die Gebäudeklasse und der Bestandsschutz verfällt. Fortan bestehen dann strengere brandschutztechnische Anforderungen an die Bauteile (von „feuerhemmend" zu „hoch feuerhemmend", §§ 2, 26 MBO). Weiterhin ist die Einhaltung der Abstandsflächen zu beachten, um eine ausreichende Belichtung und Belüftung, den Brandschutz und einen Sozialabstand zu gewährleisten (§ 6 MBO). Die nach GEG vorgeschriebenen Wärmedämmungs-, Schallschutz- sowie energetischen Maßnahmen im Neubau müssen dann in den bestehenden Geschossen nachgerüstet werden. Für die Sanierung sieht dass BBSR den Bestand der 1950 bis 1960er Jahre ebenfalls im Vorteil, da durch den standzeitbedingten Sanierungsbedarf und die geometrisch unkomplizierten Fassaden der neueste Energiestand mit einfach technischen Mitteln erreicht werden kann.[10] Durch die Vorgabe von zwei unabhängigen Rettungswegen je Geschoss (§ 33 MBO) ist für die Erschließung der ausgebauten Dachgeschosse häufig ein neues Treppenhaus notwendig, da die durch ein Rettungsgerät erreichbaren Stellen zu hoch oder von Baumkronen verdeckt sind. Als zusätzlicher Prüfschritt steht der Kostenfaktor "nachträglicher Einbau eines Personenfahrstuhls" an; die nationale Aufzugspflicht besteht ab einer Gebäudehöhe von 13m (§ 49 Abs 4. MBO) bzw. in den Landesbauordnungen überwiegend ab fünf (Berlin: vier) Vollgeschossen. Mit Abschluss dieses integrativen Planungsabschnitts muss folgende Frage beantwortet sein: Ist es für den Investor wirtschaftlich betrachtet sinnvoll, neuen Wohnraum zu finanzieren, der eine komplexe Sanierung der "alten" Wohnflächen bedingt?

Sind die technischen und rechtlichen Planungsfragen abgeschlossen, müssen die sich mit den neugewonnen Wohnflächen bzw. Arbeitsplätzen einstellenden Bedürfnisse geplant werden. Dazu ist eine Gesamtbetrachtung des Mikrostandortes notwendig, um die Lebensgrundfunktionen rund um ein städtisches Viertel zu analysieren. Im Schwerpunkt werden hierbei soziale Belange, die Nahversorgung sowie die Mobilität in Form von Ziel- und Quellverkehr untersucht. Der Sozialgedanke lässt sich zum Einen am Verhältnis zwischen alten und neuen Bewohnern des Hauses messen. Andererseits stellen sich Sickereffekte auf dem Wohnungsmarkt ein: Durch den Zuwachs an Wohneinheiten können vergleichsweise kostenintensive Mietobjekte im Dachgeschoss Besserverdienenden überlassen werden, welche aktuell den durchschnittlich teuren Wohnraum für Bürgerinnen und Bürger der Unter- und Mittelschicht blockieren. Die Berücksichtigung beider Komponenten stellt eine Lösung dar, aktiv gegen das Problem der Gentrifizierung zu handeln und auf die sozialen Interessen aller Menschen im Viertel einzugehen. Hinsichtlich der Versorgung und Mobilität liefert POPELKA mit dem Ausdruck einer positiven Dichte das Stichwort, welches die notwendige Kapazität der vorhandenen Infrastruktur aufstellt.[11] Handelt es sich bei vertikalem Wachstum im Sinne einer flächensparenden Verdichtung von zusätzlichem Wohnraum, so nimmt die Einwohnerzahl am Mikrostandort nur geringfügig zu. Als Resultat sollte die existierende Infrastruktur die neu hinzugekommenen Versorgungs- und Mobilitätsbedürfnisse aufnehmen können – sofern die Dichte

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[9] BBSR (2016), S. 31.
[10] ebd., S. 27.
[11] Popelka (2021).

positiv und die Beliebtheit eines Ortes hoch bleiben. Zum Schluss der zweiten Reihen im Schaubild "Instrumente des vertikalen Bauens" gilt es folgende Fragestellungen zu erörtern:

Ist der neu erschaffene Wohnraum so groß, dass er genügend Fläche für Tätigkeiten im Homeoffice bietet? Befinden sich am zu verdichtenden Mikrostandort genügend Arbeitsplätze in der Umgebung, sodass potentielle Mieter durch die Aufstockungsmaßnahme das Prinzip Stadt der kurzen Wegerealisieren können? oder: Wird das vertikale Wachstum in Erwägung gezogen, weil ein Wohnraumbedarf aus der Errichtung neuer Arbeitsplätze entsteht?

Im abschließenden Feld der Instrumententafel erfolgt das Resultat der vorherigen Schritte: die grün hinterlegten Vorteile und Nutzen, welche sich aus den drei Faktoren des integrativen Planungsprozesses ergeben. Der neueste Energiestandard wird zusammen mit der Leichtbauweise und den Anforderungen des GEG erreicht, Sonnenkollektoren oder Solaranlagen unterstützen in diesem Zuge die Nachhaltigkeit und Energiebilanz des neuen Wohnraums. Weiterhin kann die Umsetzung von Dachaufstockungen durch den Einsatz von Fertigbauteilen beschleunigt werden, sodass sich ein reibungsloser Bauablauf und ein gleichzeitiger Schutz der Bestandsbewohnerinnen und -bewohner durch Lärmvermeidung einstellt. Die beim Bauen anfallenden Abfallmengen können durch den Erhalt und die Pflege von Bestandsgebäuden deutlich minimiert, aber nicht vermieden werden; der geringfügige Bedarf neuer Baumaterialien im Zuge einer Aufstockung steht für eine Ressourcenschonung. Ferner besteht das Potenzial, die Wiederverwendbarkeit der aufzustockenden Bausubstanzen zu prüfen; Pfetten und Sparren können beispielsweise je nach Zustand recycelt und an anderer Stelle eingesetzt werden, ohne ein Downcycling zu erfahren. Im Zusammenspiel von Sanierung der Gebäudehülle und vertikalem Wachstum können Grünelemente sowohl an der Wand als auch auf dem Dach wertvolle Versickerungsflächen bieten; durch ihren Beitrag im ökologischen Städtebau der Zukunft eröffnen sich gar neue Wege, wie alte Bestandsfassaden eine klimafreundliche Aufwertung erfahren können, der Vorteil einer hohen Baudichte schließt den weiteren Nutzen des Flächensparens ein. Das Verhältnis von Mensch zu Nähe bleibt weiterhin positiv– die sozioökonomischen Differenzen dürfen durch die Beliebtheit eines Ortes jedoch nicht zunehmen. Die Installierung eines Supermarkts oder einer Mobilitätsstation zählen zu den Synergieeffekten, die eine Verbesserung der Infrastruktur infolge vertikalen Wachstums nach sich ziehen können. Gleichzeitig besteht auch der Vorteil einer sozioökologischen Aufwertung, wenn das Zusammenleben eines Bezirkes durch die Kommunikation zwischen alten und neuen Bewohnerinnen und Bewohnern gefördert wird. Der größte Nutzen durch vertikales Wachstum ist der Zuwachs an Wohnraum ohne Neuversiegelung einer Fläche. Die Entwicklung von Gebäude-, Frei- und Verkehrsfläche zeigt im Vergleich zu fertiggestellten Neubauten, dass der Flächenverbrauch stark in Abhängigkeit zur Bautätigkeit steht.[12] Der Bausektor in Deutschland dient daher als einer von mehreren Stellschrauben, die je nach Ausrichtung das vorgegebene Flächensparziel der Bundesregierung von unter 30 Hektar täglichen Verbrauchs nachhaltig beeinflussen zu können.

4   WOHNRAUMPOTENZIAL AM FALLBEISPIEL DER KÖLNER FORDSIEDLUNG

Das Potenzial des durch vertikales Wachstum erschaffenen Wohnraums lässt sich anhand verschiedener Kriterien messen. Die Wirtschaftlichkeit der Baumaßnahme steht in Abhängigkeit zur gewählten Erweiterungsstrategie (vgl. Abbildung 3). Die Arbeitsgemeinschaft für zeitgemäßes Bauen stellt im Kostenvergleich die wohnraumschaffenden Maßnahmen Neubau, Modernisierung und Umbau gegenüber (vgl. Abbildung 4). [13] Die neubaugleiche Modernisierung gilt als kostenintensivste Möglichkeit, als kostensparende Alternative besteht die Option einer Vollmodernisierung in kleineren Interventionen mit der bestehenden Bausubstanz. Der Umbau von Büroflächen stellt die günstigste Option dar, in diesem Fall ist der Aufwand und Materialeinsatz am geringsten. Der in diesem Paper aufgestellte Schwerpunkt eines Dachgeschossausbaus bzw. Aufstockung sticht mit knapp 1000 Euro pro Quadratmeter Einsparung gegenüber dem Neubau eines Wohnhauses hervor; die nachhaltige Verdichtung ist vor allem aufgrund des Kostenfaktors "Grundstückserwerb" ein sparsames Mittel zur Wohnraumschaffung.

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[12] TU Darmstadt und Pestel-Institut (2016a), S. 45.
[13] Walberg et al. (2022), S. 41.

▪ in €/m² Wfl.

3.938,53 **3.616,18** **3.405,28** **2.526,37** **2.484,23** **1.280,60**

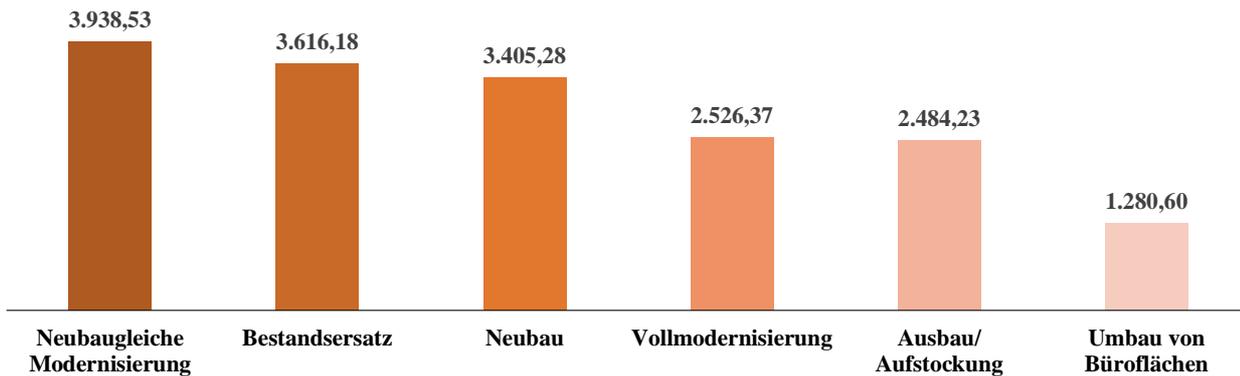| Neubaugleiche Modernisierung | Bestandsersatz | Neubau | Vollmodernisierung | Ausbau/ Aufstockung | Umbau von Büroflächen |

Abbildung 4: Baukostenvergleich wohnraumschaffender Maßnahmen (Vergleich der gemittelten Bruttokosten für verschiedene Möglichkeiten der Wohnraumschaffung im 4. Quartal 2021)[14]

Wie setzen sich die Baukosten für die Erweiterungsstrategie einer Aufstockung zusammen? Den größten Anteil bildet die Kostengruppe (KG) 300 für die allgemeine Baukonstruktion eines oder mehrere Vollgeschosse. Hinzu kommen die KG 400 für technische Kosten und die KG 500 für Außenanlagen. Um die Traglast der obersten Geschossdecke zu schonen und die hinzukommenden Lasten über die Außenwände abzutragen, ist gegebenenfalls eine Ertüchtigung der bisherigen Konstruktion von Nöten. Ein weiterer Kostenpunkt kann der bereits erwähnte Personenfahrstuhl sein (vgl. S. 4), eine nachträgliche Installation an der Außenfassade gilt hier als denkbare Umsetzung.

Zur weiteren Bestimmung des Wohnraumpotenzials sind die nationalen Bestandsgebäude zu differenzieren. Je nach Baualtersklasse, Dachfläche und Bundesland ergeben sich unterschiedliche Potenziale für zusätzliche Wohnflächen bzw. Wohnungen. Sinnvolles Aufstockungspotenzial befindet sich vor allem in Metropolregionen und Ballungsräumen, in denen ohnehin ein erhöhter Wohnungsbedarf festzustellen ist. Demgegenüber weisen ländliche Regionen einen zu hohen Gebäudeleerstand auf, der sich vor allem aufgrund der Urbanisierung eingestellt hat. Wie bereits im vorherigen Abschnitt erwähnt, weisen Gebäude der Bauperiode ab den 1950er Jahren eine hohe Eignung für eine Gebäudeerweiterung auf (vgl. S. 4). Gemessen an den drei Kriterien stellt das Pestel-Institut in seiner Deutschland-Studie 2015 fest, dass der Gebäudetyp "Baujahr 1960 bis 1969, drei bis zwölf Wohnungen je Gebäude, alte Bundesländer im nördlichen Teil Deutschlands) mit 198 Quadratmetern Dachfläche im Durchschnitt die beste Grundlage für das vertikale Wachstum bietet.[15] In der übergreifenden Bauperiode 1950 bis 1969 stehen in den neuen Bundesländern durchschnittlich 110 Quadratmeter Dachfläche zu Verfügung, welche als niedrigster Wert in die Gesamtberechnung einbezogen wird. Aus dieser ergibt sich laut der Studie ein Wohnungspotenzial von1.5 Millionen Wohnungen[16] durch Gebäudeaufstockung, wovon 317.000 Wohnungen im Besitz von Wohneigentumsgemeinschaften sind.[17]

Durch die Option der Anpassungsfähigkeit der neu entstehenden Grundrisse kann eine effiziente Nutzung der Wohnfläche sichergestellt werden. Im Zeitalter einer globalen Pandemie blüht das Homeoffice auf, der Bürotisch wird durch die Küchentheke ersetzt, das hauseigene WLAN auf Belastungsspitzen geprüft – diese Adaptivität war in den vergangenen Jahren von Arbeitnehmerinnen und Arbeitnehmern in ihren eigenen vier Wänden gefordert. Vergleicht man den Trend der Telearbeit und die Entwicklung des Wohnflächenbedarfs, ergibt sich eine Parallele: steigende Bedürfnisse benötigen mehr Raum, ergo werden bei aktuellen Bauprojekten mehr Quadratmeter für Single-Haushalte und allgemeine Wohneinheiten veranschlagt. Die Bundesstiftung Baukultur sieht in der räumliche Qualität hingegen keine wechselseitige Beziehung zu dem Flächenausmaß; vielmehr sei ein intelligenter Grundriss und die Anordnung der Möblierung durch erfahrene Innenarchitektinnen und Innenarchitekten ein neuer Lösungsansatz.[18] Dieser wird durch eine Studie im Auftrag der Vereinigung der Bayerischen Wirtschaft (vbw) gestützt, da die Energieeinsparung bei

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[14] ebd., S. 41.

[15] TU Darmstadt und Pestel-Institut (2016a), S. 62.

[16] 75 Quadratmeter pro Wohnung, insgesamt zusätzlich 116 Millionen Quadratmeter Wohnfläche

[17] TU Darmstadt und Pestel-Institut (2016a), S. 63.

[18] Neue Umbaukultur (2023).

Reduzierung der durchschnittlichen Wohnfläche um 15 Prozent auf 40,5 Quadratmeter pro Kopf insgesamt mehr als zehn Megatonnen CO_2-Äquivalent betrage.[19] Daran anknüpfendbesteht durch das vertikale Wachstum die Möglichkeit, Grundrisse des neu zu erschließenden Wohnraums in Abhängigkeit von lokaler Wohnraumnachfrage durch Studierende, Familien oder Wohngemeinschaften adaptiv zu gestalten. Das folgende Fallbeispiel verdeutlicht die effiziente Nutzung der Wohnfläche, die auf einem rechteckigen Bestandsgebäude je nach Bedarf angepasst werden kann.

Wie Wohnraum durch vertikales Wachstum samt Gebäudesanierung behutsam und zugleich bedarfsgerecht erschaffen werden kann, zeigt das mit dem Bauherrenpreis prämierte Projekt von ARCHPLAN. Die Kölner Fordsiedlung liegt inmitten des Grüngürtels der Stadt, die günstige Lage erweist sich durch die Nähe zum Stadtzentrum, dem Rheinufer und mehreren Arbeitsstätten. Die dreigeschossige Zeilentypologie wies in ihrem Bestand aus den 1950er Jahren310 Wohneinheiten mit durchschnittlich 47 Quadratmeter Wohnfläche auf, ehe die Aufstockung der elf Wohnblöcke einen Zuwachs von 6.350 Quadratmeter erzielte. Das wirtschaftliche Ergebnis lässt sich anhand eines 45-prozentigen Wohnflächenzuwachses messen, insgesamt erhielt die Fordsiedlung durch das vertikale Bauen 81 neue Wohneinheiten mit großzügiger geschnittenen und familiengerechteren Grundrissen. Der in Abbildung 5erkennbare Instandhaltungsbedarf wurde mithilfe einer umfassenden Sanierung der Gebäudehülle gelöst. Der Sanierungskatalog enthält vor allem Wärmeschutzmaßnahmen: Dämmung von Außenwänden undGeschossdecken, Einbau moderner Fenster und Türen mit dreifacher Verglasung, Isolierung der bestehenden Gebäudehülle auf KfW60.

Abbildung 5: Bestandsgebäude und Objekt nach Sanierung und Aufstockung im Vergleich.[20]

Die vertikale Erweiterung wurde mithilfe von vorgefertigten Holzbauelementen realisiert, der nachhaltige Baustil wurde im 3-Liter-Standard (KfW 40) durchgeführt. Reduzierte Energiekosten durch Modernisierung des Bestandsgebäudes, Verschönerung und Erweiterung von Freiflächen zwischen den Wohnblöcken, Heterogenität zwischen neuen und alten Bewohnerinnen und Bewohnern – all diese Kernelemente gaben 75 Prozent der langjährigen Mieterinnen und Mietern Anlass, während des Bauprozesses in ihren alten und neuen vier Wänden wohnhaft zu bleiben. Demnach baute das Jury-Urteil des Bauherrenpreises[21] auf den entsprechenden Instrumenten des vertikalen Bauens auf: neuester Energiestandard, aktives Flächensparen, Wohnraumzuwachs, sozioökologische Aufwertung (vgl. Abbildung 1).

5 HERAUSFORDERUNGEN IN DER GESETZGEBUNG

Im Zuge der rechtlichen Thematik gilt es zunächst, die Begrifflichkeiten voneinander abzugrenzen. Denn der Umbau an sich ist von anderen Eingriffen in den Bestand zu differenzieren: Die Wiederherstellung eines früheren Zustands charakterisiert eine Restaurierung, wohingegen durch eine Renovierung lediglich kleinere Mängel ausgebessert werden. In der Verordnung über die Honorare für Architekten- und Ingenieurleistungen (HOAI) ist die Modernisierung als „bauliche Maßnahme zur nachhaltigen Erhöhung des Gebrauchswertes eines Objekts" paraphrasiert. Alle drei Bestandseingriffe sind letztlich von dem vertikalen Wachstum zu unterscheiden: der Umbau in Form von Erweiterungsbauten wird als „Ergänzung eines vorhandenen

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[19] VBW (2020), S. 97.
[20] ARCHPLAN (2011).
[21] GDW et al. (2011), S. 37.

Objekts" definiert. Dabei verändert jener Umbau, der mit „wesentlichen Eingriffen in Konstruktion oder Bestand" einhergeht, auch die räumliche Struktur. Folglich verliert das Objekt seine Identität, da durch die Änderung etwas anderes, ein „aliud", entstanden ist.

In Bezug auf das vertikale Wachstum sieht die aktuelle Genehmigungspraxiseines baulichen Eingriffs wie folgt aus: Beabsichtigt ein Hausbesitzer bzw. eine Besitzerin einen Dachausbau oder eine Aufstockung auf seinem bzw. ihrem Bestandsgebäude zu realisieren, so ist eine Genehmigung bei der zuständigen Baubehörde einzuholen. Die Erteilung jener Baugenehmigung verbinden die Bauämter häufig mit Nachbesserungen im Bestand. Die sogenannten Anpassungsverlangen zielen darauf ab, das nicht nur der geplante Ausbau, sondern auch das übrige Gebäude im Nachhinein auf den neuesten Stand der Technik modernisiert werden soll. Im Umkehrschluss ergeben sich durch die zusätzliche Forderung seitens Bauamt höhere Investitionskosten, die von den Bauwilligen im Zuge der Kostenaufstellung nicht einkalkuliert wurden – sodass die Absicht der Gebäudeerweiterung und somit der Bauantrag zurückgezogen werden. Summiert man die Quadratmeterpreise der wohnraumschaffenden MaßnahmenAufstockung und Vollmodernisierung (vgl. Abbildung 4: 5.010 Euro pro Quadratmeter) und vergleicht diese mit den Baukosten eines Neubaus, wiegt die reine Neuerrichtung ohne Grundstückskosten für Investorinnen und Investoren aus finanzieller Sicht deutlich attraktiver.

Im Zuge der Voraussetzungen im ersten Abschnitt der Instrumente des vertikalen Bauens wurde bereits die Erschließung der neuen Aufstockungsfläche als Hauptgrund für den Wegfall des Bestandsschutzes thematisiert (vgl. S. 3).Je nach Ausprägung des vertikalen Wachstumsentfällt jener Schutz ebenso durch die Änderung der Gebäudeklasse (GK): Überschreitet die Gebäudehöhe im Sinne der Fußbodenoberkante des höchstgelegenen Geschosses durch die Erweiterung beispielsweise den Wert von sieben Meter, so ist fortan das gesamte Objekt der GK4 zuzuordnen. Es gelten dann strengere brandschutztechnische Anforderungen an Geschossdecken sowie Zwischen- und Außenwände. Auch ein Feuerwehreinsatz ist ab diesem Zeitpunkt nicht mehr mit Steckleiter, sondern einer Drehleiter von Nöten. Als Lösungsansatz sieht das BBSR hier die Option, den Bestandsschutz infolge eines Dachausbaus oder einer Dachaufstockung lediglich für bestimme Teilbereiche des bestehenden Objektes entfallen zu lassen;[22] z.B. für das an die Erweiterungsmaßnahme angrenzende Geschoss. Weiterhin sind pro Geschoss zwei unabhängige Rettungswege zu gewährleisten, Fluchtwege über einen befestigten Weg entlang des Daches werden häufig von den örtlichen Feuerwehren als genehmigende Stelle abgelehnt – unabhängig davon, ob die politischen Zielsetzungen der Stadtentwicklung erreicht werden und man sich dabei auf brandschutztechnische Alternativen einlassen müsste.

Neben den drei hervorgehobenen Problematiken in der Rechtsgebung bestehen mit Abstandsflächen (§ 6 MBO), Ausgleichsmaßnahmen bei Überschreitung der Geschossflächenzahl, einer Stellplatz- und Aufzugspflicht weitere Faktoren, welche die Realisierung einer Dachaufstockung im Interesse eines nachhaltigen Städtebaus erschweren oder gar verhindern. Es lässt sich feststellen, dass die aufgezeigten Regelungen allesamt aus der Musterbauordnung stammen und je nach Bundesland gar in einer strengeren Landesbauordnung festgehalten werden.

Einerseits verlangt das Baugesetzbuch eine „städtebauliche Entwicklung vorrangig durch Maßnahmen der Innenentwicklung (§ 1 IV BauGB), verbunden mit einem schonenden und sparsamen Umgang von Grund und Boden, um eine Verringerung der zusätzlichen Inanspruchnahme von Flächen zu erzielen (§ 1a II BauGB). Andererseits legen die Regeln der Landesbauordnungen sowie die Genehmigungspraxis der Bauämter potentiellen Investoren wortwörtlich die Steine in den Weg, um ihren eigenes formulierten, im Gesetzbuch verankerten Zielen näher zu kommen. Dabei besitzen jene Genehmigungsstellen ausreichend Ermessensspielraum, um vor allem in Regionen mit angespannten Wohnungsmärkten mittels vereinfachten Genehmigungsverfahren für Entlastung zu sorgen.

6 DISKUSSION

Während die Baubranche das Potenzial von Bestandsbauten und die Erweiterungsoption derer unlängst erkannt hat, hemmen Gesetzesbücher und Verordnungen die großflächige Anwendung in der Praxis. Welche Schritte sind folglich notwendig, um häufiger Wohnraum dort neu zu erschaffen, wo die Infrastruktur bereits vorhanden ist?

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[22] BBSR (2016), S. 37.

Zu Beginn gilt es, die Bedeutung und auch den Wert des Baubestandes zu schätzen. In diesem Zuge konstatiert die Bundesstiftung Baukultur: "Eine selbstbewusste Auseinandersetzung mit dem Vorhandenen"[23] sei von Nöten, um weg von der Denkweise hoher Betonblöcke in den Agglomerationsgürteln der Stadt, hin zu vereinzelten, mit architektonischer Intelligenz lückenfüllenden Wohnräumen auf solchen Objekten zu errichten, die bereits dem Flächenetat einer Stadt angehören. Dazu ist die bereits thematisierte Vereinfachung von Baugenehmigungen erforderlich, welche unter anderem auch mit politischen Forderungen mehrerer Bauverbände untermalt wurde.[24] Verfolgten im Jahr 2016 oftmals Kommunen „eine explizit auf Nachverdichtung ausgerichtete Stadtentwicklungsstrategie" durch eher großzügig ausgelegte Ermessensentscheidungen[25], so änderten Nordrhein-Westfalen und Bayern ihre Landesbauordnungen im Interesse der Bauherrn: nach § 63 BauO NRW bzw. Art.58 BayBO ist die „Änderung und Nutzungsänderung von Dachgeschossen zu Wohnzwecken einschließlich der Errichtung von Dachgauben" fortan genehmigungsfrei. Als nächste Handlungsanweisung ist es von nun an unabdingbar, eine stärkere Aufklärung über die Voraussetzungen, den Ablauf und die entstehenden Kosteneiner Gebäudeaufstockung zu betreiben. Der eingangs erwähnte Vorreiter bildet hier der Internetauftritt der Stadt Wien, die hiesige „Begutachtung eines Dachausbaus" stellt von Bedingungen über Fristen und Termine, den zuständigen Stellen bis hin zu den erforderlichen Unterlagen alles an Informationen barrierefrei bereit, die ein möglicher Investor bzw. eine Investorin für sein bzw. ihr Vorhaben benötigt.[26] Jener Handlungsleitfaden steht vor allem für die Ursache, warum das Projekt Dachaufstockung in der österreichischen Landeshauptstadt eine hohe Beliebtheit erfährt.

Je nach Wohnungsmarktlage können dann Großstädte genauso wie Kommunen entscheiden, ob die flächenschonenden Wohnbaumaßnahmen über finanzielle Anreize beworben werden. Denkbar sind an dieser Stelle die Forderungen der Bauverbände von 2015, wie sie bereits für den allgemeinen Wohnungsbau übernommen wurden: steuerliche Sonderabschreibungen, Investitionszulagen sowie Förderprogramme (z.B. KfW).[27] Infolgedessen können größerer Wohnungen durch das vertikale Wachstum aufgrund lokaler Nachfragen nachgesteuert werden, die sich beispielsweise durch das Redevelopment Homeoffice ergeben. Neben den drei Funktion im Wohnungsbau ergibt sich für das zeitgemäße Wohnen der Zukunft somit eine vierte Komponente, die in neuzugestaltenden Grundrissen berücksichtigt werden muss.

Die letzte Zutat für eine großflächige Anwendung von nationalen Dachaufstockungen ist die Kooperation zwischen der Bauindustrie und den mit Aufstockungen vertrauten sowie erfahrenen Architekturbüros. Zwar sind die identifizierten Objekte der Baualtersklassen (vgl. S. 4) mit hohem Potenzial für eine Erweiterung individuell und unterschiedlich, jedoch ist, wie am Fallbeispiel der Kölner Fordsiedlung gezeigt (vgl. S. 5),eine industrielle Vorfertigung der aufzustockenden Wohneinheiten auf mehreren Wohnblöcken ein Ansatz, der auf langfristige Perspektive durch eingespielte Produktionsstraßen Baukosten senken und Produktionszeit sparen kann. In diesem Zuge ist auch der Einsatz recycelter Bauteile denkbar.

7 FAZIT

Dachaufstockungen und Dachausbauten können in Zukunft einen Beitrag zur Deckung des nationalen Wohnbedarfs und damit zur Entlastung angespannter Wohnungsmärkte leisten. Sie dienen ebenso als Ventil, behutsames Wachstum bei gleichzeitigem Schutz des Umweltguts Fläche in den Städten zu integrieren. Die Nutzung des hochwertigen Raumes hoch über den Dächern der Stadt darf allerdings nicht zur Luxusplattform werden, woraus die Gefahr der Gentrifizierung und damit verbundenen sozioökonomischen Differenzen in neuaufkommenden Szenevierteln drohen.

Die Maßnahme der Gebäudeerweiterung lässt sich anhand der Instrumente des vertikalen Bauens (vgl. Abbildung 1) von Voraussetzung über Planung bis hin zu den entstehenden Nutzen charakterisieren. Hervorzuheben ist hier die Differenzierung zwischen Bestandssanierung und Gebäudeaufstockung, die vor allem in der Genehmigung jener Baumaßnahme ihre jeweiligen rechtlichen Probleme bergen. Verfällt der Bestandsschutz des Objektes, entstehen durch die Anforderung des neuesten Energiestandards zusätzliche Sanierungskosten. Auch die Änderung der Gebäudeklasse kann aus der anfangs beabsichtigten

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[23] Neue Umbaukultur (2023).
[24] TU Darmstadt und Pestel-Institut (2016b).
[25] BBSR (2016), S. 38.
[26] Stadt Wien (2023).
[27] TU Darmstadt und Pestel-Institut (2016b).

Dachaufstockung eine kostspielige Erweiterung für die Investorin oder den Investor bedeuten. Dennoch sind durch die Novellierung der Bauordnungen in Bayern und Nordrhein-Westfalen genehmigungsfreie Dachausbauten möglich, die schnell und einfach Wohnraum schaffen. Weiterhin kommt es sanierungsbedürftigen Gebäuden wie den Wohnblöcken der Kölner Fordsiedlung zugute, wenn durch eine Gebäudeerweiterung auch der Bestand eine Aufwertung durch Modernisierung erfährt.

Der Bau in die Vertikale stellt zusammenfassend eine nachhaltige Lösung dar, wie die Lücken auf dem Wohnungsmarkt nachhaltig minimiert werden können. Um die vorhandenen Reserven auf den Dächern unseres Gebäudeetats aktiv für neuen Wohnraum zu nutzen, ist eine selbstbewusste Auseinandersetzung mit jenem Bestand unerlässlich; es gilt fortan, das Aufstockungspotenzial zu werben, zu fördern und schließlich die Industrie für eine nachhaltige Serienfertigung mit recyceltem Baumaterial vorzubereiten.

8 LITERATURVERZEICHNIS

ARCHPLAN (Hg.) (2011): Nachhaltiger Wohnungsbau: Fordsiedlung Köln. Werkstatt-Stadt der LEG.

Bundesamt für Bau-, Stadt- und Raumforschung (BBSR) (Hg.) (2014): Innenentwicklungspotenziale in Deutschland. Ergebnisse einer bundesweiten Umfrage und Möglichkeiten einer automatisierten Abschätzung. Bundesamt für Bauwesen und Raumordnung (BBR).

Bundesamt für Bau-, Stadt- und Raumforschung (BBSR) (Hg.) (2016): Potenziale und Rahmenbedingungen von Dachaufstockungen und Dachausbauten. Bundesamt für Bauwesen und Raumordnung (BBR).

Bundesverband deutscher Wohnungs- und Immobilienunternehmen e.V. (GDW); Bund Deutscher Architekten (BDA); Deutscher Städtetag (DST) (2011): Deutscher Bauherrenpreis Modernisierung 2011. Hohe Qualität - Tragbare Kosten.

Neue Umbaukultur (2023). 2. Auflage. Berlin: Bundesstiftung Baukultur (Baukultur Bericht / Hrsg.: Bundesstiftung Baukultur, 2022/2023).

Pestel Institut (Hg.) (2023): Bauen und Wohnen in der Krise. Aktuelle Entwicklungen und Rückwirkungen auf Wohnungsbau und Wohnungsmärkte.

Popelka, Anna (2021): MIN 05:10. In: Sabine Reeh (Hg.): Drunter und Drüber. Wie Städte nachhaltig wachsen können. Unter Mitarbeit von Birgit Eckelt und Frieder Käsmann.

Reinhard, Leonardo (2022): Vertikales Wachstum als Städtebau der Zukunft. Europäische Fallbeispiele.

Stadt Wien (2023): Dachausbau - Begutachtung.

Technische Universität Darmstadt (TU Darmstadt); ISP Eduard Pestel Institut für Systemforschung e.V (Pestel Institut) (Hg.) (2016a): Deutschland-Studie 2015. Wohnraumpotenziale durch Aufstockungen.

Technische Universität Darmstadt (TU Darmstadt); ISP Eduard Pestel Institut für Systemforschung e.V (Pestel Institut) (Hg.) (2016b): Politische Forderungen der Verbände in: Deutschland-Studie 2015. WohnraumPotenziale durch Aufstockungen.

Vereinigung der Bayerischen Wirtschaft e. V. (VBW) (Hg.) (2020): Klima 2030. Nachhaltige Innovationen.

Walberg, Dietmar; Gniechwitz, Timo; Paare, Klaus; Schulze, Thorsten (2022): Wohnungsbau: Die Zukunft des Bestandes. Studie zur aktuellen Bewertung des Wohngebäudebestands in Deutschland und seiner Potenziale, Modernisierungs- und Anpassungsfähigkeit. Kiel: Arbeitsgemeinschaft für zeitgemäßes Bauen (ARGE) (Bauforschungsberichte, 82).

Weitkemper, Uwe (2018): Bauen im Bestand. In: Biener (Hg.): Wendehorst. Bautechnische Zahlentafeln. Wiesbaden: Springer Fachmedien Wiesbaden, S. 989–1031.

BlueGreenStreets – Adapting Urban Streets for Climate Change

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1 ABSTRACT

Strategies for the adaptation of cities to the consequences of climate change such as dry periods, heat waves and urban flooding are needed. As urban streets account for about 25% of the area in inner-city neighbourhoods, they also have to be included. In the project BlueGreenStreets concepts are being developed to increase the resilience of cities by means of blue-green infrastructure in urban streets. The basic philosophy is to develop streets as 'multi-talents', taking into account not only the traffic function but also the requirements of urban drainage and green infrastructure. Concepts for the multidimensional redesign and retrifiting of existing streets in urban neighbourhoods are being developed, and tested in pilot projects. Two innovative solutions "the street as a drain" and "stormwater tree pits" are presented in detail.

Keywords: streets, blue-green infrastructure, cities, climate change, urban neighbourhoods

2 CLIMATE ADAPTATION OF URBAN STREETS

Urban citizens and greenspaces are suffering the consequences of climate change. There is a growing number of heavy rainfall events exceeding the design capacity of the urban drainage systems, resulting in urban flooding. The consequences of climate change also include the increased occurrence of urban heat islands and prolonged dry periods. Thus, the vitality of urban greenspaces and especially street trees is affected by the drought periods. These already existing challenges are expected to intensify in the near future as climate change progresses. Solutions for the adaptation of cities to the consequences of climate change are required. There is the need to adapt urban streets to these challenges, which account for about 25% of the area in inner-city neighbourhoods. Conflicts of use are particularly prevalent in street spaces, as there are spatial demands from many users and there is limited space. In dense cities, the street space is one of the large reserves of space for the provision of open space and the qualification of the quality of stay in the residential and living environment of the residents. Accordingly, there will be a demand in the future to develop the street space as a 'multi-talents' to create a win-win situation that promotes environmentally friendly transport, traffic calming climate adaptation and quality of life. Within the framework of the R&D project BlueGreenStreets (BGS) pilot projects and tangible solutions to multifunctional climate-adapted streetscape design are tested and the results summarised as guidelines for practitieners (BlueGreenStreets 2022). In addition in-depth research on technical design and effectiveness of blue-green elements in streetscapes is conducted.

3 MULTIDIMENSIONAL STREETS

Initial approaches for water-sensitive, multifunctional streetscape design have been discussed in various publications (Benden 2014; Klimakvarter 2013; Dörr & Schöning 2014; ReStra 2014 and Deutscher Städtetag 2015) as well as in R&D projects such as MURIEL, KURAS, SAMUWA and RISA. These publications from the field of urban water management stress the increasing importance of land use and in particular street space for the adaptation to climate change In a white paper on urban green (BMUB 2017), the strategies of multi purpose, water-sensitive and heat-adapted urban space is presented, but remain very general. Bridging the disciplines between urban water management, landscape design and traffic planning has been attempted sporadically with Benden 2014 and Eckart & Blaszczyk 2017 but is still predominantly at the conceptual level and has not yet reached the level of detail required for the practical design of streets. Solutions for water-sensitive streetscape design, adapting to heavy rainfall events and droughts, discussed in the field of urban water management have not yet been taken up in the design of streets. Also heat-sensitive street design with potentials for evaporation, cooling and shading have not yet played a role in practice. So far, there is a lack of tangible approaches on how a climate adaptive street design could function. This gap was addressed by the R&D project BlueGreenStreets which developed concepts to increase the resilience of cities by means of blue-green infrastructure in urban streets. The basic philosophy is to develop streets as

'multi-talents', taking into account not only the traffic function but also the requirements of urban drainage and green infrastructure.

In Germany, the concept of decentralised rainwater management has been established since the 1990s, which aims at surface retention, storage, evaporation, infiltration and delayed discharge of rainwater. Decentralised rainwater management uses an established repertoire of solutions such as water-permeable pavements, infiltration swales, trough infiltration, trough-rigole systems etc. The strategy of BlueGreenStreets builds on these concepts of decentralized rainwater management, but adds new perspectives:

- Overall planning of flow path: Decentralized rainwater management was based on a small-scale "parcel principle" draining single properties, which no longer meets the challenges of flood protection during heavy precipitation. The decentralised rainwater management is expanded to include an overall planning of the flow paths for heavy precipitation and urban flooding, taking into account streets, playgrounds and sports fields as well as open spaces (Kruse 2015).

- Multipurpose land use: For climate adaptation of urban streets, it is not longer sufficient to add up the different space demands of pedestrians, cyclists, parking flowing car traffic, street trees, rainwater management etc. as in many existing streets not sufficient space is available. Rather streets design are required, which combined the different functions of streets at the same space. For example, areas that primarily serve another main use such as the roadway or parking spaces can temporarely be used specifically as retention space or flow paths for a short time during heavy precipitation.

- Balancing water and micro climate: The elements of BlueGreenStreets aim to restore all dimensions of the natural water balance and micro climate. Thus, in addition to reducing runoff and favouring infiltration, also retention, evaporation as well as the harvesting and use of rainwater are considered. BlueGreenStreets are thus simultaneously the solution to both heat and flooding problems by integrating planting into stormwater management. In addition, the use of rainwater becomes more important for dealing with drought events and evaporation becomes more important to reduce local heat islands.

- Integrated planning: In BlueGreenStreets, different interests such as traffic safety, underground infrastructures, rainwater management, parking management, biodiversity, micro climate and human well-being come together. Through innovative approaches to the design and integration of these demands in urban streets, the vitality of the street green can be improved, water management and urban climate concerns be addressed and valuable ecosystem services can be preserved and improved. In order to realise the possibilities of multidimensional design of urban streets there is the need to overcome the inherent logics of subject-specific planning. The cooperation between different disciplines such as urban water management, urban planning, landscape planning and traffic planning is required.

Within the framework of the project BlueGreenStreets, concepts for the multipurpose redesign and retrofiting of existing streets in urban neighbourhoods are being developed, and tested in pilot projects. The results are compiled in a toolbox as a practice-oriented guideline (BlueGreenStreets 2022). The tried and tested solutions of decentralised rainwater management continue to be suitable for the collection, retention, infiltration and evaporation of rainwater of urban streets. This includes elements such as water-permeable pavements, infiltration swale, trough infiltration, trough-rigole systems, street trees greened central reservations, green walls and green facades (compare figure 1). However, BlueGreenStreet design also requires solutions that have so far been used less frequently in practice, such as the use of streets for the temporary drainage of heavy rainfall events or stormwater tree pits . These two innovative solutions are described in more detail below.
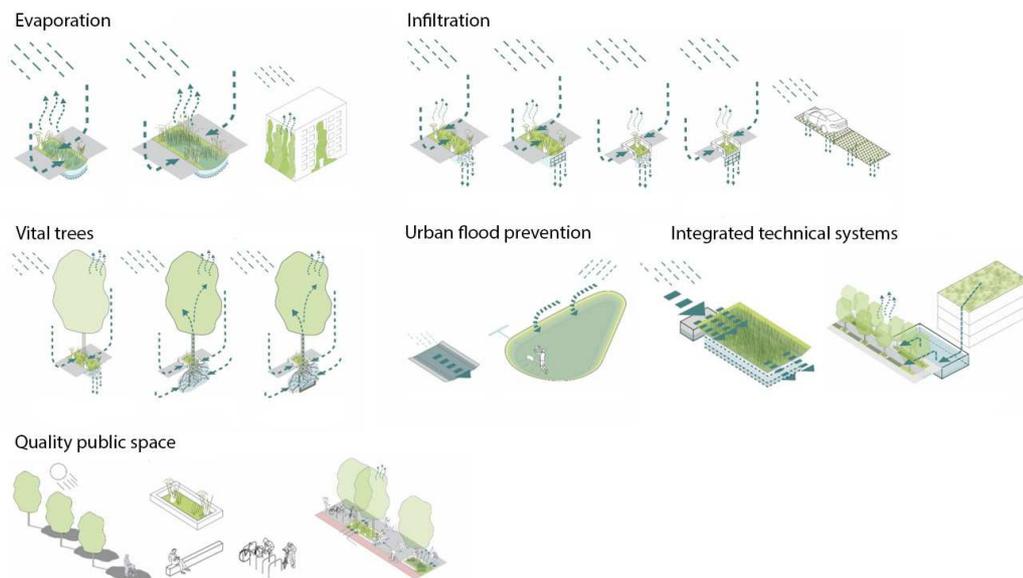
Fig. 1: Extract of the BlueGreenStreets toolbox with green infrastructur for the redesign of urban streets (BGS, bgmr Landschaftsarchitekten GmbH)

4 THE STREET AS A DRAIN

As a result of climate change, in the future heavy rainfall events will increasingly exceed the design capacity of urban drainage systems. The runoff will flow on the surface following the topography often using urban streets as the "natural" flow paths in urban settings. As result there is the danger, that urban flooding events will impact urban land uses worthy of protection. Increasing the capacity of the urban drainage infrastructure is not a realistic solution for many municipalities because of ecological and economical considerations. Up to now, mainly technical retention basins of various types have been used to manage the impact of heavy rainfall events. A new strategy to reduce flood damage in urban streets is the multidimensional use of streets for controlled temporary emergency drainage and retention of heavy rainfall (Benden 2014, Valée and Benden 2010, Günthert and Faltermaier 2016). In other words, the street is temporary used as a drain. The strategy of planned joint use of traffic areas for controlled temporary emergency drainage and retention of heavy rainfall events is being analysed in the R&D project BlueGreenStreets.

For the strategy of the street as a drain, the obligation to ensure road safety must be observed. The costs due to possible detours or accidents should be lower than the benefits of avoided damage costs from flooding. Based on an analysis of accidents during heavy rainfall events in the cities of Bretten, Karlsruhe, Solingen and Hamburg as well as video-based traffic conflict analyses a framework for the safe design of the street as a drain are identified.

- If the vehicle fording depth of passenger cars of usually 30 cm (Kramer et al. 2015) is exceeded, the cars are damaged due to the penetration of water into the engine. The traffic conflict analysis of flooded roadways shows that from water depths of more than 20 cm (plus the wave impact of the vehicles), there is a significant increase in such single-vehicle accidents (Mettmann et al. 2016). In addition the danger of slipping of pedestrians increases at water levels above 20 cm (Shu et al. 2011). Safe driving and walking on flooded roadways is therefore possible at water levels of up to 15 to 20 cm. If the water level exceeds this, the roadways must be closed.

- Depending on the water level and tyre profile, aquaplaning of cars can occur at speeds above 60 km/h (Reed et al. 1984). In order to avoid these dangers, the temporary retention of rainwater in roads with a maximum permitted speed of over 50 km/h should be avoided. The analysis of the speed driven on flooded road sections shows that most road users drive at a maximum of 30km/h (Mettmann et al. 2016). Road users thus compensate for the adverse road conditions by reducing their speed appropriately for the situation (Kyte et al. 2000). Also the accident analysis does not show more accidents on urban streets during heavy rainfall events. Hence the strategy of the street as a drain is suitable for urban streets with a maximum permitted speed of 50 km/h or even better 30 km/h.

- In order for drivers to be able to react to the flooded roadway, sufficient visibility for stopping and space for possible manoeuvres is required (Mettmann et al 2016). The road section should also not have any obstacles that are covered by water on the roadway and are not visible to road users.

Taking into account the information on road safety, concepts for the design of "streets as a drain" can be developed. In most cases, simple structural adjustments to the road profile are sufficient. High curbs, generously dimensioned gutter systems or sills are suitable for directing rainwater and keeping it away from land uses worthy of protection. The flow cross-section and retention volume of a "street as a drain" is defined by the height of the lowest trailing edge of the pavement. The retention volume of the road space can be increased by using centre channels (V-profile of the roadway) and increasing the cross slope. Swales or depressions in the road gradient should be avoided. In addition, an emergency overflow is to be provided to areas, where the flooding does not cause any damage.

The possibility of the street as a drain was investigated in BlueGreenStreets as part of a pilot project in Solingen. The goal for pilot project was to design it multifunctionally street, combining the temporary retention of rainwater on the street with the provision of additional green infrastructure in the street. The reduction of the maximum permitted speed from 50 km/h to 30 km/h allows for a reduction of the roadway width and the large intersections can be reduced. Together with a reorganisation of the parking cars, space can be provided for the design of infiltration ditches combined with trees. In addition, the profile of the roadway is redesigned in a V-shape, so that can be retained during heavy rainfall events.

5 STORMWATER TREE PITS

The vitality of the street green can be improved through innovative approaches for the design and integration of multifunctional green spaces in the streetscape. Street trees play an important role in multifunctional streetscape design. They provide a whole range of ecosystem services to the urban environment, such as reducing the urban heat island effect, filtering air pollutants, increasing urban biodiversity and having positive effects on the quality of stay. In addition, trees have important influences on urban stormwater management. They reduce stormwater runoff and soil erosion through direct retention on or wetting of leaves and branches with water (interception), drainage of water through trunk (stem runoff), and infiltration through the soil (Elliott et al. 2018). Additionally, substrates filter pollutants from stormwater before it infiltrates into groundwater (CRWSA 2009). However, urban and especially street trees often face more difficult site conditions due to various environmental factors. According to Embrén et al. (2009), the most common problems for the development of urban tree populations include lack of space (root zone), lack of oxygen, and lack of water. Drought stress, in particular, is already causing loss of vitality today. Climate change may lead to increased mortality of street trees due to an increase in extreme events (Savi et al. 2015). One possible solution is to identify tree species that can cope well with urban stresses, including heat and water shortage. Another approach is to modify tree locations and conditions to increase the vitality of urban street trees. Adapting planting sites to meet the needs of urban trees can be done primarily through the design of the planting pit and/or the composition and layering of planting substrates. Combining street trees with stormwater management measures can, in some circumstances, both increase tree vitality and reduce flooding risk by directing stormwater into tree pits (Grey et al. 2018). In terms of technical feasibility, there are several options for combining decentralized stormwater management and tree pits. Two systems have become established, so-called box or cell systems and structural soils. In Europe, the "Stockholm model", a structural soil with a coarse soil content of > 100 mm grain size, is established in several countries (f.e. Sweden, Austria, Switzerland, Denmark).

The suitability of different systems in urban locations depends on different environmental factors and objectives. The origin of the rainwater (e.g. street or roof water) plays a decisive role for the possible unproblematic use from the point of view of tree vitality and groundwater protection. The substrates or planting systems used must provide sufficient air and water storage capacity (pore distribution and volume). In addition, compaction must not occur, which is ensured by either structural soil substrates or cellular systems.

In the BGS project, different stormwater tree pit systems were planned, built and evaluated. In order to make statements on the functionality with regard to rainwater infiltration and tree vitality, monitoring of the water (level, water content and water tension) and soil air (O_2, CO_{22}) balance is carried out in the pilot projects. Long-term results demonstrating improved tree vitality in such elements or effectiveness as a stormwater

982

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management measure, especially during heavy rain events, are not currently available. In the long term, the diversity of the pilot projects in terms of substrates and technical/structural elements should help to close the gaps in knowledge regarding water and oxygen supply to tree roots. In addition, the interrelationships between the discharge of additional rainwater from traffic and/or roof areas and the vitality of the trees planted in them will be investigated by measurements. In 2020 and 2021, different types of tree pits with and without underground water storage were built in Hamburg. The structurally similar types in Hölertwiete in Hamburg-Harburg and Am Beckerkamp in Hamburg-Bergedorf are supplied with rainwater from the roof or the street (Fig. 1). To store more water for dry periods, underground water reservoirs were built and their functionality is tested.
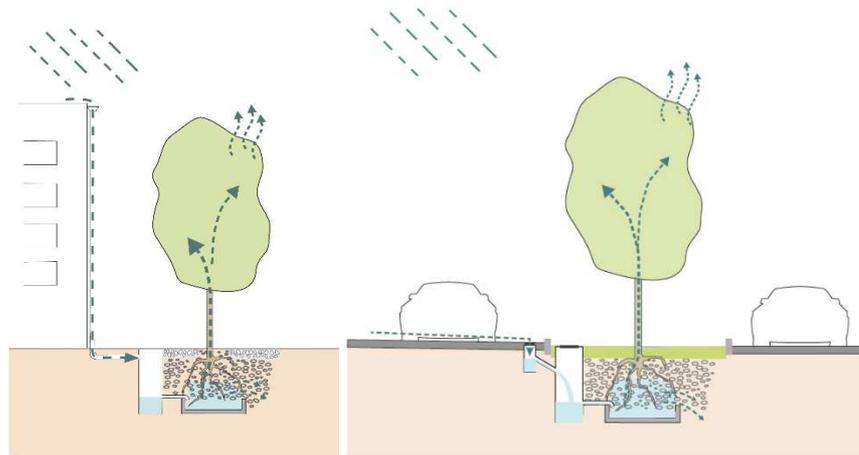
Fig. 2: Stormwater tree pits in Hamburg-Harburg (left) and Hamburg-Bergedorf (right) with underground storage elements and drainage from roofs and streets (© HCU, BGS).

The construction methods of the pilot sites differ in terms of substrates, waterproofing and drainage areas. In the Hamburg-Harburg, 2 tree pits (+ 2 reference tree pits without additional stormwater drainage) were constructed with underground bentonite waterproofing, conventional tree substrate (after FLL 2010) and an underground supply of stormwater from roof areas (Fig. 1). The tree infiltration trenches Hamburg-Bergedorf (3 + 3 reference sites) have a similar design, but are supplied from street stormwater and have a substrate mix based on the Stockholm model.

The tree pit systems showed high water management effectiveness during the first years of operation. At the site in Hamburg-Harburg, for example, < 10% of the stormwater runoff from the roof areas was discharged to the sewer system via the emergency overflow. Waterlogging, which could affect tree roots as a result of heavy rain, was effectively prevented by lateral infiltration of excess water. The stormwater tree pits and reference tree pits showed little difference in dynamics of water contents and tensions, O_2 and CO_2 contents at different depths in the first two years (2020 & 2021), as rooting to areas > 40 cm was probably not yet achieved. In deeper areas > 70 cm, desiccation hardly occurred and, accordingly, relatively low O_2 contents prevailed in stormwater and reference tree pits. The vitality parameters stomatal conductance, leaf chlorophyll content, and leaf chlorophyll fluorescence also showed no significant differences between stormwater tree pits and references in the first two stand years. However, in the third growing season, a difference in rooting depth became apparent, possibly due to the summer drought. At the tree trench sites, several parameters indicate deeper rooting in 2022, which may indicate more effective water supply from the water storage elements. Further monitoring over as many years as possible will probably highlight the differences between stormwater tree pits and references and describe the possible effects of the increased water supply for the trees.

6 CONCLUSIONS AND MANUAL

It still seems largely unclear how trees will react in the long term to the targeted infiltration of rainwater in stormwater tree pits and how much water will be available to the trees, especially during dry periods. Technical options such as additional storage elements are currently being investigated to hold water for dry periods and make it available to the trees. Currently, there are no technical standards for such tree-rainwater systems, which makes it difficult to implement in day-to-day planning outside of pilot projects. Further categorization or standardization of built systems may be another step toward technical codest. Additional

research into the effects of different systems on the urban (soil) water balance and flood and heat prevention is just as essential as gaining knowledge about the long-term effect on the vitality of different tree species.

The strategy "street as a drain" seems to be a promising solution to reduce the risk of urban flooding caused by heavy percipitation events. The minor impairment of traffic safety through flooded streets could be offset by the reduction of damages caused by urban floods. Cost estimates indicate, that the cost for designing streets as a drain are much lower than the costs for adapting the urban drainage infrastructure to increasing rainfall events. Further questions on the operation and maintenance of streets as a drain have to be investigated pilot projects. The above mentioned requirements for the traffic safety on flooded streets can help to design and implement such pilot projects.

In the BlueGreenStreets project, a guideline "BlueGreenStreets toolbox" (BGS 2022) was created from the experience gained in pilot projects with the planning and implementation of blue-green elements in streets. It presents the current state of knowledge on such elements and is intended to contribute to the integration of water-sensitive design in planning. In the ongoing second phase of the project this guideline will be tested and evaluated in new pilot projects. Goal is the transfer of the results to practice.

7 REFERENCES

Benden J (2014) Möglichkeiten und Grenzen einer Mitbenutzung von Verkehrsflächen, Promotion RWTH Aachen.

BlueGreenStreets (Hrsg.) (2022): BlueGreenStreets Toolbox – Teil A. Multifunktionale Straßenraumgestaltung urbaner Quartiere, März 2022, Hamburg. Erstellt im Rahmen der BMBF-Fördermaßnahme „Ressourceneffiziente Stadtquartiere für die Zukunft" (RES:Z)

BlueGreenStreets (Hrsg.) (2022): BlueGreenStreets Toolbox – Teil B. Multifunktionale Straßenraumgestaltung urbaner Quartiere, März 2022, Hamburg. Erstellt im Rahmen der BMBF-Fördermaßnahme „Ressourceneffiziente Stadtquartiere für die Zukunft" (RES:Z).

Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB)(Hrsg.)(2017): Grün in der Stadt – Für eine lebenswerte Zukunft – Weißbuch Stadtgrün. 52 S.

Charles River Watershed Stormwater Association (CRWSA)(2009) Stormwater, Trees, and the Urban Environment: A Comparative Analysis of Conventional Street Tree Pits and Stormwater Tree Pits for Stormwater Management in Ultra Urban Environments.

Deutscher Städtetag (Hrsg.)(2015): Hochwasservorsorge und Hochwasserrisikomanagement - Positionspapier des Deutschen Städtetages. Deutscher Städtetag Berlin und Köln.

Dörr A, Schöning F (2014) Die "wasserwirtschaftlichen Aufgaben" einer Straße - Beitrag der Straßenentwässerung bei Starkregen und urbanen Sturzfluten, in: Straße und Autobahn 65/4

Eckart, J., Blaszczyk, R., (2017) Auswirkungen der temporären Rückhaltung und Ableitung von Starkniederschlägen auf Straßen auf die Verkehrssicherheit, Tagungsband DWA Landesverbandstagung 2017 Baden-Württemberg

Elliott, R. M., Adkins, E. R., Culligan, P. J. and Palmer, M. I. (2018) Stormwater infiltration capacity of street tree pits: Quantifying the influence of different design and management strategies in New York City, Ecological Engineering, vol. 111, pp. 157–166.

Embrén, B.; Alvem, B. M.; Stål, A.; Orvesten, A. (2009) Planting beds in the city of Stockholm. A Handbook.

FLL - Research Society Landscape Development Landscaping (2010) Recommendations for tree planting - Part 2: Site preparation for new plantings; planting pits and root zone expansion, construction methods and substrates. 2nd ed., 64 p.

Günthert W. und Faltermaier S. (2016) Studie Niederschlagswasser Anpassung der quantitativen Niederschlagswasserbeseitigung an den Klimawandel -Urbane Sturzfluten- Hintergründe – Risiken – Vorsorgemaßnahmen

Grey, V., Livesley, S. J., Fletcher, T. D. and Szota, C. (2018) Establishing street trees in stormwater control measures can double tree growth when extended waterlogging is avoided, Landscape and Urban Planning, vol. 178, pp. 122–129.

Klimakvarter (2013): Copenhagen Climate Resilient Neighbourhood.

Kramer M., Terheiden K., Wieprecht S. (2015) Safety criteria for the traffic ability of inundated roads in urban floodings, International Journal of Disaster Risk Reduction

Kruse, Elke (2015) Integriertes Regenwassermanagement für den wassersensiblen Umbau von Städten. Großräumige Gestaltungsstrategien, Planungsinstrumente und Arbeitsschritte für die Qualifizierung innerstädtischer Bestandsquartiere. https://repos.hcu-hamburg.de/handle/hcu/423

Kyte, Khatib, Shannon, and Kitchener (2000) Effect of Environmental Factors on Free-Flow Speed

Mettmann K., Müller M., Wieschhörster J., Lorenz J. (2016) Starkregensensible Straßenräume, Seminararbeit Hochschule Karlsruhe WiSe 2016/17

Reed, J. R., Kibler, D. F., Huebner, R. S., & Marks, G. W. (1984). Hydrop user's manual: program for predicting hydroplaning potential on road surfaces due to rainfall runoff depths.

ReStra (2014): Hamburger Regelwerke für Planung und Entwurf von Stadtstraßen.

Savi, T., Bertuzzi, S., Branca, S., Tretiach, M., Nardini, A. (2015) Drought-induced xylem cavitation and hydraulic deterioration: risk factors for urban trees under climate change? The New Phytologist, vol. 205 (3), pp. 1106-1116.

Shu C., Xia J., Falconer R. & Lin B. (2011) Incipient velocity for partially submerged vehicles in floodwaters, Journal of Hydraulic Research, 49:6

Valée D. und Benden J. (2010). Städtebauliche Anpassung an Starkregenereignisse durch multifunktionale Flächennutzung – Beispiele aus den Niederlanden. Schriftenreihe Gewässerschutz – Wasser – Abwasser der RWTH Aachen, Band 220, S. 6-1 bis 6-15. ISSN 0342- 6068.

984

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Building Land Register – an Important Step towards Effective Space Management

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1 ABSTRACT

Space is a limited natural resource that is subject to many pressures, such as the expansion of building land to agricultural land, whereas building land within settlements often remains vacant and unused. The reasons for this are the many constraints to the development of these areas, such as inadequate plots and ownership structures, inadequate communal infrastructure, or the dilapidation of this infrastructure, which needs to be renovated (MES PILOT, 2022).

Currently, there is no adequate register of building land and its properties in Slovenia, which would provide insights into the current state of the land and provide a basis for the implementation of land policy instruments. As a result, spatial planning is not in line with the principles of sustainability as defined in the Slovenian spatial planning legislation; that is, the treatment of space as a limited good that requires comprehensive treatment, coordination, and management of its social, environmental, and economic aspects (Spatial Planning Act - ZUreP-3). The lack of data is reflected in the reckless direction of settlement and placement of investments, whithout taking into account the possible acitvation of empty building land, possibility of revitalisation of brownfields, and without foreseeing possible negative impact on the living and natural environment.

In response to the described problem of urban management in the country, the idea of creating a systematically regulated spatial data record, called The Building land Register, was developed. The Building land Register contains data on the existing state of built-up land and vacant building land. Based on the properties of the land, it will be possible to determine the presence of degradation of the built-up land; therefore it will be possible to identify areas where, by activating the already occupied space, its functionality would be restored. According to their characteristics, vacant building land is classified into land development phases, which define the possibility of actual land construction. Spatial planing Act (ZUreP-3) defines five cetegories of land development phases: 1 – unbuildable land, 2 – spatially disordered land, 3 – building land without urban ifrastructure provided, 4 – unorganized buildable land and 5 – buildable land. In order to classify land into these five categories, it is necessary to know the current state of communal infrastructure, planned spatial development, and limitations in space (ZUreP-3, explanation to Article 142.)

Establishing Building land Register is the first step in effective urban management at all levels (local, regional, and national). To achieve this goal, collaboration of all levels of urban management is necessary, in addition to providing high-quality data about the building land.

This article states the reasons for the establishment of the Building land Register, the importance of data in the management processes of space, the content of the Building land Register and the method of its establishment provided for in the Slovenian spatial legislation.

Keywords: development phases of vacant building land, actual use of built-up land, building land register, land policy, urban management

2 CIRCUMSTANCES AND REASONS FOR IDEA OF BUILDING LAND REGISTER

All users of the space usually ask themselves similar questions. What does it offer us, where can we build, what can we build, and what are the costs of planned investments? Where should the development of settlements and activities be directed? Spatial planners and investors want to establish a safe and stable environment for work and living. To achieve this, a targeted development of activities is necessary, which requires knowledge of the situation in the area. Sustainable spatial management needs to be based on legally backed data that enable different stakeholders to make decisions that facilitate the focused, harmonized, and rational use of space. Credible data play an important role in spatial and urban policy planning, implementation of land policies, and real estate valuation.

Spatial planning is the responsibility of municipalities in Slovenia. Municipalities are autonomous administrative territorial systems that operate relatively independently of the state. Self-governing local communities are independent in decision-making and implementation within their original powers, and must act in accordance with law (Tasks of municipalities, 2023). The main tasks of municipalities in space

management are spatial planning, planning communal infrastrucure, determining the actual use of land, managing land in the public interest, and implementing land policy measures. On the other hand, the state determines the goals of spatial development; determines the starting points, rules, and guidelines; and implements spatial measures and land policy tasks at the state level (Spatial planing act – ZureP-3). At the same time, by performing tasks related to the operation of the spatial information system and monitoring the state of spatial development, tries to follow the trends of the digitalization of space and related data.

For municipalities and the state to carry out their tasks in a high-quality way and manage land efficiently, it is necessary to understand the situation in the area. Information is needed on the fund of already used building land on the one hand and the fund of vacant building land on the other hand. It is necessary to know the properties of building land and the necessary inputs for the development of these lands to achieve their suitability for planning purposes.

A already mentioned, there is no adequate register of building land and its properties in Slovenija, which would provide insights into the current state of the land and provide a basis for the implementation of land policy instruments. As a result, spatial planning is not in line with the principles of sustainability as defined in the Slovenian spatial planning legislation; that is, the treatment of space as a limited good that requires comprehensive treatment, coordination, and management of its social, environmental, and economic aspects (Spatial Planning Act - ZUreP-3). The lack of data reflects on poor spatial planning, the reckless direction of settlement and placement of investments, whithout taking into account the possible acitvation of empty building land, possibility of rehabilitating brownfields, and without foreseeing possible negative impacts on the living and natural environment.

2.1 From idea to implementation

In response to the described problem of urban management in the country, the idea of creating a systematically regulated spatial data record, called The Building land Register, was developed. The first step from idea to implementation began at the national level, within the framework of the eProstor project program, under the common slogan "one space for all". The project was led by Surveying and Mapping Authority of the Republic of Slovenia and Spatial Planning, Construction and Housing Directorate under the Ministry of Natural Resources and Spatial Planning in the years of 2016 to 2022. The basic purpose was to increase transparency and efficiency in spatial planning, construction, and real estate management for local and state governments. At the same time, the goal was to make it easier for individuals, engineers, designers, and domestic and foreign investors to edit real estate documents and to have better and more transparent access to standardized spatial data collections. With this aim, the activities were carried out to cut red tape and allow paperless e-commerce in public sector, private sector, and public administration resulting in easily accessible official data on real estate and space (One space for all. Brochure, 2019). Under the Spatial Planning Act, Slovenia introduced the establishment of a digital environment in the fields of spatial planning, building construction, and real estate registration into its legal system. This regulates the operation of the spatial information system, within which, among other things, data on the Building land Register is managed. The Building Land Register is intended to serve as a multi-purpose database containing data on built-up land and vacant building land and providing information on development stages and other features of building plots. The records of building land retain data regarding: land area, land characteristics, connection with real estate an other information required for record-keeping (Building land register, Spatial information system, 2023).

Reliable data on built-up land is a prerequisite for the determination of vacant building land. As part of the project of mass capture of inhabited land, a record of the actual use of inhabited land was established in which data on the types of more detailed actual use of inhabited land were kept. Data on the actual use of built-up land were entered into the land cadastre of real estate and are publicly available (Recordes of the actual use of inhabited land. Spatial information system. 2023).

Spatial data on the actual use of built-up land hdad been captured for all municipalities in Slovenija, which was the first step toward creating a building land register made by the government. The second is to identify vacant building land and its characteristics. This is the part that is supposed to be taken by municipalities until the end of the year 2026. Since it is a completely new field of work, a methodology was created for the purpose of implementation to support municipalities in their work. The document describes in detail the key steps in the process of establishing an Building land Register, and it was created based on a pilot

implementation of the establishment of an Buliding land Register in which the municipality of Kranj actively participated. The task was carried out by the Geodetic Institute of Slovenia as part of the large-scale Pilot MOP project, which was led by the Ministry of Natural Resources and Space. The main purpose of the Pilot MOP was to establish the conditions for the successful implementation of many innovations introduced by the current spatial and construction legislation in the field of spatial and real estate management and to establish better cooperation between the state and local communities as carriers of spatial planning (MES PILOT, 2022).

Fig. 1: Records of the actual use of inhabited land (Insights into the building land records, 2023).

3 DATA CONTAINED IN BUILDING LAND REGISTER

As mentioned before, the Building land Register contains data on built-up land (Chapter 3.1) and vacant building land (Chapter 3.2). It provides information on the development stages and other features of building plots (Figure 2).

3.1 Built-up land

Built-up land consists of land of public road and railway infrastructure, inhabited land and construction plots.

For existing buildings, built-up land was determined using mass capture of data. Built-up land includes the area that a facility uses for its operation in nature. Built-up land is determined on the basis of data on the actual state of nature with man made and natural boundaries, the condition of registered real estate and ist ownership and the intended use of space in accordance with the provisions of spatial planning acts. For each piece of land, its actual use was also determined (Methodology for mass capture of inhabited land, 2019). The types of more detailed actual land use are taken from the Decree on Actual Land Use (Official Gazette of the Republic of Slovenia, nos. 43/18 and 35/19) and is kept in the land cadastre. Figure 3 shows an example of determining the area of inhabited land for residential and agricultural buildings.

Fig. 2: Data contained in Building land Register (Image material of the project MES PILOT 2022).

Fig. 3: Example of determining the area of inhabited land (Image material of the project MES PILOT 2022).

Building plot represents the land utilized by regular use of the building. By the new legislation it is obligatory to identify the building plot for new buildings, which is usually recorded as a single land parcel with arranged plot boundaries. By recording it in the Building land Register, the building plot represents an instrument for maintaining data on built-up land. By accurately recording real rights and restrictions on the plot, the building plot represents an instrument of spatial planning that connects real estate evidence with other spatial data (Spatial planning act – ZureP-3).

988

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In addition, in the future, data will be kept for areas of built-up land on the possible devaluation of the space. Like many other countries around the world, Slovenia faces brownfields. Brownfields are degraded areas that have lower value due to inappropriate use or lack of settlements and can have a negative impact on the environment, society, economy or the visual image of the space. The areas are built and often equipped with communal infrastructure, but do not fully fulfill their original function (Methodology of derelict areas. MES PILOT, 2022). The basis for the determination of devalued areas as part of the Building land Register is the data of derelict land, which were obtained in the framework of the target research project entitled Comprehensive methodology for the inventory and analysis of abandoned land, the implementation of a pilot inventory and the establishment of an up-to-date register (Lampič et al., 2017). To direct the development of these areas, it is necessary to determine their quantity and characteristics. By recording in the systematically regulated spatial data record Building land Register, the possibility of activating the brownfield becomes more perspective.

Fig. 4: Example of Brownfield - An area that is built but does not fulfill its original function (Author: Barbara Lampič).

3.2 Vacant building land

Slovenian spatial legislation defines vacant building land as a plot or several plots or their parts, which are intended for the construction of buildings by the Municipal Spatial Implementation Act and are not built-up land. Spatial planning Act (ZUreP-3) defines five categories of land development phases: 1 – unbuildable land, 2 – spatially disordered land, 3 – building land without urban ifrastructure provided, 4 – unorganized buildable land and 5 – buildable land. In order to classify land into these five categories, it is necessary to know the current state of communal infrastructure, planned spatial development, and limitations in space (ZUreP-3, explanation to Article 142.)

Fig. 5: An example of vacant building land, which is classified into one of five categories of land development phases, depending on the current state of communal infrastructure, the planned spatial development and the limitations in the space (Image material of the project MES PILOT 2022 and Insights into the building land records, 2023).

It should be noted that the level of the development phase does not determine whether construction is permissible or not, but rather, based on the collected data on the space, an assessment is given of the stage of

development the land is in, according to its construction purpose. The fact that a piece of land is classified as building land does not mean that it can be built on; many other parameters affect the buildability of the land, in particular, the provision of communal infrastructure, compliance with the regulations of the spatial act, and the possible existence of space restrictions, which are thus determined for the purpose of preserving nature, protecting cultural heritage, protecting the environment, protecting agricultural land, protecting forests, water management, protecting human health, defending the country, protecting against natural and other disasters, and protecting economic and public infrastructure.

The important information provided by the Building land Register is not only the development levels determined for individual plots of land. An essential contribution of the record is all data on the condition of the space, collected accurately per plot. Such a detailed identification of the condition of the land provides a basis for decision-making in all spatial planning processes, from planning, equipping, building, and using the public space to the maintenance and renovation of its components at all levels of operation – local, regional, and national.

Qualitative and legally valid data will be the basis for the valuation of building land. Through the process of development, undeveloped building land gains in value. First, appropriate spatial acts are prepared for them, which define the possibility of construction. Subsequently, subdivision procedures are carried out, and if necessary, consolidation procedures are carried out to create a structure of building land that enables the spatial arrangements foreseen by the spatial act. In each step, certain resources are invested in the land, which increases its value. For land to be suitable for construction, it is necessary to provide it with communal infrastructure, which is the highest investment in land in the process of its development to the level of buildable land. This also increased the value of the land to the greatest extent. However, buyers and sellers currently do not have detailed, publicly available information, as Building land register will provide. This situation is reflected in the sale prices of real estate, as the data show that the price of building land does not follow the actual value of the land or does not increase in the same proportion as the value of land. It is assumed that high-quality and legally formally supported data provided by the Building land Register will be the basis for the regulation of current prices in the real estate market, which will be a reflection of the actual value of land and at the same time, a measure for the valuation of land and duties related to it, which, taking into account quality data, will be allocated more fairly.

4 BUILDING LAND REGISTER ESTABLISHMENT PROCESS

Establishing a building-land register involves several phases (Chapter 3.2). Currently, the first phase has been completed, wherein a proposal for inhabited land and its actual use have been prepared as part of the mass capture of inhabited land. As previously mentioned, the proposal for inhabited land was prepared by the Ministry of Natural Resources and Spatial Planning. Municipalities are taking over data management now. They have to determine the amended proposal for inhabited land and the proposal for vacant building land. To determine the amended proposal for inhabited land, the municipality will use data from the proposal for inhabited land, which is the result of mass data collection, data on building plots, data on associated land of public roads and public railway infrastructure, and other data on built-up land. Data on degraded areas will be also considered when determining the final proposal for the extent and characteristics of build-up land. After this activity, they will identify vacant building lands and their characteristics. It is an extensive and complex process in which it will be necessary to use a multitude of datasets to determine the properties of individual lands. In their work, municipalities will use at least data on real estate cadastre parcels, economic public infrastructure, spatial acts, spatial restrictions, and many others. These data will be collected for each vacant building land and these plots will be classified into one of the development levels based on the collected characteristics (Methodology for mass capture of inhabited land, 2019 The register of building land. Spatial information system, 2023).

The preparation of the first proposal for built-up land and vacant building land will be followed by informing property owners. Based on the comments of the owners and views of the municipality, a final proposal for the data will be prepared. The municipality will then submit data on inhabited land, associated land of public roads and public railway infrastructure, and vacant building land with development levels to the register of building land at the state level.
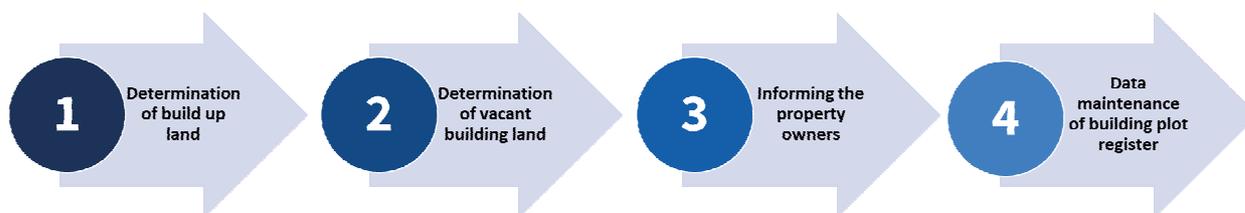
Fig. 6: The process of setting the Building land Register.

This is the moment when the real-life building land register will be started. Data from the building land register will be maintained based on changes resulting from the adoption of individual or general legal acts in the field of spatial planning, construction, or public finance (Spatial Planning Act, ZureP-3).

5 CONCLUSION

Sustainable management and land use (space) are priorities for sustainable development. Land, especially agricultural and forest land, is recognized as a non-renewable natural resource, which, when lost, is very difficult (and expensive) to replace. Many strategic documents and policies at different levels address the necessity of changes in approaches to the location of activities and the management of space and, at the same time, point to the critical consequences of the development of the last decades. The report on the environment (2015) of the European Environment Agency points out two things in this connection: a) the extremely rapid loss of (mostly agricultural) land due to construction and b) the great threat to soils and related ecosystem services due to soil "sealing," erosion and pollution (Methodology of derelict areas. MES PILOT, 2022).

The development of system-driven evidence, such as Building land Register, is a long-term and extremely complex process that involves various actors and a multitude of data sources. The implementation began with mass collection in 2017, and the Building land Register is currently in a phase where it is waiting for the municipalities to take it over in their administration and upgrade the data with properties about vacant building land.

With a detailed identification of land properties, the Buidling land register will provide a basis for decision an policy making in all spatial planning processes, from planning, construction, and use of space to maintenance and renovation of its components and at all levels of operation–local, regional, and national. Building land Register will offer greater transparency over the situation in the area and answer questions about where I can build, under what conditions, and whether the land on which we can build is equipped with the necessary infrastructure.

The article draws knowledge and information from the projects of mass capture of inhabited land, eProstor, and Pilot MOP, in which the Geodetic Institute of Slovenia participated as a contractor. We believe that with our work, we have taken important steps towards effective, balanced and sustainable management of space with improved quality of life for all.

6 REFERENCES

Building land register. Spatial information system. 2023. [Online]. Available: Evidenca stavbnih zemljišč | PIS (gov.si). [Accessed 17. July 2023].

Insights into the building land recors. [Online]. Available: Grafični vpogled EVT (gov.si). [Accessed 18. July 2023].

Lampič, B., Cigale, D., Kušar, S., Potočnik Slavič, I., Foški, M., Zavodnik Lamovšek, A., Barborič, B., Meža, S., Radovan D.. 2017. Comprehensive methodology for the inventory and analysis of abandoned land, the implementation of a pilot inventory and the establishment of an up-to-date register. Final report. Ljubljana, Faculty of Arts, University of Ljubljana, Faculty of Civil and Geodetic Engineering, University of Ljubljana, Geodetic Institute of Slovenia.

Methodology for mass capture of inhabited land. Ministry of Natural Resources and Spatial planning. 2019.

Ministry of Natural Resources and Spatial planning. MES PILOT. Pilot project for the implementation of spatial planning and construction legislation. Presentation flyer. Ljubljana, 2022.

Ministry of Natural Resources and Spatial planning. Draft of Spatial management act (ZUreP-3). 2021. [Online]. Available: https://skupnostobcin.si/wp-content/uploads/2020/09/zurep3_obrazlozitve.pdf [Accessed: 7. April 2023].

Ministry of Natural Resources and Spatial planning, Surveying and Mapping Authority of the Republec of Slovenia and Spatial Planning, Construciton and Housing Directorate. The programme of the projects eProstor. One space for all. Presentation flyer. 2019. [Online]. Available: https://www.e-prostor.gov.si/projekt/fileadmin/user_upload/gradiva/The_Programme_of_the_projects_eProstor.pdf [Accessed 17. July 2023].

Recordes of the actual use of inhabited land. Spatial information system. 2023. [Online]. Available: Records of the actual use of inhabited land (gov.si) [Accessed 18. July 2023].

Spatial Management Act (ZUreP-3).2021. The Official Gazette of the Republic of Slovenia; št 199/21.

The register of building land. Spatial information system. [Online]. Available: The register of building land (gov.si) [Accessed 18. July 2023].

Tasks of municipalities. The central website for easy access to comprehensive information on the organisation and functioning of the state administration. 2023. [Online]. Available: https://www.gov.si/teme/naloge-obcin/ [Accessed 17. July 2023].

The development of a methodology to establish and maintain records of derelict areas. MES PILOT, 2022.

992

REAL CORP 2023: LET IT GROW, LET US PLAN, LET IT GROW
Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities

Cool Down Güssing: Sustainable Cooling Concepts for Existing Buildings using the Example of the Municipality of Güssing

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1 ABSTRACT

Within the Cool-down Güssing project, measures for sustainable cooling of existing buildings were investigated. While in new buildings the heat input can be reduced by intelligent construction and passive cooling measures can be integrated relatively easily by installing surface cooling system (e.g. concrete core activation), the situation in existing buildings is much more difficult. Nevertheless, with suitable measures, sustainable cooling, or at least a significant reduction of the residual cooling demand, can be achieved. It has been shown that there is no universal solution for all different types of existing buildings. For example, different measures are suitable for large production halls of companies compared to private households. Therefore, the buildings were divided into several categories, like private households, companies and public buildings.

Different types of night ventilation have shown good potential for public building and companies to reduce room temperatures by at least a few degrees. This can be done either by means of decentralized ventilation units or automatic window openers, or by intelligent control of existing infrastructure such as fire ventilation systems which is especially suitable for production halls. Especially for public buildings, financing is often a major challenge, so that suitable financing models must be found. In addition, the heat input should be reduced as far as possible. This can be achieved by external shading and by reducing internal loads. Proper user behavior should also not be underestimated. The remaining electricity demand should be covered as far as possible with electricity from renewable generation. If the installation of an own photovoltaic system (PV) is not possible, energy communities offer the possibility to purchase local renewable electricity at favorable conditions.

Keywords: public buildings, companies, private households, existing buildings, sustainable cooling

2 INTRODUCTION

In Austria, as well as in many other countries, there has been a massive increase of hot days. The number of days above 30 °C has doubled to tripled in recent decades.[GeoSphere Austria, 2022] What used to be a record a few years ago has become average now. In connection with the rising temperatures, the energy demand for cooling has also increased steadily in the recent years. This is problematic, as the operation of conventional cooling devices is very energy-intensive and can thus contribute to a further advance of the climate change. Moreover, due to (currently) high electricity prices, the operation of such cooling systems can cause significant costs. While in new buildings the heat input can be reduced by intelligent construction and passive cooling measures, which can be integrated relatively easily by installing surface cooling system (e.g. concrete core activation), the situation in existing buildings is much more difficult. Surface cooling respectively surface heating systems can only be retrofitted at great constructional and financial expense as part of a comprehensive renovation. To enable climate-friendly cooling in these buildings, therefore, not only new technologies are needed, but also new and, above all, holistic approaches that combine different measures and evaluate their suitability for the use in existing buildings.

Therefore, the Cool-down Güssing project[1] investigates different measures based on nine pilot buildings. The pilot buildings are composed of companies, private households and public buildings in order to take into account a broad cross-section of different requirements and initial situations. The cooling should be carried out as sustainable as possible. In the first step, this means reducing the required cooling energy as much as possible. Various measures to reduce the heat input (insulation, sun protection films, installation of external shading elements, construction of canopies, etc.) were investigated and their suitability for the use in existing buildings was evaluated. Furthermore, the potential for intelligent (night) ventilation was investigated, that the cooler air during the night hours can be used to lower the temperature in the interior spaces. Only if the

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[1] https://smartcities.at/projects/cool-down-guessing/

use of passive cooling technologies is not (economically) possible or the required cooling capacity cannot be achieved with them, the use of active cooling technologies was examined. If this was the case, the energy demand should at least be supplied with renewable electricity. Especially photovoltaic systems are very well suited to supply cooling devices due to their simultaneity with the occurring cooling demand. In addition to the installation of own photovoltaic systems on the roof of the pilot buildings, renewable energy communities offer stakeholders without photovoltaic systems the opportunity to obtain renewable electricity locally at advantageous conditions in order to operate their cooling equipment. Furthermore, this offers the possibility to use additionally available photovoltaic electricity within the energy community for other purposes. These measures were combined with an extensive stakeholder involvement for demand assessment, awareness raising and training for an optimal user behavior.

The right choice of measures always depends on the individual circumstances. No company, public institution or private household is exactly the same as another. Therefore, general valid solutions are difficult. However, it could be shown that there are many similarities, especially within the respective building categories, where recommendations for measures could be derived from.

3 PUBLIC BUILDINGS

3.1 General conditions

Public buildings are often characterized by large glass surfaces, such as large window fronts or glass-covered staircases. A shading or cooling concept was usually not considered, especially in buildings constructed in the second half of the twentieth century. Although this creates a pleasantly bright indoor climate, many of these buildings are now affected by overheating in summer due to rising temperatures. An example of this is the BORG in Güssing, which is one of the pilot buildings. Already in early summer, temperatures beyond 30°C were measured in some classrooms, which have a negative impact on the students' ability to concentrate.

A second characteristic of public buildings is the difficulty to finance cooling measures. The necessary budget is usually only available to a very limited extent or, in some cases, not at all. Depending on the type of public buildings, there are different stakeholders, which often have a very limited radius of action. Significant changes to buildings often involve a high planning effort, as various committees have to be passed through. Depending on the owner of the building, the responsible parties can be found at the municipal, state or federal level. As a result, this type of building requires particularly cost-effective solutions, both in terms of investment and operation. In the rarest of cases, those responsible for the individual buildings are in a position to implement extensive cooling measures on their own. Therefore, an overriding strategy is required that promotes or finances cooling measures in schools and other public buildings. Otherwise, the implementation of an extensive cooling concept will rarely succeed.

3.2 Recommendations for public buildings

In the case of public buildings, measures to reduce solar radiation and intelligent night ventilation concepts have proved particularly suitable. Although the installation of a central cooling system would be desirable, it is usually beyond the financial scope. The operation of decentralized cooling units causes high operating costs, which in turn burden the budget. In addition, the air conditioning units used are not optimal from an ecological point of view. It is therefore advisable, if not already done, to install external shading options for the window surfaces. In most public buildings, the rooms are used during the day. So, there is nothing to be said against operating the shading manually. However, consistent and early shading is important. If rooms are used only occasionally, a time control can help to carry out the shading. Sun protection films also offer another possibility to minimize solar radiation without completely darkening the rooms. Removable solar protection films also make it possible to take them off in winter to avoid negative effects in terms of heating requirements.

With intelligent night ventilation, the cooler night temperature can be used to cool the building during the night hours, so that temperature peaks during the day can be reduced or at least postponed. Either decentralized ventilation units installed in the respective rooms or automatic window openers are suitable for this purpose.

Automatic window openers can be easily retrofitted to many windows and are cheaper to purchase than decentralized ventilation units. Windows are opened automatically in the summer months as soon as the outside air temperature drops below the temperature inside the building. Rain sensors enable the windows to be closed automatically in case of bad weather. An additional timer control also makes it possible to lock the automatic window openers for certain times to reduce the potential risk of injury from trapped fingers. This can be particularly relevant for schools or kindergartens. Basically, a distinction is made between window openers that tilt the window and those that open the window completely. The wider windows are opened, the higher the air exchange and thus the cooling effect. However, since public buildings are usually not used during the night hours, burglar protection must be taken into account in this regard. Automatic window openers are therefore particularly suitable for higher floors. Optimal are rooms that have windows on several sides or concepts that combine several rooms by means of wall openings or open doors. Another issue are animals such as birds or bats that can get into the building when the windows are open, setting off alarms. Meshes mounted in front of the windows can remedy this, but also reduce the air exchange rate.

Decentralized ventilation units are more expensive to purchase and have, albeit slightly, higher operating costs. On the other hand, the windows remain closed and all the problems associated with open windows are eliminated. In addition, they offer the advantage of providing controlled ventilation during the day, depending on the CO_2 content, thus ensuring that there is no higher heat input than absolutely necessary during the ventilation process. In winter, these ventilation units can also be used to reduce heating costs through integrated heat recovery. Furthermore, it is often possible to retrofit cooling modules in case they are needed later on.

3.3 Example: BORG Güssing

This pilot building houses the BORG and the ECOLE HLW Güssing. The students and teachers suffer from far too high temperatures in the classrooms as early as May. Although the building has external blinds, they are not sufficient as a stand-alone measure to prevent overheating in summer. The classrooms on the south and east sides of the building are particularly affected. A glass roof also causes additional heating of the stairwell.

Measurements have shown that 30 degrees and more are not uncommon. It has also been shown that even during comparatively cool nights, temperatures in the classrooms cool only slightly, as can be seen in Fig 1. While outside air temperatures drop below 13 degrees during the night, indoor temperatures do not drop below 25 degrees. It was therefore decided to equip two of the particularly affected classrooms with decentralized ventilation units for night ventilation. Automatic window openers have not be an option in this case because there is a heating plant in the immediate vicinity, from which a stronger dust input must be assumed in unfavorable wind conditions.
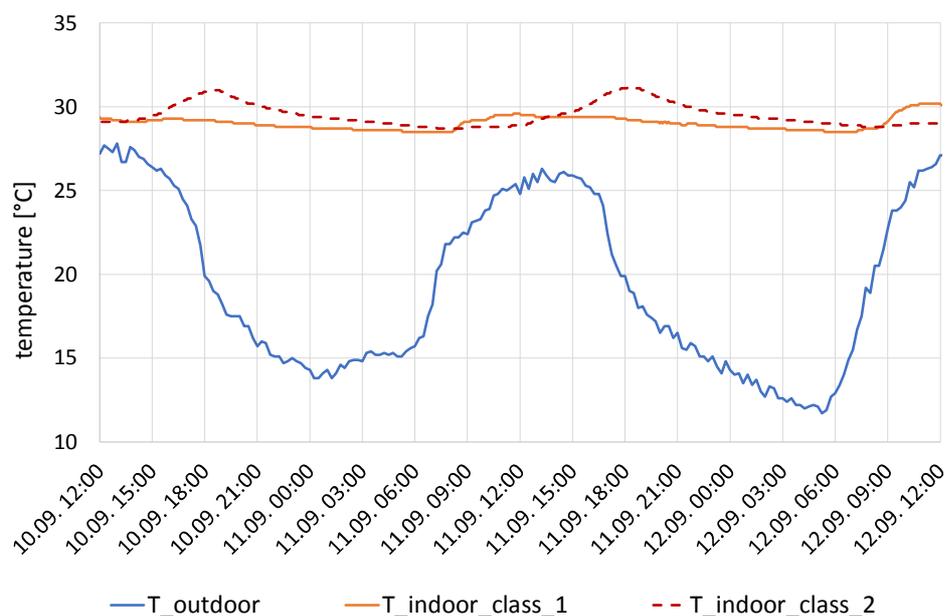

Fig. 1: Temperature profile in the school building measured in the year 2020.

The units will be installed in the summer of 2023. It is assumed that there will be a significant reduction in room temperatures during the night hours, which should result in a much more pleasant indoor climate, at least in the mornings. In addition, an outdoor class (see Fig. 2) has been installed to escape the hot classroom on particularly hot afternoons.

Fig. 2: Picture of the outdoor class of the BORG Güssing

The financing of the cooling units was achieved by sponsoring from an executing company, as this would not have been possible from the school's budget alone. Within the framework of the project, further financing models were developed (crowdfunding, leasing, events), on the basis of which schools can generate further income for cooling measures. However, the integration of a comprehensive cooling concept is only possible through the provision of financial resources and subsidies from a higher authority (in this case the Bundesimobiliengesellschaft). Such measures are urgently needed and should be rolled out nationwide, as the BORG Güssing is by no means an isolated case.

4 COMPANIES

4.1 General conditions and recommendations for companies

Companies were divided into office areas and production halls, as these are subject to very different requirements. In the case of office areas, parallels can be found with public buildings, although the financial constraints are usually less pronounced. The first step is to minimize solar heat gain. External shading options and solar protection films are suitable for this purpose. The installation of canopies can also reduce solar radiation. Optimally, these are combined with photovoltaic systems so that renewable electricity can be generated at the same time to operate cooling equipment. Cooling can also be provided by night ventilation, as described in chapter 3. In addition, roofs of commercial buildings are usually well suited for the installation of PV systems, so that, if necessary, the power supply of conventional air conditioning units can be covered with local renewable electricity.

The cooling of production halls is usually a major challenge if it has to be achieved at reasonable cost. As shown in chapter 4.2 on the example of the Guttomat company, the control of the already installed fire ventilation for night ventilation has proven to be a cost-effective measure, with which the temperatures in the halls could be significantly reduced overnight. How quickly the halls warm up again during the day depends on the structure of the building and its use, but in many cases the time of severe overheating can be postponed by at least a few hours. If possible, an earlier start to work in the summer months can also be considered to take advantage of the cool morning hours. Another option for cooling production halls is adiabatic cooling. Adiabatic cooling is based on the evaporation process. The water evaporates in the air as the air stream passes over the water. The air cools down because the thermal energy required for this is extracted from the air. The advantages lie in the relatively low energy input and low maintenance requirements. The performance depends on the outside air temperature and the humidity. Humid air is more difficult to cool than dry one. Nevertheless, the cooling capacity is significantly higher than the cooling capacity of night ventilation, especially at high outdoor air temperatures during nighttime, but adiabatic cooling also involves significantly higher investment costs.

In addition, it is advisable to take a look at the internal loads. In many cases there are devices that emit heat. Often this heat input can be reduced by suitable insulation measures or by targeted heat dissipation.

4.2 Example: Guttomat[2]

Guttomat is a production company for overhead, sectional, tilt-up and industrial doors. Overheating occurs in the summer months due to the structural conditions and large windows in the production halls as a result of direct solar radiation as well as heat input via the roof surfaces. In this case the existing fire ventilation system (smoke and heat extraction) was adopted to be used for natural ventilation. The fire ventilation system at Guttomat consists of louvre and hood ventilators. In addition to the fire ventilation function the system is designed to provide natural ventilation by utilizing the thermal load within a building as a function of pressure or temperature difference. Based on a test operation, the potential of night ventilation could be confirmed. An example of this is shown in Fig. 3.
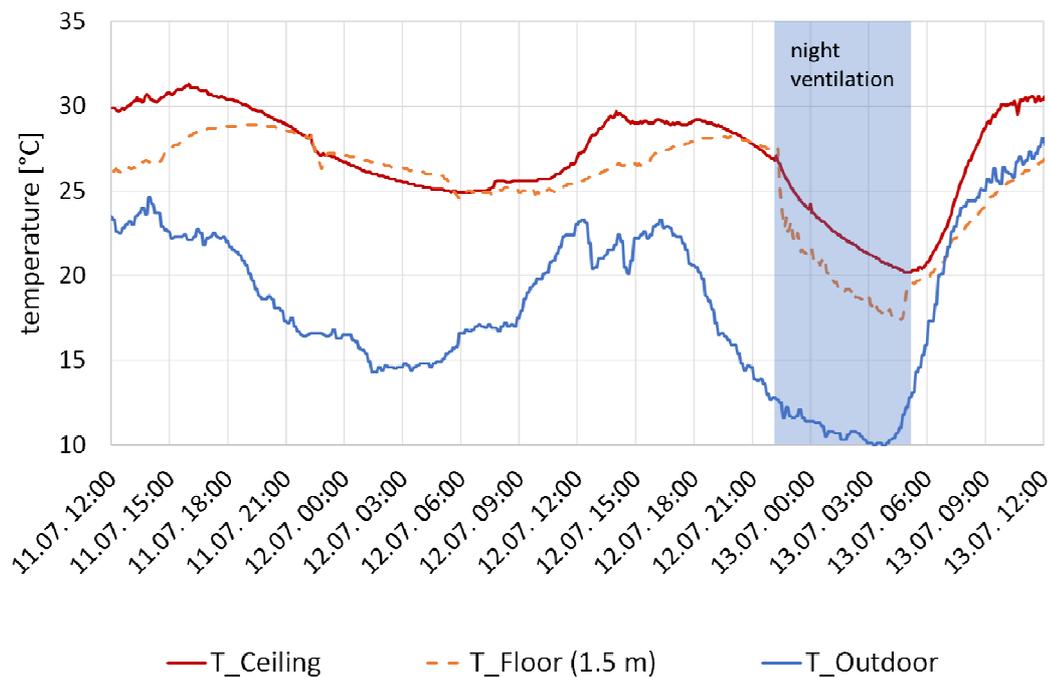
Fig. 3: Effects of the night ventilation test by using the fire ventilation system.

In this case, night ventilation was activated by means of a fire ventilation system on the 13th of July at 10 pm. It can be seen that an immediate reduction of the inside air temperature, especially the one near the floor was dedicated. The temperature drops continuously until the night ventilation was stopped at about 4 o'clock due to precipitation in order to avoid moisture ingress. Despite the early termination of the night ventilation, significantly lower temperatures could be reached in the morning hours than for example on the 12th of July where no night ventilation was carried. It has to be mentioned, that the outside air temperature on the 13th of July was lower than on the 12th of July which might have an additional beneficial effect on the indoor temperatures on the 13th of July, but nevertheless the effects of the night ventilation test are shown clearly. According to the employees who are in this area, the night ventilation brought a noticeable improvement especially in the morning hours. After that, a renewed heating of the hall occurred, but the time of overheating could be postponed for several hours. This solution was preferred to adiabatic cooling because of the significantly lower investment costs.

5   PRIVATE HOUSEHOLDS

Private households differ from other building types in terms of hours of presence. Solutions for automatic night ventilation, which are advantageous for public buildings and companies, are usually not needed for private households, as the occupants are usually at home during the cool night hours and can carry out the ventilation manually. If this is not the case, such solutions are of course an option. Furthermore, private

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[2] https://www.guttomat.at/

households in the Cool-down Güssing project were divided into single- and multi-party residential buildings. Depending on ownership and dedication, different options are available to residents.

If single-family homes are heated with a heat pump, or if a heating system replacement is imminent, it makes sense to use the heat pump for cooling in the summer months. Ground source heat pumps are particularly well suited for cooling, as the cooling circuit can be used for passive cooling in summer (i.e. without operating the heat pump itself). In the case of air-source heat pumps the heat pump can be operated as a chiller. This requires a higher energy input, but especially in combination with a PV system, it is still a comparatively effective solution. If no heat pump is available, ground heat exchangers with air flow can be used to precondition the supply air in combination with a ventilation unit.

In multi-apartment buildings, the individual residents usually have only limited options available to them. In most cases, a conventional air-conditioning split unit is the only possibility to realize cooling. Tenant power models, i.e. common PV systems installed on the roof of multi-party apartment buildings, as well as participation in an energy community offer possibilities to supply them with local renewable electricity.

Proper user behavior should also not be underestimated. Ventilation procedures should be carried out as shock ventilation. The windows should not remain open longer than necessary. CO_2-sensors can help determine the correct ventilation time. Windows should be shaded in good time with external shading measures. Before leaving the house or apartment, it is recommented to shade all windows where a direct exposure to sunlight may occur. Automated systems, such as Smart Home, can support this but are not mandatory.

6 CONCLUSION

The installation of sustainable and at the same time affordable cooling solutions in existing buildings is a major challenge if no comprehensive renovation will be carried out. The installation of conventional air conditioning split units is often the much simpler solution. Nevertheless, with suitable measures, sustainable cooling, or at least a significant reduction of the residual cooling demand, a cooling effect can be achieved. In public buildings, which usually have a particularly limited budget, automatic window openers and decentralized ventilation units have proven to be particularly suitable. These are characterized by low investment and low operating costs. In this case, the cool night air is used to cool the classrooms during the night hours. The performance of night ventilation is limited by the outside air temperature, but in many cases it helps to improve the situation significantly and to postpone overheating at least for a few hours. In production halls, the cool night air can also be used for cooling. For this purpose, the fire ventilation system, which is installed in many cases anyway, can be used. Another option is the installation of an adiabatic cooling system. In addition, internal loads should be identified and reduced. In the case of private houses or apartments, automatic night ventilation is usually not expedient, since people are usually present during the night hours and can carry out night ventilation manually. For houses, the combination of cooling with the heating system is a good option. Especially geothermal heat pumps are well suited for this purpose. Air-source heat pumps can also be used for cooling, although in this case the energy rate is higher. A combination with a PV system is a good way to cover the electricity demand with own renewable electricity and to reduce the operating costs. In apartments, where often only the installation of a conventional split air conditioner is possible, the electricity consumption can be covered by a common PV system on the roof of the apartment building (tenant electricity model) or by joining a renewable energy community with local renewable electricity at more favorable conditions.

These solutions should always be combined with measures to reduce solar gain, e.g. in the form of external shading measures. During the day, ventilation should only be as much as necessary and should be carried out as shock ventilation.

7 REFERENCES

GeoSphere Austria: Massive Zunahme an Hitzetagen, online, 2022, requested on: 29.03.2023,
https://www.zamg.ac.at/cms/de/klima/news/massive-zunahme-an-hitzetagen

Der Beitrag temporärer Straßenexperimente zur kollaborativen Planung lebenswerter urbaner Quartiersstraßen

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1 ABSTRACT

Öffentliche Straßenräume erfüllen vielfältige Funktionen: Sie sind Orte der Kommunikation/Interaktion, des Konsums, des Aufenthalts und nicht zuletzt unserer Mobilität. Ein Blick auf die derzeitigen städtebaulichen und verkehrlichen Realitäten/ Verhältnisse (Flächenkonsum und rechtliche Vorrangstellung des motorisierten Individualverkehrs (MIV)), lässt jedoch Zweifel an der Funktionsvielfalt und nicht zuletzt am Schlüsselbegriff des „Öffentlichen" sowie an einer damit einhergehenden am Gemeinwohl und Lebensqualität orientierten Stadt- und Verkehrsplanung aufkommen.

Vor diesem Hintergrund beschreibt der Artikel einen dreistufigen kollaborativen Beteiligungs- und Planungsprozess mit der Zivilgesellschaft, der Stadtverwaltung und der Kommunalpolitik für den Umbau einer Quartiersstraße in Dortmund (Deutschland). Ziel des Prozesses war es, die Zieldimensionen Verkehrswende, Aufenthaltsqualität und Klimaresilienz (Blau-Grüne-Infrastrukturen) integriert zu betrachten, um eine gleichermaßen ambitionierte wie gesellschaftlich tragfähige Planung zu entwickeln. Der Artikel beschreibt hierbei nicht nur die empirischen Arbeiten und Befunde, sondern stellt vor allem dar, wie die Rückmeldungen aus dem Beteiligungs- und Planungsprozess in die Planungsentwürfe integriert wurden.

Ausgehend von dem Fallbeispiel diskutieren die Autorinnen und Autoren die Relevanz von temporären Straßenexperimenten für einen dauerhaften Umbau zu lebenswerten Straßen und Städten.

Keywords: Kollaboration, Straßenexperiment, Lebenswert, Beteiligung, Straßenumbau

2 HINTERGRUND

Städte in Deutschland – aber auch in fast allen Industrieländern - sind in den letzten Jahrzehnten stark vom Leitbild der „autogerechten" Stadt geprägt worden. Um den ökologischen, sozialen und ökonomischen Herausforderungen des 21. Jahrhunderts gerecht zu werden, gilt es den urbanen Raum zu transformieren. Daher fordern die Vereinten Nationen, dass Städte „inclusive, safe, resilient and sustainable" (SDG 11) sind bzw. dahingehend entwickelt werden. Ebenso plädiert die Neue Leipzig-Charta für eine gemeinwohlorientierte, integrierte und nachhaltige Stadtentwicklung. Die Klimakrise mit den bereits heute erkennbaren Klimafolgeschäden für urbane Räume verdeutlicht zudem die Notwendigkeit für ein rasches und radikales Umsteuern. Daher haben die Vereinten Nationen auch die 2020er Jahre zur „Dekade der Umsetzung" ausgerufen.[1]

Dem Straßenraum kommt im Kontext dieser urbanen Transformationsprozesse eine besondere Bedeutung zu, da dieser Raum durch Stadtverwaltungen direkt adressiert werden kann. Er spiegelt heute vielfach ein ausgedientes stadt- und verkehrsplanerisches Leitbild wider, nachdem der Verkehr, d.h. der MIV, möglichst ungestört von einem zu einem anderen Ort fließen kann. Versteht man ihn jedoch nicht allein als Verkehrs-, sondern als öffentlichen Raum, besitzt er das Potenzial multifunktionale Flächenansprüche zu erfüllen. Dadurch können sich Städte an die Folgen von Starkniederschlagereignissen und Hitzeperioden anpassen, aktive Mobilität und damit auch Gesundheitsschutz befähigen, Nachbarschaften durch Teilhabe und Interaktion zu stützen oder auch um lokale Ökonomien fördern zu können.

Auch wenn diese Ansprüche an den öffentlichen Raum heute immer stärker in der Planungspraxis berücksichtigt werden, bestehen dennoch hohe Barrieren und Beharrungskräften, die grundlegende strukturelle Veränderungen behindern. Wie kann es gelingen, diese Barrieren abzubauen, so dass sich die Alltagsroutinen der Stadtgesellschaft verändern und sie sich gleichzeitig mitgenommen und nicht überfordert fühlt? TemporäreStraßenexperimente (tactical urbanism, street experiments, street reclaiming) können hierfür ein wichtiger Baustein sein. Sie stellen einen schnellen, kostengünstigen und umsetzungsorientierten Ansatz dar, um für städtebauliche und/oder verkehrliche Problemlagen im Straßenraum zu sensibilisieren und zukunftsgerichtete Lösungen zu erproben. Das Experimentieren erlaubt eine frühzeitige Partizipation der

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[1] https://www.un.org/sustainabledevelopment/decade-of-action/

Stadtbevölkerung, um mögliche Fehlplanungen bzw. Konfliktlinien zu identifizieren und auf diese kommunikativ wie planerisch einzugehen. Um den Mehrwert von Straßenexperimenten zu heben, gilt es jedoch diese intelligent in Beteiligungs- und Planungsprozesse zu integrieren.

3   TEMPORÄRE STRAßENEXPERIMENTE ALS PLANUNGSINSTRUMENTE

Der Umbau von Stadtstraßen erfordert in Deutschland häufig eine formelle Bürgerinnen- und Bürgerbeteiligung im Rahmen eines sogenannten Planfeststellungsverfahren. Da dieses jedoch meist erst recht spät im Planungsprozess ansetzt, setzten Kommunen häufig in frühen Planungsphasen auf informelle Beteiligungsformate, um frühzeitig die Planungen zu erläutern und rückzukoppeln, Konflikte zu identifizieren und ggf. Planungen dahingehend anzupassen.

In den letzten Jahren haben sich, international (z.B. Superblocks/Barcelona, Piazze Aperte/Mailand, Grätzloasen/Wien) aber auch in Deutschland (z.B. Ottensen Macht Platz/Hamburg, Friedrichstraße/Berlin, Piazza Zenetti/München), temporäre Straßenexperimente als weiteres Element einer Bürgerinnen- und Bürgerbeteiligung im Planungsprozess zunehmend etabliert. Straßenexperimente sind allerdings keineswegs ein neues Phänomen: Bekannte Beispiele sind die Ciclovía, die 1974 in Bogotá, Kolumbien, ins Leben gerufen wurden und der mittlerweile international etabliertePARK(ing) Day, der erstmals 2005 in San Francisco, USA stattfand. Diese Straßenexperimente der ersten Stunde zielten vor allem auf eine Sensibilisierung der Bürgerinnen- und Bürgerschaft für die negativen Auswirkungen einer autogerechten Stadtentwicklung ab. Der konkrete Straßenumbau, d.h. die dauerhafte Umverteilung des öffentlichen Straßenraums, stand jedoch nicht im Mittelpunkt des Interesses.

Im Zuge der in den letzten Jahren immer deutlicher werdenden Klimakrise und vor allem durch die Covid-19-Pandemie, haben Straßenexperimente als kurzfristig realisierbarere Straßenraumumnutzung als Zwischenschritt hin zu einem dauerhaften Umbau bzw. zur Erprobung der Wirksamkeit eines dauerhaften Umbaus an Bedeutung gewonnen. Heutige radikale Stadtumbaupläne wie in Paris, Mailand oder Barcelona sind das Resultat eines Zusammenspiels aus Notwendigkeiten (Klimakrise, Covid-19) und politischem Mut. Die positiven Erfahrungen aus Straßenexperimenten (z.B. Pop-up-Bikelanes) können in diesem Kontext wichtige Impulsgeber sein. Bertolini (2020) definiertStraßenexperimenteals "intentional, temporary change of the street use, regulation and/or form, aimed at exploring systemic change in urban mobility, away from 'streets for traffic', and towards 'streets for people'".

Die Vorteile von Straßenexperimenten für Stadtverwaltungen liegen dabei auf der Hand. Durch die vorübergehende Veränderung des Straßenbildes ermöglichen sie Stadt- und Verkehrsplanerinnen sowie Stadt- und Verkehrsplanern, aktuellen räumlichen wie auch sozialen Anforderungen gerecht zu werden. Gleichzeitig bieten sie die Möglichkeit, Lösungsansätze für langfristige Herausforderungen wie Luftverschmutzung, Lärm, Verkehrsunfälle und Staus zu testen. Straßenexperimente "aim to provide a glimpse of a drastically different future scenario, wherein streets are for mixed uses including socializing, playing, and exercising – that is, 'for people' (Gehl, 2010) - rather than for traffic" (Van Hoose et al., 2022). Sie sind dabei deutlicher schneller und zu deutlich niedrigeren Kosten als ein dauerhafter Umbau zu realisieren und eignen sich als Beteiligungsformat, um a) ortsspezifisches Wissen frühzeitig in den Planungsprozess einzubinden, b) mögliche Konflikte zu antizipieren und aufzulösen, um so die Planungen sowie die Akzeptanz dafür zu verbessern.

Damit Straßenexperimente all diese Funktionen erfüllen können, gilt es jedoch, sie intelligent in den Planungsprozess einzubinden. Das nachfolgende Beispiel zeigt hierfür einen möglichen Weg auf.

4   METHODISCHE VORGEHENSWEISE

Der dargestellte Beteiligungs- und Planungsprozess war angeleitet von dem normativ-konzeptionellen Leitbild einer ‚lebenswerten Straße'. Als solches werden Straßenräume bezeichnet, bei denen die Zieldimensionen Verkehrswende, Klimaresilienz durch blau-grüne Infrastrukturen und Aufenthaltsqualität integriert betrachtet werden, sodass Straßen für Menschen und nicht für Autos entstehen (März et al., 2020). Dieses Leitbild wurde auf die Dortmunder Quartiersstraße „Neuer Graben" angewendet. Das betrachtete 560m lange und circa 16m breite Teilstück befindet sich im Dortmunder Kreuzviertel und umfasst bereits heute Elemente einer lebenswerten Straße. Es existiert ein alter Baumbestand, die Straße ist insgesamt aufgrund zahlreicher Cafés, Restaurants und Einzelhandelsgeschäften belebt und die Bewohnerinnen und Bewohner sind vielfach zu Fuß oder mit dem Rad unterwegs. Allerdings ist das Straßenbild insgesamt stark

vom ruhenden Verkehr geprägt. Im Straßenraum parken, zu relevanten Anteilen nicht StVO-konform, bis zu 220 Pkw. Anlass für die Auswahl waren anstehende grundhafte Kanalsanierungsarbeiten (März et al., 2022).

Im Rahmen des LesSON-Projekts hat ein Forscherinnen- und Forscherteam ein Straßenexperiment in einen rund eineinhalb Jahre andauernden Planungsprozess integriert, bei dem sowohl die Stadtverwaltung, die Kommunalpolitik als auch die Zivilgesellschaft mehrfach bei der Ideenentwicklung für einen zukunftsfähige Straßenumbau aktiv eingebunden wurden. Das Ziel war die Entwicklung einer gleichermaßen ambitionierten wie gesellschaftlich tragfähigen, d.h. mehrheitsfähigen Planung für den Neuen Graben. Der kollaborative Planungsprozess gliederte sich insgesamt in die drei Phasen Bestands- & Bedarfsanalyse, Zukunftsbilder und temporäres Straßenexperiment und kennzeichnet sich durch ein iteratives Vorgehen. In jeder Phase wurde zunächst die Stadtverwaltung, anschließend die Kommunalpolitik und im Anschluss die Zivilgesellschaft eingebunden, um die jeweiligen Planungsschritte auf eine breite Basis zu stellen (vgl. Abbildung 1).
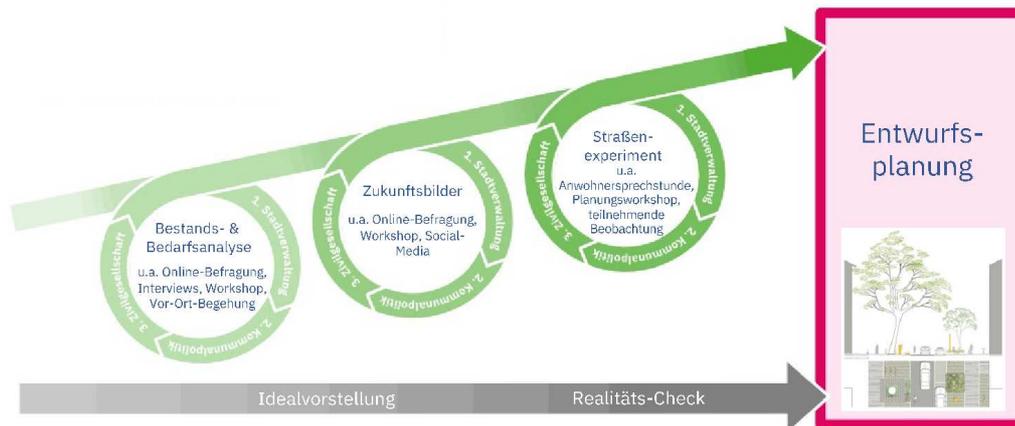
Abbildung 1 Schematischer Ablauf des Beteiligungs- und Planungsprozesses

Nachfolgend werden die verschiedenen Phasen mit Blick auf deren Einfluss auf den Planungsprozess kurz dargestellt.[2]
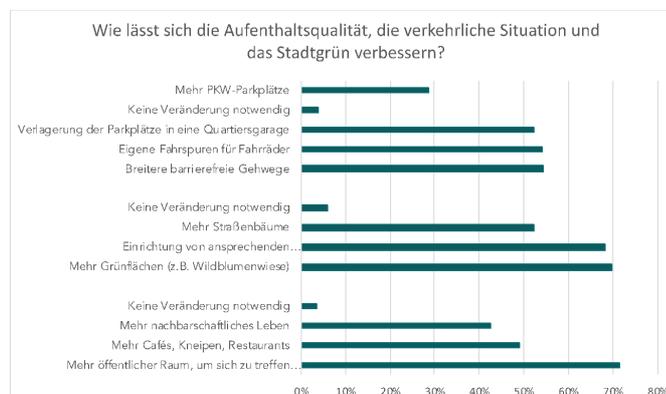
Abbildung 2 Zentrales Feedback für eine Zukunftsvision des Straßenraums

5 ERGEBNISSE

5.1 Bestands- und Bedarfsanalyse

In der Bestands- und Bedarfsanalysen erfolgten verschiedene Analysen mittels klassischer Methoden der empirischen Sozialforschung und Verkehrsplanung (u.a. Interviews, Online-Befragungen, Vor-Ort-Begehung, Parkraumzählung). Die mittels Geo-Targeting durchgeführte Online-Befragung (n=709) unterstrich den hohen Parkdruck, die Unzufriedenheit damit und den Wunsch nach einer Qualifizierung des öffentlichen Straßenraums durch Stadtgrün und attraktive Verweilorte (im Grünen) (vgl. Abbildung 2). Das Ergebnis bestätigt andere Studien (z.B. Zoderer et al., 2021), nach denen die hohe Wirksamkeit grüner Infrastrukturelemente (insb. bei Erhöhung des Grünanteils) hinsichtlich ihrer Ökosystemdienstleistungen wie

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[2] Der Fokus liegt im Rahmen dieses Papers auf der zivilgesellschaftlichen Beteiligung und nicht auf den Arbeiten mit der Stadtverwaltung bzw. der Kommunalpolitik.

u.a. die Regulierung des Mikroklimas oder eine verbesserte Biodiversität sowie der positiven Eigenschaften für das menschliche Wohlergehen als erstrebenswert angesehen werden.

5.2 Zukunftsbilder

Aus den abstrakten Anregungen der Anwohnerinnen- und Anwohnerschaft wurden zwei Zukunftsbilder abgeleitet in eine Vorplanung übersetzt und visuell aufbereitet (Abbildung 3). Im Wesentlichen unterscheiden sich die „Fahrradstraße" (minus 75% ruhender Verkehr) und der „Shared-Space" (minus 100%) im Ambitionsniveau bzgl. der Reduktion des ruhenden Verkehrs und der damit verbundenen Umwidmung der freiwerdenden Verkehrsfläche. Im Rahmen der zweiten digitalen Anwohnerinnen- und Anwohnerbefragung konnten die Varianten bewertet und diskutiert werden. Beide Zukunftsbilder wurden mehrheitlich deutlich besser bewertet als der aktuelle Status quo. Während der Status Quo auf einer 10-stufigen Likert-Skala eine mittlere Bewertung von 3,93 erhielt, wurden die Zukunftsbilder mit 6,67 (Fahrradstraße) bzw. 6,17 (Shared Space) bewertet.[3] Allerdings variierte die Beurteilung zwischen den untersuchten Subgruppen teils signifikant. Sowohl die Zustimmung von Personen, die einen privaten Pkw im Haushalt besitzen, sowie von Personen, die diesen ebenfalls häufig nutzen, fällt in Bezug auf beide Zukunftsbilder signifikant geringer aus.[4]

Abbildung 3 Status-Quo (oben links), Zukunftsbilder „Shared-Space" (unten links) / „Fahrradstraße" (unten rechts) und eine Vorzugsvariante (oben rechts) für den Neuen Graben (Bildrechte: MUST Städtebau GmbH)

5.3 Temporäres Straßenexperiment

Ausgehend von den überaus positiven Rückmeldungen der bisherigen Beteiligungsformate, erfolgte im August 2021 (31.07 bis 14.08) ein Straßenexperiment in Anlehnung an das „Shared Space"-Zukunftsbild. Zwar blieb die Fahrbahn im gesamten Zeitraum regulär nutzbar, auf den Flächen des ruhenden Verkehrs (ca. 40 Pkw-Stellplätze) wurde jedoch mittels verschiedener atmosphärischer und grüner Elemente (u.a. Rollrasen, Pflanzkübel, Liegestühle, Sitzbänke etc.) ein lebenswerter Raum geschaffen. Begleitet wurde das Straßenexperiment durch vielseitige Partizipationsformate, um sowohl analog wie digital in den direkten Dialog (Anwohnersprechstunden, Planungsworkshops, Online-Workshop) zu treten, als auch anonymes Feedback (Fragebogen, Briefkasten) einzuholen.

Die positiven Bewertungen aus vorangegangenen Beteiligungsformaten trafen während des Straßenexperiments auf z.T. konträre Alltagsrealitäten. Zwar fiel die Bewertung insgesamt überwiegend positiv aus. Die Wahrnehmung divergierte jedoch entlang der drei Faktoren 1) Alter, 2) Pkw-Besitz und 3) direkte Anwohnerschaft. Aufgrund der Konkretheit des räumlichen Experiments konnten frühzeitig nicht-intendierte Nebeneffekte identifiziert werden wie bspw. eine hohe Lärmentwicklung oder vermehrte

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[3] n = 1.545

[4] Eine detaillierte Beschreibung der Umfrageergebnisse erfolgt bei März et al. (2022).

Verschmutzung durch die intensive Nutzung des Experimentierraums. Ebenso wurde der komplette Wegfall der Pkw-Stellplätze, trotz Ausweichstellplätzen, die Ausweitung der Außengastronomie oder die Spielmöglichkeiten entlang der Straße kritisch gesehen.

Abbildung 4 Impression des temporären Straßenexperiment (links) und Bewertung (rechts) (Bildrechte:T.Weyland)
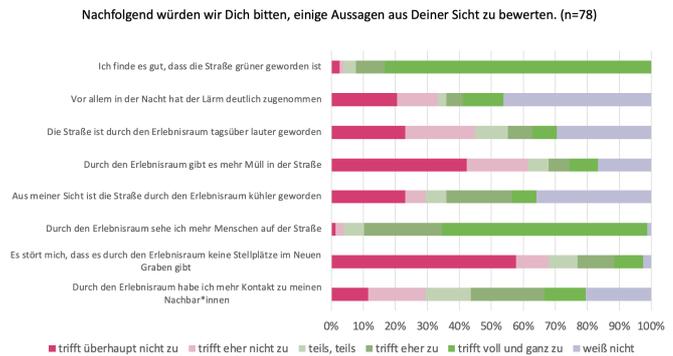
5.4 Anpassungen der Planungsentwürfe im Rahmen des kollaborativen Beteiligungsprozesses

5.4.1 Motorisierter Individualverkehr und ruhender Verkehr

Der MIV, aber vor allem der ruhende Verkehr dominiert heute das Straßenbild des Neuen Grabens, obwohl bereits heute rund ein Viertel der Haushalte im Quartier kein eigenes Auto besitzen. Insgesamt parken in den Abendstunden bis zu 220 Pkw im Straßenraum, obwohl nur rund 140 legale Parkplätze existieren. Die Zukunftsbilder skizzierten daher eine Straßennutzung, in der der MIV nur noch Gast ist. Die Bilder sollten bewusst provozieren, um eine Debatte anzustoßen und so den Möglichkeitsraum zu verschieben. Ausgehend von dem Straßenexperiment wurde schließlich eine Kompromiss gefunden, bei dem rund 50 % der legalen Stellplätze umgewidmet werden. Da das heute weitgehend geduldete Falschparken durch planerische Eingriffe (z.B. Poller, Beete) nicht mehr möglich sein wird, reduzieren sich die heutigen Stellplatzflächen um bis zu 75 %. Die verbleibenden Parkplätze werden baulich so gestaltet, dass eine spätere Nutzungsumwidmung mit geringem Aufwand und Kosten verbunden ist.

5.4.2 Umweltverbund

Der Fußverkehr spielt bereits heute eine wichtige Rolle. Die Beteiligungsphasen haben seine Rolle weiter gestärkt, in dem in den Entwurfsplanungen die Gehwege barrierefrei und 2,50m breit geplant werden. Zudem werden Nutzungskonflikte mit der Außengastronomie und auf dem Gehweg parkenden Autos vermieden. Das Fahrrad ist ebenfalls bereits heute ein wichtiges Verkehrsmittel, allerdings existiert keine adäquate Infrastruktur. Lediglich 9 % der Haushalte im Viertel besitzen kein eigenes Rad. Ausgehend von den Rückmeldung aus der Bestandsanalyse wurde das Rad in den Zukunftsbildern zum wichtigsten Verkehrsmittel, zu Lasten des MIV. Das Straßenexperiment verdeutlichte jedoch, dass solch eine radikale Veränderung der Verkehrsmittelpriorisierung, den gesellschaftlichen Rückhalt deutlich negativ beeinflussen würde, zumal im direkten Umfeld des Neuen Grabens ein Radschnellweg in Planung ist. Es wurde sich daher gegen ein Shared-Space, Fahrradstraße oder Fahrradzone entschieden. Vielmehr wurde die Straße in eine mind. 4m breite Einbahnstraße, die für den gegenläufigen Radverkehr freigegeben ist, in der Entwurfsplanung umgewandelt. Zudem wurden Radabstellanlagen für 300 Räder geschaffen. Die Straße wird nicht durch den ÖPNV bedient, allerdings sieht die Entwurfsplanung Car- und Bikesharing Stellplätze vor.

5.4.3 Blau-Grüne Infrastrukturen

Der Erhalt der heutigen Baumstandorte sowie der Wunsch nach zusätzlichem Stadtgrün durchzogen alle Beteiligungsphasen. Entsprechend wurde in der Entwurfsplanung der Baumbestand gesichert und insgesamt 16 neue Baumstandorte definiert. Es ist ein Wasserspiel vorgesehen.

5.4.4 Interaktionsräume/Aufenthaltsqualität

Der ursprünglich identifizierte Bedarf nach mehr öffentlichen, nicht kommerziellen Aufenthaltsräumen zum Verweilen oder auch zum Spielen wurde durch ein Wasserspiel, Sitzecken, Spielgeräte sowie eine

Ausweitung der Außengastronomie in den Zukunftsbildern umgesetzt. Das Straßenexperiment deckte jedoch nicht intendierte negative Auswirkungen (Gesprächslärm, Müll) auf. Zudem zweifelten Eltern an der Sicherheit und Notwendigkeit der Spielgeräte im Straßenraum, aufgrund der unmittelbaren Fahrbahnnähe sowie vorhandenen Spielplätzen in der Nachbarschaft. Daher enthält die Entwurfsplanung zwar noch Sitzmöglichkeiten (zur Pause beim zu Fuß gehen), aber keine größeren Sitzecken oder Spielgeräte mehr. Auch die Außengastronomie wurde nicht erweitert, sondern nur vom Gehweg weg verlagert, um Nutzungskonflikte mit Fußgängerinnen und Fußgängern zu vermeiden.
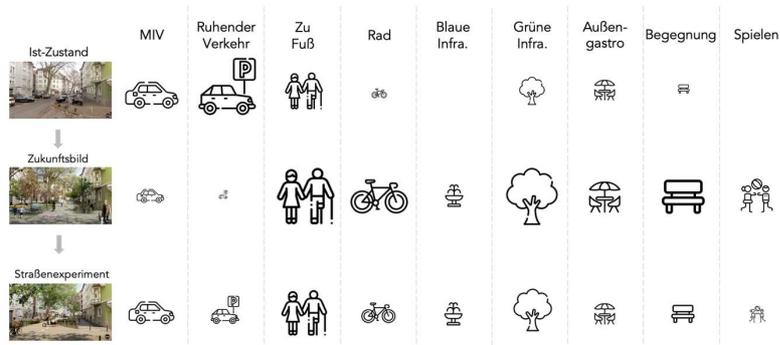
Abbildung 5 Schematische Darstellung der Veränderungen der Planungsentwürfe im Beteiligungsprozess

6 DISKUSSION

Insgesamt war das Straßenexperiment ein wichtiger Baustein im kollaborativen Beteiligungs- und Planungsprozess, da es neue Perspektiven auf die heutige wie zukünftige Straßennutzung erlaubte. Insgesamt ziehen die Autorinnen und Autoren folgende Schlussfolgerungen:

- Temporäre Straßenexperimente erlauben stärkere Diskussion auf Augenhöhe

In formellen wie informellen Beteiligungsformaten werden Planungen häufig über Lagepläne oder Schnitte dargestellt. Dies setzt jedoch ein gewisses planerisches Verständnis bei der Zivilgesellschaft (und Kommunalpolitik) voraus. Durch die Verortung von Planungen bzw. Planungselementen im Raum wird die Verständlichkeit erhöht, sodass Diskussionen stärker auf Augenhöhe erfolgen können.

- Temporäre Straßenexperimente helfen neue/zusätzliche Zielgruppen zu erreichen und fördern das Demokratieverständnis

Durch Straßenexperimente verlagern sich Diskussionen an die Transformationsorte. Dies erhöht nicht nur den Grad der Konkretheit von Diskussionen, sondern verringert auch die Einstiegshürden in die Diskussion. Menschen werden dort abgeholt, wo die Planungen später wirken. Dies schafft Transparenz und verringert den Eindruck, dass Planungen "irgendwo" am Schreibtisch entstehen. Der öffentliche (Straßen-)Raum wird dadurch öffentlich "produziert", wodurch sich auch die Identifikation mit den Planungen erhöhen kann.

- Temporäre Straßenexperimente sind kein Allheilmittel

Viele Städte haben in den letzten Jahren Straßenexperimente umgesetzt. Dafür braucht es finanzielle und vor allem personelle Ressourcen. Letztlich binden Experimente Ressourcen, die an anderer Stelle womöglich fehlen. Gleichzeitig wecken sie Erwartungen, z.T. auch falsche Erwartungen. Daher gilt es sich die Intention von Straßenexperimenten klar zu machen und kritisch zu reflektieren, ob das Experiment hierfür die richtige Methode ist. Dies gilt umsomehr, da Straßenexperimente Wirkungen von Planungen bzw. Umbauten immer nur andeuten können. Gerade die positiven mikroklimatischen Effekte von NBS lassen sich nur sehr eingeschränkt darstellen.

- Temporäre Straßenexperimente "nur" ein Baustein eines kollaborativen Planungsprozesses

Die Eignung und der Zeitpunkt des Einsatzes von Straßenexperimenten für Planungsprozesse hängt stets vom jeweiligen Einzelfall ab. Im Fallbeispiel hat es sich als zielführend erwiesen, das Straßenexperiment zu nutzen, um die artikulierten Bedarfe und daraus abgeleiteten Zukunftsbilder dar- und damit zur Diskussion zu stellen. Dadurch wurden die bisherigen Planungen qualifiziert. Das Experiment diente jedoch auch der Stadtverwaltung und Kommunalpolitik zur Selbstvergewisserung, dass die Planungen nicht nur planerisch möglich sind, sondern auch gesellschaftliche Akzeptanz finden. Das Straßenexperiment war folglich eines

1004

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von mehreren Bausteinen, bei dem Stadtverwaltung, Kommunalpolitik und Zivilgesellschaft kollaborativ die Zukunft des Straßenraums gemeinsam entwickelten.

7 FAZIT

Das Fallbeispiel des Neuen Grabens, Dortmund, hat gezeigt, dass Straßenexperimente als Teil eines Beteiligungsprozesses die Qualität von Planungsentwürfen verbessern können. Sie ermöglichen eine verbesserte Diskussionskultur mit den Akteurinnen und Akteuren vor Ort und bieten Gelegenheit, Planungsideen frühzeitig im Feld zu testen. Sie sind jedoch mit einem nicht zu vernachlässigen personellen, zeitlichen und finanziellen Aufwand verbunden. Ihre Nutzung sollte daher kein Selbstzweck sein, sondern immer vom Einzelfall abhängig gemacht werden. Richtig eingesetzt, können sie jedoch die gesellschaftliche Akzeptanz veränderter Planungsparadigmen und notwendiger urbaner Transformationen erhöhen, damit Straßen und Städte zukünftig wieder zu lebenswerten Orten für Menschen werden.

8 LITERATUR

Bertolini, L. (2020). From "streets for traffic" to "streets for people": can street experiments transform urban mobility? Transport Reviews, 40:6, 734-753. https://doi.org/10.1080/01441647.2020.1761907

März, S., Schüle, R., Koop, C., & Peter, L.-K. (2020). Lebenswerte" Straße in resilienten urbanen Quartieren: Projektergebnisse eines Teilprojektes im Gesamtprojekt „Eckpunkte für die Umsetzung einer Landesstrategie zur Klimaanpassung aus wissenschaftlicher Sicht. Wuppertal Institut für Klima, Umwelt, Energie. https://epub.wupperinst.org/frontdoor/index/index/docId/7518

März, S., Broesi, R., & Verheyen, L. (2022). Transformation urbaner Quartiersstraßen: Straßenraumplanung zwischen Verkehrswende, Klimaanpassung und Aufenthaltsqualität. Handbuch der kommunalen Verkehrsplanung, Erg.-Lfg. 94

VanHoose, K.; Rivas de Gante, A.; Bertolini, L.; Kinigadner, J.; Büttner, B. (2022). From temporary arrangements to permanent change: Assessing the transitional capacity of city street experiments. Journal of Urban Mobility 2 (2022) 100015. https://doi.org/10.1016/j.urbmob.2022.100015

Zoderer, B. M., &Tasser, E. (2021). The plurality of wilderness beliefs and their mediating role in shaping attitudes towards wilderness. Journal of Environmental Management, 277, 111392. https://doi.org/10.1016/j.jenvman.2020.111392

Evaluation of High-Resolution Simulation of the Urban Heat Island in Vienna, Austria

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1 ABSTRACT

The recently developed microscale model for urban applications PALM-4U was used to simulate the thermal variability in Vienna on different spatial scales and to evaluate its ability to capture thermal characteristics in real urban environment.

The model simulations cover the entire city of Vienna with a spatial resolution of 20 m. The static data related to geographical information and urban infrastructure are based on GIS data provided by the city administration of Vienna, available as spatial multi-purpose maps (Flächen-Mehrzweckkarte - FMZK), street tree cadastre, Digital Elevation Model and Digital Surface Model, which were combined with the national land cover data (Land Information System Austria - LISA) to account for the unresolved vegetation and Open Street Map to include building properties in the surrounding region (Lower Austria) of the model domain. The simulations were performed for a selected clear-sky hot day in August 2022.

The results for hourly air temperature were evaluated with conventional weather stations of the national weather service and the city of Vienna and with quality-controlled data from citizen weather stations from the company NETATMO. The results show high intra-urban variability during daytime, but distinct spatial patterns at night with higher air temperatures in urban regions. In addition, spatial patterns of surface temperature were compared to remote sensing data from ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and with the modelling results from previous studies, but with coarser grid spacing (e.g. urban climate model MUKLIMO_3 with 100 m spatial resolution).

The results indicate that the microscale model PALM-4U shows general agreement with observations and is able to simulate atmospheric processes in urban regions. However, during the night a strong temperature inversion is present in the model, which can be related to the choice of model configuration and requires further investigations. The spatial patterns in urban-rural temperature gradient are similar as found in coarser scale model simulations and remote-sensing data, but show higher variation in surface temperature amplitude.

Keywords: surface temperature, climate modelling, urban heat island, simulation, palm-4u

2 INTRODUCTION

Due to the modified energy balance in built-up environment, urban areas are generally warmer than their surroundings (e.g. Oke, 2019; Oke et al., 2017), an effect known as the Urban Heat Island (UHI), or Surface Urban Heat Island (SUHI), when surface temperatures are considered. Building materials often have low reflectivity, high heat capacity and thermal conductivity, which enhances the absorption of solar radiation during the day and the excess heat is being slowly released during the night. Especially in densely built areas, with lack of vegetation and appropriate ventilation, the heat is being trapped in street canyons. Large water surfaces and green areas, usually provide regulating function in reducing the temperature extremes, through evaporative cooling and enhanced ventilation, in case of water, and shading, in case of trees. However, diversified relief, land use and land cover of cities, as well as characteristics of built-up structures, make the distribution of urban temperatures spatially inhomogeneous. Mapping of areas with extreme heat or cool zones and understanding the development of UHI became an important issue in urban planning in order to protect the beneficial natural areas, decrease the impact of existing and avoid generation of new hot-spots through further urban development.

As a measure to reduce negative aspects of urban climate, the City of Vienna developed an UHI strategic plan (UHI MA22, 2015) including a number of urban planning measures for buildings and open spaces, particularly measures based on green infrastructure. The strategic plan was based on various data sources and climate studies assessing urban climate of Vienna (e.g. Schwab&Steinicke, 2003; Zuvela-Aloise et al. 2013; Stiles et al., 2014). Additional heat vulnerability map of Vienna was published in 2019 based on the thermal infrared sensor from Landsat 8 with a spatial resolution of 100 m, which was used to derive a weighted

average surface temperature for Vienna, covering the years 2015 to 2019 and combined with information on distribution of vulnerable age classes and a vegetation index (Bhattacharjee, 2019). An updated urban climate analysis map was provided in 2020 based on a GIS procedure and illustrates thermal characteristics, but also the cold air flow during the night. All studies of urban climate in Vienna indicate higher heat load in the densely built urban centre and lower temperatures in forested areas westward and along the river Danube. However, detection and exact localization of hot-spots, as well as selection of appropriate measures to reduce the UHI effect remained an issue. Various background data, spatial resolution and different mapping techniques lead to uncertainties in resulting urban heat maps.

One of the main tools for analysing UHI development are the urban climate models that take into account both urban morphology and meteorological data and can be used for climate assessment, as well as for evaluation of urban planning measures and spatial development plans. Newly developed urban microclimate model PALM-4U (Maronga et al. 2020) allows simulation of entire cities with a very high-resolution enabling detection of small-scale temperature variations on a building-scale. However, the model has not been tested yet in various urban environments and an evaluation of model performance is needed to quantify possible uncertainties.

In this study the urban climate model PALM-4U was applied to simulate the UHI in Vienna with grid-resolved building and vegetation canopy on a spatial resolution of 20 m. The simulations are compared to existing modelling simulations with the MUKLIMO_3 model used in previous studies (Hollosi et al. 2021; Zuvela-Aloise et al., 2022) and observational data. The modelled surface temperature was compared with the remote sensing data from ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and the near-ground air temperature was evaluated against monitoring data from citizen weather stations.

3 DATA AND METHODS

3.1 Urban climate simulations

The open-source modelling system PALM (PArallelized Large-Eddy Simulation Model) with recently developed additional modules for urban boundary layer (PALM-4U) is a new modelling tool for high spatial resolution simulations of urban environment based on the large-eddy simulation (LES) technique (Raasch and Schröter, 2001; Maronga et al., 2015; 2020). In this study, the PALM-4U model was applied for the city of Vienna to evaluate the model performance and was compared with the established modelling approach based on urban climate model MUKLIMO_3 (Sievers, 2016). In comparison to PALM-4U, the MUKLIMO_3 model uses RANS-type turbulence parametrization, parametrization of buildings and land use based on a tile approach and has typically a lower spatial resolution (20 - 100 m). The simulations were performed for August, 16-17, 2022, as a representative hot day with clear-sky conditions. The models were initialized at 06:00 UTC with the initial vertical profiles of meteorological variables from the AROME numerical weather forecast model in operation by GeoSphere Austria.

Both models use information on terrain, land use and land cover, building and vegetation properties, however, in different format and spatial detail. In case of the PALM-4U model, the static information was provided from Digital Elevation Model and Digital Surface Model for the City of Vienna and Lower Austria, land cover data from Land Information System Austria (LISA), Open Street Map, street tree cadastre (Baumkataster) and spatial multi-purpose maps (Flächen-Mehrzweckkarte - FMZK) of the City of Vienna. The spatial information was prepared in a raster format with 20 m spatial resolution according to Heldens et al. (2020). In case of the MUKLIMO_3 model raster data with 100 m spatial resolution were provided for terrain height, land use types based on Copernicus Urban Atlas enriched with LISA land cover data, building height, wall area index of buildings, building density, tree cover and proportion of sealed surfaces based on High-Resolution Layers of Copernicus Land Monitoring Services.

3.2 Observational temperature data

The standard meteorological monitoring network in Vienna includes about a dozen of official semi-automatic weather stations, so-called TAWES stations, and additional environmental monitoring stations employed by the city administration departments (MA22). In order to evaluate the modelling results with high spatial resolution, a higher density of monitoring stations is needed. For this purpose, the monitoring

1008

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data from a network of over 1000 private weather stations available in Vienna provided by the company NETATMO was used. To minimize the uncertainty associated with the non-standardized temperature measurements, a statistical quality control as proposed in Napoly et al. (2018) was applied. As previous studies for Vienna have shown (Hammerberg et al. 2018, Feichtinger et al. 2020), a rigorous quality control which detects outstanding temperature observations, can help to reduce sources of errors and the data can be used to investigate the intra-urban air temperature variations.

The remote sensing data for surface temperature were provided by ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission. The ECOSTRESS Land Surface Temperature and Emissivity Daily L2 Global 70m V001 dataset (Hook & Hulley, 2019), which is part of the ECO2LSTE Version 1 data product providing atmospherically corrected land surface temperature and emissivity (LST&E) values derived from five thermal infrared bands including layers of LST, emissivity for bands 1 through 5, quality control for LST&E, LST error, emissivity error for bands 1 through 5, wideband emissivity and Precipitable Water Vapor were used. The dataset has a spatial resolution of about 70 m. In this study, the LST and corresponding quality control data for LST layers available for August 16, 2022 were considered. A short overview of data used in model validation is shown in Table 1.

	MUKLIMO_3	**PALM-4U**	**ECOSTRESS**	**NETATMO**
Type of data	RANS microscale model output	LES microscale model output	satellite imagery	private weather stations
Spatial resolution	100 m	20 m	70 m	over 1000 stations with quality-controlled data
Time output	hourly	hourly	snapshot	30-min to hourly
Air temperature	reference at 2 m, defined vertical model levels	reference at 2 m, defined vertical model levels	not available	variable
Surface temperature	temperature of soil, streets, building roofs and top of vegetation (trees)	temperature of soil, streets, building roofs and the soil under the vegetation (trees)	temperature of surface visible by satellite (excluding clouds)	not available

Table 1: Overview of meteorological data used in the study.

4 RESULTS

The observational data for air temperature based on quality-controlled measurements from NETATMO private weather stations show distinct pattern of the UHI island in Vienna during the night. Higher temperatures are found in the city centre and lower temperatures in the surroundings (Fig. 1). The model results show similar large-scale pattern, however, small-scale variation in temperature and temperature inversion with height are more pronounced in the PALM-4U model compared to the model with lower spatial resolution (MUKLIMO_3).

The spatial patterns in surface temperatures based on remote sensing (Fig. 2), show an urban-rural temperature gradient as well, with higher temperatures found in built-up areas and lower temperatures in forested areas and near water. However, agricultural areas in south and east show high surface temperatures during the day as well. This effect is most likely caused by high exposure of low vegetation and free soil to solar radiation and low soil moisture during the heat wave and is well captured by the models. The PALM-4U model overestimates the surface temperatures in urban areas, which can be partially explained by variations in temperatures due to the higher model resolution, but requires further investigation.
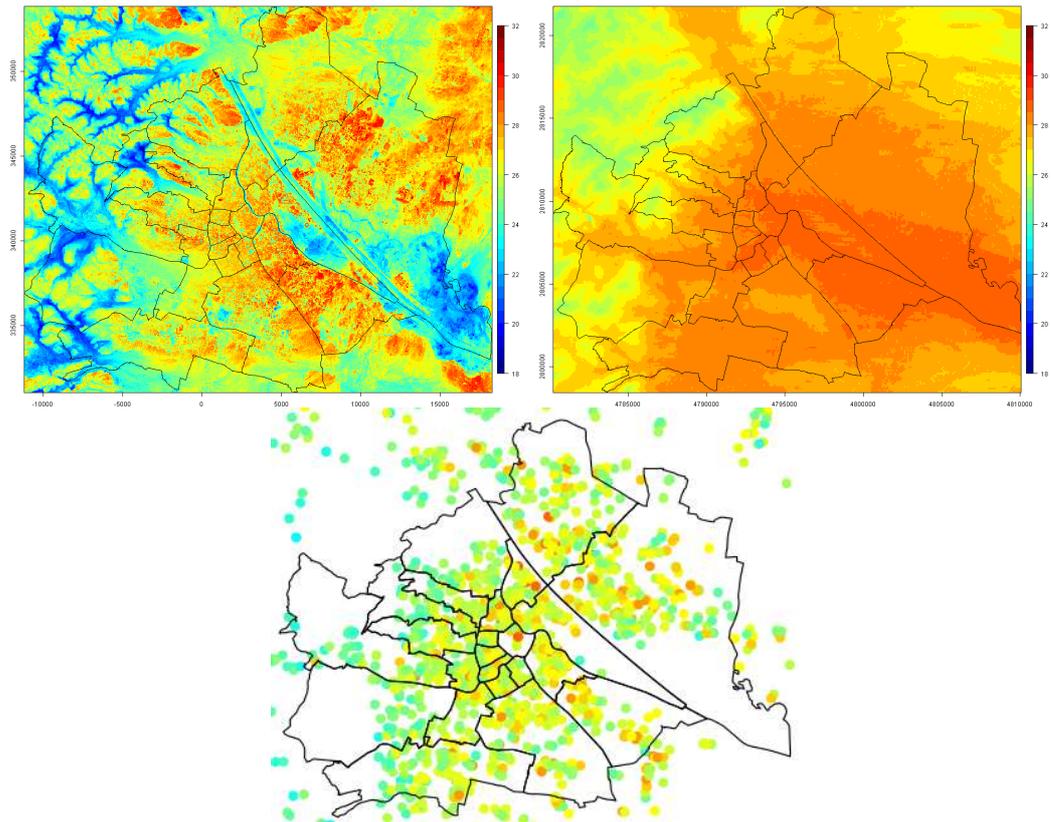
Fig. 1: Air temperature (°C) in Vienna on 16. August 2022 at 19:00 UTC calculated by PALM-4U model (top left), MUKLIMO_3 model (top right) and derived from quality-controlled monitoring dataset of NETATMO private weather stations (bottom).
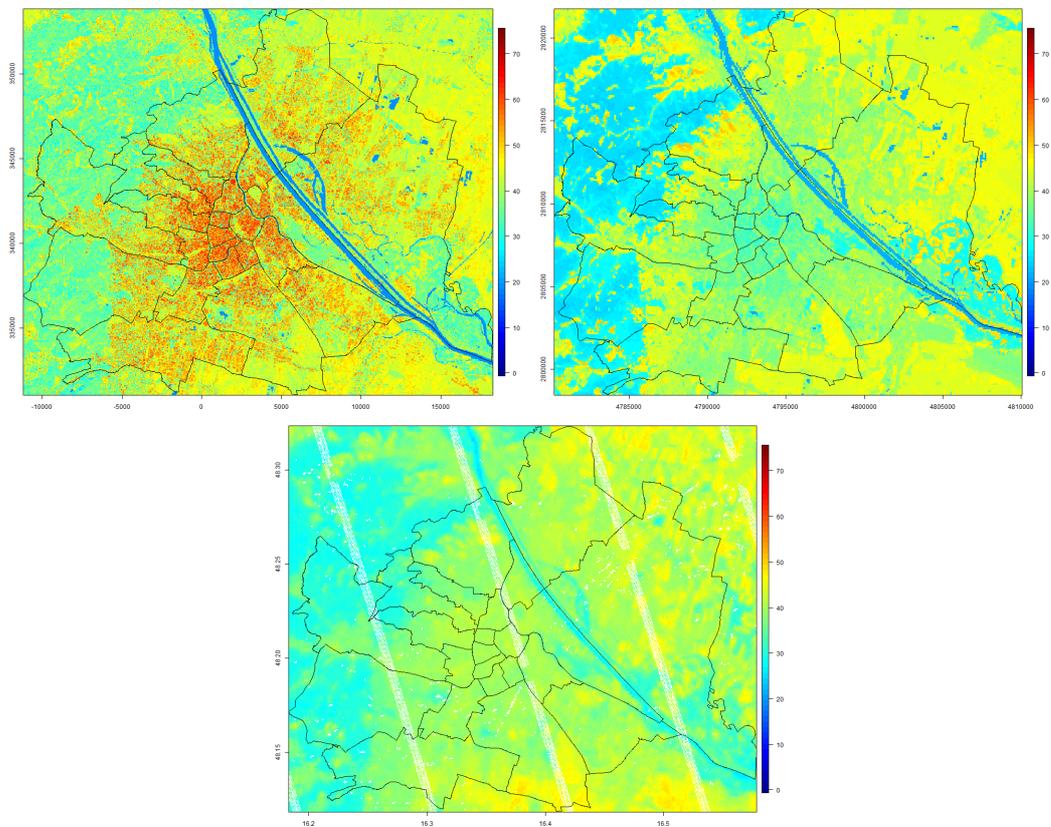

Fig. 2: Surface temperature (°C) in Vienna on 16. August 2022 at 12:00 UTC derived by PALM-4U model (top left), MUKLIMO_3 model (top right) and provided by ECOSTRESS (ECO2LSTE.001, day: 228; time: 11:38:39 UTC) remote sensing dataset (bottom).

1010

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5 CONCLUSION

This study investigated the perfomance of the PALM-4U model to simulate the development of the UHI in Vienna during summer conditions. By using models with higher resolution, small-scale processes such as turbulence, shading by buildings and vegetation, interaction between the atmosphere and urban surfaces and building materials are better represented. Increasing the model resolution enables more detailed analysis of inner-city temperature variations and allows detection of additional heat or cool zones in the city. The modelled spatial distribution of near surface air temperature and surface temperature was compared with observational data and lower resolution model results from existing studies.

The results of the PALM-4U model show typical spatial variations of urban heat with higher temperatures in built-up areas and lower temperatures in surroundings, particularly forest and water areas, which is found in previous studies and can be confirmed by observational data. The spatial distribution is different during the day and night-time. The UHI effect is more pronounced during the night, while during the day high local variations in temperatures are found.

When comparing the modelled air temperatures with measurements from NETATMO citizen weather stations, the PALM-4U model shows higher spatial variations than the MUKLIMO_3 model. Large temperature variations are also found in the observational dataset during the day. However, the correlation between the PALM-4U model and observations is not necessarily higher than the MUKLIMO_3 model. The reason is that the temperature variations in the NETATMO dataset during the day are probably related to the specific positioning of stations and influence of local factor such as shading, exposure to radiation and viscinity of buildings which could not be filtered out during the quality control completely.

At night, the spatial patterns between the models and NETATMO temperature measurements are more similar. It indicates that the strong small-scale variation diminishes and the NETATMO temperature measurements become more representative for a larger area. However, a strong temperature inversion during the night is found in the PALM-4U model, which can be related to the choice of model configuration and needs further investigation.

Comparison of ECOSTRESS LST remote sensing data with PALM-4U model simulations shows higher variability in modelled surface temperature than observed, which is partially related to higher spatial resolution of the model. The forest areas are warmer than observed. However, the results can not be directly compared since the model output reflects the surface soil level under the trees, rather than tree tops as observed by the remote sensing. While agricultural areas are well represented by the model, the built-up areas, i.e. building roofs, show very high temperature values ($> 60°C$) that require further analysis.

6 REFERENCES

BHATTACHARJEE, S.: The Urban Heat Vulnerability map of Vienna. ECOTEN sro: Praha, Czech Republic. 2019.

FEICHTINGER, M., de Wit, R., Goldenits, G., Kolejka, T., Hollósi, B., Žuvela-Aloise, M. and Feigl, J.: Case-study of neighborhood-scale summertime urban air temperature for the City of Vienna using crowd-sourced data. Urban Climate, 32, 100597. 2020.

HAMMERBERG, K., Brousse, O., Martili, A., Mahdavi, A.: Implications of employing detailed urban canopy parameters for mesoscale climate modelling: a comparison between WUDAPT and GIS databases over Vienna, Austria. Int J Climatol, 38: e1241-e1257. 2018.

HELDENS, W., Burmeister, C., Kanani-Sühring, F., Maronga, B., Pavlik, D., Sühring, M., Zeidler, J., and Esch, T.: Geospatial input data for the PALM model system 6.0: model requirements, data sources, and processing, Geosci. Model Dev., 13, 5833–5873, 2020.

HOLLOSI, B., Žuvela-Aloise, M., Oswald, S., Kainz, A., and Schöner, W.: Applying urban climate model in prediction mode - evaluation of MUKLIMO_3 model performance for Austrian cities based on the summer period of 2019. Theoretical and Applied Climatology, 144, 1181-1204. 2021.

HOOK, S., & Hulley, G.: ECOSTRESS Land Surface Temperature and Emissivity Daily L2 Global 70 m V001 [Data set]. NASA EOSDIS Land Processes DAAC. doi, 10. 2019.

MARONGA, B., Gryschka, M., Heinze, R., Hoffmann, F., Kanani-Sühring, F., Keck, M., Ketelsen, K., Letzel, M. O., Sühring, M., and Raasch, S.: The Parallelized Large-Eddy Simulation Model (PALM) version 4.0 for atmospheric and oceanic flows: model formulation, recent developments, and future perspectives, Geosci. Model Dev., 8, 1539-1637, DOI:10.5194/gmd-8-2515-2015, 2015.

MARONGA, B., Banzhaf, S., Burmeister, C., Esch, T., Forkel, R., Fröhlich, D., Fuka, V., Gehrke, K. F., Geletič, J., Giersch, S., Gronemeier, T., Groß, G., Heldens, W., Hellsten, A., Hoffmann, F., Inagaki, A., Kadasch, E., Kanani-Sühring, F., Ketelsen, K., Khan, B. A., Knigge, C., Knoop, H., Krč, P., Kurppa, M., Maamari, H., Matzarakis, A., Mauder, M., Pallasch, M., Pavlik, D., Pfafferott, J., Resler, J., Rissmann, S., Russo, E., Salim, M., Schrempf, M., Schwenkel, J., Seckmeyer, G., Schubert, S., Sühring, M., von Tils, R., Vollmer, L., Ward, S., With a, B., Wurps, H., Zeidler, J., and Raasch, S.: Overview of the PALM model system 6.0, Geosci. Model Dev., 13, 1335–1372. 2020.

NAPOLY, A., Grassmann, T., Meier, F. and Fenner, D.: Development and Application of a Statistically-Based Quality Control for Crowdsourced Air Temperature Data. Front. Earth Sci. 6:118. doi: 10.3389/feart.2018.00118. 2018.

OKE, T.R.: The heat island of the urban boundary layer: Characteristics, causes and effects. In Cermak, J. E. et al. (eds.), Wind Climate in Cities, Kluwier Academic Publishers, 81-107. 1995.

OKE, T. R., Mills, G., Christen, A. & Voogt, J. A.: Urban Climates. Cambridge and New York: Cambridge University Press. 2017

RAASCH, S. and M. Schröter: PALM - a large-eddy simulation model performing on massively parallel computers. Meteorol. Z. 10, 363–372, 2001.

UHI MA22: Urban Heat Island strategy plan for Vienna: https://www.wien.gv.at/umweltschutz/raum/pdf/uhi-strategieplan.pdf, Vienna, 2015.

SCHWAB, U. & Steinicke, W. (2003): Urban Climate Investigation Vienna, commissioned by MA 22, Vienna, 2003.

SIEVERS, U.: Das kleinskalige Strömungsmodell MUKLIMO_3 Teil 2: Thermodynamische Erweiterungen. Berichte des Deutschen Wetterdienstes 248. 2016.

STILES, R., Gasienica-Wawrytko, B., Hagen, K., Trimmel, H., Loibl, W., Köstl, M., Tötzer, T., Pauleit, S., Schirmann, A., Feilmayr, W.: Urban fabric types and microclimate response - assessment and design improvement. Klima-und Energiefonds: Final Report, Vienna. 2014.

ZUVELA-ALOISE, M., Koch, R., Nemec J., Matulla C.,: Future of Climatic Urban Heat Stress Impacts – Adaption and mitigation of the climate change impact on urban heat stress based on model runs derived with an urban climate model, Klima-und Energiefonds: Final Report, Vienna. 2013.

ZUVELA-ALOISE, M., Goler, R., Hahn, C., Hollosi, B., Kainz, A., Oswald, S.: LUCRETIA - The role of Land Use Changes on the development of intra-urban heat islands, Klima-und Energiefonds: Final Report, Vienna. 2022.

1012

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From Pixels to Planning: Large-scale Mapping of Urban Morphology and Population Distribution with the World Settlement Footprint 3D

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1 ABSTRACT

Urban morphology and human population distribution are two interrelated aspects of our urbanization that play a critical role in shaping the sustainability, resilience and liveability of cities. In recent years, the advent of global datasets with 3D information derived from Earth Observation (EO) technologies has revolutionised our ability to study and analyse these two aspects of urbanisation, providing information that is essential for designing cities that can accommodate the needs of their residents while minimizing their environmental impact.

One such dataset is the novel World Settlement Footprint 3D (WSF3D) produced by the German Aerospace Center (DLR). The WSF3D was the first global dataset providing detailed information of the fraction, area, average height and total volume of buildings, at unprecedented spatial resolution, coverage and consistency. Since its development, researchers from different organizations (e.g. WorldBank, United Nations, WorldPop) have employed the dataset as input data for large-scale studies in urban morphology and population distribution, with a level of detail that was previously impossible.

In this paper we present a selection of WSF3D-driven applications with the objective of demonstrating how the new data can be used to support urban planning and management. First, the WSF3D has been employed to demonstrate how the four layers of the dataset can be used to determine a building's functional use, and how this information can be leveraged to improve large-scale models of population distribution at large-scale. Thereafter, the WSF3D has been used to determine the relationships among building height/volume, population density and income, which can provide insights into the efficient use of space (e.g. crowding vs layering) on the one hand, and shed light into infrastructure disparities and variations, on the other. With that being said, due to the global nature of the WSF3D dataset, the previous analyses were conducted from local to regional scales, which can also help identify opportunities for interventions that can be replicated across different locations.

Overall, with the results of this research, the authors aim to provide planners and policy-makers with valuable insights into usability of the globally available WSF3D dataset. By demonstrating its potential as reliable and robust input data, this study seeks not only to empower evidence-based decision-making, but also to advocate for the widespread adoption of geospatial layers in the implementation of strategies towards sustainable development strategies of the built environment.

Keywords: Sustainability, World Settlement Footprint 3D, Earth Observation Data, Large-scale Population Distribution, Large-scale Urban Morphology

2 INTRODUCTION

Understanding of how cities are structured and how populations are distributed is crucial for the development of sustainable, resilient and liveable cities. On the one hand, from a socio-economic perspective, being able to identify areas of high population density and areas with high building density (2D and 3D), can promote efficient planning and utilization of resources like water, energy, transportation and waste management (Chokhachian et al., 2020; Wang et al., 2021b). This allows creating more vibrant cities, which in return, attract business, tourists and investments, generating an economic boost that enables social equality and inclusivity. On the other hand, from an environmental point of view, knowledge on these two factors aids in designing cities that minimize urban sprawl and population crowding, promoting compact, secure and eco-friendly urban centres (Lall et al., 2021; Wang et al., 2021a). For example, with up-to-date and precise information, governments and planners can conduct better hazard and environmental assessments that aim at reducing pollution levels and habitat fragmentation and loss, as well as promoting cities that are more

resilient to climate-related impacts like sea-level rise, flooding or extreme heat (Cai et al., 2021; Carpio et al., 2021; Mills et al., 2021; Scheba et al., 2021).

In this framework, with the advancement of Earth Observation (EO) technologies (e.g. remote sensing) and artificial intelligence (e.g. machine and deep learning), the development of geospatial datasets has revolutionised our ability to study and analyse urban morphology and population distribution (Chen et al., 2023) . Global-scale datasets, in particular, allow for cross-regional comparisons that enable researchers and planners to understand similarities and differences among cities and countries, helping identify best practices and solutions that can be applied in different contexts (Wang et al., 2023).

In this paper, we present the novel World Settlement Footprint 3D dataset (WSF3D) produced by the German Aerospace Center (DLR) (Esch et al., 2022), and showcase a series of insightful applications that can be performed with the data. Our research objectives are twofold: Firstly, we emphasize the dataset's potential for enhancing large-scale population modelling by leveraging volume and building use information exclusively from the WSF3D dataset. To achieve this, we explore the capabilities of a machine learning algorithm to categorize buildings into residential and non-residential classes, using the fourWSF3D layers: building area, height, fraction, and volume. Additionally, we provide accuracy results obtained from other population modelling methods, demonstrating the significant improvements attained through the utilization of the new WSF3D. Secondly, we conduct analyses across diverse spatial domains to investigate how the WSF3D dataset can be employed to compare and contrast different urban patterns, such as crowding versus layering across cities, countries, and regions. Moreover, we examine how infrastructure disparities and variations relate to income data. The primary focus here is to demonstrate the capability of combining the WSF3D with other information sources to facilitate the derivation of crucial statistical analyses that can be replicated across various locations.

3   APPLICATIONS BASED ON THE WORLD SETTLEMENT FOOTPRINT 3D

The WSF3D was the first global dataset providing detailed information of the fraction, area, average height and total volume of buildings. The dataset has unprecedented spatial resolution (~90m at the Equator) and is open-and-free for download at https://geoservice.dlr.de. In regards to its processing framework, the WSF3D was generated using a combination of a modified version of the ~10m WSF binary settlement mask derived from S1-S2 data (Marconcini et al., 2021) and ~12m digital elevation data and radar imagery collected by the TanDEM-X mission (Zink et al., 2014). Its production relied on three automatic workflows: one to estimate the building fraction and areas, a second to estimate the mean building height, and a third to estimate the total built-up volume. For a more detailed description of these three modules, please refer to Esch et al. (2022).

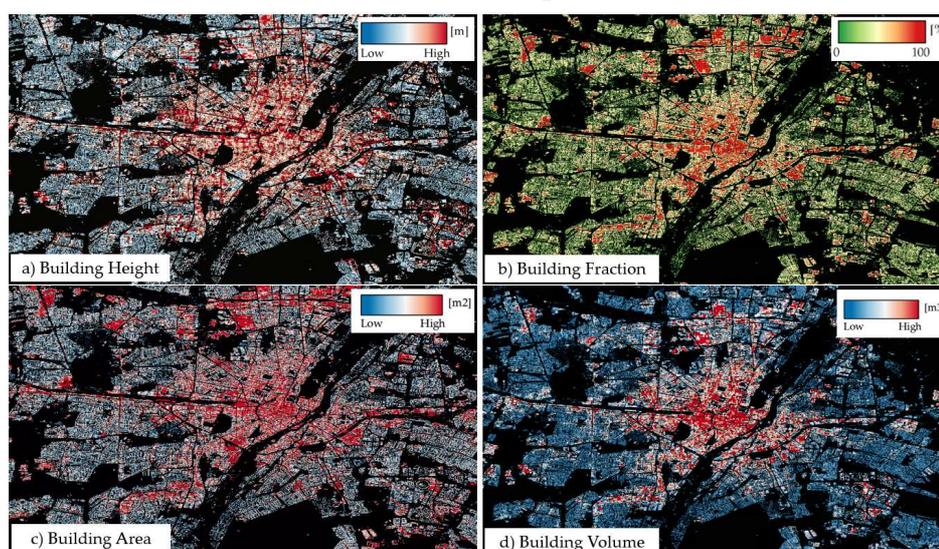Figure 1 illustrates a subset of the four main layers that compose the WSF3D.

Fig. 1: WSF3D for the city of Munich, Germany. a) Building height [m], b) Building Fraction [%], c) Building area [m2] and d) Building Volume [m³]. Image reference: Palacios-Lopez et al. (2022)

3.1 Large-scale gridded population modelling

Gridded population datasets model human population distributions using a dasymetric modelling approach, in which census counts are disaggregated from administrative units into a reference grid, using different geospatial layers as determinants of allocation. While gridded population datasets have been produced for more than 20 years, recently we have witnessed a significant breakthrough in the field, as current products have begun incorporating 3D and functional use information into their models, thus reducing underestimation errors in rural regions and overestimations in urban areas

In this section we show how the WSF3D can be used to improve the qualitative and quantitative accuracy of residential population estimations without relying on any other data source. The analyses presented here are based on the research of Palacios-Lopez et al. (2022), where the authors apply the same methodology at a Pan-European scale.

First, using a Random Forest (RF) classifier and training data collected from the Urban Atlas 2018 , we show how spatial metrics derived from the WSF3D dataset are sufficient to identify large industrial/commercial areas in the built-up environment. In particular, the use of the mean, median and stdev. of the four WSF3D-layers, are enough to accurately recognise these areas. Using the city of Ljubljana in Slovenia as an example, Figure 2 shows outcome of this classification. At the country level, the classification achieves an overall accuracy (OA): 86.31% and a Kappa coefficient (K) of 0.7. According to the results presented in Palacios-Lopez et al. (2022), at a Pan-European scale the average OA and K can achieve average values of 84.43% and 0.68, respectively.
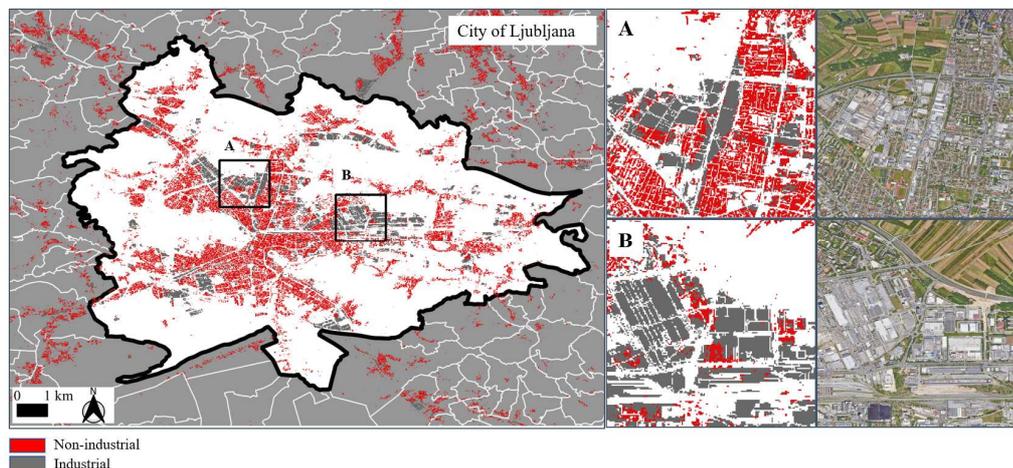

Fig. 2: Industrial/Non-industrial classification based on spatial metrics derived from the WSF3D and RF algorithm.

Using this binary classification, as a second step we evaluate how the accuracy of gridded population maps improves by incorporation building volume and building use information into the modelling framework. We compare our results with methods that are based on general 2D proxies and no building use information, which represent methods that are still largely employed (Leyk et al., 2019). For the city of Ljubljana (NW-area), Figure 4 shows the outcome of population distribution maps produced on the basis of a binary settlement layer (BM), a fraction layer (BF), a volume layer (BV) and volume + use layer (BV-IS).

As observed, gridded population maps based on the BM proxy layer show homogeneous distributions, with each pixel having the same population. In contrast, maps using BF, BV, and BV-IS proxies exhibit more spatial heterogeneity, following changes in density and volume values. Without settlement use information, BF and BV maps allocate a large population proportion to industrial areas. The BV proxy, however, minimizes this effect, allocating more population to dense non-industrial areas compared to BF, where populations in both dense non-industrial and industrial areas seem balanced. By comparing the relative error produced by the layer, it is clear that the BV-IS delivers the best results. In areas where a large share of industrial areas are found, overestimations are minimized by more than 500%. Comparably, in areas where the share of industrial areas is less (e.g. residential areas), the BV-IS also produced errors closer to 10%.
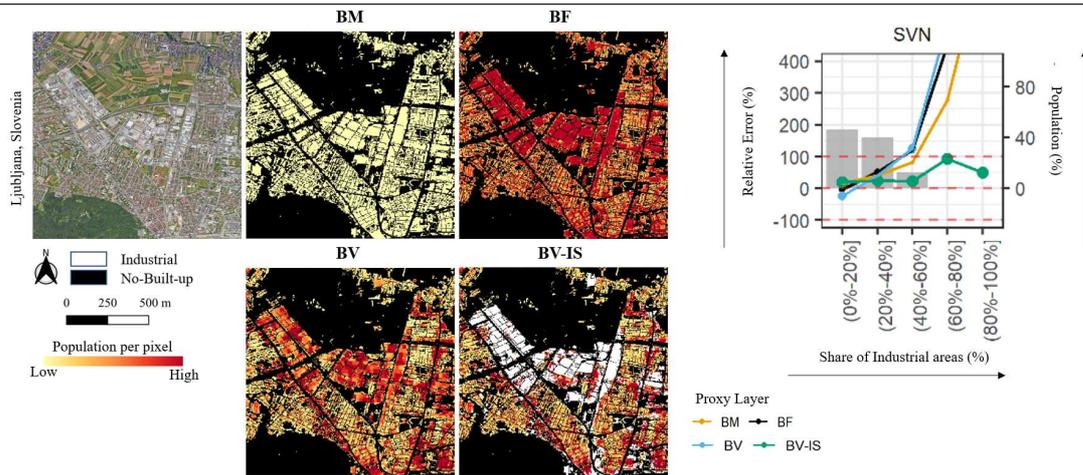
Fig. 3.

3.2 Analysis of urban morphology

In the following two subsections we present a set of applications that demonstrate how the WSF3D can be integrated with different data sources, to understand the correlations that might exist between urban morphology and socio-economic development. Analyses are carried-out in two spatial domains:

(1) at the country level using the GADM v4.1 polygons and socio-economic data downloaded from the WB development indicators catalogue.

(2) at the urban cluster level (globally) using the GHS Urban Clusters, which provide socio-economic information at the level or urban areas,

For each spatial domain the following variables have been collected/used: average building height and total built-up area from the WSF3D, and population, income group, and GDP.

3.2.1 Analysing "Crowding vs Layering"

Figure 4 provides a graphical representation of each country's position concerning its population (x-axis), average height (y-axis), and built-up area (bubble size), coloured according to their income group. The chart categorizes countries based on their tendencies towards "layering" (top-left) or "crowding" (lower-right) based on their urban development patterns.

Analysing the chart, we observe that high-income (HIC) countries predominantly cluster towards the top-left quadrant, indicating their inclination to construct buildings with greater height and extensive built-up areas compared to lower-income (LIC), lower-middle income (LMIC), and upper-middle-income (UMIC) countries. The behaviour of HIC, coupled with their relatively smaller populations, suggest that they offer more space to their citizens (including industrial and commercial buildings), contributing to a lower population density and -presumably - less crowding.
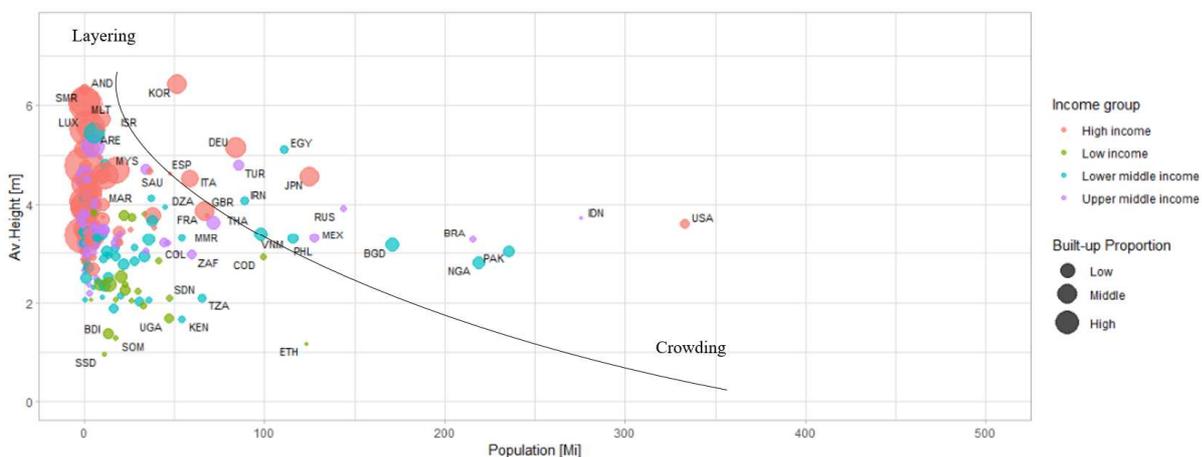

Fig. 4: Country-scale representation of "layering" and "crowding" trends. Total population and income group represent the year 2022.

Comparably, the same data can also be displayed as shown in Figure 5. Here for example, it can be seen that countries that are located in different income groups, but that have similar populations and similar GDP, do not necessarily offer the same space to people. These differences can also be appreciated for countries within the same income group, where the amount of GDP does not necessarily play a role in built-up space. While somehow simple, information like this can help, for example, to shed light into how building policies and financial resources are being implemented to define building space, as well, as well as to understand how possible geographical restrictions including, being an island or having coastal areas, might influence infrastructure development.
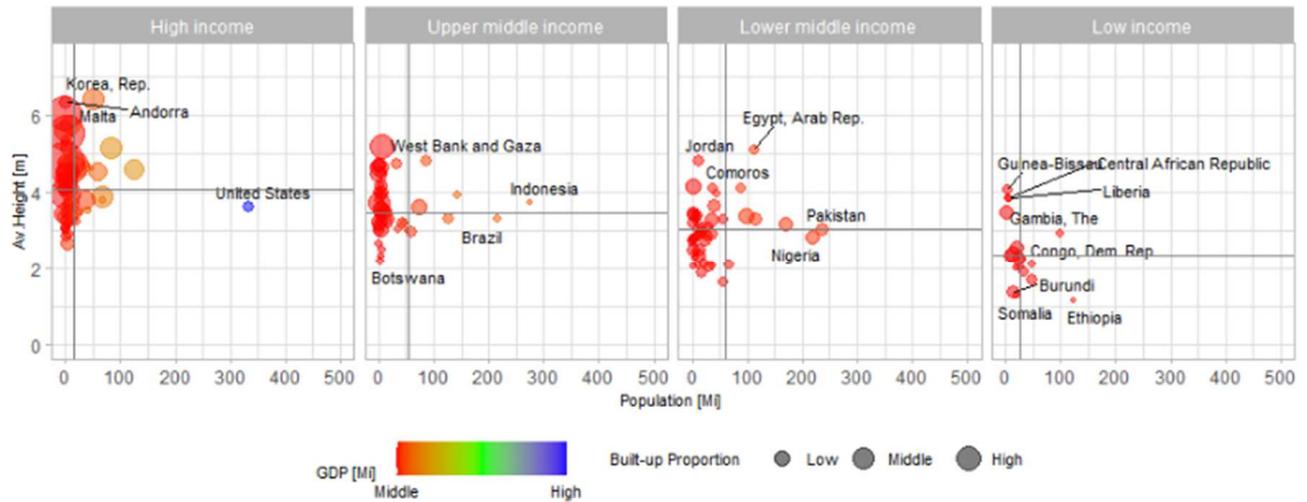
Fig. 5: Country-scale distribution of av. height, built-up area and population with respect GDP and income group.

3.2.2 Analysing "Infrastructure disparities"

While the continental-scale analyses presented in the previous section can be found already useful to define some correlations between morphology and economic development, the use of the WSF3D can also help to analyse infrastructure disparities at the city level. For a number of selected countries, Figure 6 shows the position of different urban clusters in relation to their average height and built-up area proportion.
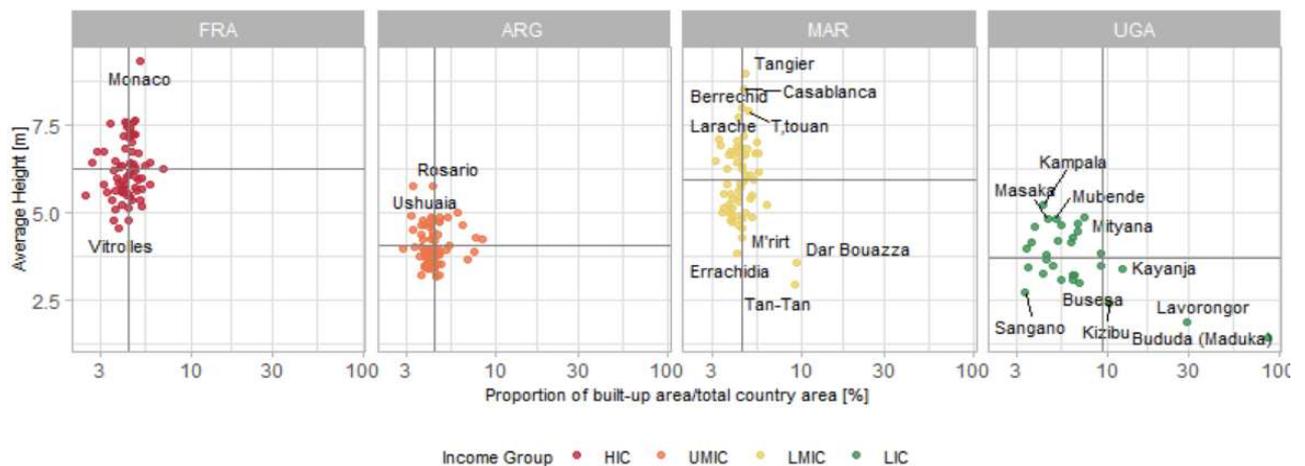

Fig. 6: Urban Cluster distribution in terms of av. height and built-up proportion for France, Argentina, Morocco and Uganda. Each country belongs to a different income group.

Notably, at the country level, France and Morocco display strikingly similar patterns in terms of average height and built-up proportion, as indicated by the horizontal and vertical black lines. This suggests that income levels may not be the sole determining factor influencing infrastructure choices. Surprisingly, Argentina, despite being classified as an upper-middle-income country, exhibits lower average building heights compared to Morocco and appears relatively close to Uganda, which falls into a lower-income group.

In contrast, analysing within-country disparities reveals a different narrative. Within each country, cities exhibit greater variation in their morphological characteristics, as depicted by the spread of points in both the

x and y directions. This variation is notably pronounced among Ugandan cities, indicating that local policies and institutional forces play a significant role in shaping urban development patterns within the country

4 CONCLUSION AND DISCUSSION

Accurate knowledge of the 3D characteristics of the built-up environment and population distribution holds significant potential to enhance aspects of sustainability and resilience in urban planning and related decision-making processes. However, a major obstacle in advancing our understanding of these factors on a large scale has been the scarcity of data with sufficient accuracy, spatial detail, and consistency.

This paper introduces and showcases a series of applications that leverage the WSF3D dataset. First, we demonstrate how this data can improve existing population models by integrating volume and functional use information of the built-up environment, leading to more precise population estimates. The key advantage of this approach lies in achieving higher quantitative and qualitative accuracies over binary and density approaches using a single dataset, thus eliminating the technical complexities associated with gathering extensive data. As we continue to develop a multi-temporal WSF3D layer, our outlook is to produce and openly release a global-scale, multi-temporal population dataset with unparalleled accuracy and spatial resolution (approximately 10 meters).

Furthermore, we illustrate how the WSF3D dataset can be employed to comprehend the complex correlations between economic and institutional forces with urban morphology. We highlight how patterns and trends vary depending on the spatial domain of analysis. For example, the observed similarities in urban morphology between countries with different income levels highlight the need to consider various factors beyond income when formulating urban development strategies. Moreover, the substantial variation in urban morphology within a single country underscores the importance of context-specific policies and governance in shaping the built environment. These insights provide valuable guidance for policymakers and urban planners to foster equitable and sustainable development practices, tailoring solutions to address the unique challenges and opportunities presented by different urban contexts.

In conclusion, due to the remarkable versatility and seamless integration of the WSF3D with other data sources, our main goal in presenting these results is to encourage further exploration and utilization of this dataset to address diverse spatial and socio-economic challenges worldwide. By leveraging this valuable resource, researchers and policymakers can make informed decisions that foster sustainable urban development and enhance the overall well-being of communities globally.

5 ACKNOWLEDGEMENTS

6 REFERENCES

Cai, M., et al. (2021). The need for urban form data in spatial modeling of urban carbon emissions in China: A critical review. Journal of Cleaner Production, 319, 128792.

Carpio, A., et al. (2021). Urban form, land use, and cover change and their impact on carbon emissions in the Monterrey Metropolitan area, Mexico. Urban Climate, 39, 100947.

Chen, T.-H. K., et al. (2023). Detecting urban form using remote sensing: spatiotemporal research gaps for sustainable environment and human health. In Earth Data Analytics for Planetary Health (pp. 185-217). Springer.

Chokhachian, A., et al. (2020). Urban performance and density: Generative study on interdependencies of urban form and environmental measures. Sustainable Cities and Society, 53, 101952. https://doi.org/https://doi.org/10.1016/j.scs.2019.101952

Esch, T., et al. (2022). World Settlement Footprint 3D-A first three-dimensional survey of the global building stock. Remote Sensing of Environment, 270, 112877.

Lall, S. V., et al. (2021). The Evolution of City Form.

Leyk, S., et al. (2019). The spatial allocation of population: a review of large-scale gridded population data products and their fitness for use. Earth Syst. Sci. Data, 11(3), 1385-1409. https://doi.org/10.5194/essd-11-1385-2019

Marconcini, M., et al. (2021). Understanding current trends in global urbanisation-the world settlement footprint suite. GI_Forum, 9(1), 33-38.

Mills, G., et al. (2021). Characterising urban morphology for urban climate modelling. Urban Climate Science for Planning Healthy Cities, 339-354.

Palacios-Lopez, D., et al. (2022). Towards an improved large-scale gridded population dataset: A Pan-European study on the integration of 3D settlement data into population modelling. Remote Sensing, 14(2), 325.

1018

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Scheba, A., et al. (2021). Inequality and urban density: Socio-economic drivers of uneven densification in Cape Town. Environment and Urbanization ASIA, 12(1_suppl), S107-S126.

Wang, J., et al. (2023). EO+ Morphometrics: Understanding cities through urban morphology at large scale. Landscape and Urban Planning, 233, 104691.

Wang, P., et al. (2021a). Sustainability of compact cities: A review of Inter-Building Effect on building energy and solar energy use. Sustainable Cities and Society, 72, 103035.

Wang, W., et al. (2021b). From simulation to data-driven approach: A framework of integrating urban morphology to low-energy urban design. Renewable Energy, 179, 2016-2035.

Zink, M., et al. (2014). TanDEM-X: The New Global DEM Takes Shape. IEEE Geoscience and Remote Sensing Magazine, 2(2), 8-23. https://doi.org/10.1109/MGRS.2014.2318895

Hochauflösendes Monitoring der Flächennutzungsentwicklung in Städten und Regionen mit dem IÖR-Monitor

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1 ABSTRACT

Es wird der Monitor der Siedlungs- und Freiraumentwicklung (IÖR-Monitor) und seine Entwicklung vorgestellt. Er visualisiert die Flächennutzungsentwicklung in einem interaktiven Viewer. 90 Indikatoren in 15 Indikatorkategorien stehen zur Verfügung und werden in Form von Karten, Tabellen, Statistiken und Entwicklungsgraphen visualisiert. Die Indikatorwerte werden für administrative Gebietseinheiten vom Bund bis zu den Gemeinden und Gemeindeteilen und in unterschiedlicher Rasterauflösung bis zu 100 m-Rastern gezeigt. Die Zeitreihen beginnen ab 2000 und umfassen inzwischen 18 Zeitschnitte. Exportfunktionen ermöglichen vertiefte statistische Auswertungen und WebGIS-Dienste die Einbindung der Daten in Geoinformationssysteme. Der Beitrag geht anfänglich auf die wichtigste Datengrundlage ein, das Amtlich Topographisch-Kartographische Informationssystem (ATKIS Basis-DLM). Dieses beschreibt die topographischen Objekte der Landschaft im Vektorformat nach der AAA-Modellierungsvorschrift der AdV flächendeckend für Deutschland in hoher räumlicher Auflösung. Diese Datengrundlage hat viele Vorteile im Flächennutzungsmonitoring gegenüber den Nutzungsinformationen des Liegenschaftskatasters ALKIS, welches Grundlage der amtlichen Flächenstatistik ist. Am Ende wird auf ausgewählte Indikatoren zur Beschreibung der Nachhaltigkeit der Entwicklung eingegangen. Das betrifft die Zeitreihe zur Flächeninanspruchnahme, zur Siedlungsdichte, zur Entwicklung der Flächen für Freiflächen-Photovoltaik und die bauliche Entwicklung in Überschwemmungsgebieten.

Keywords: Flächennutzungsmonitoring, Quantitative Indikatoren, Nachhaltige Entwicklung, Städte- und Rgionenvergleich, Flächensparen

2 PROBLEM FLÄCHENVERBRAUCH

Immer noch wird weltweit zu viel Freiraumfläche umgewandelt in Siedlungs- und Verkehrsflächen. Dieser Prozess ist verbunden mit dem Verlust natürlicher Böden, die überbaut und zu großen Teilen damit auch versiegelt werden. Dieser Prozess ist in aller Regel irreversibel. So werden in Zukunft Flächen fehlen für eine ökologische Landwirtschaft, die mehr Fläche benötigt als eine Konventionelle. Zudem bedingt eine Bodenversiegelung städtische Überwärmungen, verhindert die Wasserspeicherung im Boden, befördert einen schnellen Wasserabfluss, Hochwassergefahren usw..

Natürlichen Böden kommt eine Schlüsselrolle in der Nachhaltigkeitstransformation zu. So formuliert der Wissenschaftliche Beirat der Bundesregierung Globale Umweltveränderungen (WBGU) in seinem Hauptgutachten: „*Nur wenn sich unser Umgang mit Land grundlegend ändert, können die Klimaschutzziele erreicht, der dramatische Verlust der biologischen Vielfalt abgewendet und das globale Ernährungssystem nachhaltig gestaltet werden.*" (WBGU 2021).

Inzwischen wurden für alle administrativen Ebenen Begegnungsziele formuliert, beginnend mit der weltweiten Agenda 2030 mit den SDG-Nachhaltigkeitszielen. So wird im Kapitel „Nachhaltige Städte und Gemeinden" das Ziel verfolgt, Städte und Siedlungen inklusiv, sicher, widerstandsfähig und nachhaltig zu gestalten (SDG 11). In Europa wird das „No Net Land Take-Ziel" verfolgt, den Flächenverbrauch bis 2050 auf Netto-Null zu senken (EU 2011). Auch in Deutschland soll bis 2050 nach dem „Klimaschutzplan 2050" eine Flächenkreislaufwirtschaft verwirklicht werden (BMUB, 2016).

Ein konkretes Ziel zur Reduktion der Flächenneuinanspruchnahme in Deutschland wurde erstmals im Jahr 2002 in der Deutschen Nachhaltigkeitsstrategie formuliert. Ausgehend von dem damaligen hohen Wert von mehr als 120 Hektar pro Tag wurde für das Jahr 2020 das Ziel von maximal 30 Hektar pro Tag definiert (Bundesregierung, 2002; Jakubowski & Zarth, 2003). Nachdem sich abzeichnete, dass dieser Wert bis 2020 nicht erreichbar sein würde, enthielt die Neuauflage der Nachhaltigkeitsstrategie von 2016 die Formulierung der Erreichung eines Wertes von „weniger als 30 Hektar pro Tag" bis zum Jahr 2030, allerdings ohne konkrete Bezifferung des anzustrebenden Wertes (Bundesregierung, 2017).

In Deutschland sind Flächensparziele formliert in der Nachhaltigkeitsstrategie der Bundesregierung (weniger als 30 ha/Tag bis 2023) bzw. im Klimaschutzprogramm der Bundesregierung eine vollständige

Flächenkreislaufwirtschaft bis 2050 (Bundesregierung). Auch viele Bundesländer in Deutschland verfolgen eigene Flächensparziele (Tab. 1).

Bundesland	Flächensparziel [ha/d]	Flächenverbrauch (2022)
Baden-Württemberg	3	5,2
Bayern	5,00	8,9
Berlin		0,0
Brandenburg		1,4
Bremen	0,1-0,3	0,1
Hamburg		0,0
Hessen	2,5	2,1
Mecklenburg-Vorpommern	1,2	4,0
Niedersachsen	3,0	11,9
Nordrhein-Westfalen	5,0	4,8
Rheinland-Pfalz	1,0	3,2
Saarland	472m²/Einw.	0,7
Sachsen	2,0	2,1
Sachsen-Anhalt	1,3	0,6
Schleswig-Holstein	1,3	1,2
Thüringen		0,7
Deutschland gesamt	< 30	46,7

Tabelle 1. Flächensparziele und aktueller Flächenverbrauch der Bundesländer (Stand: 2022) . Quelle: eigene Recherchen

3 FLÄCHEN(NUTZUNGS)MONITORING

Um den Erfolg flächenpolitischer Maßnahmen zu messen, bedarf es eines verlässlichen Monitorings der Siedlungs- und Verkehrsfläche. Wichtigster Indikator dabei ist die Flächenneuinanspruchnahme (FNI) oder „Anstieg der Siedlungs- und Verkehrsfläche" gemessen in ha/Tag. Mit diesem Indikator kann der Zielerreichungsgrad und die Wirksamkeit flächenpolitischer Maßnahmen beurteilt werden. Seine Bestimmung sollte dafür so aktuell, genau, räumlich hochauflösend und vor allem auch in seiner Veränderung für eine robuste Zeitreihe sicher bestimmt werden. Wie hoch die Anforderungen an die Genauigkeit des Indikatorwertes ist, der derzeit bei ca. 55 ha/Tag (Destatis) liegt bzw. bei 47 ha/Tag (IÖR-Monitor), wird bewusst, wenn man diesen in Beziehung zu dem SuV-Flächenanteil setzt. Denn diese erhöht sich bei einer Zunahme um 50 ha/Tag nur um 0,1 % pro Jahr. In allen Monitoringsystemen werden leider die Veränderungen nicht direkt, sondern nur als Differenz der Flächennutzungenwerte im Jahresvergleich gemessen. Eine direkte objektscharfe Auswertung aller Neubauten über die primären Bauerfassungsbögen ist leider derzeit durch das Hochbaustatistikgesetz nicht möglich. Denn die Adressen der Neubauten sind ein Primärmerkmal und dürfen darum weitergegeben werden. Sie dienen innerhalb der Statistik zur Aggregation der einzelnen Bauaktivitäten auf Bundeslandebene. Die Einzelauswertung der Bauerfassungsbögen aber würde eine viel verlässlichere Indikatorwertbestimmung des Flächenverbrauchs ermöglichen (Meinel, 2017). Eine fernerkundlichen Erhebung der Flächennutzung ist derzeit nur mit einer max. 95–98 % Klassifikationsgüte möglich, eine Veränderungsdetektion wäre noch ungenauer. Damit sind verlässliche Aussagen und Bewertungen der Veränderungsrate in robusten Zeitreihen bis heute nicht möglich.

Prinzipiell ist die Erfassung des Flächenverbrauchs primär- oder sekundärstatistisch möglich (Meinel 2023). Bei der Primärerfassung ist das Erhebungsprogramm direkt auf die Erfassung der Flächennutzungsveränderung ausgerichtet. Vertreter davon sind die Arealstatistik Schweiz (Bundesamt für Statistik 2023 und Meinel 2023) und das Bodenbedeckungs-/ Bodennutzungsstatistik-Programm LUCAS (Eurostat, 2023). Sekundärstatistische Erhebungen zeichnen sich dadurch aus, dass der Flächenverbrauch nicht das ursächliche Ziel der Erhebung ist. Damit fehlt sekundärstatistischen Erhebungen die erforderliche Methodenkonstanz, da die Programme immer wieder ihren Hauptanforderungen angepasst werden. Ein

1022

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Beispiel dafür ist die amtliche Flächenerhebung in Deutschland. Einen Vergleich von primär- und sekundärstatistischer Flächenerhebung zeigt Tab. 2. Bei der Messung der Flächenneuinanspruchnahme sind Nutzungsänderungen flächenscharf und nicht nur kumulativ zu bestimmen. Da sich in der Vergangenheit die Erhebungsmodelle zum Teil grundlegend geändert haben und dies in Zukunft voraussichtlich wieder passieren wird, ist dies vor dem Hintergrund einer insgesamt geringen Veränderungsdynamik besonders herausfordernd.

	Primärstatistische Flächenerhebung	**Sekundärstatistische Flächenerhebung**
Auswertemethodik	statistische Hochrechnung	Kumulation von Flächen, Pufferung von Linien bzw. Punkten
Aufwand	hoch	mittel
Methodenkonstanz	Weitestgehend, da keine anderen Anforderungen zu erfüllen sind	Gering, da primäre andere Anforderungen zu erfüllen sind
räumliche Auflösung der Analyseeinheiten	Gering, durch statistische Hochrechnung	hoch, da Erhebungseinheit=Analyseeinheit
zeitliche Auflösung	gering (3, 6 oder 12-jährig)	hoch (2-3 Jahre, Tendenz jährlich)
thematische Genauigkeit	Hoch, durch Vororterhebung oder sehr genaue stereometrische Erhebung	Gering, durch Abgrenzungsunsicherheiten
Homogenität	hoch, da wenige Interpreter	gering, da viele Interpreter
Stabilität der Zeitreihen	Hoch, durch Methodenkonstanz	Niedrig, durch methodische Veränderungen

Tabelle 2: Vergleich von primär- und sekundärstatistischer Flächenerhebung (Quelle: https://doi.org/10.5281/zenodo.8115880)

Ergebnisse einer vergleichenden Untersuchung zur Erhebung der »Tatsächlichen Nutzung« in ALKIS und der daraus abgeleiteten Zeitreihe zur Flächenneuinanspruchnahme sind hier zu finden (Blechschmidt & Meinel, 2022)

4 FLÄCHENNUTZUNGSMONITORING IM IÖR-MONITOR

Seit seiner Einführung im Jahr 2010 werden im Monitor der Siedlungs- und Freiraumentwicklung (IÖR-Monitor) Indikatoren zu Struktur und Dynamik der Flächenentwicklung in Deutschland veröffentlicht. Am Beginn der Arbeit stand eine Untersuchung geeigneter Datengrundlagen (Schumacher und Meinel 2009). Viele Gründe sprachen für die Nutzung des ATKIS in seiner höchsten räumlichen Auflösung, dem Basis-DLM (AdV 2023). Seine hohe räumliche und thematische Auflösung, seine zyklische flächendeckende Grund- und Spitzenaktualisierung, seine freie Verfügbarkeit und seine gegenüber dem Kataster vergleichsweise geringen Migrationsartefakte und Inhomogenitäten ermöglichen ein verlässliches Flächennutzungsmonitoring. Allerdings verlangen seine digitale Ablage eine Flächenpriorisierung und seine nur linienhafte Führung von Verkehr und Gewässern deren Pufferung mit den jeweiligen Objektbreiten. Die Methodik dazu wird hier detailliert beschrieben. Ausgangspunkt für die Indikatorenberechnung ist eine Rasterkarte der Flächennutzungsarten in einer Rasterweite von 2,5 m (Krüger et al. 2013).

Sowohl das thematische Spektrum der Indikatoren, die Funktionalität der interaktiven Webanwendung als auch die Daten- und Dienstbereitstellung durch Exportdienste wurden seit 2010 kontinuierlich ausgebaut und werden stetig weiterentwickelt (Meinel et al. 2021 und Meinel 2023).

Im Jahr 2020 wurde der IÖR-Monitor vom Rat für Sozial- und Wirtschaftsdaten (RatSWD) als Forschungsdateninfrastruktur akkreditiert. Dies hat seine Nutzung auch auf sozialwissenschaftliche Fragestellungen ausgedehnt und belegt die gesellschaftliche und wissenschaftliche Relevanz seiner bereitgestellten Indikatoren.

Neben Messgrößen zur Flächennutzungsstruktur (Flächenanteile unterschiedlicher Landnutzungskategorien) werden auch komplex berechnete Indikatoren bereitgestellt, beispielsweise zur Landschaftsqualität (z. B. Fragmentierung der Landschaft, Hemerobie), dem räumlichen Muster von Siedlungen (z. B. Zersiedelung) oder zum Flächenbedarf für nachhaltige Energiegewinnung (Windpark- und Solarenergieflächen).

5 AUSGEWÄHLTE ERGEBNISSE

Im Folgenden werden ausgewählte Ergebnisse gezeigt, die Belege für die Nutzung des IÖR-Monitors in der raumanalytischen Forschung und der Planungspraxis sind.

5.1 Flächenneuinanspruchnahme

Abb. 1 zeigt die Entwicklung des Nachhaltigkeitsindikators „Anstieg der Siedlungs- und Verkehrsfläche" für Deutschland im Vergleich der amtlichen Flächenstatistik mit den Werten des IÖR-Monitors. Die Werte des IÖR-Monitors liegen immer unter dem Wert der amtlichen Flächenerhebung, wobei sich die Differenzen zwischen 2010 bis 2020 stetig verkleinern. Allerdings laufen die Kurven ab 2021 wieder auseinander, was u. a. auf die Berücksichtigung von Vormigrationen im IÖR-Monitor zurückzuführen ist. Für 2022 liegt bedingt durch Erhebungsverzögerungen seitens der amtlichen Flächenerhebung noch kein Wert vor.
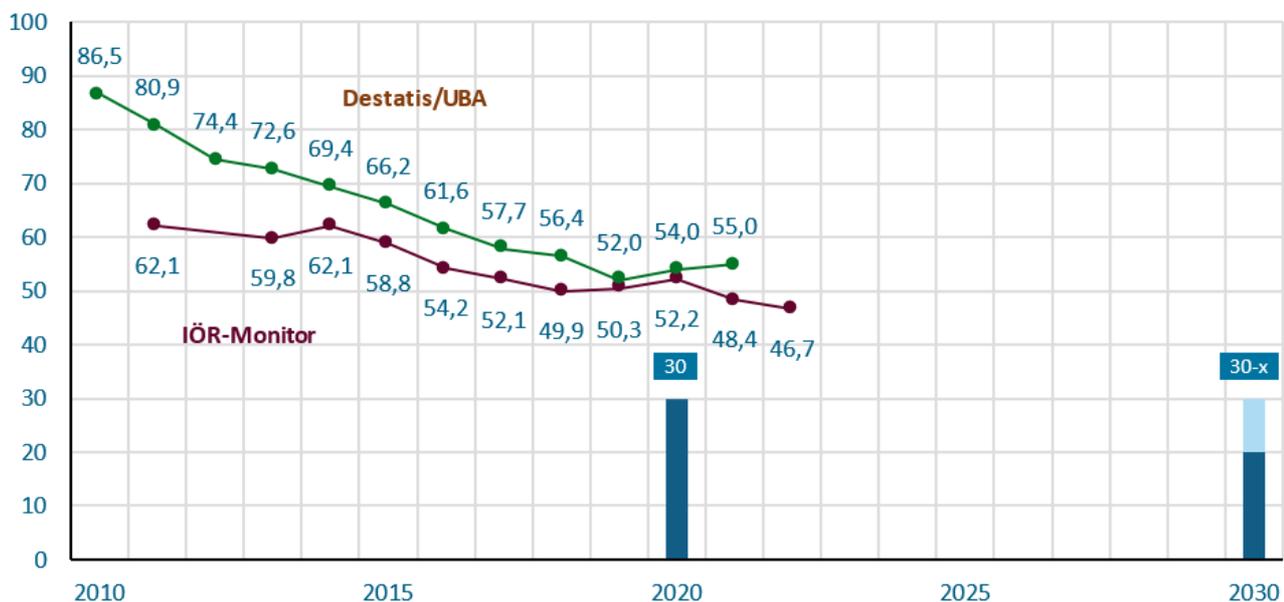

Abb. 1: Entwicklung der Flächenneuinanspruchnahme (grün=amtliche Flächenstatistik, braun=IÖR-Monitor) (Quelle: https://doi.org/10.5281/zenodo.8115880)

5.2 Entwicklung der Siedlungsdichte

Abb. 2 zeigt die Entwicklung des Nachhaltigkeitsindikators „Siedlungsdichte" seit 2010. Dieser Indikator wurde seit 2016 mit der Neuauflage der Nachhaltigkeitsstrategie der Bundesregierung und im Zuge der Anpassung an die weltweiten SDGs neu aufgenommen (Bundesregierung 2016). Die „Siedlungsdichte" beschreibt, wie viele Einwohner auf einem Quadratkilometer Siedlungs- und Verkehrsfläche leben. Anders als die Einwohnerdichte kann damit die Effizienz der Siedlungsflächennutzung bewertet werden. Ziel der Bundesregierung ist eine Stabilisierung der Siedlungsdichte auf den Wert des Referenzjahres 2000 (Bundesregierung 2016). Der Kurvenverlauf zeigt allerdings, dass dieses Ziel verfehlt wird. Dabei ist die Siedlungsdichte in Landkreisen stärker rückläufig als in kreisfreien Städten. Aber auch dort sank die Siedlungsdichte gegenüber dem Jahr 2010. Weiterführende Details sind publiziert in (Hübsch 2017).

1024

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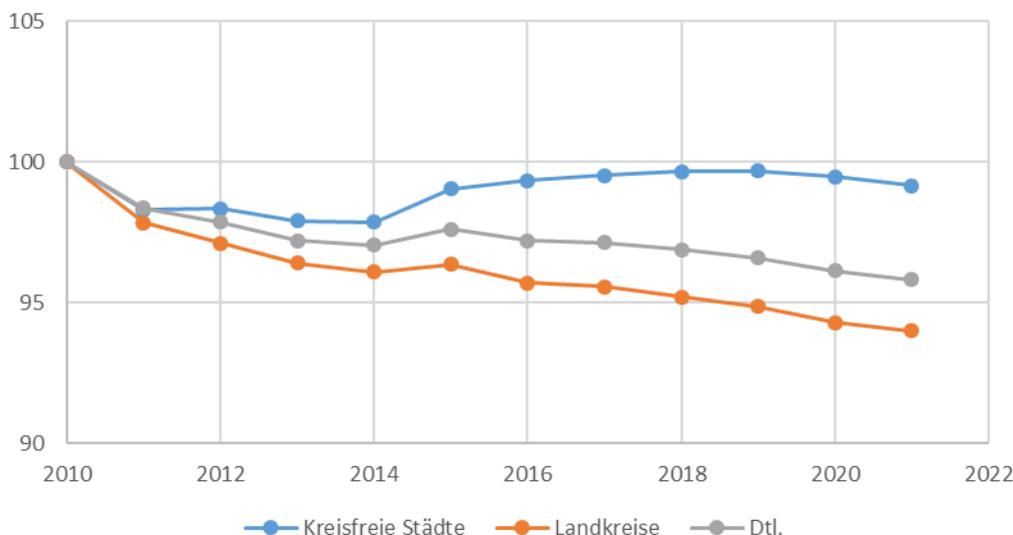
Abb. 2.: Entwicklung des Nachhaltigkeitsindikators Siedlungsdichte (Quelle: IÖR-Monitor)

5.3 Energieflächeninanspruchnahme durch Freiflächenphotovoltaik

Der Bedarf an Flächen für Freiflächenphotovoltaik (FF-PV) ist gewaltig. Auch wenn diese für die Energiewende gebraucht werden, ist der damit in der Regel verbundene landwirtschaftliche Flächenverlust problematisch zu sehen. Das gilt insbesondere dann, wenn hochwertige Böden mit FF-PV überbaut werden. Selbst wenn unter den Anlagen noch eine Beweidung erfolgt, ist die ackerbauliche Nutzung nicht mehr möglich. Lösung wäre hier eine multifunktionale Flächennutzung, wie die Agro-PV oder die Aqua-PV (Kern 2023). Abb. 3 zeigt die rasante Flächeninanspruchnahme durch FF-PV in Deutschland.
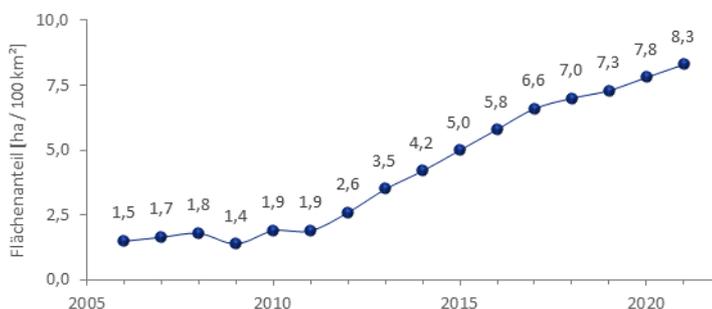
Abb. 3: Entwicklung der Freiflächen-PV in Deutschland (Quelle: IÖR-Monitor?)

Die Abbildungen 4 und 5 zeigen die unterschiedliche Ausbausituation in den Bundesländern. Ersichtlich ist der höhere FF-PV-Flächenanteil im Osten und Südosten Deutschland gegenüber dem Westen und Norden (Walz et al. 2022). Dort dominiert die Windkraft, wie im Indikator „Anteil Windparkfläche an Gebietsfläche" im IÖR-Monitor in einer Karte auf Kreisbasis von 2022 gezeigt: https://monitor.ioer.de/?rid=4359) Weitere Details sind Krüger et al. 2023 und Lipfert 2023 zu entnehmen.
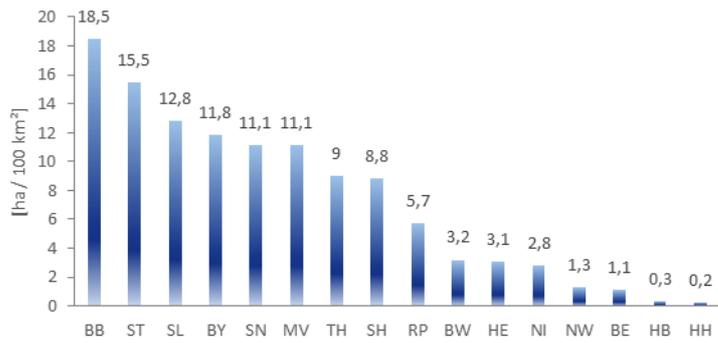
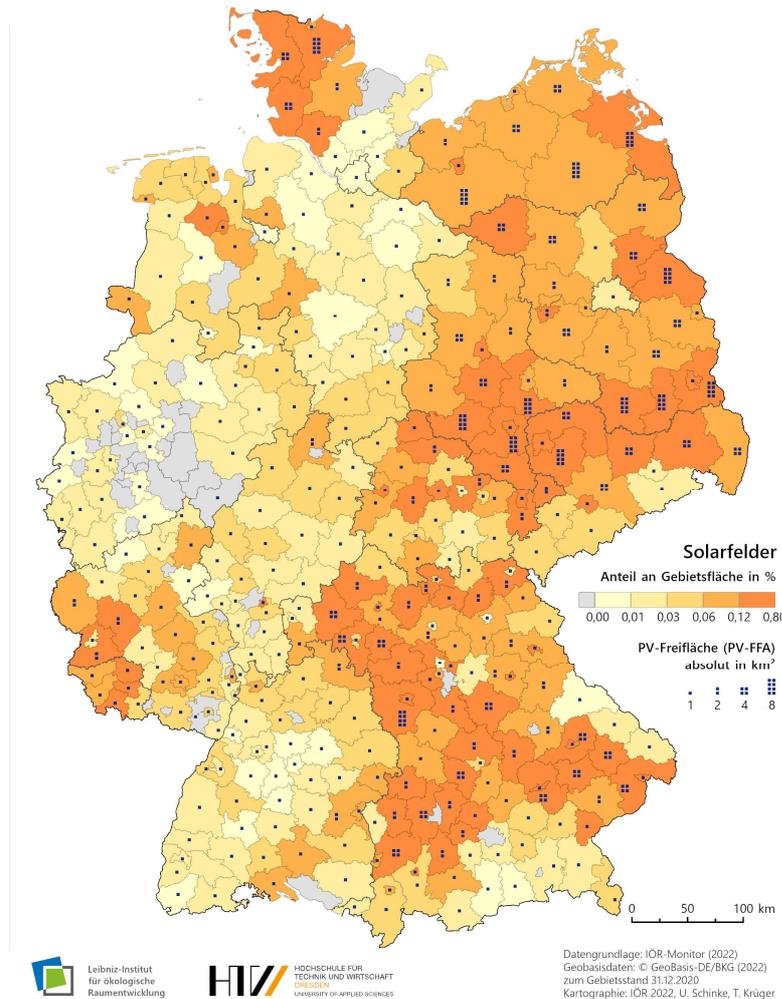Abb. 4: Flächenanteile PV-FFA für die Bundesländer (Quelle: IÖR-Monitor)

Abb. 5.: Anteil der FF-PV an den Gebietsflächen der Kreise Deutschlands (Quelle: IÖR-Monitor)

5.4 Bauliche Entwicklung in Überschwemmungsgebieten

Abb. 6 zeigt die im IÖR-Monitor visualisierte bauliche Entwicklung in amtlich festgesetzten Überschwemmungsgebieten (Indikator Siedlungslast der Kategorie Risiko, Kreiskarte 2022: https://monitor.ioer.de/?rid=4358). Die Siedlungslast berechnet sich dabei aus dem Flächenanteil des amtlich festgesetzten Überschwemmungsgebietes, der von baulich geprägter Siedlungs- und Verkehrsfläche eingenommen wird. Obwohl amtlich festgesetzte Überschwemmungsgebiete eigentlich frei zu halten sind vor baulichen Entwicklungen, zeigt die Abb. 6, dass die bauliche Entwicklung in Überschwemmungsgebieten (blau) höher ist als die allgemeine Siedlungsentwicklung (orange). Selbst die öffentliche Hand ist in dieser Hinsicht oft kein Vorbild. So wurde beispielsweise das Dresdner Kongresszentrum wegen der Attraktivität des Standortes unmittelbar an der Elbe errichtet, obwohl die Fläche in einem festgesetzten Überschwemmungsgebiet liegt.
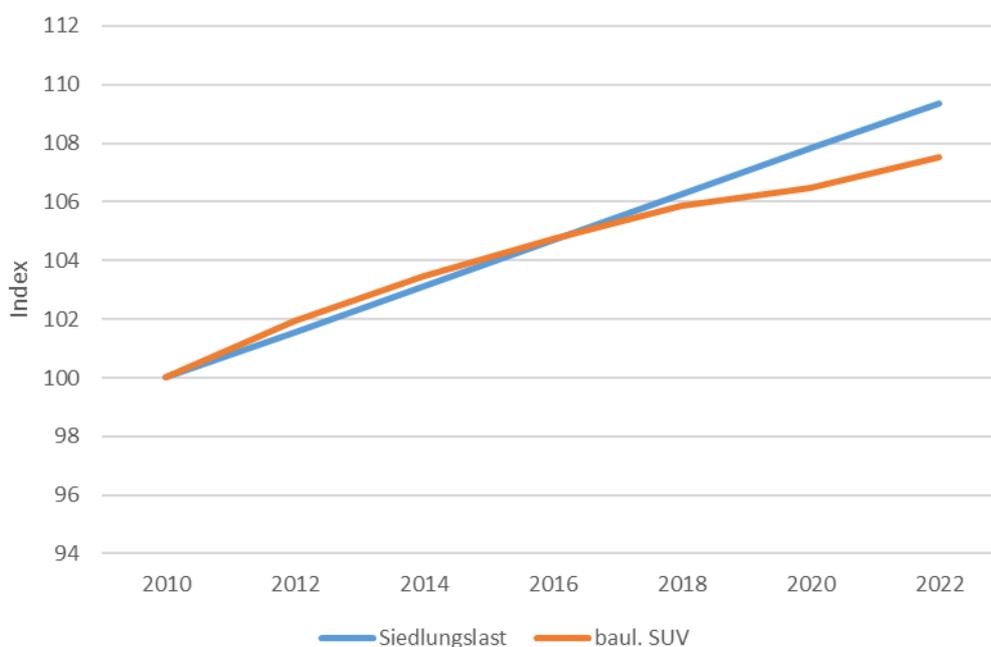
Abb. 6.: Bauliche Entwicklung in amtlich festgesetzten Überschwemmungsgebieten (Quelle: IÖR-Monitor)

6 SCHLUSSFOLGERUNG

Das Flächennutzungsmonitoring ist und bleibt eine große Herausforderung. Erst lange robuste Zeitreihen ermöglichen die sichere Bewertung der Veränderungstendenzen der Flächennutzung. Sowohl ALKIS (optimiert für den Grundstücksverkehr) als auch ATKIS (optimiert für geotopographische Visualisierungen) sind beide nicht ursächlich für ein Flächennutzungsmonitoring und eine daraus abgeleitete Flächenstatistik konzipiert. Beide Systeme werden sich mit der Umsetzung der GeoInfoDok NEU (AdV, 2023) zum 31.12.2023 verändern. Während die Flächenerfassung in ALKIS sehr inhomogen ist und noch verschiedene methodische Veränderung vor sich hat, sind die ATKIS-Daten homogener und die Analysen führen zu robusteren Zeitreihen.

Beste Ergebnisse werden mit einer Primärerhebung der Flächennutzung erzielt, wie die Arealstatistik in der Schweiz zeigt. Nur mit einer über Jahrzehnte nahezu unveränderten Methodik einschließlich der genutzten Basisdaten, können präzise flächenstatistische Analysen und flächenpolitische Schlußfolgerungen gezogen werde. Allerdings nur für vergleichweise große Gebietseinheiten (Kantone) und auch nur über lange Zeiträume (12 Jahre).

Die amtliche Flächenstatistik in Deutschland ist hinsichtlich robuster Zeitreihen des Kernindikators „Anstieg der Siedlungs- und Verkehrsfläche" schon auf Bundeslandebene im räumlichen und zeitlichen Vergleich problematisch. Aber auch Städte und Gemeinden brauchen für ihre Bebaungsplanung und Flächenhaushaltspolitik verlässliche Zahlen zum Flächenverbrauch. Mit dem IÖR-Monitor werden verlässliche Daten angeboten. Allerdings sind es Daten aus der Forschung, denen der Stempel der Amtlichkeit fehlt, was die Arbeit und Zitation dieser Daten in der Praxis erschwert. Die Perspektiven des IÖR-Monitors werden in (Meinel 2022) aufgezeigt.

Die Indikatorwerte des IÖR-Monitors zeigen einen stabilen Abwärtstrend der Flächeninanspruchnahme auf Bundesebene im IÖR-Monitor. Dagegen sprechen zum einen die deutliche Verfehlung des 30-Hektar-Ziels im Jahr 2020, zum anderen die Trendumkehr zu steigenden Werten seit 2018 und eine fehlende verbindliche Kontingentierung des Bundesziels auf der Ebene der Planungs- und Entscheidungsträger. Ohne rechtsverbindliche Flächenkontingentierung wird das Fernziel einer Flächenkreislaufwirtschaft nicht zu erreichen sein. Zu groß sind die Triebkräfte des Marktes.

Die Einbeziehung der Primärdaten der Erhebungsbögen der Bautätigkeitsstatistik als Referenzdaten neuer Gebäude könnte die Qualität der Erhebung und der Zeitreihen wesentlich verbessern (Meinel, 2019). Anzustreben wäre auch die Erstellung eines Referenzdatensatzes der Flächennutzung einschließlich dessen

zyklischer Aktualisierung für eine Teilfläche. Nur so könnte die Güte von Flächennutzungserhebungsmethoden bestimmt bzw. ein Training neuer KI-basierte Klassifikatoren erfolgen.

7 LITERATURVERZEICHNIS

ADV (2023): Digitales-Basis Landschaftsmodell (Basis-DLM), abgerufen am 06.09.2023 von https://www.adv-online.de/AdV-Produkte/Geotopographie/Digitale-Landschaftsmodelle/Basis-DLM/ , 2023.

ADV (2023): GeoInfoDok neu: abgerufen am 06.09.2023 unter https://www.adv-online.de/GeoInfoDok/GeoInfoDok-NEU-Referenz-7.1/

BLECHSCHMIDT, J.; MEINEL, G. (2022): Vergleichende Untersuchung zur Erhebung der »Tatsächlichen Nutzung« in ALKIS und der daraus abgeleiteten Zeitreihe zur Flächenneuinanspruchnahme, In: zfv – Zeitschrift für Geodäsie, Geoinformation und Landmanagement 147 (2022) 4/2022, S. 250-260, https://doi.org/10.12902/zfv-0400-2022, 2022.

BMUB (2016): Klimaschutzplan 2050 - Klimaschutzpolitische Grundsätze und Ziele, der Bundesregierung, , abgerufen am 06.09.2023 unter https://www.bmwk.de/Redaktion/DE/Artikel/Industrie/klimaschutz-klimaschutzplan-2050.html , Berlin, 2016.

BUNDESAMT FÜR STATISTIK (2023): Arealstatistik Schweiz, abgerufen am 06.09.2023 unter https://www.bfs.admin.ch/bfs/de/home/statistiken/raum-umwelt/erhebungen/area.html, 2023

BUNDESREGIERUNG (2016): Deutsche Nachhaltigkeitsstrategie – Neuauflage 2016, abgerufen am 06.09.2023 unter https://www.bundesregierung.de/breg-de/suche/deutsche-nachhaltigkeitsstrategie-neuauflage-2016-730826

BUNDESREGIERUNG (2020): Deutsche Nachhaltigkeitsstrategie - Weiterentwicklung 2021, abgerufen am 06.09.2023 in https://www.bmuv.de/themen/nachhaltigkeit-digitalisierung/nachhaltigkeit/strategie-und-umsetzung/deutsche-nachhaltigkeitsstrategie , 2020.

EU (2011): Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions - Roadmap to a Resource Efficient Europe, Document 52011DC0571, abgerufen am 06.09.2023 unter https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0571 S. 30, 2011.

EUROSTAT (2023): Land Use and Coverage Area frame Survey (LUCAS), abgerufen am 06.09.2023 unter https://ec.europa.eu/eurostat/de/web/lucas, 2023.

HÜBSCH, B. (2017): Entwicklung der Siedlungsdichte und des Freiraumverlustes eine empirische Untersuchung auf Grundlage des IÖR-Monitors, Masterarbeit, TU Dresden, 2017.

KERN, L. (2023): Agrarflächenverlust in Deutschland - Bilanzierung und Begegnungsstrategien im Sinne einer nachhaltigen Entwicklung, Masterarbeit, TU Dresden, 2023.

KRÜGER, T.; MEINEL, G.; SCHUMACHER, U. (2013): Land-use monitoring by topographic data analysis, In: Cartography and Geographic Information Science 40 (2013) 3, S.220-228, 2013.

KRÜGER, T., LIPFERT, L., WALZ, U. (2023): Freiflächen-Photovoltaik in Deutschland. Naturschutz und Landschaftsplanung 55 (3), 12-13., abgerufen am 06.09.2023 unter https://www.nul-online.de/artikel.dll?AID=7312952&MID=1111 .

KRÜGER, T., LIPFERT, L., WALZ, U. (2023): Windkraftanlagen in Deutschland, In Landschaft und Natur in Karten, DOI: 10.1399/NuL.2023.03.04.

LIPFERT, L. (2023): Analyse der Flächeninanspruchnahme von Windenergieanlagen und Freiflächen-Photovoltaikanlagen in der Bundesrepublik Deutschland, Masterarbeit, Universität Leipzig, 2023.

MEINEL, G. (2023): Flächenmonitoring – die ewige Herausforderung?!, abgerufen am 06.09.2023 von https://doi.org/10.5281/zenodo.8115880

MEINEL, G. (2022): Monitoring der Siedlungs- und Freiraumentwicklung – Entwicklung und Perspektiven des IÖR-Monitors, In: Meinel, Gotthard; Krüger, Tobias; Behnisch, Martin; Ehrhardt, Denise (Hrsg.) : Flächennutzungsmonitoring XIV: Beiträge zu Flächenmanagement, Daten, Methoden und Analysen. Berlin : Rhombos-Verlag, 2022, (IÖR-Schriften; 80), S.167-182, https://doi.org/10.26084/14dfns-p018, 2022.

MEINEL, G.; SIKDER, S.K.; KRÜGER, T. (2022): IOER Monitor: A Spatio-Temporal Research Data Infrastructure on Settlement and Open Space Development in Germany, In: Jahrbücher für Nationalökonomie und Statistik 242 (2022) 1, S.159-170, https://doi.org/10.1515/jbnst-2021-0009 (Online First 2021).

MEINEL, G. (2019): Bestimmung der Flächenneuinanspruchnahme auf Grundlage der Bautätigkeitsstatistik – konzeptionelle Überlegungen, In: Flächennutzungsmonitoring IX, Hrsg: Meinel, G.; Schumacher, U.; Schwarz, S.; Richter, B., Rhombos-Verlag, IÖR-Schriftenreihe 73, Berlin, 2017, abgerufen unter https://nbn-resolving.org/urn:nbn:de:bsz:14-qucosa2-212790, 2017.

SCHUMACHER, U.; Meinel, G. (2009): ATKIS, ALK(IS), Orthobild - Vergleich von Datengrundlagen eines Flächenmonitorings, In: Meinel, G.; Schumacher, U. (Hrsg.) : Flächennutzungsmonitoring : Konzepte - Indikatoren - Statistik. Aachen : Shaker, S.47-67, 2009.

WALZ, U.; MEINEL, G.; GÖHLER, L., KRÜGER, T., SCHINKE, U. (2022): Freiflächen-Photovoltaik in Deutschland, In Naturschutz und Landschaftsplanung, Band54(12), S. 8-9 DOI: https://doi.org/10.1399/NuL.2022.12.04 .

WBGU (2021): Hauptgutachten: Landwende im Anthropozän: Von der Konkurrenz zur Integration, abgerufen am 06.09.2023 unter https://www.wbgu.de/de/publikationen/publikation/landwende, 2022.

1028

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How can Climate Learning be Initiated? Piloting Unconventional Interventions in Neighbourhoods

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1 ABSTRACT

Bottom-up initiatives by citizens and communities are essential to increase acceptance of, and engagement in climate related actions. Yet, conventional approaches for raising awareness often fail to provoke a change in perspectives and actions. The CLEANcultures project conducts disruptive interventions in neighbourhoods to stimulate transformative learning processes to tackle climate change bottom-up at the neighbourhood level. The aim is not only to provide the neighbourhood with facts about the climate crisis, but also to trigger the citizens' emotions and attitudes, ultimately encouraging individual and collective action. Building on Transformative Learning Theory, local knowledge shall be activated, accepted norms questioned and alternative narratives of change co-created. A mixed-methods approach in two urban districts of Graz and the rural municipality of Admont combines 14 stakeholder interviews and a standardised postal survey of about 770 households with unconventional and interactive discussion formats involving 20 to 30 citizens per intervention.

In the urban districts, commuter traffic, increasing heat stress, soil sealing and the decline of green spaces pose the biggest challenges. By contrast, the rural area struggles with insufficient public transport and lack of protection against extreme weather events. In line with Transformative Learning Theory, residents were first invited to critically assess their prevalent practices, prejudices and assumptions. Residents were confronted with the perceived climate-related threats in their direct surroundings as they appeared in the interviews and survey results, in order to generate reflection and self-examination. Next, the residents were engaged in iterative and interactive phases of stimulus, discussion, and reflection to discover local capacities to address the identified issues. The goal is to point out to the neighbourhoods their own possibilities for action and to strengthen their collective efficacy. The first intervention consisted of an impromusical play in which the climate-related problems were conveyed and reframed in a humorous way. The second intervention involved representatives of different religions who discussed various perspectives on ethics of climate responsibility with local citizens. Both interventions invited the audience to engage in an interactive and open discourse.

As part of the transformative learning process, people realised that they were not alone in their thoughts and fears, and they were supported in developing ideas on how to get personally involved in their neighbourhood. Many mentioned that they were surprised by the relevance of climate-related issues in their residential surroundings. While citizens as individuals often do not feel heard and hardly see options for meaningful and effective contributions, the sense of belonging to a like-minded group can be empowering to explore new roles, relationships and actions. Working closely with (local) politicians also illustrated to decision makers the importance of the climate crisis in their neighbourhood and reinforced joint discourse. In all, unconventional interventions provide a promising entry point for introducing neighbourhood-level transformation processes in terms of climate change awareness, empowerment, and citizen involvement in decision-making.

Keywords: neighbourhoods, climate learning, transformative learning theory, mixed-methods approach, citizen engagement

2 INTRODUCTION

Many countries and communities have declared a climate emergency, but the desired results in reducing greenhouse gas emissions have not been achieved (Gills & Morgan, 2022). The main reasons for this policy failure are:

- Policy actions do not reach the ground level of individual behaviour.

- Top-down measures are proposed without engaging local citizens.

Thus, the research project CLEANcultures focuses on neighbourhood-level climate change issues and implements interventions to challenge existing assumptions and norms. The project conducts case studies in nine neighbourhoods across Austria, Finland, Norway, and Italy, aiming to promote sustainable practices within communities. This paper presents the results of the Austrian case studies.

3 THEORETICAL FRAMEWORK

3.1 The neighbourhood approach

Although "neighbourhood" is widely used as a category for social analysis, it is a complex construct. A neighbourhood can be viewed as a cohesive unit where individuals live close to one another and hold a sense of community, but can also be characterized by various dimensions. These dimensions include physical aspects (e.g., land use patterns and infrastructure), administrative boundaries, socio-demographic factors (e.g., similarity of residents in age, income, and education level), social aspects (e.g., cohesion and community engagement), and cultural elements like shared values, traditions, and religions (Komeily & Srinivasan, 2016). A comprehensive consideration of all these dimensions is essential to gain insights into climate-relevant behaviour in the context of neighbourhoods.

According to Bronfenbrenner's ecological theory (1979), an individual's development and well-being are influenced by interactions within multiple interconnected systems, from direct interactions with the immediate environment, including family, peers, and neighbours (microsystem), to broader cultural factors like government, media, and cultural values (macrosystem), and historical events in an individual's environment (chronosystem). Examining neighbourhoods as a unit of analysis may link the micro- and macrosystem dimensions of contemporary urban and rural communities.

3.2 Transformative Learning Theory

Mezirow's (2008) Transformative Learning Theory (TLT) explains how individuals can undergo profound personal and cognitive transformations through the process of changing their frames of reference, that is, the structures of culture and language that shape our perceptions, beliefs, and intentions. Transformative learning involves recognising and challenging problematic frames of reference, leading to a more inclusive, reflective, and emotionally open mindset that is better able to adapt and change. The theory proposes that transformative learning occurs through a series of stages:

(1) Disorienting dilemma

(2) Self-examination with feelings of fear, anger, guilt, or shame

(3) Critical assessment of assumptions

(4) Recognition that one's discontent and transformation are shared

(5) Exploring alternatives

(6) Planning for action

(7) Acquiring knowledge and skills

(8) Provisional trying of new roles

(9) Building competence and self-confidence

(10) Reintegration into one's life based on a new perspective

TLT highlights the importance of critical reflection, dialogue, and experiential learning, all of which may occur throughout a person's lifetime. CLEANcultures centres on stage 1–5 to foster a process of activating local knowledge, challenging accepted norms, and co-creating alternative narratives.

4 METHODOLOGY

The paper examines three case studies in Austria: two districts of Graz, Eggenberg and Jakomini, and the rural municipality of Admont in Upper Styria. To assess the initial situation of the climate culture and local climate-related issues in each neighbourhood, a mixed-methods approach was employed: Fourteen

1030

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stakeholder interviews were conducted with key actors in the respective neighbourhoods, and a standardised postal survey was carried out in which 767 households participated.

In order to operationalise the psychological concepts underlying the TLT, survey data were aggregated into a set of variables using an exploratory factor analysis (Hamann et al., 2021; Stern, 2000; Steg & Vlek, 2009):

- Participatory efficacy refers to an individual's belief in their ability to actively contribute to achieving a collective goal by collaborating with other people in the neighbourhood (3 items, Cronbach's Alpha α=.72).
- Collective intention represents a shared commitment and motivation among community members to engage in certain actions (1 item).
- Collective awareness encompasses the shared understanding that the decisions and behaviours within the neighbourhood have direct consequences for future conditions (2 items, α=.75).
- Social norms refer to the perceived expectations of other community members about what behaviour is considered acceptable and appropriate (3 items, α=.62).

Subsequently, unconventional and interactive intervention formats were utilised, involving groups of 20–30 citizens per intervention, to explore how disruptive interventions in neighbourhoods can stimulate climate learning. After conducting interventions, participants were interviewed in a semi-structured qualitative format about their experiences, and the project team reflected on interactions and reactions.

5 RESULTS AND DISCUSSION

5.1 Initial situation

5.1.1 Climate Change Beliefs

The belief that climate change is happening, is caused by humans, and is already having visible local consequences is generally high in all neighbourhoods surveyed. Among urban respondents, 93% say that climate change is definitely or probably happening, compared to 94.5% in the rural area. In terms of cause, 70.2% of urban respondents attribute climate change mainly to human activities, in comparison to 60.8% in the rural neighborhood. While 65.3% of urban respondents report they definitely or probably observe changes in their local environment, this percentage is slightly lower in the rural area (61.1%).

However, as the interviewed local stakeholders pointed out, climate change is not considered a central concern in people's daily lives. Although climate-friendly actions are seen as potentially enhancing the quality of life, many individuals feel limited in their ability to make a significant impact on their own. There is a prevailing sense that insufficient actions are being taken to address the issue. Additionally, there is a lack of cooperation and collective effort within neighbourhoods towards addressing climate change.

5.1.2 Collective Drivers

Figure 1: Collective drivers (means with 95% confidence intervals; 0=weak, 4=strong; N=695)

For taking action against climate change on the neighbourhood level, participatory efficacy, collective intention, collective awareness, and social norms could be of central importance. In terms of collective drivers (Figure 1), social norms related to climate action were ranked lowest, indicating limited expectations and support for climate-related efforts within the community. Collective intention to engage in local climate action ranked second, indicating a medium level of commitment to collective climate-related efforts. While social norms and collective intention have similar measures in the urban-rural comparison, participatory efficacy (indicating that residents recognise the impact of their joint actions on climate change) and collective awareness (indicating that residents recognise the impact of their actions on climate change) differ. In the urban neighbourhood, both variables were ranked higher compared to the rural case study, and collective awareness slightly higher than participatory effectiveness. Conversely, in the rural neighbourhood, participatory efficacy was ranked marginally higher than collective awareness.

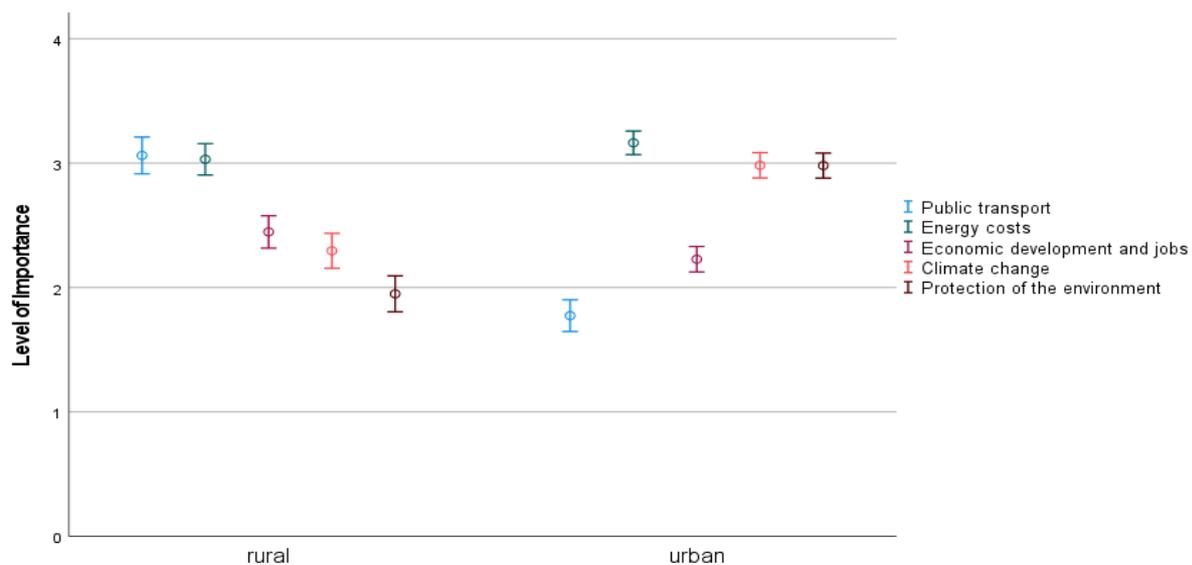### 5.1.3   Priority areas of improvement in the neighbourhoods

Figure 2: Priority areas of improvement (means with 95% confidence intervals; 0=not important, 4=extremely important, N=735)

Figure 2 demonstrates the top 5 areas of improvement based on the survey results. In urban areas, environmental protection and climate change are the most significant concerns, followed by economic development. Public transport ranks fifth in importance. According to the stakeholder interviews, urban districts face challenges like commuter traffic, rising heat stress, soil sealing, and reducing green spaces.

By contrast, in rural areas, public transport takes the top priority. Economic development and jobs come in second place, followed by environmental protection and climate change. In rural neighbourhoods, the focus lies in enhancing local infrastructure, with less attention given to climate and environmental concerns. The interviews also highlighted the importance of adapting to extreme weather events. In this analysis, energy costs are neglected due to the influence of sharply increased energy prices during the 2022 energy crisis.

5.2 Intervention design

The project's interventions involve linking abstract climate change induced problems to participants' real-life experiences and providing thought-provoking impulses in unexpected ways. Residents participate in iterative and interactive periods of impulse, discussion, and reflection to unlock the local capacity to address climate change induced problems. Three interventions were designed:

5.2.1   Intervention 1: Survey Presentation and Impromusical Play

After introducing the participants to the topic of climate change and perceptions in the neighbourhood by presenting and discussing the survey results, a theatre group transformed the previously discussed content as well as spontaneous reactions of the audience into improvised musical performances. The artists engaged the audience in a spontaneous conversation in which there was space for worries, concerns, fears and hopes regarding the climate crisis. By means of music, climate-relevant topics were conveyed in a respectful but also humorous way.

5.2.2 Intervention 2: Multi-ethical Polylogue

Representatives of different religions discussed the ethics of climate responsibility with local citizens. The aim of this intervention was to promote a deeper understanding of climate change from an ethical perspective and address questions such as morally appropriate action in times of climate crisis, collective responsibility for climate protection, and humanity's relationship to nature. Speakers' contributions from Christianity, Buddhism, Islam, and Judaism enriched the discussions and contributed to a comprehensive exploration of ethical responsibility in times of the climate crisis.

5.2.3 Intervention 3: Throwing Game "Hit Climate-Friendly Decisions"

This game is designed to engage children, teens, and their parents in reflecting on climate-friendly behaviours. In a throwing gallery, participants attempt to hit targets that represent climate-friendly decisions (e.g., vegetarian diet, no flying, buying local food); the harder the decision is to implement in daily life, the smaller the target. By posing complex climate change related choices in an interactive and playful environment, the game is designed to prompt reflections on current habits and to foster a sense of personal responsibility towards the climate.

Figure 3: Impressions of intervention 1, 2 and 3 in Graz (Source: JR/LIFE)

5.3 Intervention experiences and link to Transformative Learning Theory

Based on TLT, the interventions initiate a learning process by presenting participants with a disorienting dilemma, challenging their existing assumptions and norms about climate change. Through self-examination and critical assessment, participants reflect on their attitudes and contributions to climate change issues. The interventions evoke emotions and trigger critical reflection, empowering individuals to explore new roles and possibilities for climate action. They also discover that they are not alone in their fears and receive support to generate ideas for personal involvement in their local community.

Through the interventions, many participants were surprised to realise the relevance of climate-related issues in their own neighbourhoods. Participants were also able to connect with local politicians and community organisations and explore new roles and actions within their neighbourhood.

5.3.1 Intervention 1: Survey Presentation and Impromusical Play

The intervention's informal atmosphere fostered open discourse, making discussions on climate change related topics approachable and engaging. Playing improvised songs about the neighbourhood reinforced the connection to one's surroundings, and the positive environment encouraged participants to dance together, fostering a sense of unity and community spirit. Additionally, the intervention's low entry threshold attracted and engaged new audiences, broadening the reach of climate-related initiatives and promoting a more diverse and inclusive approach to climate learning. While initially met with scepticism in the rural community, participants eventually opened up to the approach.

5.3.2 Intervention 2: Multi-ethical Polylogue

Participants realised that their climate-related concerns were widely shared, which created a sense of belonging. Many expressed surprise at discovering ethical responsibility as a common theme across various religions, gaining new insights from the diverse perspectives presented. The polylogue provided a platform for critical self-examination of ethical beliefs and values in relation to climate responsibility, deepening participants' self-reflection and awareness.

5.3.3 Intervention 3: Throwing Game "Hit Climate-Friendly Decisions"

The experience with the climate game showed a high level of enthusiasm and engagement among the – mostly – children who played the game. The incorporation of gamification elements, such as rewards,

challenges, and social interaction, contributed to sustained interest and motivation to explore climate-friendly behaviours beyond the game itself. By awarding points in certificates depending on the hit CO2 saving targets, a competitive spirit was perceived by many children. The game also encourages reflection on personal actions, such as "I don't go on holiday" or "I am already a vegetarian".

6 OUTLOOK

The project expects to yield results at three distinct levels, contributing to the understanding of small-scale societal system dynamics (micro level), offering a transferable methodology (meso and macro level), and providing recommendations for climate policy-making. A follow-up survey will be conducted in spring 2024 to compare the perception of climate change before and after the interventions in a longitudinal study. In addition, the results of the case studies in Austria will be compared with those in Finland, Norway, and Italy.

The CLEANcultures concept can also make a valuable contribution in other areas, such as spatial planning. With regard to citizen involvement in the development of urban and rural areas, participatory processes can be loosened up by creative thematic interventions and create a low-threshold, open access for residents to get involved. The use of creative and interactive methods can attract a diverse range of individuals, ensuring a more inclusive representation of the community's perspectives and ideas. Addressing emotions empowers citizens to question existing norms and take an active role in shaping their neighbourhoods, fostering a sense of ownership, e.g., towards collaborative approaches of nature based solutions such as community gardens. Incorporating participatory processes enables drawing on community knowledge, tailoring projects to local needs, and fostering citizens' meaningful engagement in creating sustainable communities.

7 CONCLUSION

The findings of the CLEANcultures project underline the importance as well as the potential of unconventional interventions for initiating transformative climate learning and promoting bottom-up climate action at the neighbourhood level. The designed interventions demonstrated their effectiveness in triggering emotions, stimulating critical reflection, and empowering individuals and communities. The results also shed light on the particular challenges faced by urban and rural neighbourhoods, highlighting the need for tailored intervention strategies. In the future, incorporating neighbourhood-level perspectives, fostering community engagement, and co-creating solutions in policy-making will be critical for climate change mitigation and adaptation and for creating sustainable and resilient neighbourhoods.

8 REFERENCES

Bronfenbrenner, U. (1979). The ecology of human development: Experiments by nature and design. Harvard university press.
Gills, B., & Morgan, J. (2022). Global climate emergency: After COP24, climate science, urgency, and the threat to humanity. In Economics and Climate Emergency (pp. 253-270). Routledge.
Hamann, K. R. S., Holz, J. R., and Reese, G. (2021). Coaching for a Sustainability Transition: Empowering Student-Led Sustainability Initiatives by Developing Skills, Group Identification, and Efficacy Beliefs. Frontiers in Psychology, 12, 623972.
Komeily, A., & Srinivasan, R. S. (2016). What is neighborhood context and why does it matter in sustainability assessment?. Procedia Engineering, 145, 876-883.
Mezirow, J. (2008). An overview on transformative learning. Lifelong learning, 40-54.
Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. Journal of Environmental Psychology, 29(3), 309-317.
Stern, P. (2000). Psychology and the Science of Human-Environment Interactions. American Psychologist, 55 (5), 523–530.

How to Co-Create Collective Awareness on the Benefits of Trees

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1 ABSTRACT

Nature is our ally in solving all kinds of social problems. This was well understood by the researchers of the ongoing URBiNAT (2018-2023) project, with focus on the regeneration of under-served urban neighbourhoods[1], through the co-creation of Nature-Based Solutions. Combining physical and infrastructural – green - solutions with social and economic practices, this project aims at creating collective awareness and contribute to a better understanding of human and non-human dimensions of our urban environments by conducting research, exploring case studies and implementation in several cities. How can these results and working methods also apply to trees and better conservation of the tree stock[2], which also play a key role in many challenges society is facing? Trees are essential in tackling climate change through mitigation and adaptation. They are natural and free air conditioners, they purify the air, provide carbon storage and biodiversity in the soil/underground and they fulfil a landscape or social role in villages and cities. Moreover, they provice a green counterweight to the increasing use of space in Flanders[3], something that could be experienced first-hand during the corona crisis. Yet trees still often disappear to make room for other space claims in Flanders. Today, citizens and permit providers (mainly municipalities) make an important mark on the above-ground use of space: recent research by the Department of Environment & Spatial Development Flanders shows that most applications for tree felling are submitted by citizens, and that municipal authorities approve nearly every application. In this new research proposal, integrating the approach of the URBiNAT project in order to prevent the disappearing tree stock in Flanders, we want to know why trees are cut down and how we can co-create collective awareness on the benefits of trees with the stakeholders involved in Flanders.

Keywords: awareness, co-creation, ecosystem services , trees, nature-based solutions

2 INTRODUCTION AND PURPOSE OF THIS STUDY

In this research proposal, we consider whether the URBiNAT method can be used to increase collective awareness for tree preservation and for biodiversity conservation, given the benefits of trees and biodiversity (ecosystem services). After all, a previous study on tree felling and planting and vegetation changes of trees outside the forest in Flanders (Peeters et al, 2022) shows that trees still have to make room for other space claims.

The research of Peeters et al (2022) was carried out in connection with trees outside the forest because there are few reliable and area-wide figures available on the evolution of the number of trees outside the forest. In addition, the felling of trees outside the forest context is regulated by different regulations than for trees in the forest. In the first instance, the felling of trees outside the forest is regulated by the Decree on nature conservation and the natural environment of 21.10.1997 and the rules on spatial planning from the Flemish Spatial Planning Codex. For trees within the forest, this is regulated by the Forest Decree of 13 June 1990.

In section 2.1 we first explain the results of this previous research on tree felling and planting and vegetation changes (Peeters et al, 2022) and the recommendations we will focus on. In section 2.2. we explain the URBiNAT project, NBS (Nature-Based Solutions) and the SROI tool (Social Return on Investment). In section 2.3, we screen the potentially relevant information from a completed research on the felling and planting of trees, that can be combined with the URBiNAT method. To what extent can this method help to increase support for the preservation of trees?

The goal of this study is to explore the application of the URBiNAT method to increae support for tree preservervation and biodiversity conservation. But this research proposal is also innovative, because it

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[1] among other suburbs

[2] Since the generic SROI instrument of URBiNAT has so far evaluated the socio-economic-spatial impact of a Nature-Based Solution (focused on public spaces), where trees also play a role.

[3] Flanders is the northern region of Belgium and is also the most dense and urbanized part of it.

proposes a new research method, with a new tool (the SROI tool), which is still being developed. This research could help to further optimise the SROI tool.

2.1 Tree felling: a screening of the permit system

There are many initiatives to expand the tree stock. Both local and supralocal authorities recognise the importance and value of trees, and in their policy documents, they emphasise the many benefits and functions of trees in the living environment and in rural areas. The Flemish Coalition Agreement 2019-2024 contains several goals for the tree area in Flanders. The most specific goal is planting 1 million additional trees in the Flemish Periphery around Brussels. At the beginning of 2020, Flemish Minister of The Interior Bart Somers proposed the Local Energy and Climate Pact, which included the ambition to plant 3,300 km of hedges and 6.6 million trees – or 1 tree for each inhabitant of Flanders – in cooperation with local authorities by 2030. Flemish Minister for the Environment Zuhal Demir endorses the importance of these goals and the many benefits and functions of trees in the living environment and in the countryside, first in the "Vlaams Bosuitbreidingsplan" [the Forest Expansion Plan Flanders] (2020) and later in the "Vlaams Klimaatadaptatieplan" [the Flemish Climate Adaptation Plan] (Vlaams Overheid, 2022). The intention is to stimulate the planting of tall trees by means of a Flemish regulation or another instrument in the (re)construction of well-known urban heat islands such as car parks and squares, as well as the introduction of trees in climate-adaptive agriculture. But also on local level, many municipalities have expressed commitments for the expansion of their tree area. This is reflected in the signing of the Covenant of Mayors[4], an European project, or 'het bomencharter'[the Tree Charter][5] (a citizens' initiative). Parties signing the Tree Charter commit to planting 1.7 million additional trees by 2024 (Peeters et al. 2022).

If we aim at a net growth the tree stock in Flanders, we have to plant new trees, but also preserve the existing tree stock. In order to investigate this, the Flemish Department of Environment & Spatial Planning carried out a first research in order to gain insights into the felling and planting of trees outside the forest, in order to support policy (Peeters et al, 2022). The research consisted of a quantitative and qualitative analysis of data derived from the Flemish permit systems. The input of permit providers was also requested. Additionally, this report also describes the impact of other dynamics that influence the felling and/or preservation of trees. A number of methods have been explored for mapping the felling of trees without a permit requirement.

For trees in gardens, an application for a felling permit is usually filed. 75% of the applications are submitted by private individuals, and more than half are located in residential areas (according to regional land use plans). Compared to the Flemish average (8 applications/km²), the number of applications in gardens (24/km²) and residential areas (34/km²) is significantly higher, with outliers in residential parks[6], where even than ten times more tree fellings are requested.

According to the above-mentioned research, these figures indicate that 'nuisance' caused by trees around homes is one of the most common reasons why trees have to dissappear. Examples of nuisance are leaves and fruits falling of trees, or the loss of light and vision.

Since gardens make up more than 12%[7] of Flanders and 9 out of 10 applications for tree felling are approved, it is understandable that private individuals are an important stakeholder in the preservation of the tree stock. Therefore, we want to investigate what the real reason is why these trees are cut down, and later we want to examine how we can sensitize these stakeholders (to arrive at a mindset that understands and appreciates the importance of trees).

According to this study, what are the reasons for cutting down trees in relation to trees outside the forest? The competent municipal authorities estimate that the most common causes (average score on a scale of 1 to 5) are: buildings (3.7), nuisance (3.3), pavement (3.2), safety (3.1), making way for other functions (2.5) and gardens (2.4). The estimate of the number of trees that will be destroyed for buildings, pavement and other

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[4] The Covenant of Mayors is a European initiative, bringing together thousands of local authorities that voluntarily commit to achieving EU climate and energy targets: Burgemeestersconvenant | Vlaanderen.be, retrieved 27 July 2023.

[5] Through the Tree Charter, cities and municipalities commit themselves to obtain a certain number of additional trees ('the target') on the territory of the city/municipality: bomencharter.be, retrieved 27 July 2023.

[6] In Flanders, a residential park is intended as a residential area, intended for living in greenery. This specific type of zoning area accomodates many trees, on avarage more than in other residential areas.

[7] calculations based on the GARMON-project, retrieved on 26 July 2023

functions is admittedly (too) high compared to the share of permit applications within a larger project and therefore seems to be an overestimation.

Nuisance can take many different forms, but from the complaints that municipalities receive about trees, this appears to be mainly about leaf fall and fruits. Shadow casting on solar panels is mentioned as an emerging complaint. Other current reasons for felling are illness or loss of vitality in coniferous trees (due to damage by the type setter), safety nuisance around railways (often after complaints from the Belgian Railroad Company), and (fear of) storm damage.

An important observation from the discussions with municipal officials is that many municipalities indicate that the reasons for cutting down trees that are described in permit applications certainly do not always correspond to the real reason for the felling.

There are also a number of specific cases[8] where trees are cut down without a permit being required. These are difficult to quantify due to a lack of data. In order of estimated importance, these are: tree fellings around roads and pipes by the road and pipeline managers, felling of trees on the public domain (mainly redevelopment of streets and public space) and fellings of trees that pose an acute danger (e.g. after storm damage).

In order to draw up a policy to reduce the felling of trees, it is important to know why trees are cut down. Research into this can be done both by delving deeper into the reasons described in the application files, and by going through more files (submitted applications) than possible within the time frame of the previous research about trees mentioned before (Peeters et al, 2022). Research that examines the imposed conditions by delving deeper into the files can also be an added value. The other way is to question the applicants (and other actors) for tree felling (sociological research). URBiNAT is a possible way to conduct this research. That is why we will in the next section first briefly describe what this project and this method exactly entails.

Other ways to reduce the tree fellings according to the study are: stricter regulations, fewer felling permits and good communication ('what is the use of trees?'). Good commication may be important for sensitisation, but the two other possibilities are beyond the scope of this study, and we will not discuss it here.
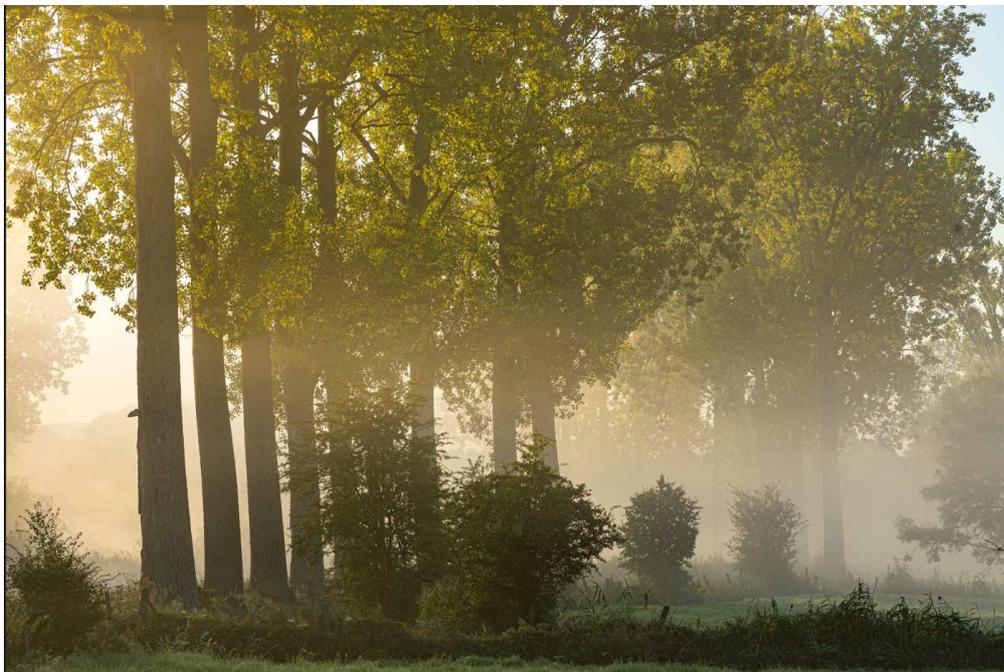
Gert Arijs 2019

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[8] Trees of less than one metre trunk circumference and trees within a radius of 15 metres around a licensed building may be freely cut down. This also applies to trees that are included in a management plan, and under certain conditions also to trees that pose an 'acute danger', trees on public land, trees in the context of agroforestry, trees that are cut down by railway managers and pipeline managers, etc

2.2 The URBiNAT method in a nutshell

URBiNAT (2018-2023) is an innovative European project that focuses on co-creation in urban environments. The project, funded by the European Union's Horizon 2020 programme, aims to transform the concept of urban development through the active involvement of citizens, stakeholders and various interest groups. The main goal of URBiNAT is to promote sustainable and inclusive cities in which people are central. The project focuses on developing and implementing new approaches to urban planning and design, with co-creation at its core. This means that all parties involved, including residents, businesses, municipal authorities and academics, work together to find solutions to urban challenges and create liveable and resilient cities. URBiNAT has three front runner cities based on their innovative use of public space through Nature-Based Solutions (NBS): Nantes, Sofia and Porto.[9]

The URBiNAT project defines Nature-Based Solution (NBS) in view of the Healthy Corridor (HC) concept.[10] The HC is situated on a macro-scale (i.e. certain urban districts/areas) consisting of various NBS positioned on a lower or micro-scale (i.e. in parts of urban districts/areas) (WP 5.4[11]).

To evaluate the socio-economic-spatial impact of a Nature-Based Solution (NBS) in urban Healthy Corridors (HC), a generic Social Return on Investment (SROI) instrument has been developed (WP5.4). The Social Return on Investment (SROI) measures the social, environmental, and economic value created by a project. SROI considers both the financial returns generated by an investment and the social and ecological outcomes it produces.

The more traditional concept of Return on Investment (ROI) is a well-known concept within the discipline of economy to assess the (relative) profitability of an organization and/or its economic investments. The nature of the SROI is clearly metric as it involves the collection of quantitative data (i.e. ratio variables) on the basis of which one ratio or indicator is calculated. The Social Return on Investment (SROI) is the present value of the actual and future social impact relative to the investments made, based on both qualitative and quantitative information.

The different phases of the SROI tool are shown in figure 1 below.
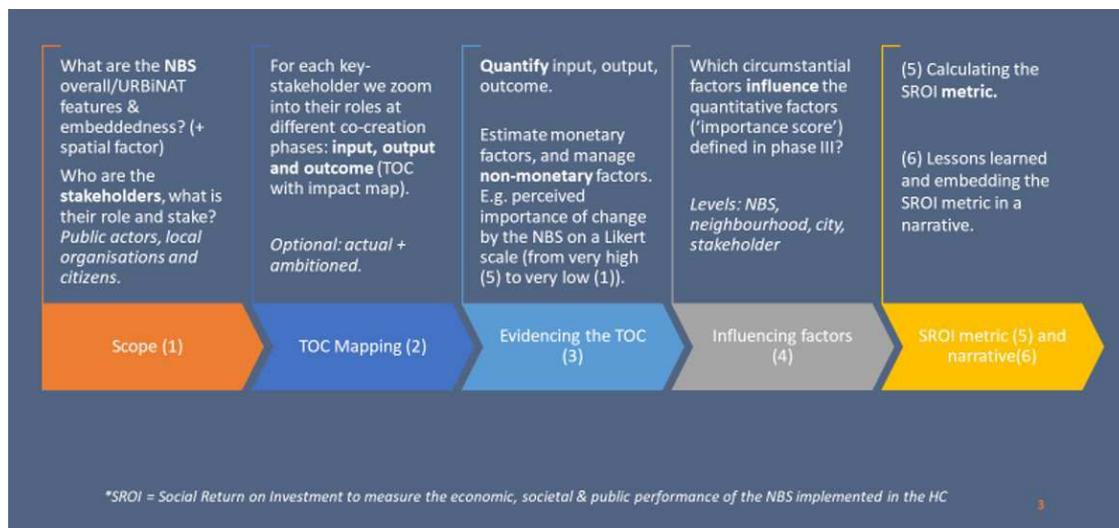

Fig. 1: Phasing the implementation of the SROI instrument (based on WP 5.4).

What are the different phases of the SROI instrument (fig. 1)? Firstly, Phase 1 describes the "scope" and "major (key)stakeholders". Secondly, in Phase 2, the researchers look at the roles of the different stakeholders in the different co-creation phases as a first screening. It is called mapping of "inputs",

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[9] The aim of these cases is to regenerate the public space in urban districts by means of project interventions or initiatives that focus on (i) the public space within these districts/areas and on (ii) the co-realization of so-called innovative nature-based solutions (NBS). Urbinat - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS., retrieved on 27 July 2023.

[10] www.URBiNAT.eu, retrieved on 27 July 2023.

[11] URBiNAT Project. WP5.4. Social & Economic Impact. The development of a generic SROI instrument to evaluate the socio-economic-spatial impact of a Nature-Based Solution (NBS) in urban Healthy Corridors (HC). (Unpublished – in development). (Expected in 2023)

"outputs" and "outcome", the mapping of the theory of change (TOC-mapping). In Phase 3, the researchers will evidence outcomes and give "values" (at this phase they will paste a number). Other factors influencing the result of Phase 3 are being looked at in Phase 4. The SROI ratio is then calculated (Phase 5). Finally, what are the lessons learned (Phase 6)? From now on, the embedding and using of the SROI-ratio of metric is possible.

In the proposed research project, we will only focus on the first three phases of the SROI tool, partly due to the fact that the SROI tool is still under development.

2.3 How can we use the SROI tool for awareness around tree conservation?

Throughout Europe, people are working on Nature-Based Solutions, complex or not. For example, simply planting a tree or not cutting it down is already a quick-win and already has many advantages. We are thinking of the many ecosystem services provided by trees: for example, wood production, noise buffering, climate regulation, regulation of hydrological processes and filtering air quality. The paper 'Het verhaal van bomen (kappen) in Vlaanderen' [The story of (felling) trees in Flanders] examines why, despite the many policy initiatives to plant trees, so many trees and other greenery still disappear in Flanders - preserving the existing tree stock and greenery is at least as important as planting new trees if we want a net growth of the number of trees (Vandevenne et al, 2023). To understand that, the authors of this aforementioned paper argue that deeper digging is needed. In their paper, starting from the figures on felling applications, the authors try to better understand the history and motives behind the felling of trees in Flanders (the so-called 'felling behaviour'), and to look for a number of causes and solutions through thinking in systems. It is first and foremost necessary to increase awareness, since there is apparently too little support for the preservation of trees. We think that with the SROI tool (from URBiNAT) we can gain insight into possibilities for creating more support for the preservation of the existing tree stock and other greenery, starting with the first phases of SROI.

We could take a wider perspective and not only limit ourselves to trees, but involve different 'types' of greenery, such as low greenery (<3 m), and high greenery (>3 m) for example. Because there, too, there is a lack of sufficient support for its preservation. Spatial aspects are also important. In the first place, executing Phase 1 of the SROI tool, we will investigate who the various stakeholders are when trees are cut down. There are different categories of stakeholders involved in the system: citizens, several authorities, farmers, schools, etc.

In the second place, in a kind of stakeholder mapping, we can analyse their influence and their role in the different co-creation[12] phases (Phase 2 of SROI tool). What is the input, output and outcome? For example, we can apply this to planting a tree in a garden.

Finally, in Phase 3 (of SROI tool), the input, output and outcome of Phase 2 will be quantified by monetary and non-monetary factors. In this phase, we could for example use the Likert-scale as a survey aid.[13] What is the importance of change by the NBS on a Likert scale (if we preserve the greenery)? This scale is an answer scale, with which data that are difficult to express in numbers can be retrieved and measured. A likert scale is used, among other things, to investigate the opinions and behaviour of respondents. In other words, we will have to list all the benefits of trees and other greenery. And this from different angles.

3 CONCLUSION

Too many trees are being cut down in Flanders, despite the many policy initiatives to plant new ones. One of the conclusions drawn from the previous research on felling and planting trees and vegetation changes outside the forest (Peeters et al, 2022), is that there is too little support for the preservation of trees and that further research is needed.

In this paper, we propose to apply the URBiNAT's SROI method to gain insight into the possibilities for creating more support and awareness. This could then be worked out in a follow-up assignment of the research on felling and planting trees, which was mentioned above. In the paper we already put forward a suggestion on how to proceed with this. But a deeper investigation will show whether this method is possible and whether is the best choice. During this future research, we may find certain limitations and/or

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[12] Co-creation is a form of collaboration in which all participants have an influence on the process
[13] Likert scale – Wikipedia, retrieved on 26 July 2023.

points for improvement in connection with the SROI method or we may find better and other possibilities to increase support. But before we come to any conclusions, we need to work on a final draft of this research proposal an implement this method.

4 REFERENCES

Peeters, P., De Vroey, L., Verstraeten, J. & Van Genechten, S.: Kappen en aanplanten van bomen en vegetatiewijzigingen: een screening van de huidige wetgeving en vergunningverlening, uitgevoerd in opdracht van Departement Omgeving. Brussels, 2022.

Vandevenne, F., and Strosse,V.: Het verhaal van bomen (kappen) in Vlaanderen: wat bomen en ijsbergen gemeenschappelijk hebben. Brussels, 2023.

Vlaams Minister van Justitie en Handhaving, Omgeving, Energie en Toerisme Zuhal Demir: Bosuitbreidingsplan. Brussels, 2020.

Vlaamse overheid: Vlaams klimaatadaptatieplan. Vlaanderen wapenen tegen de klimaatverandering. (Nr. D/2022/3241/266). Brussels, 2022.

Vlaamse Regering: Regeerakkoord van de Vlaamse regering 2019-2024. Brussels, 2019.

Team Universiteit Antwerpen. URBiNAT Project. WP5.4. Social & Economic impact. The development of a generic SROI instrument to evaluate the socio-economic-spatial impact of a Nature-Based Solution (NBS) in urban Healthy Corridors (HC). Unpublished. (expected in 2023).

1040

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Microclimate-Related Human Comfort as Aspect in Urban Planning: Indication of NBS Interventions to Increase Quality of Cycling Networks

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1 ABSTRACT

Climate change and environmental challenges affecting cities encourage them to reduce negative impacts of environmental challenges on human comfort and respond with sustainable spatial solutions such as Nature-based solutions (NBS). While spatial analyses are often limited in analysing dynamics between space–environmental characteristics and human comfort, there is a challenge to exploit new technologies (ICT) as the potential for the development of more inclusive analyses and monitoring. This paper reflects on one particular portable device for a simultaneous dynamic microclimatic data gathering, and by a protocol for microclimate street assessment evaluates microclimate-related comfort of cycling lanes in Ljubljana, Slovenia. By identifying correlations between spatial elements and microclimate conditions in different spatial settings, the study defines cycling lane sections of various levels of comfortability. The results suggest that ICT innovations for in-situ measurements can help urban analytics to gather and urban planners to interpret detailed microclimate-related information and can help to assess places according to microclimate issues such as high temperature, poor air quality, incrised humidity, but also disturbing noise levels. Collected data are interpreted within human comfort zones and can be linked with rates/levels of comfort. Thus, the paper contributes to urban planning by the provision of fine-grain localised data, with precise data spatial and temporal resolution. As the gathered data is geopositioned, it can be presented on a map enabling a linkage of environmental conditions within a spatial context.

Keywords: Urban planning, Nature-based solutions, Information and communication technologies, Human comfort, Microclimate

2 INTRODUCTION

Microclimate in urban areas is increasingly being affected by the impacts of climate change. As human comfort is directly reflected in human behavior, activity patterns, space usage [1, 2, 3], and microclimate-related human comfort become a crucial aspect in urban planning when designing solutions to address contemporary societal challenges. To improve the quality of living and mitigate the adverse effects of climate change, cities are trying to implement various innovative approaches and develop climate-change-resilient sustainable solutions. Urban planning plays a crucial role not only in climate mitigation by reducing global warming but also in designing solutions that facilitate natural processes, leading to the creation of pleasant microclimate conditions.

Nature-based solutions (NBS), a planning concept addressing various societal challenges, holds a promising potential for incorporating the aspect of microclimate-related human comfort in design solutions. Solutions based on mimic natural processes can directly address the societal challenges of cities [4]. However, to implement sustainable solutions that are as self-sustained as possible and deliver the desired environmental outcomes, it is crucial to integrate microclimate knowledge into the design process based on urban analyses of site specific conditions. Following Goličnik Marušić et al. [4], further, it is important to recognise local characteristics to identify the resources that are needed and/or available for the functioning of the NBSs so that NBSs can enhance/exploit the given sites' characteristics to the greatest possible.

The development of new Information and Communication Technologies (ICT) represents the potential for conducting comprehensive analyses, as well as exploring the interpretation of locally-based information of microclimate from a human perspective. Here, we specifically refer to portable ICT devices that enable the acquisition of detailed environmental data with precise spatial and temporal resolution. These devices have the potential to reveal the hidden dynamics between environmental characteristics and spatial context, which could assist urban planners in identifying areas where NBS interventions may be needed.

In this sense, this paper follows a pilot research that uses a particular ICT device for dynamic microclimate-related data gathering and, by using a protocol for microclimate street assessment, explores the microclimate-related comfort of cycling lanes in Ljubljana, Slovenia. Besides providing a few preliminary

examples of microclimate assessment, the paper addresses the following research question: How can ICT devices for in-situ measurements aid urban analytics in gathering detailed microclimate-related information and assist urban planners in assessing places based on microclimate-related challenges?

Summing up, the research follows a bottom up aproach, of locally based environmental data collection, such as air temperature (°C), relative humidity (%), noise level (dBA), and particulate matter (e.g. PM 2.5 (μg/m³)). It developes the aproach to analyse cycling lane as comfortable and discomforatble areas, representing a first step towards identifying possible microclimate-related challlange. Such an analysis is recognised as having potential for prioritising and selecting spatial interventions that may be needed to achieve or improve the quality of a space. Since this research is still ongoing, this paper cover only one segment of the entire research. The quality of data plays an important role in urban planning, so the paper comments on data gathered in relation to usefulness of such data for urban planning analytics. By providing a few examples of analysed cycling lanes section it illustrates what kind of data can be gathered and demonstraits the potential of such data for defining comfortable and uncomfortable cycling lane sections as well as for identifying possible microclimate challange and/or suitable NBS for improvement.

2.1 Data Characteristics

To assess spaces in terms of human comfort and microclimate-related challenges, data characteristics must be understood within the context of urban planning. To interpret microclimate conditions from a human perspective and cycling experience, urban planners should work with fine-resolution data that reflect site-specific environmental conditions.

Considering that microclimate conditions in urban areas vary between 1 to 100 meters [5], it is crucial to address the appropriate spatial resolution of microclimate-related data. Therefore, the minimum recommended accuracy for distinguishing environmental conditions is approximately 100 meters; however, achieving an optimal level of accuracy would require data with a resolution as fine as 10 meters. Data spatial resolution also plays an important role, as cyclists occupy space at different time intervals during a day, and microclimate changes within a 24-hour period [5]. Therefore, the data should reflect the environmental variability that cyclists might experience at different time intervals throughout the day. In terms of microclimate-related human comfort, it is crucial to recognize that microclimate conditions arise from dynamic interactions between various microclimate parameters. These interconnected relationships significantly influence human comfort. Therefore, when conducting microclimate assessments focused on human comfort, it is essential that the data enable urban planners to interpret such simultaneous influences of microclimate parameters. Also, in practical terms, urban planning relies on map-based approaches. Therefore, graphically geolocated data in the form of maps becomes crucial.

2.2 Presentation of the Tool

The tool was developed by the University of Deusto in Bilbao, Spain. It serves for gathering and analyzing microclimate-related data at a user-experience level, focusing on site-specific environmental details. The tool enables the tracking of movement, making it usable for walking or cycling, and can be utilized in all publicly accessible spaces. The tool consists of two components: hardware (Figure 1 and Figure 2) and software.

The hardware comprises sensors for the simultaneous collection of environmental data, including air temperature (°C), relative humidity (%), barometric pressure (kPa), particulate matter (PM 1.0, PM 2.5, and PM 10.0 (μg/m³)), CO_2 gas, and noise level (dBA). The hardware is connected to a user interface (software) and is part of the publicly accessible platform called Bike Intelligent Centre. The platform provides feedback to the user and can be accessed at http://bizkaiabikeintelligence.deustotech.eu/en/datacentre (accessed on 10 April 2023). The platform offers a range of functions for analyzing microclimate parameters. The tool allows for the measurement of each mentioned parameter and subsequently presents the environmental data on a map. The data is displayed using different colors corresponding to each parameter. These colors are assigned based on a threshold classification system, where each color represents different levels of data values. The query function on the platform (software) enables the selection of specific dates and time intervals of interest for analysis. Within the platform, there is an underlying spatial map that includes essential information, such as land use and the occupation level of bicycle paths.

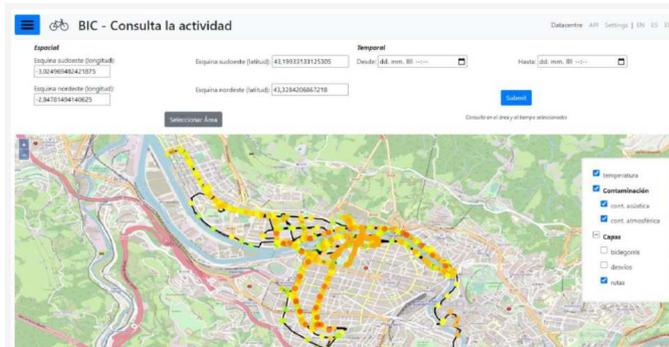Fig. 1: Hardware consists of environmental sensors and a GPS antenna.

Fig. 2: User interface (software), a platform, consisting of different functions to analyse the collected data.

3 METHODOLOGY

This study adopts a case study approach, with the fieldwork conducted along the cycling lanes in Ljubljana, Slovenia. The data gathering process was carried out as an integral part of the research methodology, where the main objective was to evaluate the microclimate-related comfort of cycling lanes in the urban area.

The paper also explores the potential of ICT for assessing the level of comfort of cycling lanes regarding microclimate-related challenges and investigates the potential to identify correlations between spatial elements and microclimate conditions in different spatial settings. In that sense, we explored the potential of this ICT tool considering the following data characteristics:

- Spatial resolution,
- Temporal resolution,
- The interpretation of environmental data through human comfort parameters,
- The interpretation of environmental data within different levels of comfort zones,
- Map-making and linking environmental conditions with a spatial setting,

3.1 Field work

Data gathering was performed using the protocol for microclimate-related street assessment, consisting of several steps, which were already defined in our previous work [6]. Beside the tool, the necessary equipment for data gathering is a bicycle. Additionally, the appropriate cycling speed for data collection in relation to the frequency of the device's data capturing was set to 8 km/h to enable precise data temporal and spatial resolutions.

3.1.1 Protocol for microclimate-related street assesment

The protocol is composed of four main steps: deffinition of the measurement area and the measurement period, selection of parameters to be measured and evaluated, definition of measurement time intervals, and analysis of collected data. They are conducted as following:

1. Definition of the Measurement Area and Measurement period

The data gathering campaign is condicted on highly occupied bicycle lanes in the urban area; in this paper applied in the case of the city of Ljubljana.

Within this first step also the duration of the measurement is defined. In our case, there were some limitations related to readiness of the device. However, as a period of observation the month of August was selected, significant for high temperatures as climate-related characteristics.

2. Selection of parameters to be measured and evaluated

To identify comfortable and uncomfortable sections and possible microclimate challenges, the microclimate-related human comfort parameters must be included in the analyses. In that sense, based on a literature review, the following microclimate parameters were selected: (a) air temperature, (b) solar radiation, (c) humidity, (d) wind velocity, and (e) air quality. In assessing human comfort, we also considered the following set of parameters: (f) level of noise, (g) human perception, and (h) other subjective parameters, such as human activity and clothing [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17].

3. Definition of measurement time intervals

As we are specifically interested in the conditions under which people cycle for their daily commute, the data gathering was scheduled for working days (Monday to Friday) between 7:30 a.m. and 9:00 a.m., and 3:00 p.m. to 5:30 p.m. The planned campaign was set for every day in August 2022, yet data gathering was not been performed on rainy days.

4. Analysing the collected data

This is the most complex step of the protocol, comprising three levels:

(1) Data visualisation to transfer gathered data on a map to provide links between environmental conditions within a spatial context.

(2) Descriptive analysis to identify areas that offer comfort or discomfort to their users.

(3) Data interpretation to identify areas where microclimate challange is present and NBS intervention is needed.

The first step, data visualisation enables linking environmental conditions within a spatial context and must be done with the tool enabling to visualize microclimate through a medium where urban planning operates—mapping.

The second step, descriptive analyses must allow for interpreting data within the range of human comfort zones, with varying colors indicating comfortable spaces, as shown in Table 1. Currently, the descriptive analysis is based on the Bike Intelligent Centre platform, (part of the tool system), enabling to analyse data within absolute values of collected data. However to interpret the value of the difference of microclimate parameters within individual cycling sections, the data interpretation within relative values must be adressed. Another important step of discriptive analyses is related to the layering of the gatered data. First, different microclimate parameters are analysed separatedly. To identify uncomfortable areas for each microclimate parameter separately, individual gathering sessions are layerd and merged into the final maps of places with uncomfortable conditions (separating the morning and afternoon sessions for each microclimate parameter). Further step is related to the comfort rating in terms of simultaneous and integrated analysis of microclimate-related comfort parameters. Within this step the maps related to uncomfortable areas of individual parameters are merged into cumulative maps to define areas that are uncomfortable in terms of two or more parameters simultaneously.

The third step is related to data interpretation to identify areas where microclimate challange is present and NBS intervention is needed. Apart from simultaneous and integrated analysis of microclimate-related comfort parameters, this step requires a definition of a criteria referring to spatial analysis and other relevant data to consider when determining the NBS intervention.

1044

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	Temperature (°C)	Level of Noise (dBA)	Air Quality (PM 2.5)	Humidity (%)
	>40	>100	75	/
	35–40	80–100	50–75	< 15
	25–35	70–80	25–50	15–30
	15–25	60–70	20–25	30–45
	/	40–60	10–20	/
	5–15	/	/	40–60
	0–5	/	/	60–90
	<0	<40	<10	/

Table 1: Legend to interpret microclimate data in relation to human comfort values (parameter threshold classification of comfort zones). The definition of a threshold for the temperature parameter was proposed by the experts who designed the ICT tool and is based on the average temperature values for Spain [18]; noise-level thresholds are based on the environmental noise guidelines for the European Region [19]; air-quality thresholds are based on the World Health Organization's air-quality guideline values [20]; and humidity levels are based on general recommendations for indoor and outdoor humidity in European climates.

4 RESULTS

Results are presented in two parts. The first part shows some illustrative examples of data gathering, indicating the potential of such a tool for defining comfortable and uncomfortable cycling lane sections. In the second part, the results are related to the quality of data, covering aspects of spatial and temporal resolution, data characteristics related to interpretation within human comfort zones, and the ability to use map-making for identifying and interpreting the correlations between space and environmental conditions.
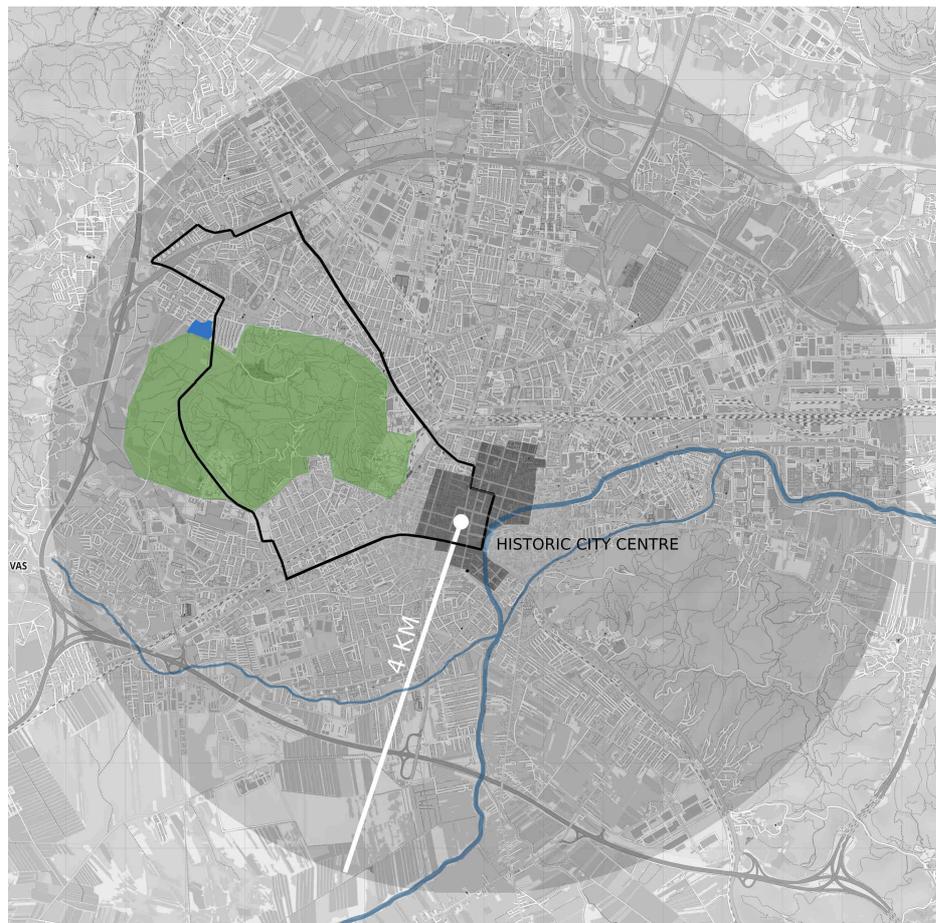

Fig. 3. Data gathering routh.

4.1 The practical performance of data gathering and illustrative examples of identifying comfortable and uncomfortable sections

Data gathering was performed almost every day in August 2022. The pre-planned route (12.5 km) led through different parts of the city, covering a variety of urban structures, including a densely built-up historic

urban area, a densely built-up urban area, and a relatively compact urban pattern with areas of low density. According to the land-use plan, the cycling paths most often crossed areas of central activity, residential areas with accompanied activities, areas of green spaces, and forest areas. Natural morphological features were related to flat terrain, open spaces, forests, clusters of trees, water areas, and artificial non-agricultural green areas, such as urban tree lines and small-sized green surfaces.

4.1.1 <u>Illustrative examples of data gathering, and the potential of such a tool for defining comfortable and uncomfortable cycling lane sections.</u>

This subchapter illustrates which microclimate-related parameters can be interpreted and how such microclimate-related human comfort related data can be used within urban planning analytics.

The illustrative example of data gathering was performed in Ljubljana on Friday, August 5, 2022, between 16:06 and 16:18. Cycling Lane section led through different spatial setting, characterised by densely built-up urban tissue and densely built-up historic urban tissue. The most common natural morphological features are related to flat terrain, urban tree lines, small-sized green surfaces and also a river.

The device enabled the collection of the following parameters: air temperature, relative humidity, noise level, and particulate matter (PM 2.5), which represents the potential of identifying possible microclimate challenges in urban areas. The inclusion of these parameters is sufficient to understand the environmental conditions from an objective–numerical standpoint, which address only the physical conditions.

The gathered data is presented trough a software of the tool, a map-based platform. The routh of data gathering is represented by a track of movement, where the microclimate values are graphically represented with dots of different colors. These colors are assigned based on a threshold classification system, where each color represents different levels of data values, indicating the level of comfort (see Table 1). Such data interpretation enables to differentiate sub-areas regarding the level of comfort.

For example, the temperature parameter on the following cycling lane section (Figure 4) is mostly represented with red colour, indicating uncomfortable conditions, varying between 35.1°C and 37.2°C. Yet, cycling lane subsection following through a historic part, near the city river, the temperature values are represented with orange colours, indicating still uncomfortable conditions, yet with a lower temperature value (varying between 34.7°C - 35°C). In terms of data precision, the data enables to interpret variable microclimate conditions every 10m, enabling to identify changeable microclimate conditions on a pedestrian level. The data related to temperature indicate that every 10 meters temperature can changes between 0.1 °C and 0.8°C. Continuing with the humidity parameter, conditions are represented with yellow colour. Such colour representation is indicating comfortable conditions, varying from 35.6% and 40.2%. Every 10 meters, the humidity value can change between 1% and 1.4 %.

The level of noise is represented with three different colours, indicating subsections are different in terms of comfort level. Green colour is indicating comfortable conditions, varying between 40–60 dBA, yellow colour is indicating uncomfortable conditions, varying between 60–70 dBA and orange colour is indicating uncomfortable conditions between 70–80 dBA. Every 10 meters, the level of noise can change for 0.1 dBA and 16 dBA.

Air quality values are comfortable during the whole section (green colour), where conditions are varying between 9–17 µg/m³. Every 10 meters values differ from 1 – 8 µg/m³.

4.2 The tool's potential for urban analysis of assessing human comfort related to microclimate challenges

The findings indicate that the data's spatial resolution is accurate in capturing the changeable environmental conditions that cyclists may encounter within a few meters. While cycling at an average speed of 8 km/h, measurements were recorded by the device at 5-second intervals, resulting in data collection approximately every 10 meters. Taking into account that environmental conditions can vary between 10 and 100 meters [5], the utilization of the ICT tool enables the generation of sufficiently detailed data. Moving on to the temporal resolution, the tool facilitated data collection at any given time period throughout the day. Given that microclimate conditions change within a 24-hour cycle [5], and assuming that a commuter cyclist travels a minimum of two times per day, the results indicate that the 5-second resolution could help identify the environmental conditions experienced by cyclists during their commute. With the tool, we achieved the

1046

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capability to collect a comprehensive set of human comfort parameters. The data obtained were then visualized across various human comfort zones, providing valuable insights into the comfort levels of a given space.
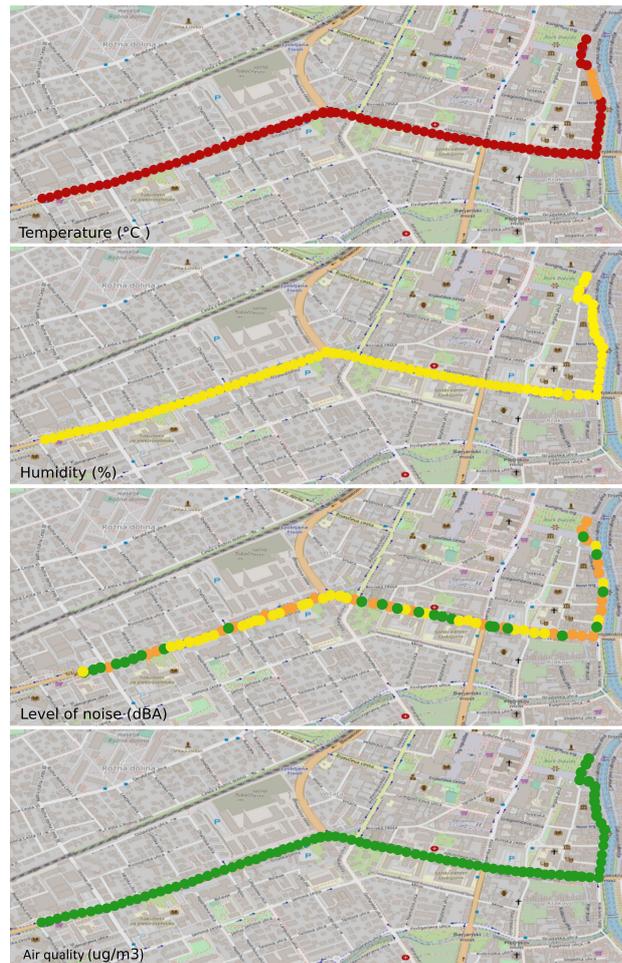

Fig. 4. The practical performance of data gathering and illustrative example of identifying comfortable and uncomfortable sections to demonstrate the potential for identifying possible microclimate challenge.
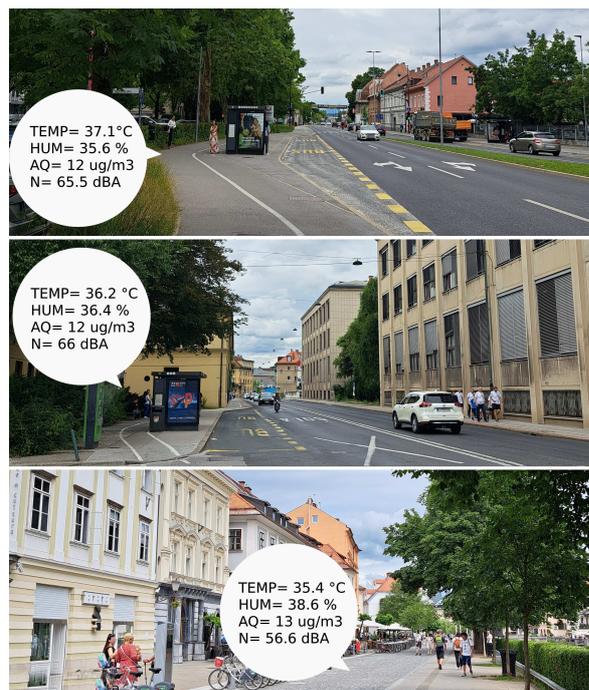

Fig. 5. Illustrative example of data gathering in real places demonstrating detailed microclimate-related information for identifying variable microclimate conditions at a pedestrian level.

The implications of these findings are seen within urban analyses of assessing spaces in terms of microclimate-related human comfort and for identifying microclimate challenges, including high temperature, air quality, humidity, and noise level. Furthermore, in terms of its map-making capabilities, which facilitate the correlation of environmental conditions with specific spatial settings, the results indicate that the platform offers a user-friendly and visually intuitive approach to conducting environmental assessment analyses.

The findings demonstrate the potential of such data in conducting urban analyses. This valuable information can be utilized to identify and allocate necessary spatial interventions or to monitor existing sustainable solutions, ensuring their long-term environmental benefits.

5 DISCUSSION AND CONCLUSION

This paper is based on the premise that considering the microclimate in the design process of sustainable solutions can lead to improvements in environmental quality, affecting environmental conditions and supporting human comfort. However, conventional urban analyses might prove inadequate in thoroughly examining the connections among microclimate conditions, environmental characteristics, and human comfort. In that sense, the paper explores the potential of one ICT tool for assessing human comfort in a case study of cycling lanes in Ljubljana, Slovenia. Based on a microclimate-related street assessment and simultaneous dynamic environmental data gathering, the paper defines sections that are comfortable and uncomfortable, representing a first step towards identifying possible microclimate challenges.

The results suggest that ICT innovations, for in-situ measurements, can help urban analytics gather and urban planners interpret detailed microclimate-related information and assess places according to microclimate challenges. The ICT tool enabled the production of data with characteristics that support better consideration of microclimatology in urban planning. The collected data have precise temporal and spatial resolutions, enabling the identification of variable microclimate conditions within a few meters, every five seconds. In terms of data characteristics related to comfort, the results indicate that the data can be interpreted through the main microclimate parameters: air temperature, relative humidity, particulate matter (PM 1.0, 2.5, and 10.0 µg/m³), noise level and additional ones; barometric pressure (kPa), and CO_2 gas, thereby assessing the comfort of the space. The findings also suggest that the data are presented through a map-based visual representation of spatial assessment, a linkage of environmental conditions within a spatial context.

Such innovative tools for analysing site-specific environmental characteristics represent a potential within urban planning of NBS, where the data's potential is seen in urban analyses, prioritizing, and selecting spatial interventions to achieve or improve the microclimate-related human comfort of a space.

6 FUNDING

7 REFERENCES

1. Gehl, J. Life between Buildings, 6th ed.; Island Press: Washington, DC, USA, 2011. [Google Scholar]
2. Lin, T. Thermal perception, adaptation and attendance in a public square in hot and humid regions. Build. Environ. 2009, 44, 2017–2026. [Google Scholar] [CrossRef]

3. Thorsson, S.; Lindqvist, M.; Lindqvist, S. Thermal bioclimatic conditions and patterns of behaviour in an urban park in Göteborg, Sweden. Int. J. Biometeorol. 2004, 48, 149–156. [Google Scholar] [CrossRef] [PubMed]

4. Goličnik Marušić, B.; Dremel, M.; Ravnikar, Ž. A frame of understanding to better link nature-based solutions and urban planning. Environ. Sci. Policy 2023, 146, 47–56. [Google Scholar] [CrossRef]

5. Barry, R.G. A framework for climatological research with particular reference to scale concepts. Trans. Inst. Br. Geogr. 1970, 49, 61. [Google Scholar] [CrossRef]

6. Ravnikar, Ž.; Bahillo, A.; Goličnik Marušić, B. A Protocol for Microclimate-Related Street Assessment and the Potential of Detailed Environmental Data for Better Consideration of Microclimatology in Urban Planning. Sustainability 2023, 15, 8236. https://doi.org/10.3390/su15108236

7. Frontczak, M.; Wargocki, P. Literature survey on how different factors influence human comfort in indoor environments. Build. Environ. 2011, 46, 922–937. [Google Scholar] [CrossRef]

8. Ekici, C. A review of thermal comfort and method of using Fanger's PMV equation. In Proceedings of the 5th International Symposium on Measurement, Analysis and Modelling of Human Functions, ISHF 2013, Vancouver, BC, Canada, 27–29 June 2013; pp. 61–64. [Google Scholar]

9. Elnabawi, M.H.; Hamza, N. Behavioural perspectives of outdoor thermal comfort in urban areas: A critical review. Atmosphere 2020, 11, 51. [Google Scholar] [CrossRef]

10. Lam, C.K.C.; Lau, K.K.L. Effect of long-term acclimatization on summer thermal comfort in outdoor spaces: A comparative study between Melbourne and Hong Kong. Undefined 2018, 62, 1311–1324. [Google Scholar] [CrossRef]

11. Mamani, T.; Herrera, R.F.; Rivera, M.-L.; Atencio, E. Variables That Affect Thermal Comfort and Its Measuring Instruments: A Systematic Review. Sustainability 2022, 14, 1773. [Google Scholar] [CrossRef]

12. Shooshtarian, S.; Rajagopalan, P.; Sagoo, A. A comprehensive review of thermal adaptive strategies in outdoor spaces. Sustain. Cities Soc. 2018, 41, 647–665. [Google Scholar] [CrossRef]

13. Stathopoulos, T.; Wu, H.; Zacharias, J. Outdoor human comfort in an urban climate. Build. Environ. 2004, 39, 297–305. [Google Scholar] [CrossRef]

14. Boduch, M.; Fincher, W. Standards of Human Comfort, Relative and Absolute. 2009. Available online: https://repositories.lib.utexas.edu/handle/2152/13980 (accessed on 10 April 2023).

15. Song, Y.; Mao, F.; Liu, Q. Human comfort in indoor environment: A review on assessment criteria, data collection and data analysis methods. IEEE Access 2019, 7, 119774–119786. [Google Scholar] [CrossRef]

16. Morris, K.I.; Chan, A.; Morris, K.J.K.; Ooi, M.C.G.; Oozeer, M.Y.; Abakr, Y.A.; Nadzir, M.S.M.; Mohammed, I.Y.; Al-Qrimli, H.F. Impact of urbanization level on the interactions of urban area, the urban climate, and human thermal comfort. Appl. Geogr. 2017, 79, 50–72. [Google Scholar] [CrossRef]

17. Tong, S.; Wong, N.H.; Tan, C.L.; Jusuf, S.K.; Ignatius, M.; Tan, E. Impact of urban morphology on microclimate and thermal comfort in northern China. Sol. Energy 2017, 155, 212–223. [Google Scholar] [CrossRef]

18. The State Meteorological Agency, Spain (AEMET) (n.d), Maximum and Minimum Temperatures. AEMET. Available online: http://www.aemet.es/en/eltiempo/prediccion/temperaturas?dia=&zona=penyb&img=maxima (accessed on 9 November 2021).

19. World Health Organisation (WHO). Environmental Noise Guidelines for the European Region; WHO: Geneva, Switzerland, 2018; Available online: https://www.who.int/europe/publications/i/item/9789289053563 (accessed on 10 April 2022).

20. World Health Organisation (WHO). WHO Global Air Quality Guidelines; WHO: Geneva, Switzerland, 2018. [Google Scholar]

Modelling the Efficiency of Nature-Based Solutions to Decrease Extreme Summer-time Heat in Dense Urban Environment on Example of Vienna, Austria

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1 ABSTRACT

Densely built urban environments experience extremely high temperatures during summer heat waves. Nature-based Solutions (NbS), such as increasing green infrastructure by replacing sealed surfaces with vegetation, installing green roofs and especially planting trees can ameliorate severe heat conditions by providing cooling through evapotranspiration and shading. This study analyses the effectiveness of NbS to reduce the summer maximum temperatures in Vienna using an urban climate modelling approach that takes into account NbS performance criteria on micro-scale and upscales the application of NbS for the entire city.

Using existing data of the Viennese urban structure, status-quo urban climate simulations were performed. Further, based on evidence on NbS performance criteria different climate scenarios for implementation of NbS were designed. A densely-built area in Vienna, for which the possibility of implementation of NbS was analysed, was chosen as a study area for micro-scale simulations. The adaptation measures included: 1) reduction of soil sealing, 2) increase in surface reflectivity of sealed surfaces, 3) implementation of green roofs, 4) new park areas with trees and low vegetation and 5) a combination of all NbS.

The modelling simulations were performed for a representative clear-sky heat day for NbS scenario first for the selected area with the ENVI-met model and later for the entire city of Vienna with the MUKLIMO_3 model. The extent of NbS was proportionally scaled for the city-level simulations and the measures were applied for all densely-built areas in the city.

The results show the highest cooling effect for the combination of NbS with a similar intensity of cooling found both in microscale and city-scale simulations. In case of city-scale simulations, the results show mean difference in daily maximum temperature of about 0.1°C and maximum difference of about 1.4°C. The effect is strongest in the densely-built areas where the measures were applied. However, the cooling effect can be detected in the surrounding areas as well.

The robustness of the urban scale results was tested using different modelling setups, varying the parameters describing land-use properties, such as variations in land use mapping, soil sealing, building density and tree coverage. Different representation of land use characteristics in the model leads to variations in spatial pattern of heat load. The cooling effect also varies spatially, dependent on the possibility to implement the adaptation measure. However, the results confirm similar efficiency of NbS regardless of the background data and method applied.

Keywords: urban heat island, urban climate, nature-based solutions, microclimate, climate modelling

2 INTRODUCTION

Urban environments are particularly sensitive to negative impacts of climate change. Especially, increasing occurrence of extreme weather events like heat waves poses a serious threat for urban regions (e.g. EEA 2012), since the prevailing structures increase the the experienced heat due to the Urban Heat Island (UHI) effect (e.g. Oke et al. 2017). Regulating urban climate by reducing the UHI effect and extreme temperatures during heat waves has become an important issue in sustainable and climate sensitive urban planning. One approach towards UHI mitigation is the implementation of the so-called Nature-based Solutions (NbS), such as parks, forests, water bodies, green roofs, green facades and other green and blue infrastructure, that have positive effect on reducing temperature peaks and provide multiple other ecological and social benefits (e.g. Nesshöver et al. 2017).

In case of Vienna, strong increase in temperature and heat-related climate indices has already been observed and further intensification in urban heat is expected in the next decades (Chimani et al. 2016; Bokwa et al. 2018; Bokwa et al. 2019). This can cause severe impact on public health by increasing the level of heat-

related mortality (Muthers et al. 2010). The climate trend towards higher temperatures relates also to growing energy demand for cooling of buildings (Bird et al. 2019). The energy consumption depends on the building performance as well as specific microclimate conditions. The NbS can provide further benefits in reducing cooling energy demand by reducing outdoor temperatures as well as regulating indoor temperatures through insulation of buildings, for example by implementation of green walls and roofs.

As a measure to reduce the negative aspects of urban climate, the City of Vienna developed an UHI strategic plan (UHI, 2015) to implement various climate adaptation measures on buildings and open space including urban ecology measures based on planning tools and instruments on different governance levels. The scientific data base for the strategic plan are a number of climate studies providing an urban climate assessment, future climate scenarios and possible impacts, climate function map including thermal imaging, as well as strategic papers and information on the physical implementation of actions such as green space networks, green roofs, living walls and rainwater management.

As a supporting evidence for strategic plans for climate adaptation and sustainable urban development, many modelling applications have provided estimates on efficiency of NbS to reduce the UHI effect in Vienna. Most of the studies (e.g. Orehounig et al. 2014; Vuckovic et al. 2018) were focused on a specific building block and considered possible implementation and optimization of adaptation measures to find best-suitable solution for the particular study area, for example unsealing of paved surfaces and planting trees considering the orientation of streets and building geometry to enhance the shading effect. The quantitative results of these studies were difficult to transfer on other areas in the city, as well to draw general conclusions for implementation on a strategic level.

Another modelling approach considered implementation of adaptation measures on a city-scale, however, with limited spatial detail. For example, the implementation of blue and green infrastructure (Žuvela-Aloise et al. 2016) and application of green roofs and albedo modifications (Žuvela-Aloise et al. 2018) was modelled for Vienna and the results show that moderate to strong cooling effects can be achieved by extensive implementation of NbS. However, these studies calculated the cooling effect of NbS in terms of theoretical potential based on existing urban morphology, but not considering realistic application and actual urban development plans.

One of the main challenges of urban planning response to climate change impacts is that adaptation measures need to be implemented consistently at different planning levels and that the right amount of NbS needs to be identified in order to achieve a sufficient cooling effect as well as to engage appropriate planning instruments for the implementation (Reinwald et al. 2021). In the study of Reinwald et al. (2021) a combined approach with micro-, local- and meso-scale climate simulations and a green and open space factor was adopted to assess current and future urban heat stress and to evaluate the cooling effect of NbS in a standardized way on different spatial and planning levels.

Similar climate modelling approach was used in this study with a goal to identify appropriate NbS specifically for densely built urban environments, which are most severely affected by the UHI effect and quantify their cooling effect on the micro- and city-scale. The study examines a typical building block in dense urban environment in Vienna and considers different adaptation measures, including reduction of soil sealing, increase in surface reflectivity of sealed surfaces, implementation of green roofs, new park areas with trees and low vegetation and a combination of all NbS above. The modelling simulations are performed with a micro- and city-scale urban climate model and the results are analysed in the context of climate change adaptation for the use case example of "Supergrätzl" and the strategic plan on the level of the city of Vienna.

3 DATA AND METHODS

3.1 Micro-scale model

The state-of-the-art microclimate model ENVI-Met was selected to simulate status-quo and "resilience" scenario on a micro-scale level. ENVI-Met provides the possibility to design buildings, vegetation, surfaces, pollutant sources or waterbodies on a 3D grid and simulate atmospheric and surface interaction processes (ENVI-Met, 2023). Buildings and trees are explicitly resolved, thus enabling representation of adaption measures on a granular scale. The model domain focuses on a demonstrative quarter called "Supergrätzl" in

1052

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the 10th district of Vienna and expands to 792 x 476 x 60 m with a spatial resolution of 2 m and higher resolved vertical resolution of 0.4 m within the lowest 5 model levels. The meteorological boundary conditions were chosen from a clear-sky hot day (19.07.2014), with fixed low wind direction from West to represent an autochthon weather situation. Around 350 m of the domain in the Western part are considered as buffer zone to account for effects induced by boundary conditions.

For the NbS scenario, different streets in the domain have been redesign with NbS. Surrounding streets of the quarter have been greened with additional trees and sealed parking lots have been unsealed or adapted to grass pavers. One street has been paved with higher albedo plaster and adjacent buildings gained façade and roof greening where applicable. Some streets received façade greening, removed and unsealed parking lots, additional trees, street greening, water features and higher albedo plaster, while others have been refurbished with technical solutions like sun sails, fog showers and as well higher albedo plaster to compare NbS and technical solutions (Fig. 1).

Fig. 1: Domain overview and depiction of status-quo and planned measures (left) and implemented measures (right) for urban quarter ("Supergrätzl") in the micro-scale simulation.

3.2 City-scale model

The simulations of urban climate for the city of Vienna were performed with the urban climate model MUKLIMO_3 (in German: 3D Mikroskaliges Urbanes KLImaMOdell) developed by the German Weather Service (DWD). The thermo-dynamical version of the model described in (Sievers, 2016) with model updates released in 2020 was used. The model is based on Reynolds-averaged Navier–Stokes (RANS) equations and includes parametrisation of vegetation and building morphology. The modelling approach takes into account terrain elevation, land use types and spatial distribution of land use parameters such as building density, building height and wall area index, sealing fraction and tree cover. The model domain covered the City of Vienna and its immediate surroundings with a grid size of 314 x 239 points and horizontal grid spacing of 100 m. The vertical resolution of the 3D model with 39 levels varied from 10 to 100 m with higher resolution near the ground and maximum height of about 1000 m. The simulations were conducted for a chosen clear-sky hot day (19.07.2014) representative for heat conditions during a summer period in Vienna, adopted from (Reinwald et al. 2021).

3.3 NbS assessment

The calculation of NbS cooling effect was performed by comparing the model results for mean and maximum air temperature between the reference simulation with current urban structure and the NbS scenario. In the NbS simulation the land-use parameters that are used as model input, as well as their spatial distribution, were adjusted to account for reduction of sealed surfaces and increase in vegetation (Table 1).

	Reference	NbS Scenario
Building area	43.6%	43.6%
Green roof area	0.0%	5.0%
Streets	53.7%	35.5%
Unsealed surface	0.0%	15.2%
Vegetation (low vegetation and tree trunks)	2.7%	5.7%
Number of trees	84	231

Table 1: Percentage of different land use areas in reference simulation and the NbS scenario as input parameters for the model simulations.

Realistic values of available surface area and possible greening measures were estimated on the example of Supergrätzl (Fig. 2). In case of the city-scale simulations the measures were applied in all densely built areas

in Vienna. To account for increase of number of trees that could not be simulated in the city-scale model due to the low spatial resolution, a park area was assigned to grid cell with buildings for every ninth grid-point of the dense built-up area. Additionally, albedo value of sealed surfaces was increased by 30%, as the existing street areas where considered to be partially replaced by higher reflective concrete and porous pavement.
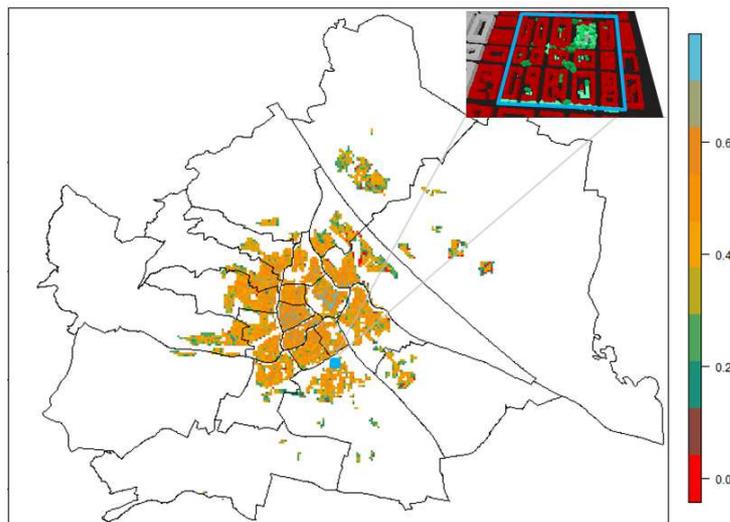

Fig. 2: Building density in Vienna for the dense built-up areas (land use typology: Blockrandbebauung; Green4Cities/GREENPASS, 2018, adapted from Reinwald et al. (2021)) and the location of the Supergrätzl.

4 RESULTS

4.1 Micro-scale simulations

Evaluation and comparison of NbS scenario with status-quo has been carried out for the parameters air temperature and mean radiant temperature (MRT) on pedestrian level. During the entire course of the day, NbS demonstrated stronger cooling capacities than technical solutions with averaged 0.8°C vs. 0.4°C during the day and 0.6°C vs. 0.3°C during the night for air temperature over the entire urban quarter. The cooling effect on air temperature is stronger during the day than during the night as differences of surface temperatures are higher during daytime (Fig 3, left, middle). Shading function of trees and evapotranspiration of vegetation are the main drivers of the temperature reduction. Sun sails only fulfil a partial shading function, as they can not be applied over the entire street scape for ventilation reasons. On the contrary, increased albedo on sun exposed areas even lead to higher MRT due to reflection of solar radiation (Fig 3, right).
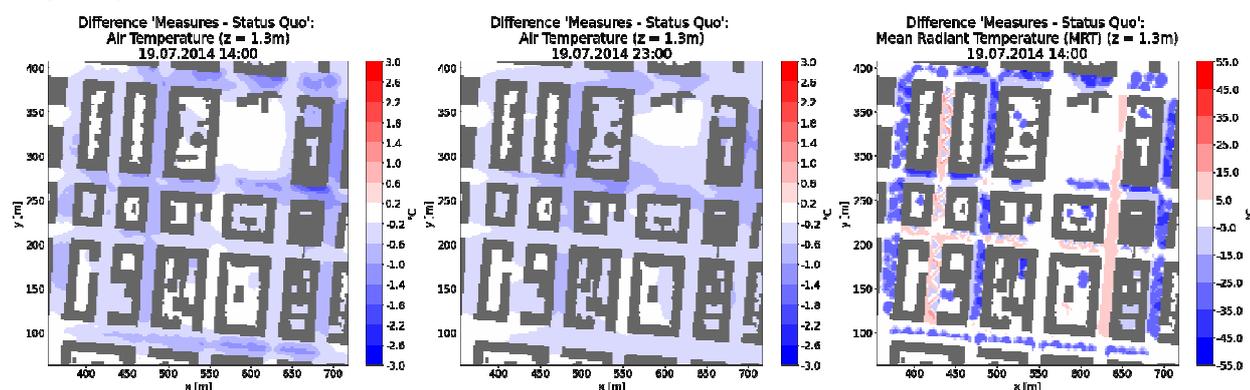

Fig. 3: Difference plots between scenario measures and status-quo of simulations for urban quarter ("Supergrätzl"). Left plot shows air temperature difference at 14:00, middle plot at 23:00. Right plot shows mean radiant temperature difference at 14:00.

4.2 City-scale simulations

A reference simulation based on the current urban morphology (Fig. 4, top) shows a typical development of the UHI in Vienna, characterized by higher temperatures in the densely built city-centre and lower temperatures in the surroundings, especially the elevated forest areas in the West and the national park Donau-Auen in East. By applying the NbS in densely built areas, a moderate cooling effect is found (Fig. 4

1054

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bottom). The maximum difference in mean air temperature was 0.7°C and 1.4°C in maximum air temperature. The mean difference is, however, lower and yields to 0.1°C in maximum temperature. The cooling effect varies spatially and depends on the availability of open spaces where NbS can be implemented. The cooling is most effective in the areas where the NbS is applied. However, due to the prevailing wind from Northwest, the cooling effect can propagate further Southeast and the surrounding areas where no measures where applied.
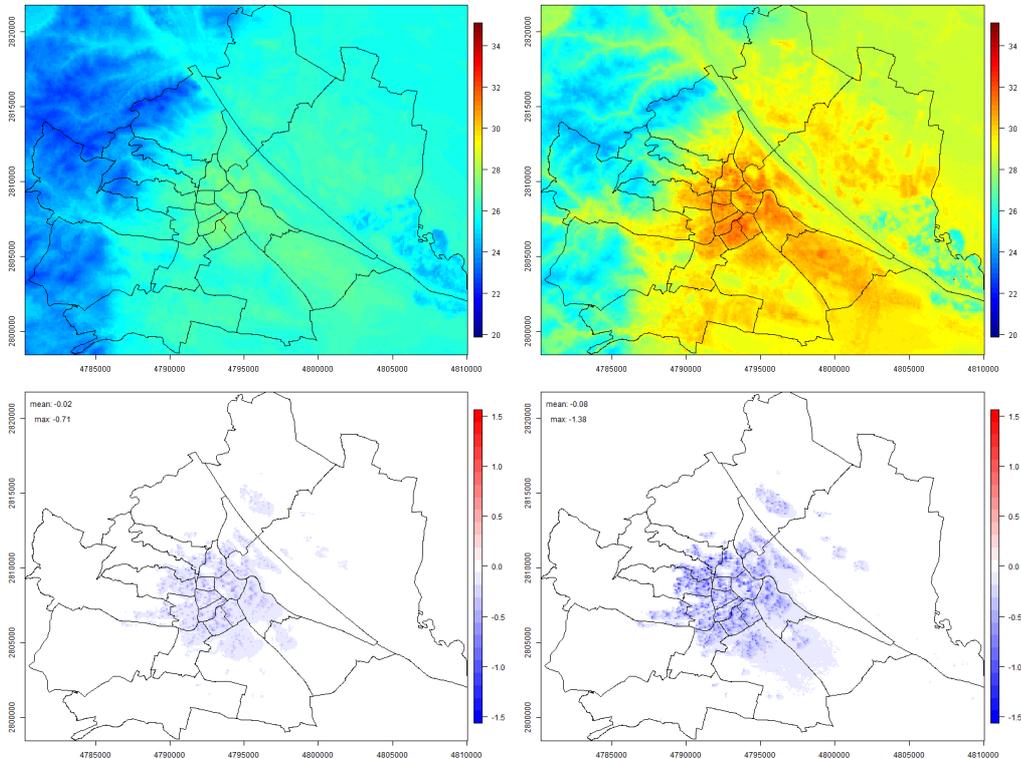

Fig. 4: City-scale simulations of air temperature (°C) in Vienna for July 19, 2014. Upper panel indicates daily mean (left) and daily maximum temperature (right) values for the reference simulation. The lower panel shows the difference in respective temperatures between the NbS simulation and the reference simulation.

5 CONCLUSION

This study demonstrates the cooling effect of NbS applied in a densely built environment based on the micro-scale and city-scale model simulations. The results from both modelling approaches confirm similar efficiency of NbS. The maximum cooling effect when different greening measures are applied is a difference in maximum air temperature of about 1.5°C. The cooling effect is limited by the availability of free spaces in densely built environment.

On the micro-scale the cooling effect of NbS is stronger than of technical solutions like sun sails or fog showers. The applied measures show stronger cooling effects (absolute) during the day than during the night. On the city-scale, the highest cooling effect is achieved by implementing green areas with trees (ΔT_{max}~1.2°C), while unsealing of surfaces has minor effect (ΔT_{max} ~0.3°C). The effect of green roofs, which was limited to 5% in the study area, is negligible (ΔT_{max} ~0.1°C). With higher availability of green roofs (30%) a larger, but still minor, cooling effect (ΔT_{max} ~0.4°C) could be achieved.

These results show that the NbS has a moderate cooling effect even in densely built environment, where their implementation is physically limited. As such, the NbS are an important instrument to address negative impacts of climate change and particularly to reduce the UHI effect. In further steps, the results of this study will be analysed in scope of climate risk assessment, where social aspects and vulnerability of urban population will be considered. These results can help improve existing urban development plans and accelerate the urban adaptation to climate change in Vienna.

6 ACKNOWLEDGEMENT

7 REFERENCES

BIRD, D. N., de Wit, R., Schwaiger, H.P., Andre, K., Beermann, M., Žuvela-Aloise, M.: Estimating the daily peak and annual total electricity demand for cooling in Vienna, Austria by 2050. Urban Climate, 28: 100452. 2019

BOKWA, A., Dobrovolný, P., Gál, T., Geletič, J., Gulyás, A., Hajto, M. J., Hollósi, B., Kielar, R., Lehnert, M., Skarbit, N., Šťastný, P., Švec, M., Unger, J., Vysoudil, M., Walawender, J. P., & Žuvela-Aloise, M.: Urban Climate in Central European Cities and global climate change, ACTA CLIMATOLOGICA ET CHOROLOGICA Universitatis Szegediensis, Tomus 51-52, 7-35. 2018

BOKWA, A., Geletič,J., Lehnert, M., Žuvela-Aloise, M., Hollósi, B.,Gál, T., Skarbit, N., Dobrovolný, P., M. J. Hajto, R. Kielar, P. Šťastný, J. Holec, K. Ostapowicz, J. Burianová, M. Garaj, & Walawender, J. P.: Heat load assessment in Central European cities using an urban climate model and observational monitoring data. Energy and Buildings, 201: 53-69. 2019

CHIMANI B., Heinrich G., Hofstätter M., Kerschbaumer M., Kienberger S., Leuprecht A., Lexer A., Peßenteiner S., Poetsch M.S., Salzmann M., Spiekermann R., Switanek M., & Truhetz, H.: ÖKS15 – Klimaszenarien für Österreich. Daten, Methoden und Klimaanalyse. Projektendbericht, Wien. 2016

EEA (European Environment Agency): Urban Adaptation to Climate Change in Europe: Challenges and Opportunities for Cities Together with Supportive National and European Policies. EEA Report No. 2/2012. Copenhagen: EEA. 2012

ENVI-MET: Envi-met model architecture. Retrieved from https://envi-met.info/ on July, 10th, 2023

MUTHERS, S., Matzarakis, A., & Koch, E.: Climate change and mortality in Vienna—a human biometeorological analysis based on regional climate modeling. International journal of environmental research and public health, 7(7), 2965-2977. 2010

NESSHÖVER, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., Külvik, M., Rey, F., van Dijk, J., Vistad, O. I., Wilkinson, M. E., & Wittmer, H.: The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of the total environment, 579, 1215-1227. 2017

OKE, T. R., Mills, G., Christen, A. & Voogt, J. A.: Urban Climates. Cambridge and New York: Cambridge University Press. 2017

OREHOUNIG, K., Mahdavi, A., Doppelbauer, E. M., Loibl, W., & Tötzer, T.: Projections of design implications on energy performance of future cities: a case study from Vienna. Sustainable Cities and Society, 12, 92-101. 2014

REINWALD, F., Brandenburg, C., Gabor, A., Hinterkörner, P., Kainz, A., Kraus, F., Ring, Z., Scharf, B., Tötzer, T., & Damyanovic, D.: Multi-Level Toolset for Steering Urban Green Infrastructure to Support the Development of Climate-Proofed Cities. Sustainability, (12111). 2021

SIEVERS U: Das kleinskalige Strömungsmodell MUKLIMO_3. Teil 2: Thermodynamische Erweiterungen. Berichte des Deutschen Wetterdienstes 248. 155 pp, ISBN 978-3-88148-490-9. 2016

UHI 2015: Urban Heat Island strategy plan for Vienna: https://www.wien.gv.at/umweltschutz/raum/pdf/uhi-strategieplan.pdf, Vienna, 2015

VUCKOVIC, M., Maleki, A., & Mahdavi, A.: Strategies for development and improvement of the urban fabric: A Vienna case study. Climate, 6(1), 7. 2018

ŽUVELA-ALOISE, M., Koch, R., Buchholz, S., & Früh, B.: Modelling the potential of green and blue infrastructure to reduce urban heat load in the city of Vienna, Climatic Change 135.3-4 (2016): 425-438. 2016

ŽUVELA-ALOISE, M., Andre, K., Schwaiger, H., Bird, D. N., & Gallaun, H.: Modelling reduction of urban heat load in Vienna by modifying surface properties of roofs. Theoretical and Applied Climatology, 1-14. 2017

1056

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Small Lexicon on Ecology (for those Interested in Cities)

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1 ABSTRACT

Some notions about ecology show that if there is not a corpus there is an interesting and pertinent debate. We quote: on the environment itself, negative commons, mistake of the isolated system, dealing with the symptoms and not the causes (the tragedy of the horizons), and on the Opinion, Great Reversal, laws of opinion, greenwashing and the return of enclave economy. The cities are concerned by the two different stakes, adaptation and mitigation. Also, the question is posed of the places where ecological awareness can appear.

Keywords: cities, adaptation, urban policy, ecology, mitigation

2 INTRODUCTION

The ecological and climatic crisis has burst out in a society which was already a consumers society where Opinion is all powerful. Opinion is also elusive and arbitrary, according to the French philosopher Castoriadis. He compares it to a "magma" (Castoriadis, 1975). In some aspects, it is reassuring, since Opinion cannot be programmed, at least in democratic countries. Also, it is risky. If we distinguish, like the German sociologist Tonnies, two opinions, one "gaseous", volatile, sentimental, the other stable, educated (in progress like a Parliament learning during years, thanks to accumulated experience) we fear a too slow "learning" of the stable opinion. The pace of learning cannot be too slow, since the global warming worsens threatening to go out of control. Tonnies uses also the words "essential will" and "arbitrary will". The essential will is in conformity with the identity of a group, often a tribe. The arbitrary will is able to trigger decisions taking into account some evolution of the society, which is understood (Tonnies, 2012). Therefore, the fear can be described with the words of Tonnies: the disaster is if the pace of climatic change is faster than the pace of appearance of an arbitrary will (which is needed, to trigger the struggle against climatic change). That is why in in this "lexicon" we insist on what concerns the Opinion: Laws of Opinion, Great Reversal, Greenwashing.

Also of interest is the mental representation of Nature, and its evolution. Here we refer to the French theorist George Sorel, who distinguished "artificial nature" and "natural nature" (Sorel, 2019). In the industrial society knowledge was accumulated on "machinic systems". Nature was considered as a provider of energy and the goal was to avoid the waste of this energy (degradation of energy because of frictions). "Will" was needed to struggle against the machines' wear. Nature itself was forgotten. It is "natural nature". It is not only that artificiality of the city won around 1900. The famous urban planner Patrick Geddes wanted that the pupils of the schools in the cities take trips in the countryside, to learn what Nature is (otherwise, they never saw it). It is also that the relationship Man/Nature was not an interesting topic (only the "will", justifying productivism and extractivism). Before the industrial era, the relationship Man/Nature was taken into account, but on the religious mode (before the Newtonism in the 18 th century). The historian Wittfogel has described how in Old China, the Emperor was a half god responsible for the weather. He was guaranteeing the good working of the Universe. If there were disastrous floods, the dams being broken, he was at least removed. Recently a procession was seen in a city of the South of France, to get rain. To put an end to irony, we need to pay attention to Nature, and, of course, taking into account Science (climatology, scientific ecology, biology …).

What is of interest in the notion of "artificial nature"/"natural nature" is that the two knowledges, knowledge of causes (Science) and knowledge of reasons (sentiments, beliefs) are considered. Speaking of sentiment at the time of productivism / extractivism, it was "will". That there are debates in Science and on beliefs, both, has been theorized by the French sociologist Tarde, commenting on the works of the French philosopher Cournot (Tarde, 2012). It is interesting to understand the shift of the two knowledges when the era of productivism/extractivism ends, while the era of Sustainable Nature begins. Concerning the knowledge of causes, the sciences which matter are no more thermodynamics, mechanics, the science of motors (fluid dynamics …) but climatology, scientific ecology, biology, studies on health etc. And concerning the sentiment, one passes from "will" to "prudence". Indeed, the precautionary principle is the pilar at the time

of sustainable nature. It matters because we have understood that the impact of human activities on Nature is disastrous and cannot be neglected like in the past. And the indispensable science allowing to understand this impact does not (yet) exist. We are obliged to suppose the worse, when the impact of an activity on the environment is unknown. And, of course, we have to give up any project if its consequences on environment, that current science does not understand, or understands not enough, are possibly disastrous.

Now one can give the plan of this paper:

- First, some articles concern more the environment itself: negative commons, mistake of the isolated system, dealing with the symptoms and not the causes.

- Other articles concern Opinion, and economic or political topics: Laws of Opinion, Great Reversal, Greenwashing and return of the enclave economy.

- In the conclusion, we shall examine how the stakes of the ecological transition concern the cities.

3 ARTICLES CONCERNING THE ENVIRONMENT ITSELF

3.1 Negative commons

They are places where waste is illegally put: ocean floors, underground dumps, illegal burials etc. At the time of Soviet Union, the floor of the White Sea was used as a dump by the military nuclear industry. On the floor of the Tyrrhenian Sea, in Italy, is put waste from industry (this is under the control of an Ecomafia). Etc. If a user has waste to evacuate, he can make a gain by choosing the illegal way. There are rules concerning waste: they have to be burnt, or stored in some conditions, or recycled etc. If one avoids these rules, the cost is less and there is a profit. Think of an owner who destroys a building and wants to evacuate the waste. Until today, the waste in the building industry was not a problem. But this changes. The dumps are full. In some regions, where there is much wind, the wind carries dust from the dump far away. The materials used to build houses are complex and need recycling. Etc.

- A negative common works thanks to a "group of actors":

- The user makes a gain because the price for the evacuation of the waste is less.

- Some civil servants are bribed.

To find the people who carry out the illegal task itself is easy. According to the American economists Akerlof and Schiller, fraud works like the capitalism: if there is an opportunity of fraud, there are always the people who will launch this fraud, and benefit from it. It is like in the capitalism, if there is an opportunity to invest in some way, and win money, this investment occurs (Akerlof, 2016). The "group of actors" appears, and acts in coherence. Of course, it is because the rules are not enforced, and are not tough enough (only fines …). The society could "capitulate". That is to say, one tolerates the negative commons. In this case, the opportunity to make a gain thanks to a negative common, is open to anybody. It is the characteristic of a common. This common is negative because of the pollution of waters, air, soils … is aggravated.

3.2 Mistake of the isolated system

We simplify when we pose the problem of struggling against pollution. One considers one pollution, separately, and the goal is to eliminate it. Often, the struggle against a pollution creates another pollution, or hampers the struggle against some other pollution. There are many examples:

- Aerosol: These airborne particles often reflect the solar light and mitigate the warming of the atmosphere. But they are toxic pollutants. One has to remove them, even if they have a favorable impact on the warming of the atmosphere.

- Chlorofluorocarbons: After the Montréal Protocol (1987) one has ceased to produce chlorofluorocarbons, which destroy the ozone in the stratosphere (useful to protect against UVs). They have been replaced by the HFCs, hydrofluorocarbons … but these products strengthen the greenhouse effect… Finally, currently one removes the HFCs also.

- Methane: This gas in the atmosphere contributes to the greenhouse effect. Curiously, when one removes the gases NOx from the air in the cities because they are toxic for people, it hampers the

1058

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struggle against methane … because the presence of NO_x in the air triggers chemical reactions which make methane molecules break.

- etc.

All is interdependent in the environment. This makes the methodology, when one studies the impact of chemical products on environment, very complex. For instance, it is not enough to study impact of some product. It would be necessary to study the impact of cocktails of products or their metabolites (the products into which a product breaks down in the water).

Awkward problems arise. For instance, conflicts are possible between experts in public agencies (who give advices on the danger of some products being diffused in the environment) and scientists (who make the scientific studies on the danger of some products). The experts could simplify while the scientists reckon that the methodology has to take into account the complexity of the problem. All this advocates for the precautionary principle.

3.2.1 <u>Dealing with the symptoms and not the causes</u>

We have to distinguish "adaptation" and "mitigation". "Adaptation" means measures taken and infrastructures created or upgraded to cope with the negative consequences of global warming in cities. The goal is to maintain livable the cities. The short term is considered. Are concerned networks of refrigerated water (to refresh buildings during hot summers), measures to deliver potable water even when there are droughts, measures against the disastrous effects of floods (which will be more frequent), raised dams etc. "Mitigation" of global warming concerns the long term. It is to deal with the causes themselves (too many emissions of CO_2 in the atmosphere).

One has coined the term "tragedy of the horizons" to describe the possible mistake. To deal with the symptoms, forgetting the causes, would be a mistake. As the worse is besides the horizon (an unbearable increase of the mean temperature of the atmosphere), and there are preoccupations in the present, one is tempted to give the priority to adaptation forgetting mitigation.

Since in this paper we explore the hypothesis of an Opinion all powerful, elusive and arbitrary, we cannot avoid to discuss this possible evolution: "adaptation" is taken in charge efficiently, the Opinion is reassured and this leads to the stake of "mitigation" neglected. This, because the consequences of adaptation are visible, while the consequences of mitigation are invisible (but matter very much). Obviously, if we lose time to carry out mitigation, it becomes more and more costly. The Stern[1] report (2006) has stated that mitigation of climatic change, carried out more lately, will be costlier. During the lost time, the expenses for adaptation would increase. Finally, the Humanity would cope with a double investment wall: for adaptation and for mitigation (this, without speaking of a possible no return point).

Take the example of water in Paris. The works to master the problems of water in Paris started a century ago. One has created several water reservoirs (lakes) upstream of Paris, to master the flow of the river Seine (to retain water in winter, to deliver water in summer). After, the works have reached a pharaonic size. One has promised the Parisians to allow swimming in the river Seine in 2024, year of the Olympic Games in Paris. For that, the water treatment plants upstream of Paris have been upgraded. The cleanness of the water in the river is threatened when there are storms, because the rainwater and the wastewater overflow the sewage system. One builds two huge reservoirs connected by a tunnel to collect these waters, which will be released in the river lately, after a treatment cleaning them. Notice that the promise (to Parisians that swimming in the river Seine will be possible) has already been made for the year 2000 … without effect. Now suppose that the promise is kept. Concerning another recreational activity, fishing in the river Seine, it is definitively lost, because of chemical pollution in the river Seine. One corrective action (swimming) is possible and costly, while another one (fishing) is impossible. Again, this shows that the precautionary principle should be applied.

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[1] Nicholas Stern is a British economist.

4 ARTICLES CONCERNING OPINION

4.1 Great reversal

Again, given our hypothesis on the Opinion which is all powerful, elusive and arbitrary, one has to consider the possibility of a turning back in environmental matters. Already some European leaders claim a "pause" in environmental legislation. In the Nederland, a political party claiming to maintain the productivist agriculture has made significant electoral gains. In the European Parliament a law poised at restoring the totally or partially destroyed ecosystems in the EU, has been voted by a narrow majority, after many articles have been cancelled. However, it is absurd. One cannot limit the ambitions of the struggle against global warming to a decarbonated economy at a certain date (2050). We have also to maintain the carbon sinks. To limit the emissions of CO_2 in the atmosphere while destroying carbon sinks (forests, wetlands, meadows …) is absurd. In an impossible rational approach, we should choose at each time the less costly means: either to reduce emissions of CO_2, either to strengthen or to restore a carbon sink. Again, it is the precautionary principle: we should reduce the emissions and restore the carbon sinks.

Even, one can imagine that in case of success, the opponents to environmental legislation get that one gives up on decarbonated economy.

One knows, at the time of the social networks, that there are techniques to manipulate the Opinion. One displaces the "Overtone window"[2] alongside an axis marked from "unthinkable" to "policy" via "radical" and "acceptable". It is done step by step. Of course, it is purely empirical. To use the words of the American author Cass Sunstein, there is an "entrepreneur in availability". One cannot know in advance if he will succeed or fail, but if he succeeds one cannot know if he has worked on the "gaseous" opinion (the triggered change is temporary) or on the "stable" opinion (the triggered change is definitive). In the same vein, the famous "nudging" should concern only a change of the gaseous opinion or a change explained by the evolution of the stable opinion in some field.

Let us comment on the examples of "battlegrounds" where proponents of comprehensive environmental rules and opponents, struggle: oil and gas, vehicles electrification, industry.

4.2 Oil and gas

Are concerned the NOCs (National Oil Companies). They want to benefit from the resources they have in their reserves, oil, and they say it. Notice that the production of oil increased every year except during the pandemic. And the emissions of CO_2 have not started to decrease! However, the NOCs are in an awkward dilemma. If they choose as a strategy to produce very much oil, the price will decrease and their proceeds will diminish. And if they choose to shrink the production, the high price will favor the renewable energies, which substitute to fossil energies.

4.3 Electrification of vehicles

We live in a "society of the supermarket" (Fourquet, 2022). So, the logistics has become a huge activity (Fourquet, 2020). The goods sold to consumers have to be carried as far as the supermarkets, or, in case of electronic commerce, the door of the customer' home. Only trucks are useful for this task, and are used. Trains are used mainly to carry heavy products. As it has been said by Jean Marc Jancovici[3], there is this negative consequence, from an environmental point of view, of the consumers society: the cars (and mainly the heavy cars) being fashionable, one is committed to electrification of cars, and electrification of trucks, which would be of great benefit for the environment, is forgotten.

4.4 Industry

Manufacturers, in recent years, have made many efforts to save energy. So, their emissions of CO_2 were reduced (industry is not the main source of emissions, it is transport). It is the notion of "good cost": a good cost is when one euro spent generates a revenue of more than one euro. The industry, by saving energy, increased its profits. But the reduction of emissions of CO_2 from industry is not enough. One has decided to levy a carbon tax. The "good cost" becomes: one euro spent generates more than one euro in carbon tax which is not paid.

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[2] The overtone window is the list of the positions currently accepted in the society.
[3] He is a voice on ecology in France.

4.5 Laws of Opinion

One has to be cautious when Laws of Opinion are concerned. At best, these laws allow identifying an evolution of Opinion when it has started a long time ago. The French specialist of Opinion Jérôme Fourquet gives the example of sexual minorities in France. One has seen a sequence of reforms, changes in laws and in the society itself: homosexual rights (1981), civil solidarity pact (for homosexual couples also, allowing a usual fiscal status, but not adoption of a kid), same sex marriage (allowing adoption of a kid), and assisted procreation technology (for married women also). At every stage, there was an opposition sometimes ferocious. To explain the sequence, Fourquet proposes ratchet effect, domino effect and catalyst (Fourquet, 2020):

4.6 Ratchet effect

When some law is passed, the reform is decided and finally the change is accepted.

4.7 Domino effect

Every law passed, reform made, creates the conditions for the following step. The evolutions of Opinion come one after another.

4.8 Catalyst

The catalyst is the legal environment, that is to say all the laws already passed. It is an encouragement for the Opinion to evolve in some direction, to accept many changes of the same kind, in the same field.

But there is no absolute certainty when Opinion is concerned. Take this example: in France the law on free abortion (1976) is sacrosanct. But in the USA, one has seen an offensive against free abortion. It could fail but, in any way, it is a kind of alert.

The hope is that the laws passed in the European Parliament in the context of the European Green Deal will create a shock setting out a model imitated in the entire world. This sequence of laws should be helped by the ratchet effect, the domino effect and the catalyst. It remains to be confirmed that the change concerns the "stable" opinion in Europe (see the article "Great reversal").

4.9 Greenwashing

Decades ago, the French author Jacques Ellul, a proponent of political ecology, noticed that advertisers have taken the side of technology. Since this time greenwashing has appeared. The risk is an invisibilisation of environmental stakes. To explain that, we have recourse to the theories of the French sociologist Jean Baudrillard. There are two stages, naturalization and greenwashing:

Naturalization. In "The consumers society" Baudrillard defines it: "the signs of Nature restored while capitalism destroys it" (Baudrillard, 1986). After Baudrillard, the consumers buy signs, mainly, the use value of the consumed objects being secondary. "Naturalization" means that the consumers buy the signs of restored Nature (when they buy care articles, food, trips etc.).

Greenwashing. Now the signs are that of the saved Planet. Advertising creates this consumer's belief: buying a good, he contributes to save the Planet. A simulacrum is seductive (Baudrillard, 1988). And a simulacrum is to simulate that one has that one has not. Greenwashing is the simulacrum of having a safe environment thanks to consumption.

Take just an example: the car. The democratization of the car is explained by its popularity. Someday, the consequence of this democratization of the car, the traffic congestion in metropolises, threatened the car with unpopularity. The reaction of advertising was the denial. Advertisers and designers in the car industry refused the obvious solution, the small car. At the opposite, they promoted the large and heavy car. And this, notwithstanding the alerts on global warming. Around 2010, it was obvious that there was the victory of the model of the large car, the small cars being bought by only a few customers. Even when the cars are electrical, large cars are not the good choice: the carbon footprint of a large car is more than that of a small

car, not because of the use (provided that green electricity is used) but because of the manufacturing.[4] Add to this the fact that electrical trucks are neglected (see the article Great Reversal).

Greenwashing has created in the mind of the public, such reactions, that one can fear an invisibilisation of the environmental stakes. And this could contribute to a possible Great Reversal. In other words: greenwashing has persuaded the consumers that there is nothing to worry about environment, since the issue has been addressed, thanks to the purchase of goods.

4.10   The return of the enclave economy

Enclave economy was theorized by the Brazilian sociologist Cardoso. It was due to a powerful country investing in a poor country getting a grip on the government of this country. Later, it was due to multinational firms. And today, two new causes have appeared, "liquid Nature" and militarism:

"Liquid Nature". It has been theorized by Naomi Klein. In some project (1) Nature is a resource, monetized, of course (2) Nature is presented as kept safe, preserved (3) Nature is at the core of the project, and is a justification (Klein, 2010). For instance, a village in Italy losing its population, is "saved" by a single vocation, three-star tourism. An example of enclave is when a foreign country buys the land in an entire region, in a poor country, to cultivate it on a large scale.

Militarism. Militia control mines and get a revenue from them. The militia can be from the country itself (Libya, Sudan). Or in African countries the militia are from foreign countries. They trade military services for the revenues from the controlled mines. And this, when the countries importing raw materials want to control the conditions in which they are extracted, the environmental conditions and how the workforce is treated.

5   CONCLUSION

In conclusion, we shall insist on two points: adaptation and mitigation, and the places favorable to some ecological awareness.

The cities are concerned by two stakes, adaptation and mitigation, which are very different. Either adaptation strengthens mitigation, either they are not linked, and possibly they are in conflict. Let us comment on a few examples:

Adaptation strengthens mitigation. Energy efficient refurbishment is adaptation and mitigation, both. Renovated buildings are fresher in summer (one makes economies of energy, avoiding air conditioning) and hotter in winter (economies of heating). Therefore, the buildings will emit less CO_2 in the atmosphere. Another example is low emissions zones. It is adaptation (upgrading quality of air in metropolises) and struggle against global warming (there are less emissions of CO_2 from thermic motors, people walking or using the public transport).

Adaptation and mitigation are not linked. Huge works on infrastructures in cities (to raise dams to avoid the consequences of floods, to dig large reservoirs for rainwater like in Paris and London …) are poised to make cities livable and safer. But nothing is made for mitigation. Soon or later, if global warming continues, the new infrastructures will become insufficient … Opinion in cities could be reassured (since the cities remain livable) and forget the necessity of long-term objectives like struggle against the global warming … It would be to treat the symptoms and not the causes.

Adaptation and mitigation are in conflict. District cooling is an example. Of CO_2, it makes the cities livable in summer, but it requires huge amounts of energy, hence emissions of CO_2 (as far as the electricity is not decarbonated). Desalinization is another example. One can solve the problem of bringing potable water to cities, but it is costly, requires very much energy and degrades environment, since large quantities of brine are rejected.

The metropolises are the places where are labs and universities. Here, the knowledge on environment develops. But again, knowledge of causes and knowledge of reasons matter, both.   The places for knowledge of beliefs, sensitivity to threatened environment and degraded Nature, are small cities and countryside. They are near Nature. Beside the "right to the city" there is a "right to the village" (Fourquet,

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[4] Today the metals industry uses fossil energies. In the future, when it uses electricity, the large and heavy car will trigger a waste of energy.

2021). Take an example in France, the lower part of the Drôme valley. The place is called Biovallée (Bio valley). There live many newcomers having left cities, bio farmers or growers of aromatic plants. They are proponents of ecology and biopharming. They are networked. Among them some work at the University of Lyons, which is near, as teachers or researchers. Ecology requires knowledge of causes, science (in cities) and experience, sensitivity to Nature (in small cities and countryside).

6   REFERENCES

AKERLOF George, SCHILLER Robert. Marché de dupes. L'économie de la tromperie et de la manipulation. (Phishing for fools : the economies of manipulation and deception) Paris. 2016.

BAUDRILLARD Jean. La société de consommation (The consumers society). Paris. 1986.

BAUDRILLARD Jean. De la séduction (On seduction). Paris. 1988.

CASTORIADIS Cornelius. L'institution imaginaire de la société (The imaginary institution of society). Paris. 1975.

FOURQUET Jérôme. L'archipel français (The French archipelago). Paris. 2020.

FOURQUET Jérôme. La France sous nos yeux (France under our eyes). Paris. 2021.

FOURQUET Jérôme. La société de supermarché (The supermarket society). Paris. 2022.

KLEIN Naomi. Tout peut changer : capitalisme et changement climatique (This changes everything: capitalism versus the climate). Paris. 2016.

SOREL George. De l'utilité du pragmatisme (On the utility of pragmatism). Paris. 2019.

TARDE Gabriel. Philosophie de l'histoire et science sociale : la philosophie de Cournot (Philosophy of history and social science : the Cournot's philosophy). Paris. 2012.

TONNIES Ferdinand. Critique de l'opinion publique (Criticism of public opinion). Paris.2012.   ords: cities, adaptation, urban policy, ecology, mitigation

The Positive Effects of Active Mobility on Health with a Focus on Children's and Youth Mobility

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1 ABSTRACT

The "Health Targets Austria" from 2012 define, among other things, an increase in healthy life years in Austria. These are the years of our lives that we do not spend in illness. According to Eurostat, the average EU citizen over the age of 65 still has 10.3 healthy years of life. In comparison, Austria has only 7.7 healthy years. Now, a report by the Austrian Court of Audit has criticized the fact that this target has not been met because the number of healthy years of life from the age of 65 is falling significantly despite various measures that have been taken to date. Healthy life years are closely related to a lack of physical activity. The World Health Organization (WHO) recommends 150 minutes of moderately intensive exercise per week. In Austria, only about half of adults meet these recommendations. According to the WHO, children and adolescents between the ages of 5 and 17 should engage in at least 60 minutes of moderate to vigorous physical activity daily.

Encouraging in active mobility during young ages holds tremendous potential for preventing later diseases associated with physical inactivity. In Austria, one of the most frequent causes of death are cardiovascular diseases. These are closely linked to a lack of physical activity. Research shows, the positive effects on personal health are a decisive motivator to achieve a lasting change in behaviour towards active mobility. Sufficient physical activity in old age has an enormous impact on extending "quality years" and can help prevent dementia. In addition, active mobility prevents obesity, osteoporosis and various types of cancer. Active mobility thus also reduces the likelihood of belonging to one of the risk groups mentioned above.

In addition, the developments in the choice of means of transport in recent decades from active mobility to passive jeopardize the promotion of active forms of mobility. Especially the increase of so-called "parent cabs" and the reduction of free play in the residential environment due to the increased traffic volume contribute to this. The increased traffic volume also causes a higher health burden due to noise and pollutants.

Among the factors that can influence health is physical activity, which has a positive effect on the physical and psychological development of children and adolescents. As an area of physical activity, active mobility also plays an important role alongside sport in achieving a health effect. Active mobility in everyday life (walking or cycling) is the key to changing this.

Active mobility is also conducive to healthy sleep patterns (sufficient sleep and quality of sleep) and subsequently has a positive effect on subjectively perceived well-being and stress levels. Other positive effects of active mobility include a better attention span compared to peers with little to no physical activity. This also results in better school performance among children and adolescents who are physically active. These are just a few reasons why it is important to promote active forms of mobility among children and adolescents.

Keywords: physical activity, adolescents, children, health, active mobility

2 POSITIVE EFFECTS OF ACTIVE MOBILITY ON HEALTH

Active mobility significantly contributes to several of Austria's health goals such as creating health-promoting living and working conditions (Health Goal 1), enhancing health literacy (Health Goal 3) as people become more aware of the health benefits associated with mobility. Furthermore, active mobility, when pursued collectively (e.g. Pedibuses), foster social cohesion which in turn strengthens health (Health Goal 5). More general, active mobility plays a crucial role in providing a healthy upbringing for children and adolescents (Health Goal 6). Another essential aspect is promoting safe and healthy movement in daily life (Health Goal 8). In addition, encouraging children to explore their surroundings and experience things actively rather than relying on passive transportation also fosters psychosocial health (Health Goal 9). These factors highlight the value of active mobility in achieving Austria's health goals while co-creating a health-promoting and socially supportive environment. (BMGF, 2017)

2.1 Physical health

In Austria, one of the most frequent causes of death are cardiovascular diseases. These are closely linked to a lack of physical activity. Research shows, the positive effects on personal health are a decisive motivator to achieve a lasting change in behaviour towards active mobility. Sufficient physical activity prevents obesity, osteoporosis and various types of cancer. According to the World Health Organization (WHO), obesity is considered a disease and the WHO even speaks of a global epidemic of the 21st century. Obesity can lead to a number of secondary diseases: In addition to psychological consequences, shortness of breath an increased risk of high blood pressure and cardiovascular diseases, an increase in the probability of strokes and an increased risk of diabetes are possible effects (Voitl, 2004).

According to statistics, Austria is in line with the Central European trend in terms of overweight among children and adolescents. One in four adolescents is classified as overweight and just under nine percent as obese. The strong rates of increase over the observed period are particularly drastic. (The Lancet, 2017)

Everyday trips in particular can often be done by bike or on foot, and at little cost. Studies show that the positive effects on personal health are a decisive motivator for a lasting change in behavior toward active mobility. In addition, active mobility prevents obesity, osteoporosis and various types of cancer. According to Statistics Austria, one in four adolescents in Austria is overweight and almost nine percent are already obese. Habits learned in childhood and adolescence are usually maintained into adulthood. (Lohaus, 1993) This transfer of behavior is also known as the tracking effect. Thus, the literature also indicates that physical inactivity in childhood is also highly likely to lead to an inactive lifestyle in adulthood. (Völker, 2008)

As an area of physical activity, active mobility, along with sports, also plays an important role in achieving a health effect.

The development of transport mode choice in recent decades from active mobility to passive (MIV) puts a particularly heavy burden on children. In one of his studies (Children's travel behavior and its health implications), Mackett (2013) investigated the positive effect of an actively completed walk to school on the consumption of calories and contrasted this with a usual physical education class (2 hours per week). Older children aged 12 to 13 years burned more calories walking to and from school than during physical education classes. This indicates a physical activity advantage to walking (Mackett, 2013).

It was also shown that the positive effect of active walking to school could not only be attributed to the activity itself (walking versus driving), but positive effects were also found later in the day. For example, children who walked to school behaved more energetically across all subsequent activities than children who were taken by car. This effect could be observed not only on the way to school, but also on the modal split over the entire daily life of the children.

However, walking or biking actively to school and gym time at school cannot be compensated by any extracurricular behaviors. Yet, considering that children and adolescents cover a defined route during 40 school weeks and 200 days per year while commuting to school, the cumulative duration of these active or inactive periods of movement becomes substantial (Schneider 2012). Therefore, it is imperative not to underestimate the significance of these additional activities in promoting overall physical activity levels, as mentioned by Goodman et al. (2011).

2.2 Menthal health

Active mobility also promotes healthy sleep patterns (sufficient sleep and quality of sleep), which in turn has a positive effect on perceived well-being and stress levels. A study with 152 primary school children in lower Austria shows a tendency how parents could observe that their children slept better, if their level of active mobility during the day was higher. On the other hand it showed, that children who moved by car during the day, were more irritated and had a tendency of an inner restlessness (Stark et al. 2018). Particular the connection with the aspect of well being, their health status and a good night sleep Schneider 2012 shows in her study that a certain tiredness has an affect on children´s self consciusness (Schneider 2012).

Furthermore, active mobility helps to counteract diseases. It also reduces Alzheimer's disease and dementia. Another positive effect is the reduction of risk for depression and anxiety.

It is clear that mobility influences children's psychological well-being at different levels, both in the short term (via direct experience and activation on the route itself) and in the long term (e.g. as a result of traffic

1066

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accidents). Even though a predominant part of the influences on well-being is based on the external influence of traffic (traffic noise and accidents), the results indicate that the choice of means of transport additionally influences the psychological cognitive and social domain.

2.3 Cognitive and social skills

Active mobility has a positive effect on the attention span as well. Compared to peers with little or no physical activity the attention span is better. Physically active children and adolescents also perform better in school. Another positive aspect is the independence and the children have more social contacts. For instance, engaging in a pedibus, a joint walking initiative, offers numerous opportunities to fortify social bonds among children and adolescents, which in turn yields a wealth of profound health advantages. Social interactions at a young age play a pivotal role in shaping cognitive, emotional, and physical development, and walking together in a pedibus setting fosters an environment conducive to these beneficial connections (e.g. it combats feelings of loneliness, promotes a sense of belonging, enables to share experiences and a sense of teamwork which in turn fosters resilience).

3 CURRENT PHYSICAL ACTIVITY SITUATION OF CHILDREN IN AUSTRIA

The World Health Organization (WHO) recommends 150 minutes of moderately intensive exercise per week. In Austria, only about half of adults meet these recommendations. According to the WHO, children and adolescents between the ages of 5 and 17 should engage in at least 60 minutes of moderate to vigorous physical activity daily. (WHO, 2010)

A common measure to describe a burden of disease and its impact on the duration and quality of life is the DALY (Disability-adjusted life years) defined by the WHO. A DALY corresponds to the value of a lost "healthy" year of life resulting from the current state of health compared to an ideal situation (WHO, 2009). Across Austria, it is assumed that the risk factor physical inactivity is responsible for 6% of all deaths and for 3% of all DALYs. Risk factors and diseases are interrelated and are therefore included with different proportions in the total DALY burden. A healthy lifestyle as a preventive measure against the major risk factors of high blood pressure, tobacco and alcohol consumption, high cholesterol, overweight and obesity, too few fruits or vegetables, and physical inactivity can largely prevent diseases and leads to a reduction of the DALY burden by almost 30% (WHO, 2005).

Sedentary behavior among children and adolescents has been shown to have a negative impact on health. It can be assumed that the sedentary lifestyle contributes to the development of obesity. (Huber & Köppel, 2017). This study, which covers Germany, Luxembourg, and Austria, shows that the median sitting time of children and young adults aged 4 to 20 years is 10.6 hours on weekdays and 7.5 hours on weekend days. This is particularly alarming because at the same time it is shown that long sitting times of more than 8 hours have massive health effects and are associated with the risk of premature death. Furthermore, significant correlations between sitting times and the prevalence of many chronic diseases are shown, with the increased prevalence of obesity in adolescents still insufficiently researched.

3.1 Independent mobility among children as driver for active mobility

Regarding active mobility another term to put in connection is independent mobility of children. Independent mobility means that children are able to move in the residential environment without the accompaniment of an adult (Hillman et al. 1990 quoted after Seemüller et al.). The ability to manage schoolways independently is an component which influences the mobility behaviour of children in the long run. There is a tendency that independent and active trips of children can be associated with an increased physical activitiy (Oliver et al. 2016). Larouche et al. got an similar result: independent trips of children support physical activity (Larouche et al.). Furthermore independent mobility can contriubute to the well being of children. There are first results which are indicating a positive correlation (Stark et al. 2018). However, there is no causality to report here and in general the field of psychological well-being in connection with mobility is still a rather unexplored area. Altough it is known that independent mobility can have a positive impact on the mobility behaviour of children regarding active mobility the amount of children which are independet mobile is decreasing. In Germany the number was decrasing from 93% to 76% during the years 1990 ans 2010 (Shaw et al. 2013).

What steps are to be taken now to ensure that children are moving more actively and independently? There are different needs to consider. On the one hand regarding children´s needs in partcular – an individual factor

– and on the other there are factors from outside which have an effect on children: the social environment and infrastructure conditions.

3.2 Factors influencing the mobility of children

Figure 1 shows that the factors, which can influence the mobility behaviour of children is very diverse. An important factor is the infrastructure. To build and shape infrastructure in a way people and especially children are able to be mobile in a safe and independent way is one goal. Another important aspect is to build awarness and knowledge. Especially regarding new mobility services such as e-bikes and e-scooters.

In the study from Seemüller et al. is described which individual factors affect the urge to use active mobility. For the children motivation and personal attitude are beneficial. Nevertheless, a lack of knowledge about road traffic conditions could have a negative effect (Seemüller et al. 2022). Regarding this result safety is an important topic for children, which is also shown in the study from Landwehr and Kolip 2021 (Landwehr & Kolip 2021). This can be correlated if the outside factore infrastructure. If traffic infrastructure is designed poorly, it effects safety of children and their well-being regarding everyday ways (Seemüller et al. 2022, Landwehr & Kolip 2021). In addition, to consider is, as mentioned earlier, the outside factor social environment. Regarding children, it is their parents, which make up a large share of their social environment. Children want to be mobile in an independent way (Seemüller et al. 2022). Often their parents are concerned, and it is important to consider them, when talking about mobility during children. Needs of this particular target group are diverse and merge into eachother.
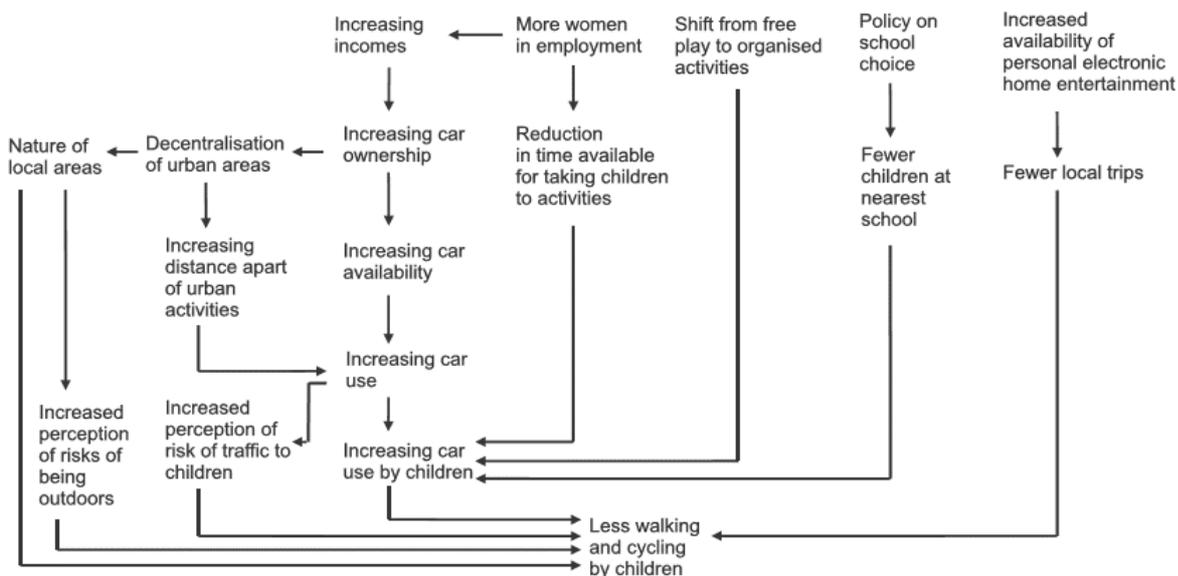

Figure 1: The influence of modern life on children's walking and cycling levels (Mackett, 2013, S. 68).

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4   CONCLUSION

Active mobility and health are closely linked and play an important role for the development of children and adolescents. Different studies already showed that there is a positive correlation between active mobility and

health. Unfortunately the exercise recommendations are already not achieved and the trend does not seem to change soon either. Active mobility in everyday life (walking or cycling) is one key to change this.

If we want to change the travel behaviour towards more active mobility, it is necessary to start with the children.

5 REFERENCES

Bundesministerium für Gesundheit und Frauen (BMGF): Gesundheitsziele Österreich. Vienna, 2017.

Oliver, M., Parker, K., Witten, K., Mavoa, S., Badland, H.M., Donovan, P., Chaudhury, M., & Kearns, R.: Children's out-of-school independently mobile trips, active travel, andphysical activity: a cross-sectional examination fromthe kids in the city study. Journal of Physical Activity and Health, 13(3), 318–324, 2016.

Goodman, A., Mackett, R. L., & Paskins, J. (2011). Activity compensation and activity synergy in British 8–13 year olds. Preventive Medicine, 53(4-5), 293-298. https://doi.org/10.1016/j.ypmed.2011.07.019, 2011.

Hillman, M., Adams, J., & Whitelegg, J.: ONE FALSEMOVE ... A study of children's independent mobility. London:Policy Studies Insitute. Aus Seemüller et al., 1990.

Landwehr, J., & Kolip, P.: Die Perspektive von Kindern auf aktiven Transport: Ergebnisse einer qualitativen Studie zur Erfassung der Bedürfnisse von Grundschulkindern. Prävention und Gesundheitsförderung, 16, 110-115, 2021.

Larouche, R., Barnes J.D., Blanchette, S., Faulkner, G., Riazi, N.A., Trudeau, F. & Tremblay M.S.: Relationships among children's independent mobility, active transportation, and physical activity: a multisite cross-sectional study. Pediatric Exercise Science. https://pubmed.ncbi.nlm.nih.gov/32570211/, 2020.

Lohaus, A.: Gesundheitsförderung und Krankheitsprävention im Kindes- und Jugendalter. Riehe Gesundheitspsychologe Vol. 2. Hogrefe Verlag für Psychologie, Göttingen, 1993.

Mackett, R. L.: Children's travel behaviour and its health implications. Transport Policy 26, S. 66-72, 2013.

Schneider, A.: Das Körperbewusstsein bei Kindern und Jugendlichen: Entwicklung, altersabhängige Ausprägung und Einfluss auf Gesundheitsförderung und Gesundheitsprävention (Doctoral dissertation, Dissertation, Albert-Ludwigs-Universität), Freiburg, 2012.

Shaw, B., Watson, B., Frauendienst, B., Redecker, A., Jones, T., & Hillman, M.: Children's independent mobility: a comparative study in England and Germany (1971–2010). London:Policy Studies Institute, 2013.

Stark, J., Meschik, M., Singleton, P. A., & Schützhofer, B.: Active school travel, attitudes and psychological well-being of children. Transportation research part F: traffic psychology and behaviour, 56, 453-465, 2018.

Seemüller, S., Reimers, A. K., & Marzi, I.: Eine Perspektive von Grundschulkindern auf Bedingungsfaktoren der aktiven und eigenständigen Mobilität–eine qualitative Studie. In Forum Kinder-und Jugendsport (Vol. 3, No. 2, pp. 137-149), Springer Fachmedien Wiesbaden, Wiesbaden, 2022.

The Lancet: Von Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults: https://doi.org/10.1016/S0140-6736(17)32129-3, 2017.

Völker, K.: Wie Bewegung und Sport zur Gesundheit beitragen - Tracking-Pfade von Bewegung und Sport zur Gesundheit. In W. Schmidt, Zweiter deutscher Kinder-Jugendsportbericht. S. 520, 2008.

World Health Organization (WHO): Der Europäische Gesundheitsbericht 2005. Maßnahmen für eine bessere Gesundheit der Kinder und der Bevölkerung insgesamt. Kopenhagen, 2005.

World Health Organization (WHO): Global health risks. Mortality and burden of disease attributable to selected major risks, Geneva, 2009.

World Health Organization (WHO): Global recommendations on physical activity for health, S. 7, Geneva, 2010.

Huber, G., & Köppel, M.: Analyse der Sitzzeiten von Kindern und Jugendlichen zwischen 4 und 20 Jahren. Deutsche Zeitschrift für Sportmedizin, S. 101-106, 2017.

XR-Supported Communication in Green Urban Projects. Participating in Urban Change through Virtual and Augmented Reality

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1 ABSTRACT

Public participation in urban planning and design processes is becoming increasingly important in European cities to improve transparency, enhance decision-making, and encourage community engegamement. However, broad and inclusive participation faces a number of significant challenges. Typical participation processes rely on face-to-face interaction and are only able to reach small and non-representative groups of people. To this day, direct means of communication are important because of the high complexity of urban planning and design tasks and the multi-faceted demands on urban spaces, which can hardly be represented in online questionnairs and one-way information campaigns. Additionally, urgent measures to reduce heat in cities and to counteract other negative effects of the climate crisis need to be explained to gain the support of local communities. These challenges are often compounded by low budgets for participation processes and a lack of commitment to a thorough communication strategy.

Over the past few decades, new information and communication technologies have radically changed the way we communicate. The advent of smartphones and the institutionalization of the internet have made it possible to interact with many people simultaneously in real time and at a low cost. Today, powerful mobile devices and the emergence of virtual and augmented reality applications promise new ways to communicate spatial change and to interact with the urban environment. The exploitation of these new technologies to support climate-friendly urban design projects with broad public participation was the declared goal of the Green Living Augmented+virtual ReAlity (GLARA) research and development project. At the heart of the project was the development of the GLARA app, a mobile application that visualizes the spatial and microclimatic effects of urban design projects. Choosing between the virtual and augmented reality modes, users could explore the altered urban space from home or directly in the respective public space. In the latter case, the live image of the mobile phone camera (image of reality) was overlaid with 3D elements like trees, benches and more. This type of vizualisation provided a unique spatial experience of the proposed design project. At the same time, the results of a micro-climate simulation, which shows the effects on surface temperature, perceived temperature, and wind was visualized and made tangible via the app. Last but not least, the application allowed users to provide feedback on the design from anywhere at any time, decoupling participation from the need to be physically present at a specific place and time and allowing a wider range of people to contribute their opinions to the planning process. The GLARA app was combined with a selected set of face-to-face participation tools to form a holisitc participatory planning service for open spaces with green infrastructure.

The full GLARA service was tested in a case study in Vienna's 7th district, Neubau. The local district administration had plans to redesign a narrow residential street in the course of laying new water pipes. The GLARA team accompanied the planning process over a period of one and a half years with a balanced mix of analogue and digital participation tools including the GLARA app. The introduction of a second participation loop based on the preliminary landscape design for the street was a novelty for the administration but was well received by the participating residents. The design was visualized via the app and offered an immersive experience of future spatial change. However, a number of technical and practical challenges remain for future development of the app, including better ways for device localisation, operability on less powerful mobile devices, reducing the effort required to create the 3D visualisations, and further reducing barriers for less tech-savvy populations.

Keywords: Micro Climate Simulation, Resilient Urban Design, Virtual and Augmented Reality, Public Participation, Urban Change

2   PARTICIPATION IN URBAN DESIGN: CHALLENGES AND GOALS

The importance of dialogue and citizen participation in urban planning and design has been increasingly recognized in recent years. In Austria, for example, the cities of Vienna and Graz have developed their own guidelines for citizen participation (MA18 2012; Stadt Graz 2014). In Vienna, the expansion of citizen participation was also anchored in the Smart Climate City Strategy (City of Vienna, 2022).

In order to create a solid knowledge base about the current challenges and restrictions in relation to broad citizen participation, the research team of GLARA (Green Living Augmented+virtual ReAlity)[1] conducted stakeholder interviews and focus group discussions with more than 30 people from the fields of city administration, urban planning, process design and politics. The analysis revealed some main challenges in the conception and implementation of participatory processes today:

- Budgets for participation are often limited while high demands are placed on quality.
- Contemporary approaches only reach a small, non-representative group of people.
- Communicating complex planning requirements and processes is a challenge.
- Participation often takes place at the beginning of the planning process without a follow-up in later stages.
- There is a lack of transparency about the outcomes of participatory processes and their impact on final development proposals.
- There is no standardized way of measuring the success of participatory processes.

In the face of climate change, radical urban transformations will be required in the coming years. The conversion of our cities into resilient and climate-friendly living spaces can be made much more efficient and sustainable if it is supported by a large majority of the population. This can only succeed through the consistent involvement and education of people.

The GLARA participation service aims to provide a low-threshold opportunity to participate in the design of streets and open spaces. It includes a digital component that simulates and visualizes the positive effects of greening and unsealing measures in public space. In the course of the research project presented here, the main challenges were identified, a comprehensive participation service was developed and tested using a real-life case study in Vienna.
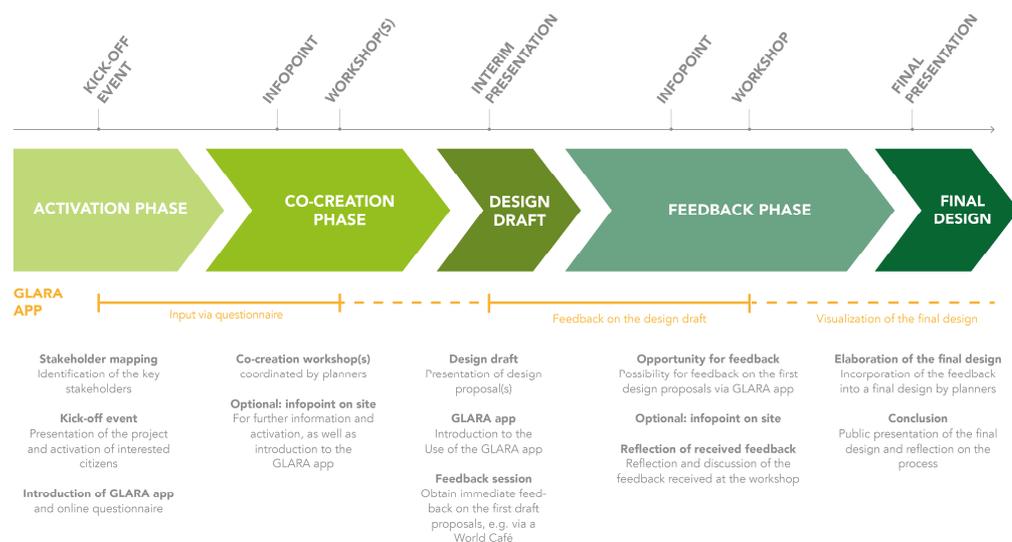

Fig. 1: Schematic process of the GLARA participation service, integrating analogue and digital methods.

3 THE GLARA PARTICIPATION PROCESS

In the GLARA participation service, the close interlinking of proven analogue methods and digital tools is central. A particular focus is on enabling as many people as possible to participate in the process. By removing time and space constraints, the GLARA app facilitates flexible participation as a digital tool in the process. This is supplemented by analogue and low-threshold participation on site to reach groups that would otherwise not have been involved in the process. A key feature of the GLARA process is the public interim presentation of a first design concept to allow feedback and possible changes before the design is finalized.

3.1 Analogue participation methods

The GLARA process is structured into several stages and starts with an activation phase. The goal here is to make users aware of GLARA and to win them over for workshops and for online participation. As a low-threshold method to reach people, a kickoff event (e.g. information evening) should take place. Parallel to this, there should be an online kickoff so that people who cannot join the event are informed. This will be followed by a co-creation phase with workshops (specific target groups or open) and information transfer (online/offline).

The portfolio of analogue methods that can be used is very large (for example, see participatory toolbox in Krebs & Mayr 2023). It should be adapted to the size and local characteristics of the project area. In addition, methods should be used that have proven themselves on site and that the local actors can handle well.

This is a selection of possible analogue participation methods, that have been used in the case study:

- Info points: The participation team meets the local community on the street. They gain the attention of people through placing some urban furniture, a large sign or other visible elements. In this way, qualitative feedback can be obtained right at the place in question and the actual users of the space are encouraged to participate in the design process.

- Workshops: These can be held with specific target groups like local entrepreneurs, children, and elderly people, or be open to all residents and interested stakeholders.

- Walkshops: Joint walk-throughs combined with co-creative methods.

- Information evenings: Large-scale information events that are announced well in advance. Politicians and administrators as well as planners should be present. Small workshop elements (e.g. written feedback with cards, post-it notes, group discussions...) can be integrated.

- Mailboxes: All neighbours receive a letter with a questionnair or feedback card and are encouraged to send it back (free of charge) to the participation team.

3.2 The GLARA app

The GLARA app is the digital component of the GLARA service. It is an innovative native application for iOS and Android that offers a new approach to green planning and its impact on the microclimate by integrating virtual reality (VR) and augmented reality (AR). The app allows for an intuitive understanding of complex issues and invites diverse audiences to explore and discover.

Fig. 2: The GLARA app's AR mode visualizing perceived temperature on a hot summer day in Bernardgasse, Vienna.

A main feature of GLARA's participatory process is providing easily understandable 3D models of the area, including the results of microclimate simulations. All are used in the app to visualize the proposed design as well as its impact on the area's microclimate. The most important factors for the perception of the environment - perceived temperature, surface temperature and wind speed - become visible as 3D overlays and can be intuitively understood by the public. A tutorial guides users and provides an overview of all features. The GLARA app marks an important step in bringing digital and analogue participation together and offers new opportunities to make green planning and its impact on the microclimate tangible.

Main functions include:

- Augmented reality: AR is a computer-based extension of the perception of reality. With the GLARA app, residents are able to immerse themselves in and move around the 3D environment with a smartphone or tablet in hand. The app uses the device's gyroscope and accelerometer sensors to track the user's movements and provide an immersive experience. On the screen, the live image from the phone's camera (a representation of reality) is overlaid with 3D elements. For example, people can walk through "bubbles" that visualize the perceived temperature on a hot summer day, or get an impression of the future of the alley with planning scenarios.

- Virtual reality: allows for an experience at any time and from anywhere. Similar to a computer game, 3D models with all relevant elements (buildings, street surfaces, furniture, plants, ...) can be explored. Users can switch between the status quo and the design, and see the effects of the redesign on the microclimate in the area. Thus, even people who cannot be there physically can get an impression of the planned changes through the app.

- Switching between different scenarios allows for comparison between the current situation and the proposed plans, as well as projected future scenarios (i.e. simulated temperature for 2050 or 2080, including the effects of the fully grown vegetation).

- Exploring the different climate parameters with the click of a button. Parameters are shown as 3D representations.

- Microclimate education: information about each parameter as well as the general microclimate situation in the area.

- Participation tools (in-app survey, picture based feedback tool).

4 CASE STUDY BERNARDGASSE

The GLARA participation service was tested in an urban regeneration project in the 7th district of Vienna. Due to the renewal of the water pipes, extensive construction works have to be carried out in one of the district's residential streets, Bernardgasse. The district mayor wanted to involve citizens in the design process and agreed to test GLARA as a new innovative tool for civic engagement.

4.1 Participation process Bernardgasse

The process was initiatied by a stakeholder mapping to identify relevant target groups and local actors. All residents were informed about the project through direct mail, additionally public awareness was raised through posters, flyers, and other media.

The first participation phase (October 14th to November 7th, 2021) focused on general challenges and ideas for the redesign of the street. Applied methods included an information evening with an interactive workshop part, questionnaires, on-site info points, and the use of the GLARA app. Emotional Mapping and Goals-Grid Analysis were used for qualitative feedback during the workshop. The survey assessed the current situation in Bernardgasse and design preferences of the citizens. The on-site info points helped to promote the use of the GLARA app and to test the AR mode in the street. In this phase, the app visualized the current micro-climatic conditions in the street and offered the opportunity for feedback through the integrated questionnaire. Moreover, the snapshot tool allowed participants to take pictures in the street, rate the situation and give comments for improvement. The results of the first participation phase were published in a comprehensive report and communicated to the landscape planners that won the design tender (GLARA, 2021).

1074

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Based on the citizen's feedback, technical framework conditions, and spatial planning strategies, a modular design concept was developed and discussed in the second participation phase (June 22nd to July 10th, 2022). Similar to the first stage, residents and entrepreneurs were invited to join an information event and workshop to provide feedback. On a large plan, stickers were used to indicate preferences for various functions and design modules. The GLARA app was used during a guided walk and at the on-site info points. The AR and VR modes visualized the design proposal and the simulated micro-climatic conditions, showing improvements where green elements, trees and impervious surfaces were proposed (see Fig. 3). Through the app, people could view the design remotely and provide their feedback via the online questionnaire. The results of the second participation phase were summarized and published in a report (GLARA, 2022). They substantially influenced the final design outcome that was presented in a concluding event in June 2023.
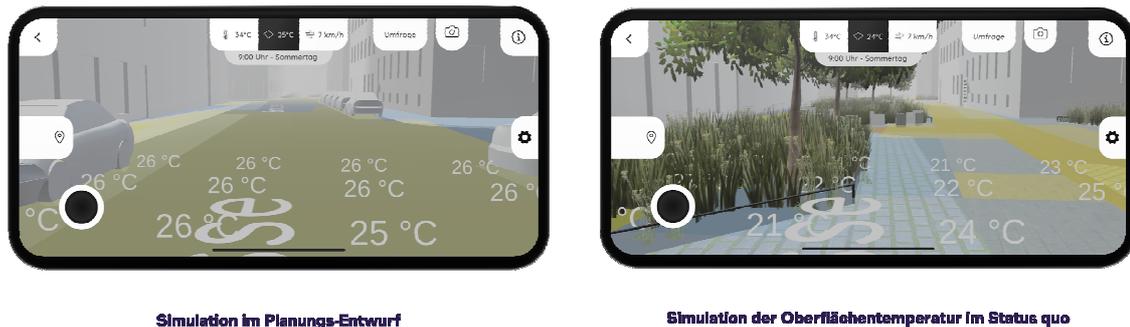

Fig. 3: The GLARA app's VR mode showing the status quo and design proposal with surface temperature for Bernardgasse, Vienna.

4.2 Feedback on the GLARA service

The case study in Bernardgasse was used to test the GLARA participation service and app in a real planning process and to collect feedback for further improvement of the service and methods. Overall, the participation was quite satisfactory. Out of the approximately 650 immediate residents in the street, 130 people attended the evening events and 160 participated at the on-site info points. In total, there were 280 responses to the questionnaire. The response rate was at 26 % in the first participation phase which is very high in comparison to other participation processes.The GLARA app recorded about 300 downloads throughout the whole process.

Participants were predominantly middle-aged residents with above-average education, as is often the case in participation processes. However, this may also be related to the general population composition in the 7th district that has a majority middle-class progressive population with a high level of education. The mix of digital and analogue methods however, has proven successful in addressing people with limited time budgets like parents or working people. The on-site participation was an integral element that established contact with people who could not attend the large events and was very well received.

In the course of the second participation phase, participants were also asked about their assessment of the process and the GLARA app. With 82 %, the participation process was rated positively by the majority of those surveyed. In personal communication, participants emphasized that the process has led to improved communication and new contacts and initiatives within the neighbourhood. This was also confirmed by the GLARA survey, in which 81 % stated that they knew more about the needs and problems of the residents and visitors of Bernardgasse after the participation process. At 56 %, a majority of app users in the survey also stated that they knew more about the effect of greening in the city after using the app. The most important result, however, is the satisfaction of the participants and residents with the final design. According to the GLARA questionnaire, 85 % like the presented vision of a green, traffic-calmed Bernardgasse.

5 REFLECTIONS AND LEARNINGS: TOWARDS MORE INCLUSIVE PARTICIPATION?

Civic engagement involves actors with different interests, with or without previous knowledge of urban planning processes. Therefore, the complex contents of planning must be well prepared and communicated simply and clearly. Visualization is considered key for successful communication and participation, as it provides participants with a shared basis for decision making. Virtual and augmented reality tools offer new

possibilities for visualizing a wide variety of data. They enable planners, policymakers and other stakeholders to experience and better understand the intended changes in the built environment and to identify potential conflicts before a development is implemented in practice (Tomkins and Lange 2020). In this context, GLARA presents the design proposals in a transparent and neutral way. The design is not exaggerated and "pretty" as is often the case with architectural renderings. The GLARA representation remains minimalist and concentrates on the essential and relevant factors of equipment, spatial distribution, microclimate, green and blue infrastructure. The GLARA app can thus empower citizens to give informed feedback on their preferences and help to make strategic urban planning decisions that are comprehensible for everyone.

Beyond the visualization of the design proposal, GLARA integrates and presents microlimatic simulations as well as a KPI-based evaluation and climate resilience analysis. GLARA is therefore particularly suitable for planning with a special focus on climate change adaptation and the construction of green infrastructure. In the case study, the GLARA app strongly supported the transfer of knowledge of climate data to the residents. It demonstrates how VR/AR tools can contribute to increasing the transparency and acceptance of climate mitigation and adaptation options among private actors and to improve the decision-making basis for politicians and planners (Othengrafen et al., 2023).

In the GLARA service, digital and analogue formats complemented each other in a meaningful manner. While digital tools can address new target groups that have been neglected so far through playful approaches and innovative forms of knowledge transfer, a holistic participatory process should also offer space and time for discussions in analogue formats. The tightly meshed, accompanying analogue formats also make key technologies such as AR and VR usable for people with a low affinity for technology. The low-threshold formats such as info points or online questionnairs ensure that all stakeholders can easily contribute their opinions.

In general, AR/VR tools have the potential to increase people's motivation to participate in planning processes by introducing innovative ways of visualization and playful means of interaction. At the same time, the acceptance of AR as a visualization and participation tool has, thus far, been rather low compared to analogue participation formats (Othengrafen et al., 2023, p. 62). The use of digital tools is still a barrier for those who are less comfortable with the use of smartphones or tablets. Moreover, the usability of high quality XR visualisations on all digital devices is still a technical challenge and representations have to be simplified to allow availability for all. These barriers, however, will diminish in the future with technical progress and higher rates of digital natives.

While the research team was confronted with technical challenges and limitations, there were also numerous ideas and approaches for even more interactive, inclusive and exciting ways to use VR/AR in planning and participation. An important question that arose in this context was how XR technologies could be used accross all planning phases, show planning options and enable a more dynamic exchange with local stakeholders. These issues will have to be addressed in the future where VR and AR applications will be applied in planning and participation processes more often and more effectively.

6 REFERENCES

CITY OF VIENNA: Smart-Klima-City-Strategie Wien. Der Weg zur Klimamusterstadt. Vienna, 2022.
GLARA: Beteiligungsprozess zur Umgestaltung der Bernardgasse. Bericht zur ersten Beteiligungsphase. Vienna, 2021. Available at: https://www.wien.gv.at/bezirke/neubau/pdf/ergebnisbericht-bernardgasse.pdf [Accessed 27.07.2023]
GLARA: Beteiligungsprozess zur Umgestaltung der Bernardgasse. Ergebnisbericht zur zweiten Beteiligungsphase. Vienna, 2022. Available at: https://www.wien.gv.at/bezirke/neubau/pdf/ergebnisbericht-2-bernardgasse.pdf [Accessed 27.07.2023]
KREBS, Roland and MAYR, Stefan (eds.): Future Public Spaces. Urban Design in Times of Crisis. Berlin, 2023.
MA 18: Praxisbuch Partizipation. Gemeinsam die Stadt entwickeln. Vienna, 2012.
OTHENGRAFEN, Frank, SIEVERS, Lars and REINECKE, Eva: Using augmented reality in urban planning processes. Sustainable urban transitions through innovative participation. In: GAIA - Ecological Perspectives for Science and Society, Vol. 32, Issue 1, pp. 54-63. Zurich, 2023.
STADT GRAZ: Leitlinien für Bürgerinnen- und Bürgerbeteiligung bei Vorhaben und Planungen der Stadt Graz. Graz, 2014.
TOMKINS, Adam and LANGE, Eckart: Bridging the Analog-Digital Divide: Enhancing Urban Models with Augmented Reality. In: Journal of Digital Landscape Architecture, Vol. 5, pp. 366-373. Berlin, 2020.

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1 ABSTRACT

Reconstructing oder Revitalisierung? Vor dieser Entscheidung stehen aktuell zahlreiche gemeinnützige Wohnbauvereinigungen, wenn sie ihren mitunter großen historischen Wohnungsbestand modernisieren und den Anforderungen der Klimaschutzziele gerecht werden wollen. Während aus ökologischer Sicht eine umfassende Revitalisierung bestehender Wohnanlagen anzustreben wäre, erscheint aus wirtschaftlicher Sicht häufig Abriss und Neubau als die einfacher realisierbare Option. Auch das Wohnungsgemeinnützigkeits-gesetz WGG sieht vor, dass „insbesondere bei einem (…) hohen energetischen Sanierungsbedarf (...) in einer unternehmensinternen Kalkulation die Kosten einer umfassenden Sanierung den Kosten eines Abbruchs samt den Kosten der Errichtung einer Baulichkeit in räumlicher Nähe (...) gegenüber zu stellen" sind.

Das Projekt „ZUSIE – Zukunft Siedlung" möchte diese ausschließlich wirtschaftliche Betrachtungsweise in Frage stellen und – im Sinne des Smart-City-Konzepts – ergänzende soziale und ökologische Kriterien entwickeln. Dabei soll aufgezeigt werden, wie investive Maßnahmen in einer multidimensionalen Betrachtung von sozialen, ökologischen und ökonomischen Kriterien sowie unter der Berücksichtigung des gesamten Lebenszyklus von Quartieren neu bewertet werden können und so neue und alternative Entscheidungen möglich machen.

Das Projektvorhaben nimmt eine Siedlung der Ersten Gemeinnützigen Wohnungsgesellschaft (EGW), die in den 1940er Jahren in Erpersdorf in der Gemeinde Zwentendorf errichtet wurde, in den Blick. Sie ist Ausgangspunkt für neue Handlungsansätze – für die Siedlung selbst, aber auch für den großen Wohnungsbestand der EGW sowie weitere Bestandssiedlungen des gemeinnützigen Wohnbaus. „ZUSIE" wird von einem interdisziplinären Konsortium – bestehend aus der Stadtteilarbeit der Caritas Wien, die für Projektleitung, Partizipation und Kommunikation verantwortlich ist, dem gemeinnützigen Wohnbauträger EGW, dem Architekturbüro einszueins, dem Landschaftsplanungsbüro grünplan sowie dem Energie- und Umwelttechnikbüro e7 – gemeinsam umgesetzt.

Keywords: Ressourcen schonen, Gebäudebestand, Klimawandelanpassung, Mitgestaltung, Sanierung

2 EHEMALIGE ARBEITERINNEN- UND ARBEITERSIEDLUNGEN IM WANDEL

2.1 Ein großer Altbestand gemeinnütziger Wohnbauvereinigungen

Viele gemeinnützige Wohnbauvereinigungen haben einen großen Wohnungsbestand, der mittlerweile in die Jahre gekommen ist. Mit 971.050 Wohnungen befinden sich insgesamt rund 20% des Wohnungsbestands in Österreich im Wohnungs- und Verwaltungsbestand gemeinnütziger Wohnbauvereinigungen (Stand 2020). Ca. 489.020 Wohneinheiten dieses Bestands – dies entspricht heute ca. 10% des österreichischen Wohnungsbestands – wurden bis 1980 errichtet (Quellen: GBV 2021, Statistik Austria 2022).

Im aktuellen österreichischen Regierungsprogramm ist das Ziel, bis 2040 klimaneutral zu werden, verankert. Um dieses Ziel zu erreichen, sind insbesondere im älteren Gebäudebestand Sanierungsmaßnahmen zu setzen, die bestehende Wohnanlagen in Richtung klimaneutrale Quartiere entwickeln. Im „Rahmenprozess zur Modernisierung von Arbeitersiedlungen" wurden Arbeiterinnen- und Arbeitersiedlungen als eine Gebäudekategorie identifiziert, bei der besonderer Sanierungsbedarf insbesondere in Hinblick auf die Verbesserung von Energielösungen und Energieeffizienz besteht (vgl. Rainer, Lang, Schreiner 2021).

2.2 Revitalisierung oder Reconstructing im Rahmen der Wohnungsgemeinnützigkeit?

Bisher wurden allerdings kaum umfassende Sanierungen, die bauliche, ökologische, soziale und ökonomische Dimensionen gesamtheitlich berücksichtigen, umgesetzt. In Hinblick auf Arbeiterinnen- und Arbeitersiedlungen aus den 1920er bis 1940er Jahren wurden in der Recherche des Rahmenprozesses im gesamten deutschsprachigen Raum nur drei Beispiele für bestandserhaltende umfassende Modernisierung

identifiziert. In Österreich war dies die Sanierung der Burgfriedsiedlung in Hallein, die unter dem Titel „Wohnen findet Stadt" als Smart Cities Projekt gefördert wurde und, laut Bericht des Rahmenprozesses, das einzig dokumentierte Beispiel einer umfassenden, bestandserhaltenden Modernisierung mit Wohngebäuden aus der Zwischenkriegszeit darstellt. Die Siedlung umfasst Gebäude aus den 1930ern bis 1970ern. Im Zuge der Modernisierung konnten Maßnahmen der Gebäudesanierung im bewohnten Zustand, der Nachverdichtung durch Aufstockung, der Dämmung und Bauteilaktivierung sowie im Freiraum durchgeführt werden.

Aktuell wird hingegen vermehrt ein Trend zum Reconstructing (Abriss und Neubau) statt umfassender Revitalisierung beobachtet – der Endbericht gibt mehrere Beispiele u.a. aus Tirol und Kärnten dafür und auch Online Berichte aus der jüngeren Vergangenheit dokumentieren dies („Reconstructing-Neubau in Friesach" vom 26.07.2022 auf 5min.at oder „Reconstructing – die Zukunft des Bauens" auf der Website des gemeinnützigen Wohnbauträgers Fortschritt). Diese Entwicklung ist bei gemeinnützigen Bauvereinigungen u.a. auch auf gesetzliche Regelungen zurückzuführen, da das Wohnungsgemeinnützigkeitsgesetz WGG explizit vorsieht, bei umfassenden Sanierungen auch Abriss und Neubau als Alternative zu prüfen und den Kosten einer Sanierung wirtschaftlich gegenüber zu stellen.

Die Basis für die Bewertung investiver Maßnahmen ist dabei eine rein wirtschaftliche Betrachtungsweise. Im Sinne von ökologischer und sozialer Nachhaltigkeit soll im vorliegenden Projektvorhaben der Versuch unternommen werden, diese wirtschaftlichen Kriterien zu ergänzen, indem auch ökologische und soziale Kriterien entwickelt werden, die in Zukunft als Entscheidungsgrundlage in Hinblick auf investive Maßnahmen dienen können und einen Weg von der Bilanz zur Ökobilanz aufzeigen.

2.3 Herausforderungen und Hürden für umfassende Sanierungen von Arbeiterinnen- und Arbeitersiedlungen

Für die Modernisierung ehemaliger Arbeiterinnen- und Arbeitersiedlungen im Bestand gemeinnütziger Wohnbau-vereinigungen besteht die zentrale Herausforderung in der Finanzierung möglicher Sanierungsmaßnahmen (vgl. Rainer, Lang, Schreiner 2021). Einerseits sind häufig geringe bis keine Rücklagen vorhanden, da diese für gewisse bestandserhaltende Maßnahmen sowie Dämmung, Dach- oder Fenstertausch in den vergangenen Jahren bereits aufgebraucht wurden. Andererseits unterliegen die Mieten laut WGG strengen Obergrenzen, um insbesondere für Menschen mit geringem Einkommen leistbares Wohnen zu gewährleisten. Für umfassende Sanierungen sind daher weder die erforderlichen Finanzmittel angespart, noch können diese über künftige Mieteinnahmen refinanziert werden (ebd.). Es werden daher meist nur Schäden repariert, Teilsanierungen durchgeführt oder Wohnungen bei Neuvermietung wieder brauchbar gemacht und auf einen zeitgemäßen Standard gehoben. Die Anreize über die aus Landesmitteln gewährte Wohnbauförderung sind für diese Bestandsquartiere oft zu gering, wie im Bericht des Rahmenprozesses festgehalten wird. Hier gilt es, neue Rechts- und Finanzierungsmodelle zu finden und Fördermodelle zu entwickeln, um für Quartierssanierungen, die mehrdimensionale Maßnahmen in Richtung Klimaneutralität verfolgen, einen entsprechenden Rahmen zu schaffen. Konkrete Projekte fungieren in diesem Kontext auch als wichtige Anlässe, um Prozessinnovation und den Dialog mit Entscheidungsträgerinnen und Entscheidungsträgern voranzubringen.

2.4 Neue Dynamiken und Chancen für Arbeiterinnen- und Arbeitersiedlungen

Gleichzeitig verfügen ehemalige Arbeiterinnen- und Arbeitersiedlungen, insbesondere jene aus den 1920er bis 1940er Jahren, in vielen Fällen über besondere städtebauliche Qualitäten. Die Anlagen, die häufig angelehnt an das Konzept der Gartenstadt errichtet wurden, haben für die Bewohnerinnen und Bewohner eine angenehme Maßstäblichkeit und verfügen über großzügige Freiräume mit großen Potenzialen. Das Smart-Cities-Projekt „Transform Ternitz" (2021-2024), das ein Teil des Konsortiums bereits seit 2021 begleitet, zeigt wie gerade durch Aktivierung der Freiräume positive Dynamiken entstehen können (vgl. Kirsch-Soriano da Silva, Botzenhart 2022). Im Rahmen einer Summer School wurden – gemeinsam mit 20 Architektur Studierenden – gemeinschaftliche Möbel und Infrastrukturen in Holzbau errichtet. Diese eröffnen neue Möglichkeiten für Aneignung und soziales Leben und werden von den Bewohnerinnen und Bewohnern gerne genutzt.

Auch Nachverdichtung kann – falls es eine entsprechende Nachfrage nach Wohnraum in der Gemeinde oder Region gibt – eine Chance sein, zusätzlichen leistbaren Wohnraum sowie den aktuellen Bedürfnissen

1078

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entsprechende Wohnformen zu schaffen, und leistet durch eine Reduktion der zusätzlichen Flächenversiegelung auch einen Beitrag zu einer klimagerechten Quartiersentwicklung.

Das Projekt „Smartes Wohnen für Generationen" (2018-2022), das in Wien umgesetzt wurde, bietet hier wichtige Anknüpfungspunkte, insbesondere auch in Hinblick auf die Entwicklung von innovativen generationen- und altersgerechten Wohnformen sowie Erfahrungen mit der Partizipation von Bewohnerinnen und Bewohnern bei Transformationsprozessen (Kirsch-Soriano da Silva et al. 2022). Im Smart Cities Projekt „ZuZugLeben" (2022-2025), das auch ein Teil des Konsortiums begleitet, wird ein Gesamtkonzept für eine Siedlung in St. Pölten entwickelt und die bestehenden, zum Teil „leer gewohnten" Gebäude der Siedlung zu attraktivem Wohnraum und Wohnumfeld für Mitarbeiterinnen und Mitarbeiter der ÖBB transformiert. Unter Einbeziehung von bestehenden und potenziell künftigen Bewohnerinnen und Bewohnern werden Konzepte für die Wohnnutzungen, die Attraktivierung der Freiräume sowie ein Klimaneutralitätsfahrplan für die Siedlung entwickelt. Zusätzlich werden Orte für Co-Working und Gemeinschaftsnutzung entwickelt, um auch Platz für „Neues Arbeiten" zu schaffen. Bei Modernisierungsmaßnahmen stellt sich dabei immer auch die Frage, wie klimaresilientes Wohnen – gerade im Sinne des gemeinnützigen Wohnbaus – leistbar bleiben und so genannte „Green Gentrification" verhindert werden kann.

3 NEUE HANDLUNGSANSÄTZE FÜR ERPERSDORF UND DARÜBER HINAUS

3.1 Die Siedlung in Erpersdorf

Die Siedlung wurde als Arbeiterinnen- und Arbeitersiedlung für die Pulverfabrik Skoda-Wetzler AG errichtet und bot in den folgenden Jahren auch Wohnraum für die Arbeiterinnen und Arbeiter im Chemiewerk der Donau-Chemie und im Raffineriewerk Moosbierbaum. Der Bau der Siedlung begann während der Zwischenkriegszeit und wurde in den 1940er Jahren fertig gestellt.

Historische Fotos der Siedlung in Erpersdorf: Abb. 1: Baustelle 1943, © HMZ. Abb. 2: Siedlung Erpersdorf 1968, © Franz Bauer. Quelle: zwentendorf.topothek.at

Bezeichnenderweise trägt die Siedlung bis heute keinen Namen – es wird nur von der „Siedlung" in Erpersdorf gesprochen – und steht so auch prototypisch für Siedlungen aus dieser Zeit. Die Anlage besteht aus zwei- und dreigeschossigen Gebäudezeilen und großzügigen gemeinschaftlichen Höfen dazwischen. Sie wurde weitgehend in Ziegelbauweise mit Holz-Dachstühlen und Holz-Stiegenhäusern errichtet. Die Energieversorgung erfolgt teilweise durch Fernwärme, die bei bereits erfolgten Sanierungsmaßnahmen angeschlossen wurde, teilweise über Einzelöfen. Die Siedlung aus den 1940er Jahren beinhaltet ca. 286 Wohnungen und die durchschnittlichen Wohnungsgrößen liegen bei ca. 60 m². In den 1990er Jahren kamen weitere Gebäudezeilen hinzu, sodass die Siedlung in Summe heute 424 Wohnungen beinhaltet und damit rund 20% der Wohnbevölkerung der Gemeinde Zwentendorf (mit rund 4.200 Einwohnerinnen und Einwohnern) ausmacht.

Die Wohnbevölkerung ist in Hinblick auf das Alter durchmischt – 20% sind jünger als 20 Jahre, 65% sind zwischen 20 und 64 Jahre alt und 15% sind 65 Jahre oder älter. Die Bewohnerinnen und Bewohner verfügen teilweise über geringere Einkommen als im Durchschnitt der Gemeinde. In den letzten Jahren zeigt sich

zudem ein steigender Anteil an Bewohnerinnen und Bewohner mit Migrationsgeschichte – 35% haben keine österreichische Staatsbürgerschaft und kommen u.a. aus den Ländern des ehemaligen Jugoslawiens, der Türkei, Ungarn, Slowakei, Rumänien, dem Irak und der Ukraine.
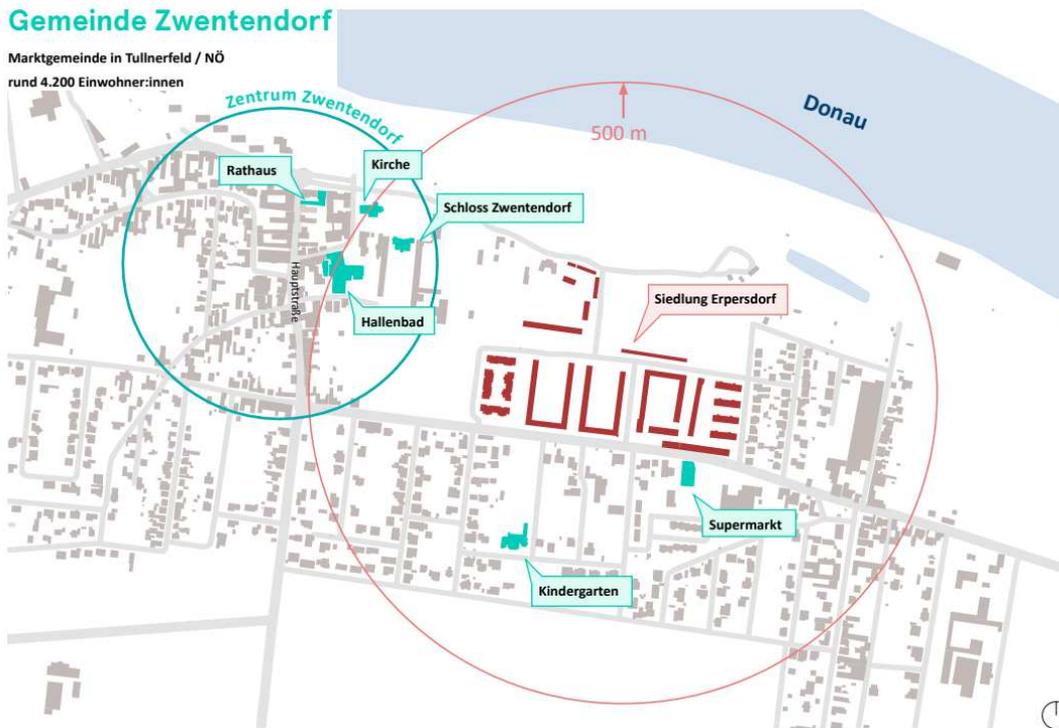

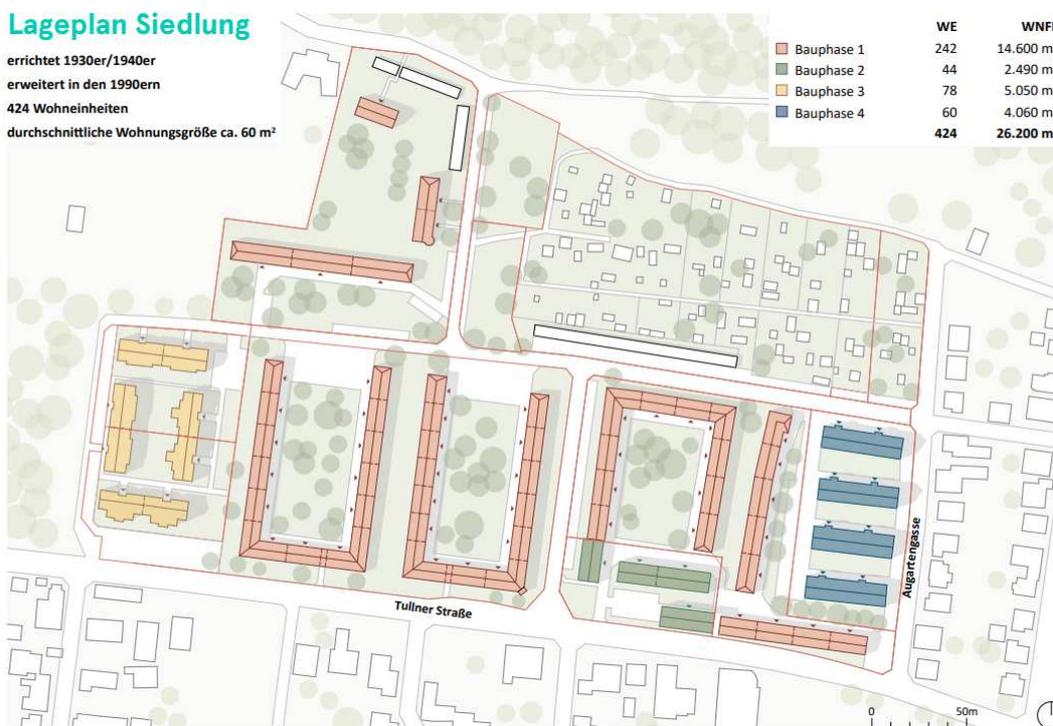Abb. 3: Lage der Siedlung in der Gemeinde Zwentendorf. © einszueins

Abb. 4: Übersichtsplan der Siedlung. © einszueins

Für viele Menschen in Zwentendorf, insbesondere für jüngere Menschen, erscheint die Siedlung nicht mehr attraktiv. Es sollen daher neue Handlungsansätze entwickelt werden, um eine nachhaltige Weiterentwicklung der Siedlung zu einem zukunftsfähigen Wohnquartier zu ermöglichen. Neue nachhaltige Energielösungen, diversifizierte Wohnformen die aktuellen Wohnbedürfnissen entsprechen, Impulse für eine lebendige Nachbarschaft, Attraktivierung und klimaresiliente Gestaltung der Freiräume sowie alternative

1080

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Mobilitätsangebote sind gefragt, um ein ökologisch und sozial nachhaltig gestaltetes Wohnumfeld zu schaffen.

Abb. 5 und 6: Aktuelle Fotos der Siedlung in Erpersdorf. © einszueins

3.2 Ziele und Maßnahmen im Rahmen des Projekts „ZUSIE"

Im Rahmen des Projekts „ZUSIE" werden folgende Zielsetzungen verfolgt und mit konkreten multi-dimensionalen Maßnahmenbündeln adressiert.

Die Identifikation mit der Siedlung wird gestärkt und eine Zukunftsvision partizipativ entwickelt.

Bewohnerinnen, Bewohner, Gemeinde und lokale Akteurinnen und Akteure haben eine aktive Rolle in der Entwicklung der Siedlung und bringen ihre Ideen dazu ein. Gestartet wird mit der partizipativen Formulierung einer gemeinsamen Zukunftsvision, wie klimafittes Leben in der Siedlung 2040 aussehen kann, und dem Finden eines Namens für die Siedlung. Aus Vertreterinnen und Vertretern von Gemeinde und Bewohnerinnen und Bewohnern wird ein Begleitgremium gebildet, das im gesamten Projektverlauf eingebunden wird und Feedback zu einzelnen Arbeitsschritten gibt. Vor Ort wird ein Zukunftsraum eingerichtet, in dem es aktuelle Informationen über das Projekt gibt und Ideen gesammelt werden, der als sozialer Treffpunkt und Kristallisationspunkt für neue Ideen und Impulse dient.

Prototypische Lösungen für eine klimaresilientere Gestaltung der Siedlung werden erprobt.

Klimaresiliente Lösungen für die Zukunft werden in prototypischer Form entwickelt und erprobt. Mögliche Prototypen sind ein „Klimabalkon" und eine „Klimapergola mit Mobilitätsstation". Beide kombinieren Elemente für klimafittes Planen (wie Begrünung, Grau-/Regenwassernutzung, Photovoltaik, Anschlüsse für E-Mobilität) zu einer neuen Lösung, können standardisiert und transferiert werden. Zudem werden auch prototypische Lösungen entwickelt, bei denen die Innovation stärker in der Prozessinnovation liegt, bspw. die Bildung einer selbstorganisierten Mitfahrbörse, die partizipative Neugestaltung von Freiräumen oder die Diversifizierung von Wohnungsangeboten durch Generationenwohnen oder Wohnen und Arbeiten im Rahmen der Modernisierung einer Gebäudezeile.

Ein Fahrplan für die umfassende Revitalisierung der Siedlung wird vereinbart.

Es wird ein Maßnahmenplan entwickelt, um die CO_2-Emissionen bis zum Jahr 2040 auf null zu reduzieren. Neben klimafitten Lösungen für Gebäude und Energieversorgung wird dabei auch auf frugale Lösungen gesetzt in Form von grün-blauen Infrastrukturen wie Vegetation und Wasserflächen. Zudem werden Finanzierungs- und Betriebsmodelle erarbeitet, mit denen die Maßnahmen realisiert werden können. Auf Basis des Konzepts wird eine Qualitätszielvereinbarung erarbeitet und von allen Beteiligten unterzeichnet. Sie dient als Grundlage für die Vorbereitung des Roll-outs auf die gesamte Siedlung.

Revitalisierung statt Reconstructing wird als Handlungsstrategie für Wohnbauvereinigungen gestärkt.

Begleitend zu einzelnen Arbeitsschritten werden Toolboxen für die klimaresiliente Revitalisierung von Siedlungen entwickelt, in anderen Sanierungsprozessen der EGW verankert und für weitere Stakeholder verfügbar gemacht. Zudem werden – ergänzend zu den wirtschaftlichen Bewertungskriterien, die im WGG vorgesehen sind – soziale und ökologische Kriterien entwickelt, die – im Sinne einer Smart City – für die Beurteilung investiver Maßnahmen und damit auch als Entscheidungsgrundlage für Revitalisierung oder Reconstructing herangezogen werden können.
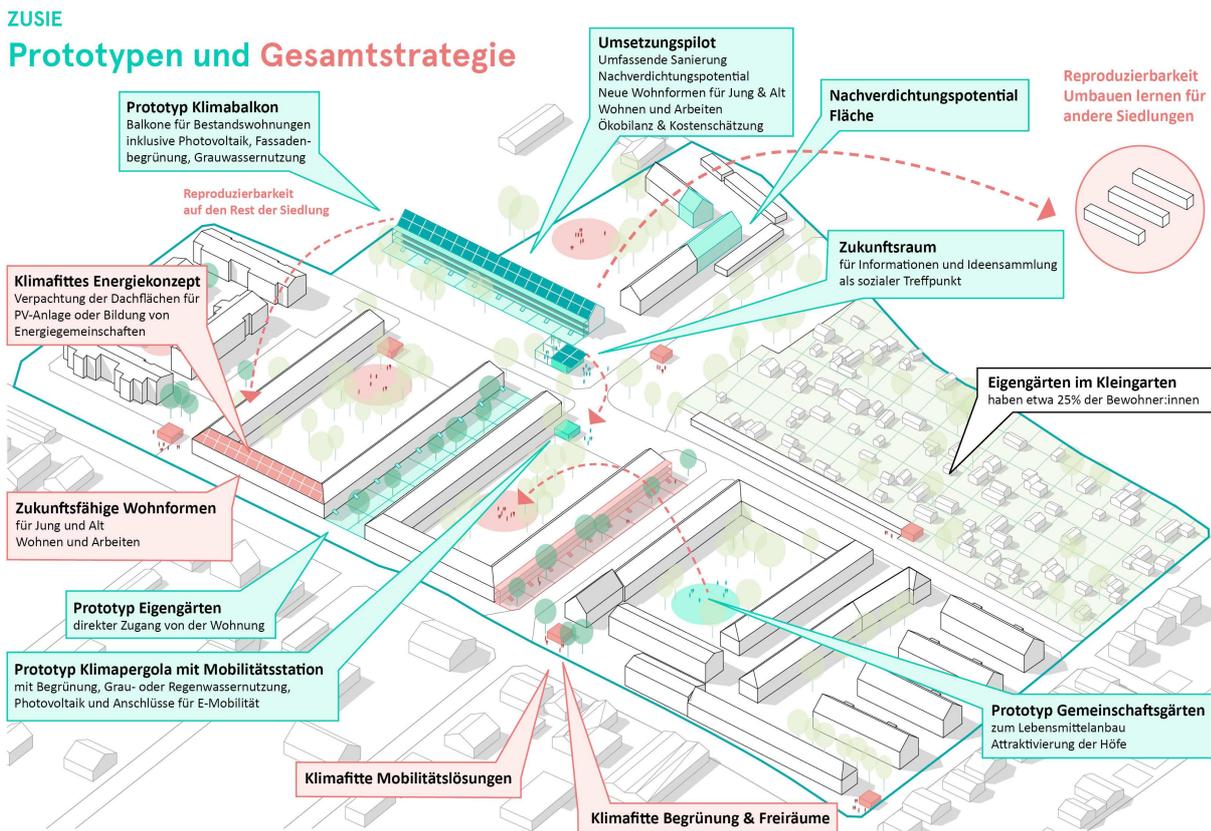
Abb. 7: Übersicht über mögliche Maßnahmen in der Siedlung. © einszueins

4   BISHERIGES FAZIT

Erste Gespräche mit Bewohnerinnen und Bewohnern bestätigen den Handlungsbedarf in der Siedlung. Die angesprochenen Themenfelder aus Sicht der Bewohnerinnen und Bewohner betreffen die Parkplatzsituation und Mobilität, umfassende Sanierungsmaßnahmen, die weiter reichen als ein neuer Anstrich oder eine Sanierung der Fassade, aber auch verschiedene Facetten des sozialen Zusammenlebens in der Siedlung.

„Die Häuser mit Farbe anstreichen wird nicht ausreichen!"

„Zwischen Migrant:innen und Österreicher:innen gibt es Barrieren. Die müsste man abbauen."

„Seit Corona Parken hier auch alle mit den Firmenautos, vor allem die Kleinlaster sind störend!"

„Ich wünsche mir für die Siedlung, dass es nicht schlechter wird! Es hängt an den Leuten – das Miteinander."

„Es gibt Gerüchte, dass abgerissen und neu gebaut wird. Die Blöcke A,B,C, die sind auch am ältesten."

„Die älteren Bewohner:innen ins Boot holen wäre wichtig!"

Abb. 8: Zitate aus Gesprächen mit Bewohnerinnen und Bewohnern im Juni 2023.

Gleichzeitig ist großes Interesse spürbar. Was wird in der Siedlung passieren? Wie kann mitgesrochen und mitgestaltet werden? Wie können verschiedene Bewohnerinnen- Bewohnergruppen involviert werden?

Auch die Gemeinde Zwentendorf war – mit vielfältigen Vertreterinnen und Vertretern – bei den ersten Projekttreffen präsent und bringt sich mit zahlreichen Ideen und Anknüpfungspunkten auf Gemeindeebene in den Prozess ein. Da Themen wie Energieversorgung, Gestaltung von Verkehrslösungen und öffentlichen Räumen, Schaffung von Infrastrukturen sowie etwaige Fördermöglichkeiten auch auf kommunaler Ebene bearbeitet werden müssen, ist die Zusammenarbeit mit den politischen Stakeholdern in der Gemeinde für die kollaborative Entwicklung und praktische Umsetzung geplanter Maßnahmen von zentraler Bedeutung. Das

1082

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breite Akteursnetz, in welches das Projekt eingebettet ist, bietet daher eine wesentliche Grundlage für das Projekt.

Neben dem Aufbau einer Projektwebsite und der Gestaltung erster Informationsmaterialien wird aktuell zudem eine große Zukunftswerkstatt geplant. Diese soll im September 2023 stattfinden und stellt den Startschuss für das partizipative Entwickeln der gemeinsamen Vision dar sowie den ersten Schritt, um die konzipierten Projektschritte – gemeinsam mit verschiedenen Beteiligten vor Ort – in die Praxis zu übersetzen.

Abb. 9: Erster Draft Projekwebsite www.zukunftsiedlung.at im Juli 2023. (Online ab September 2023).

5 LITERATUR

GBV – Österreichischer Verband der gemeinnützigen Bauvereinigungen: Verbandsstatistik 2021. Die gemeinnützige Wohnungswirtschaft in Zahlen. Wien, 2021.

Kirsch-Soriano da Silva, Katharina and Botzenhart, Lukas: Transform Ternitz – Transformation der ehemaligen Arbeitersiedlung in Ternitz: Resiliente Quartiersentwicklung bottom-up gestalten. In: Mobility, Knowledge and Innovation Hubs in Urban and Regional Development. Proceedings of REAL CORP 2022, 27th International Conference on Urban Development, Regional Planning and Information Society. pp. 1009-1015. Vienna, 2022. Online: https://repository.corp.at/917/

Kirsch-Soriano da Silva, Katharina; Botzenhart, Lukas; Pointner, Karin; Habringer, Magdalena; Christoph Stoik: Transformation mitgestalten. Partizipation und Kommunikation bei Nachverdichtung im Wohnquartier. Stadtteilarbeit, Caritas Wien. Wien, 2022. Online: https://www.caritas-stadtteilarbeit.at/fileadmin/storage/wien/Stadtteilarbeit/Publikationen/ Projektpublikationen/Publikationsreihe_Smartes_Wohnen_fuer_Generationen/WOGE_Broschuere_2_Transformation_ mitgestalten.pdf

Rainer, Ernst; Lang, Gerhard; Schreiner, Karin: Rahmenprozess zur Modernisierung von Arbeitersiedlungen aus den 1920er bis 1940er Jahren – Modul 1: Vorbereitungen, Endbericht. Klima- und Energiefonds. Wien, 2021. Online: https://smartcities.at/wp-content/uploads/sites/3/Endbericht-Arbeitersiedlungen-online.pdf

Statistik Austria: Wohnen 2021. Zahlen, Daten und Indikatoren der Wohnstatistik. Wien, 2022.

https://www.fortschritt.at/projekte-ansehen/reconstructing/

https://www.5min.at/202207545464/reconstructing-neubau-in-friesach-maximal-350-euro-miete-pro-monat/

Comparison of the Evolution Process of City Examination and Evaluation System Between China and Britain and its Enlightenment to China

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1 ABSTRACT

City examination and evaluation, as an indispensable part of urban planning evaluation, which lays the foundation for improving the governance capacity of territorial space planning by revealing the problems and weaknesses in spatial governance, has attracted more and more attention in China's urban planning. At present, city examination and evaluation of China has formed a relatively clear and complete framework in the overall planning of land and space planning, and its applied range has also expanded from statutory planning to other types of planning. With the continuous promotion of urban renewal in China, higher requirements are put forward for the urgency and refinement of city examination and evaluation. For this reason, focusing on the relatively complete and scientific urban plan annual monitoring and evaluation work in the UK, this paper firstly sorts out the development stages and evolution characteristics of planning monitoring and evaluation in the UK, and summarizes the planning practice and research progress of city examination and evaluation in China. Secondly, this paper compares and analyzes the London's Planning Annual Monitoring and Evaluation Report of the United Kingdom from 2005 to 2021,and the Territorial Space Planning Examination and Evaluation Plan of China from 2020 to 2022 from the aspects of main objectives, areas of concern, technical framework, data collection sources, evaluation index system and evaluation response mechanism, and city examination and evaluation reports of key sample cities in China are discussed in this paper. Finally, in order to obtaining positive enlightenment for the promotion of China's future planning monitoring and evaluation work, this paper puts forward suggestions on the construction of the technical framework and the improvement of the work process which are suitable for the current development stage of China's city examination and evaluation based on the above research results.

Keywords: spatial planning, planning evaluation, London planning monitoring annual report, city examination and evaulation, China

2 INTRODUCTION

City examination is a fundamental work that comprehensively evaluates the development and construction status of cities, formulates targeted countermeasures, optimizes urban development goals, fills the gaps in urban construction, and solves the problem of "urban diseases". It is an important lever for implementing urban renewal actions, coordinating urban planning and construction management, and promoting high-quality development of urban living environment.

City examination and evaluation is receiving increasing attention in planning and development. Currently, China has formed a relatively clear and comprehensive framework for city examination and evaluation in the overall planning of national spatial planning. Its application scope has also expanded from statutory planning to other types of planning. With the continuous promotion of urban renewal actions in China, higher requirements have been put forward for the urgency and refinement of city examination work.

The evaluation of urban planning implementation has been carried out early in foreign countries and has developed relatively well, especially in the UK. The technical framework, working methods, and processes of planning implementation evaluation are relatively mature. In addition, a specific planning implementation supervision system has been formed, and a relatively reasonable planning implementation evaluation and dynamic monitoring mechanism has been established, which facilitates the efficient output of urban planning implementation evaluation results and the resolution of key problems. In the assessment of the implementation of urban planning in the UK, the Annual Monitoring Report on the Planning of the City of City of London over the years, organized and published by the Greater London Authority, is the most typical

and representative official document for the assessment of the Planning of London. It is the most mature planning assessment model with the most objective results and the most far-reaching impact in the world. It is also the core document for the monitoring process and the assessment of the effectiveness of the London plan.

This article aims to explore the historical evolution and development characteristics of planning monitoring and evaluation in the UK, sort out the research progress and practical exploration of city examination and evaluation in China. Through the "Monitoring Report" and "Evaluation Regulations", compare and analyze the work of city examination and evaluation in China and the UK from the aspects of content areas, indicator systems, and response mechanisms. Based on the actual situation in China, summarize the work principles, technical methods, and evaluation mechanisms that should be followed in planning and evaluation, Provide guidance for the construction and improvement of China's city examination and evaluation system.

3   EVOLUTION AND DEVELOPMENT CHARACTERISTICS OF PLANNING MONITORING EVALUATION IN THE UK

3.1 Current Status of monitoring and evaluation work at China and abroad

At present, the practice results of planning evaluation at China and abroad have been widely used in the research of government policy making and planning preparation, and the dynamic feedback mechanism of planning evaluation has also been effective. Planning evaluation has changed from the original "pre-planning" evaluation to the current "planning" evaluation, formed a good monitoring dynamic cycle mechanism, and evolved to a multi-value planning theoretical paradigm.

Internationally, the UK takes the lead in establishing a "Three-stage, Multi-level" planning assessment mechanism, including planning programming assessment, planning implementation assessment and planning review, corresponding to the three stages of "sustainability assessment", "dynamic monitoring report" and planning review document results [1]. The evaluation system of national, regional and local levels has been constructed, and a comprehensive planning guarantee system has been formed [2].

3.2 Evolution of planning assessment in the UK

The United Kingdom began to establish the evaluation system in the planning field in the 1960s, during which the British government introduced many new analytical methods in the formulation and implementation of policies, including cost-benefit analysis and a series of derivative evaluation methods, and the planning balance sheet proposed by Lichfield and a series of evaluation methods based on the planning process derived from it.

From the mid-1970s to the 1980s, the focus on the overall effectiveness of planning policies shifted to economics and efficiency. Most government reports emphasize the 3E's principle: Economy, Efficiency, and Effectiveness.

In the late 1980s, independent testing and evaluation bodies were created in the field of policy evaluation. In this period, the planning evaluation gradually shifted from the quantitative evaluation of results to the non-quantitative evaluation of process, and began to consider the role of political, economic and social influences in the implementation of planning on the planning itself.

In 1997, the Labour government set up central to local assessment bodies. The modern British urban planning monitoring and evaluation system has been comprehensively established, and the evaluation method has been transformed into a dynamic and participatory form [3].

In 1999, the Greater London Authority Act was promulgated, clarifying the responsibility of the Mayor to supervise the implementation of the London Plan, requiring the Mayor to set up a special "implementation and supervision" chapter when preparing the London Plan, requiring annual monitoring of the implementation of the plan. The London Planning proposed that through the establishment of a reasonable monitoring title system, the key data of planning implementation can be tested to understand whether the planning objectives can be achieved and whether the planning policies are effective.

In 2004, The introduction of the Planning and Compulsory Purchase Act established the multi-level statutory system planning in the UK, and clarified the Annual Monitoring Report as the legal document to evaluate the effectiveness of the policy. It is also proposed that the main body of the planning should issue an Annual

Monitoring Report every year to measure the implementation of the planning and provide a basis for government decision-making.

Since 2005, the Annual Monitoring Report has been released to the public every year.

3.3 Content of annual monitoring report

The Annual Monitoring Report (AMR) is a key component of London's Planning Monitoring and Evaluation Management mechanism and is the central document for planning implementation to monitor and assess the effectiveness of the London Plan. The Annual Monitoring Report draws the attention of the Mayor and other departments to emerging trends, provides a comprehensive view of the impact of the Greater London Plan, and serves as an important basis for planning revisions.

The AMR consists of four chapters. The first chapter is an overview, introducing the scope and purpose of the monitoring report, as well as the main data sources. The second chapter is the achievement of key performance indicators, assessing the annual progress of each indicator and the development trend over the past years, and some indicators are implemented at the regional level. The third chapter is supplementary performance evaluation standards and statistical data, including housing, environment, transportation, related planning and other aspects. The fourth chapter is about other data sources, detailing the data sources used in the report.

3.4 Construction of index system

3.4.1   Content of index system

The monitoring indicator system is the core element of the Annual Monitoring Report, which can effectively link up the requirements of the planning content.

The annual inspection report focuses on the six urban development goals established by the 2016 London Plan: Building strong and inclusive communities, Making the best use of land, and Creating a healthy city, Delivering the homes Londoners need, Growing a good economy, and Increasing efficiency and resilience. The overall goal in strategic planning is decomposed into subdivision goals, and quantifiable indicators are further constructed to form detailed key performance indicators. Key performance indicators cover urban spatial layout, public service facilities system, and in recent years, green ecology, economic vitality, public health and employment and office are gradually included [4].

The Annual Monitoring Report forms a clear evaluation basis on the basis of many years of practice, and realizes the planning monitoring under all elements. Key performance indicators are divided into control indicators and development indicators, the control indicator specifies mandatory control, and the development indicator ensures that the development trend develops in the direction of the target.

At the same time, the setting of key performance indicators is not based on the results of data inference, but focuses on the actual development trend. The report includes relevant supplementary performance evaluation criteria and statistical data to make a holistic judgment on program implementation. Based on the test results, the City of London and the Authority will optimize and adjust the planning implementation and government decision-making, ensure the feasibility of the implementation of major strategies, and reserve more flexibility for the next stage and next level of planning assessment.

3.4.2   Index system data source

The Monitoring Report mainly uses the London Development Database (LDD) as the basic data source, and is led by the Greater London Authority to make overall statistics, and is implemented by the district government departments and relevant construction units. From November 2020, data from the London Development Database has been fully integrated into the Planning London Datahub. The Planning London Datahub contains detailed information on planning applications, permits, starts and compleations, updates the economic and social development indicators and project information for Greater London in real time, visualizes the data and shares it with the whole community.

The statistics and summarization of different data according to time frequency ensure the dynamic and immediacy of data. The accuracy, breadth and validity of different kinds of data provide guarantee for the authority and validity of the results of the AMR.

3.4.3 Development history of index system

The calendar version of the London plan will be combined with the mayor's policy ideas, the monitoring index system will be modified and improved.

Since 2004, London has published 17 Annual Monitoring Reports. Among them, AMR1-7 corresponds to the 2004 edition of the Greater London Plan, which mainly established 28 monitoring indicators; AMR8-17 corresponds to the 2011 London Plan and is adjusted to 24 monitoring indicators; The AMR19 under preparation will correspond to the 2021 London Plan and be adjusted to 12 detection indicators. The indicators of the three editions of the London Plan have their own characteristics, but they can be roughly divided into housing and public services, the economy, the ecological environment, transport, history and culture, and other special issues.

Among them, from the 2004 edition to the 2011 edition of the London Plan, the index system is basically stable. There are mainly three changes: first, some indicators have been fine-tuned; second, the target values of some indicators have been raised; third, the corresponding relationship between indicators and planning objectives has been adjusted from one-to-one correspondence to cross-correspondence.

Starting from the 2021 edition of the London Plan, the index system has been greatly simplified: first, the indicators are completely organized according to special issues, and the corresponding relationship with the planning objectives is no longer expounded; second, the number of indicators is reduced to half of the original, and the indicators emphasized in other mayor's strategies or special policies are no longer mentioned; at the same time, in the selection of indicators, it is more pragmatic, more operable, and can better reflect the role of planning approval. The 2021 London Plan inherits only five indicators from the 2011 London Plan and introduces seven new key performance indicators. From the perspective of special issues, the replacement of its adoption indicators also reflects the change of the focus of planning.

This paper focuses on AMR 17 (Table 1), the latest Annual MMonitoring Report published by the Greater London Authority in November 2022. The report continues the monitoring indicator system that has been in place since July 2011, using six strategic indicators and 24 key performance indicators. AMR17 monitored the implementation of the planning policies in the London Plan 2016 and progress towards the programme objectives between 1 April 2019 and 31 March 2020.

AMR19 to be released in the future, prepared from London in March 2023, for the first time uses the latest framework approved by the Mayor of London on 31 May 2022 and will oversee the London Plan published in March 2021. In the London Plan 2021, the "Good Growth" vision goal and six sub-goals are proposed for the first time, aiming at achieving socially and economically inclusive and environmentally sustainable growth. The plan proposes to continue to dynamically assess the sound growth of the city with Annual Monitoring Reports. and establish 12 core monitoring indicator systems covering 8 areas of housing, economy, environment, transportation, health, air quality, culture and heritage (Table 2). As can be seen from the new monitoring indicator system, in order to deal with the current "urban disease" problem, London particularly emphasizes the planning concept of sustainable development, the pursuit of high-quality development and quality of life improvement.

Number	Key Performance Indicators	Aim
1	Maximise the proportion of development taking place on previously developed land	Maintain at least 96% of new residential development to be on previously developed land
2	Optimise the density of residential development	Over 95% of development to comply with the housing density location and the density matrix
3	Minimise the loss of open space	No net loss of open space designated for protection in Local Development Frameworks
4	Increase supply of new homes	Average completion of a minimum of 42,000 net additional homes per year
5	An increased supply of affordable homes	Completion of 17,000 net additional affordable homes per year
6	Reducing health inequalities	Reduction in the difference in life expectancy
7	Sustaining economic activity	Increase in the proportion of working age London residents in employment
8	Ensure that there is sufficient development capacity in the office market	Stock of office planning permissions should be at least three times the average rate of starts over the previous three years
9	Ensure that there is sufficient employment land available	Release of industrial land to be in line with benchmarks in the Industrial Capacity SPG
10	Employment in Outer London	Growth in total employment in Outer London
11-1	Increased employment opportunities for those suffering from	(part 1) – Reduce the employment rate gap between Black, Asian

1088

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Number	Key Performance Indicators	Aim
	disadvantage in the employment market	and Minority Ethnic (BAME) groups and the white population
11-2	Increased employment opportunities for those suffering from disadvantage in the employment market	(part 2) – Reduce the gap between lone parents on income support in London versus the average for England and Wales
12	Improving the provision of social infrastructure and related services	Reduce the average class sizes in primary schools
13	Achieve a reduced reliance on the private car and a more sustainable modal split for journeys	Use of public transport per head grows faster than use of the private car per head
14	Achieve a reduced reliance on the private car and a more sustainable modal split for journeys	Zero car traffic growth for London as a whole
15	Achieve a reduced reliance on the private car and a more sustainable modal split for journeys	Increase the share of all trips by bicycle from 2% in 2009 to 5% by 2026
16-1	Achieve a reduced reliance on the private car and a more sustainable modal split for journeys	(part 1) – A 50% increase in passengers transported on the Blue Ribbon Network from 2011-2021
16-2	Achieve a reduced reliance on the private car and a more sustainable modal split for journeys	(part 2) – A 50% increase in freight transported on the Blue Ribbon Network from 2011-2021
17	Increase in the number of jobs located in areas of high PTAL values	Maintain at least 50% of B1 development in PTAL zones 5-6
18	Protection of biodiversity habitat	No net loss of Sites of Importance for Nature Conservation
19	Increase in municipal waste recycled or composted and elimination of waste to landfill by 2031	At least 45% of waste recycled or composted by 2015 and 0% of biodegradable or recyclable waste to landfill by 2026
20	Reduce carbon dioxide emissions through new development	Annual average % carbon dioxide emissions savings for strategic development proposals progressing towards zero
21	Increase in energy generated from renewable sources	Production of 8,550 GWh of energy from renewable sources by 2026
22	Increase in Urban Greening	Increase total area of green roofs in the CAZ
23	Improve London's Blue Ribbon Network	Restore 15km of rivers and streams 2009 – 2015 and an additional 10km by 2020
24	Protecting and improving London's heritage and public realm	Reduction in the proportion of designated heritage assets at risk

Table 1: Key Performance Indicators of AMR17. Source of information: the 17th Annual Monitoring Report

Number	Key Performance Indicators	Aim
1	Supply of new homes	Increase in the supply of new homes over the period (monitored against housing completions and the net pipeline of approved homes), towards meeting the 66,000 net additional homes needed each year up to March 2029.
2	Supply of affordable homes	Positive trend in percentage of planning approvals for housing that are affordable housing (based on a rolling average).
3	Supply of office capacity	Pipeline of planning permissions for office floorspace is at least three times the average office floorspace construction started over the previous three years.
4	Supply of affordable workspace	Positive trend in affordable B1 workspace as a share of total B1 floorspace in planning approvals (based on a rolling average).
5	Availability of industrial land	No overall net loss of industrial and warehousing floorspace in London (B1c, B2 and B8) in designated industrial locations (based on a rolling average).
6	Protection of Green Belt and Metropolitan Open Land	Harm to the Green Belt and Metropolitan Open Land prevented through the referred application process.
7	Carbon emissions through new development	Average on-site carbon emission reductions of at least 35%, compared to Building Regulations 2013 for approved referable development applications.
8	Modal share	Increasing mode share for walking, cycling and public transport (excluding taxis) towards the target of 80 per cent by 2041.
9	Londoners engaging in active travel	Positive trend in provision of cycle parking (based on a rolling average) to support the target of all Londoners doing two ten-minute periods of active travel a day by 2041.
10	Air quality	Positive trend in approved referable development applications demonstrating that they meet at least air quality neutral standard for emissions (based on a rolling average).
11	Impact of development on London's heritage	Positive trend in the reduction of harm and/or an increase in benefits to designated heritage assets in approved referable development applications (based on a rolling average).
12	Provision of cultural infrastructure	No net loss of culture venues and facilities* (based on a rolling average)

Table 2: Key Performance Indicators of AMR19 Framework. Source of information: the 19th Annual Monitoring Report Framework

3.5 System guarantee system

In terms of legal protection, the Annual Monitoring Report is authoritative and effective because it is guaranteed by a perfect legal system.

In terms of operation mechanism, the Annual Monitoring Report is a three-way collaborative assessment compilation mechanism led by local government departments and participated by social organizations and local departments.

Government departments are the main body of planning and evaluation, appointed directly by the mayor, and guide the relevant departments to carry out work, and each special department is responsible for the specific affairs in the corresponding field. The government makes decisions based on the evaluation results, and adjusts and improves the corresponding parts of the plan to ensure a good feedback mechanism.

Social organizations are mainly entrusted by government departments to provide technical services, participate in program discussions, and provide advice and guidance.

The community and local departments act as the grass-roots management bodies to implement the "top-down" views of the Government and collect the "bottom-up" aspirations of the public to form a bridge of communication between the two sides.

The participation mechanism of the three parties provides a guarantee for the continuous improvement of the planning evaluation system.

3.6 Monitoring process

Planning implementation in London is controlled through the issuance of permits, so most of the 24 monitoring indicators can be obtained directly from the builder's application for permission. For example, when the developer intends to build a residential development project, it needs to clarify whether the construction project uses the stock land for construction, whether it occupies open space, the relationship between the development intensity and the Public Transportation Accessibility Level (PTAL) in the region, and whether a certain proportion of affordable housing is built. Borough authorities will verify the accuracy of the data they fill in after applying for a street permit and will eventually upload the data to the London Development Database after granting the permit. Every year, the City of London will conduct a statistical review of the data collected by the London Development Database, and if there are abnormal data, it will ask the district government to re-verify the accuracy of the data.

In the whole process, the construction unit is responsible for data filling, the district government is responsible for data verification and approval of permission, the municipal government is responsible for data screening and feedback of abnormal problems, and finally data analysis and sorting (Fig. 1).
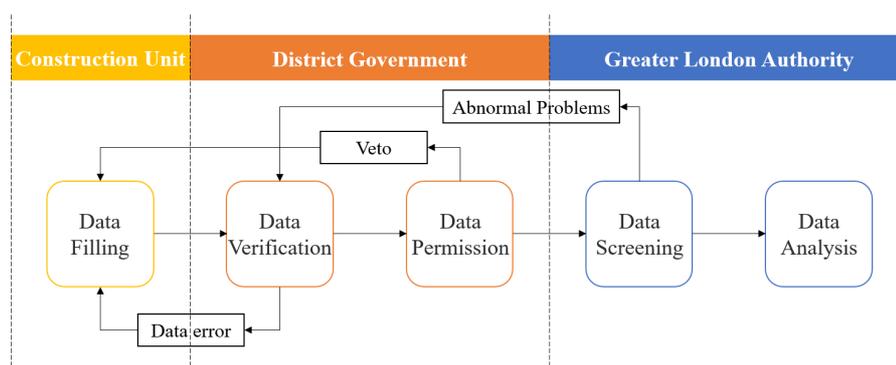

Figure 1: Monitoring processes and departmental responsibilities

4 PROGRESS AND PRACTICE EXPLORATION OF CITY EXAMINATION AND EVALUATION IN CHINA

4.1 Work progress

China attaches great importance to city examination and evaluation. In order to further strengthen the supervision and inspection of planning and improve the scientific implementation of planning, many cities have carried out relevant work of city examination and evaluation. Exploring the establishment of an city examination and evaluation mechanism of "one city examination in one year and one evaluation in five years" has kicked off the prelude of city examination and evaluation in China. In 2019, the Ministry of Housing and Urban-Rural Development selected 11 key cities such as Shenyang and Chengdu to carry out the pilot work of city examination and evaluation, and the sample size increased to 36 in 2020 and 59 in 2021, making good progress.

After entering the era of territorial space planning, city examination and evaluation work has been extended to the whole country. In 2020, the Ministry of Natural Resources deployed and carried out city examination and evaluation under the national land spatial planning system in 107 cities approved by the current State Council, in order to strengthen the supervision and management of national land spatial planning, and clarified the work requirements of "one city examination for one year and one evaluation for five years". In order to further standardize the city examination and evaluation work, the Ministry of Natural Resources

further strengthened cooperation with Beijing and other pilot cities, formulated and formed the City Examination And Evaluation Procedures for Cities in Territorial Space Planning (hereinafter referred to as the Evaluation Procedures), and issued the trial draft, approval draft and official draft of the Evaluation Procedures in October 2020, May 2021 and June 2021 (Fig. 2).
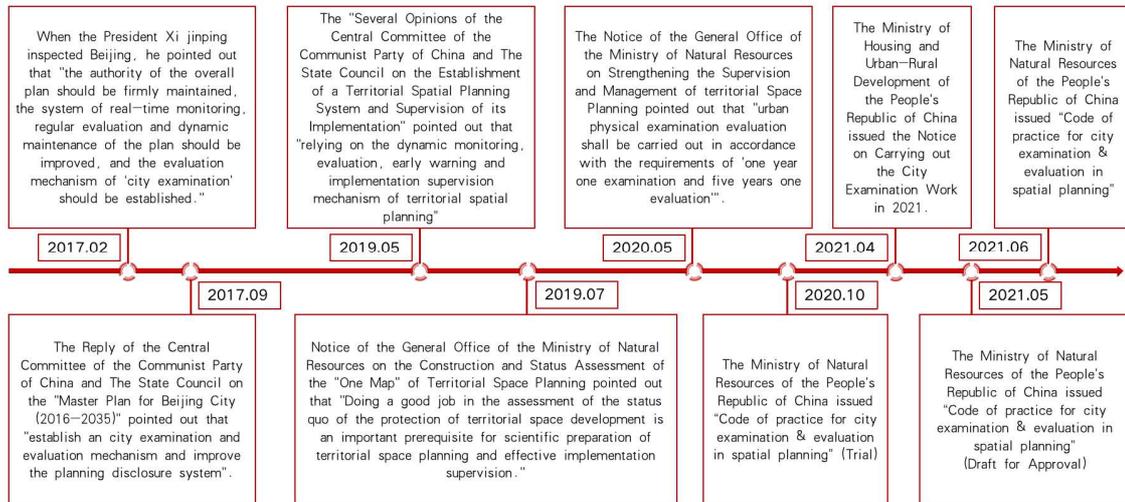

Fig 2: The development progress of China's city examination and evaluation

4.2 Index system

In the city examination and evaluation, the index system can directly reflect the implementation of the city's strategic objectives. Therefore, the index system largely determines the depth of city examination and evaluation. China has two policy documents guiding the establishment of the indicator system, respectively issued by the Ministry of Housing and Natural Resources, and the two documents guide the city examination work in different application contexts, with slightly different focuses.

In April 2021, the Ministry of Housing and Urban-Rural Development issued the "Notice on Carrying out City Examination Work in 2021", which clarified that the city examination index system in 2021 is composed of 65 indicators in 8 aspects: ecological livable, healthy and comfortable, safe and resilient, convenient transportation, features and characteristics, neat and orderly, diverse and inclusive, and innovative vitality. In July 2022, the Ministry of Housing and Urban-Rural Development issued the "Notice on carrying out City examination Work in 2022", which continued the eight aspects proposed in 2021, such as ecological livable, health and comfort, and the number was adjusted from 65 to 69, of which 22 items were added, 18 items were deleted, and 9 items were adjusted. The "Evaluation Procedures" issued by the Ministry of Natural Resources implement the national requirements, and build an indicator system with "safety, innovation, coordination, green, open and sharing" as 6 first-level categories, 23 second-level categories, and 122 indicators. Among the 122 indicators, 33 are basic indicators and 89 are recommended indicators. When carrying out city examination assessment, basic indicators are required, and recommended indicators are optional. In addition, indicators reflecting urban characteristics can be added [5].

With the advancement and deepening of city examination and evaluation, the construction of the national indicator system is diversified, based on local characteristics, and diversified indicators are expanded. For example, as the world porcelain capital, Jingdezhen has added 13 new characteristic indicators, including cultural protection, inheritance and innovation, and foreign exchanges, to focus on the two goals of the world porcelain cultural center city and the new humanistic city [6]. Shanghai city examination and evaluation explores the "linkage between city and district", emphasizing the establishment of a hierarchical and block system of city examination. On the one hand, it encourages the localization of indicators at the ministry and city level in combination with regional characteristics; on the other hand, it encourages the district-level characteristic indicator system based on its own characteristics. [7] For example, Chongming District of Shanghai puts forward a number of characteristic indicators such as "the number of waterfowl species accounting for more than 1% of the global population, the installed capacity of renewable energy, and the green food certification rate".

5 COMPARATIVE ANALYSIS OF THE UK'S "LONDON PLANNING ANNUAL MONITORING AND EVALUATION REPORT" AND CHINA'S " CITY EXAMINATION REGULATIONS FOR LAND AND SPACE MASTER PLAN"

5.1 Key focus areas

Looking at the key focus areas of the Monitoring Report and the Assessment Procedures, both of them are linked to the strategic needs and development concepts at the national level, the UK's Monitoring Report is linked to the six Grand strategy of the London Plan, and China's Assessment Procedures are linked to the five development concepts of "innovation, green, sharing, openness and coordination". However, there are differences in the content of planning and evaluation between the two, as evidenced by the fact that planning and evaluation in the UK focuses more on the needs of citizens, while in China it focuses more on policy needs and spatial control. As a developed country, the early industrialization of the UK was completed, and due to its high efficiency in urban governance, it has a high level of urban planning and management. In the process of planning and implementation, more emphasis is placed on relieving urban employment pressure, improving urban vitality, and advocating for citizen health, with a particular focus on social equity, providing more rights and protection for vulnerable groups and ethnic minorities. The corresponding indicators for the construction of city examination and evaluation revolve around issues such as housing security and poverty.

China advocates high-quality urban development and adheres to the development concept of "people-oriented". However, due to the rapid urbanization process of Chinese cities, there are many contradictions that need to be solved urgently [8]. In the formulation of the content framework of city examination, the focus is on the strategic positioning, regulatory structure, and spatial layout of the city, with strong constraints on the bottom line control of elements, and relatively weak support for the implementation of the supporting system and the implementation guarantee of planning. Therefore, the evaluation indicators for city examinations in China are more prominent in terms of "bottom line thinking", often using per capita values for calculation or the total amount and proportion within the city to characterize the specific indicator situation.

5.2 Data foundation

The "Evaluation Regulations" are based on legal data of national land and space, including national land survey and annual change survey led by the natural resources regulatory department, special survey of natural resources, geographical and national survey and monitoring, aerospace remote sensing images, and other basic status data. Data on various levels of national land and space planning achievements, land use approval, land supply law enforcement supervision, and other management data are supplemented by relevant legal statistical survey data, Including economic and social development statistical data, specialized survey statistical data from various departments, etc; Using spatiotemporal Big data as a reference, mobile signaling data, POI data, traffic IC card data, enterprise information, location services, lighting data, citizen service hotline data, etc. that are publicly released or legally obtained are used according to the relevant standards and regulations of the natural resources management department. For city examination and evaluation indicators, continuous data can be collected for many years to reflect the trend of changes in the indicators; For prominent issues, on-site special research can be conducted to grasp first-hand information; For public demands, various methods such as questionnaire surveys can be used to understand the issues and opinions on housing security public service facilities, municipal public facilities, and urban safety resilience in public spaces.

The Monitoring Report relies on the London Development Database collected by the Greater London Authority as a whole, and summarizes the data according to the corresponding indicators at different times and frequencies. The accuracy and timeliness of the data are fully guaranteed, which avoids some indicators in the Evaluation Procedures without data sources or data statistical caliber deviation, leading to data monitoring failure and disability. The Monitoring Report can truly achieve the goal of planning monitoring and avoiding future problems. Due to the failure to collect data in advance according to the Evaluation Regulations, it is often necessary to screen data on a large amount of data for city examination and evaluation, which affects work efficiency.

5.3 Evaluation index system

The indicator systems of the Monitoring Report and the Evaluation Regulations both cover aspects such as socio-economic, intensive resources, and ecological environment, and have put forward corresponding requirements in terms of public service layout, green transportation, cultural and historical heritage, etc. Both use time series to statistically analyze data and present multiple indicators in the form of evaluation and judgment tables, which can truly reflect the changes in indicators, closely connect with planning and control needs, and facilitate later analysis and summary, providing a judgment basis for early warning feedback in planning evaluation and monitoring. In addition, both of them follow certain data requirements, such as the fact that the data should truly describe the characteristics of indicators and have a certain degree of objectivity; The data should be easy to collect and update, with a certain degree of accessibility; The data should be easy to analyze, process, and quantify, with a certain degree of operability.

Due to the different national conditions between China and the UK, there are significant differences in the guidance and criteria for indicator evaluation and judgment due to the different feedback requirements for the implementation status of planning goals (Table 3). In terms of the orientation of indicator evaluation and judgment, the Monitoring Report emphasizes trend judgment and focuses on the expression of performance development status. Evaluation and judgment are generally expressed as different states such as "developing according to predetermined trends" and "developing towards opposite predetermined trends" [9]; The "Evaluation Regulations" emphasize result monitoring, focusing on a more clear progress situation, and emphasizing the progress completion of each indicator plan implementation. The evaluation judgment is generally expressed as "meeting the target direction, achieving good results" or "slow progress, requiring key progress". In terms of evaluation and judgment criteria, the "Monitoring Report" is guided by more flexible goals, focusing on preset development trends, and is a grasp of the overall performance development goals; The 'Evaluation Regulations' are evaluated based on more rigid standards, comparing the reported value of the evaluation year with the current situation value of the base year, and the planned value of the target year with the reported value of the previous year, with a focus on the differences with the planned target value.

5.4 Evaluation response mechanism

The main differences in the evaluation response mechanism between the Monitoring Report and the Evaluation Regulations are reflected in the dimensions of achievement application, the nature of the planning system, and the strength of supervision and implementation.

5.4.1 Evaluation results application dimension

The Monitoring Report is mainly used to evaluate the effectiveness of the London Plan and its policies, including the progress of implementing the planning objectives and the effectiveness of the planning policies. Its evaluation content also needs to be consistent with the regional plans, mayors, council policy guidelines, and other content. The results of the Evaluation Regulations are mainly applied to comprehensive affairs such as planning approval, planning preparation, planning implementation, and planning management, Providing performance evaluation basis for natural resource management departments and related departments, supporting the preparation of the National Economic and Social Development Plan and the Government Work Report, is beneficial for the evaluation of planning implementation and the improvement of urban governance level.

5.4.2 Nature of planning system

The 'Monitoring Report' belongs to the guiding planning system and belongs to the regional planning monitoring category in the UK planning implementation system. The annual monitoring report can serve as an important basis for local planning, conducting planning downward, and providing development guidance for local planning and community planning. The 'Evaluation Regulations' belong to the controlling planning system , Strictly control the bottom line control elements in city examination and evaluation, focusing on the "one map" of urban and rural construction land changes, as well as the basic geographical elements and analysis evaluation elements in the "one map" of each district's development. Through annual city examination and five-year evaluation, feedback is provided on the relevant content of overall planning, detailed planning, and even special planning.

5.4.3   Supervision and implementation efforts

The Monitoring Report can effectively and dynamically monitor the implementation of the plan. The reason is that the Greater London Authority Act clearly defines the mayor's responsibility for supervising the implementation of the London plan. It ensures the effective monitoring, assessment and review of the facts of the London Plan through top-level planning and clear laws and regulations, and also ensures the interconnection between the planning levels and types, It becomes the core basis for measuring regional planning and future policy directions, and has legal significance.

Content		The Annual Monitoring Report	City Examination and Evaluation In China
Data Sources		The London Development Database	Based on legal data of national territory and space
Data Description		Panel data of evaluation indicators over the years 2004-2020	Evaluation indicators: current status value of the base year, planned value of the target year, reported value of the previous year, and reported value of the evaluation year
Evaluation Description	Positive evaluation	Developing according to preset trends	Meets the target direction and completes well
	Negative evaluation	tends to develop in the opposite direction of presupposition	Slow progress, need to focus on progress

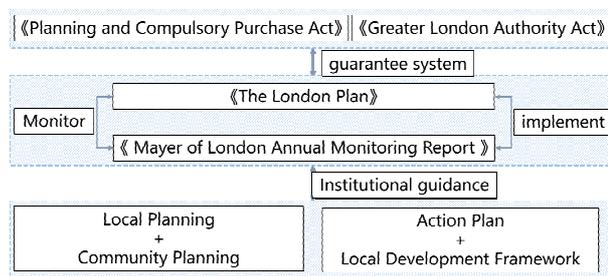Table 3:Comparison between the "Monitoring Report" and the "Evaluation Regulations"

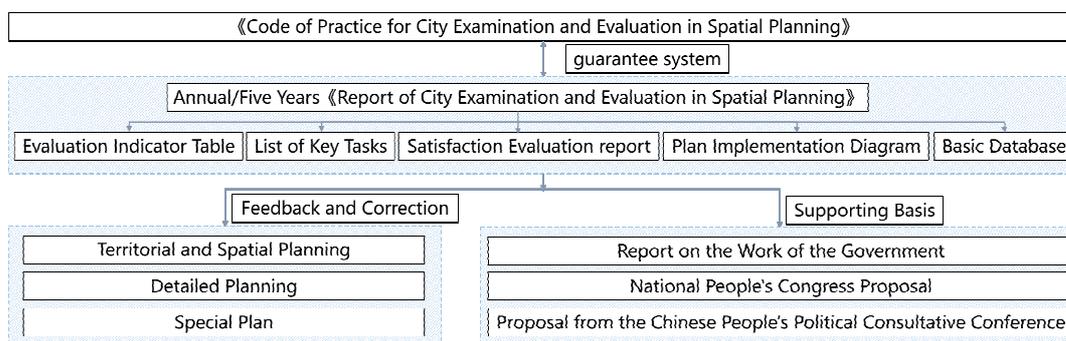Fig 3:Monitoring Report Guarantee and Response Mechanism Diagram

Fig 4:Guarantee and Response Mechanism for City Examination and Evaluation Reports

6   SUGGESTIONS FOR THE OPTIMIZATION OF CITY EXAMINATION IN CHINESE CITIES

Through the comparison of "Monitoring Report" and "evaluation procedures", it is found that London's urban planning monitoring and evaluation is advanced in the construction of dynamic monitoring system and the improvement of mechanism. Therefore, according to the current city examination work in our country, the following guidelines and suggestions are put forward.

6.1 Build a complete dynamic monitoring and evaluation system

At present, the city examination of urban planning in China is more focused on the analysis of data information, but lacks the monitoring of the implementation of specific policies. Therefore, it is necessary to further improve and supplement the supervision and feedback part, and gradually form the evaluation framework of "real-time monitoring – comprehensive judgment – feedback implementation – urban governance", so as to achieve an effective connection between territorial planning and city examination and evaluation. Thus, the integrity of urban planning evaluation is enhanced.

6.1.1   Dynamic + normal city examination mode

City examination should focus on dynamic monitoring and evaluation, and build a full chain of dynamic city examination work process of detection – diagnosis – governance – review – monitoring – early warning, so

1094

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as to achieve effective integration of city examination, result feedback and urban management. Through the information system, a normal monitoring system of instant monitoring and alarm and timely correction is established, which is timely reflected to the relevant departments, creating a daily reward incentive mechanism for the construction of urban health, and reducing the passive, static and targeted city examination of "city examination due to needs". And according to the specific situation of the city to find the contrast gap, put forward the localization of the construction path. It has gradually shifted from focusing solely on data and indicators to focusing on all aspects of policy making and decision-making.

6.1.2 Multi-level connection and coordination

In addition to the scope of city and district level assessment, the scope of city examination will gradually sink from the city to the micro-scale of streets and communities, and establish a multi-level assessment model of "city – district – street – community", which will also improve the ways and methods of social organizations to participate in urban management. The micro-scale evaluation of towns and communities can reflect the actual needs of the masses, more fully show the construction dynamics of the project, and thus improve the effectiveness of city examination and evaluation. In addition, the connection and coordination with the evaluation work at all levels is becoming more and more important, so it is necessary to pay close attention to the establishment of the provincial and even regional city examination information platform, while doing a good job with the provincial city price increase information system connection and coordination, so as to enhance the stability of city examination and evaluation.

6.1.3 Improve the multi-subject participation mechanism

In addition to the public satisfaction survey and third-party city examination, we will expand more channels for social subjects to participate, and deeply adopt the opinions and suggestions of experts, scholars, representatives of social groups and the masses, so as to effectively reflect the needs of the people and social concerns. Government departments should actively stimulate the initiative of social subjects in the promotion of work, and promote the normal development of city examination more efficiently; In the process of data collection, actively coordinate the staff of the city examination department to maintain the authority and credibility of the data; In the publicity of the work, we will take the initiative to invite representatives of well-known enterprises, experts and scholars in universities and the general public to participate in the city examination work and offer suggestions for urban construction. Grass-roots people should participate in or assist the investigators in the city examination survey, and actively respond to the evaluation of livable conditions and living needs; In terms of reflecting the situation and improving opinions, the government departments' information websites and other formal channels are used to reflect the construction situation or provide improvement opinions.

6.2 Integration of city examination objectives

6.2.1 Strengthen implementation orientation

The strategic goal of London's urban planning monitoring and evaluation has changed from problem-oriented to opportunity-oriented, and there are two main types of city examination in China at this stage, one is the city examination carried out by Beijing and Shanghai, focusing on the implementation of the urban master plan, which is similar to the London's urban planning monitoring and evaluation [11]. The other type is represented by the city examination of the current status of urban development conducted in Guangzhou and Chongqing, which focuses on the problem orientation .The technical framework of dynamic monitoring and evaluation corresponding to different types of city examination is different, and the two should not be confused. Cityexamination for urban development problems has problems such as a huge workload of city examination, the need to collect a large number of city-related data, and sometimes there are conflicts and missing data. The focus of city examination is often biased to a certain aspect of the city, forming a problem of partial overview. The dynamic monitoring for planning and implementation has stronger purpose, more targeted operation, and easier to control the direction of city examination. Therefore, we should strengthen the goal orientation and use development goals to lead the promotion of cityexamination.

6.2.2 Multiple guidance support

In view of the advantages of the city examination index system with flexibility and broad application basis, it can continue to enhance the comprehensive service guarantee ability of city examination and evaluation, and

according to the needs of government policies and departments at all levels, according to the social political and economic conditions of high-quality urban development, urban and rural construction management, urban service facilities and many other management and service requirements. Combined with the evaluation requirements of social and economic planning, territorial spatial planning, urban construction planning, environmental protection planning, etc., on the basis of the concept of comprehensive integration of city examination, a support system with multiple guiding functions is further formed to promote the healthy and high-quality development of the city .Relying on the multidimensional orientation of the indicator system, we will develop a more stable and extensive support system [12].

6.3 Optimize the index system

6.3.1 Widening of data sources

City examination and evaluation should combine traditional economic and social data, including social and economic data, territorial spatial survey data and urban big data, such as mobile signaling data, government data, POI data, LBS data, enterprise information, traffic data and social media data, street view data, remote sensing data and lighting data .In addition, combining with social satisfaction survey, the rational objective data and perceptual subjective survey are integrated. Promote the construction of intelligent data network platforms, efficiently integrate multi-source data information, and promote resource sharing among departments and even for the public. In addition to economic and social macro data sharing, explore the addition of new projects, new facilities and other functions in the information platform to provide more effective information support for the calculation of city examination indicators. Through the use of advanced means such as big data analysis, artificial intelligence, and digital services, the accuracy and scientific nature of city examination assessment are enhanced to achieve real-time dynamic monitoring of urban healthy development [13].

6.3.2 Indicator content deepening

The types of ecological monitoring indicators of London's urban planning monitoring and evaluation are constantly expanding. In order to realize China's ecological civilization construction, respond to the transformation and change of sustainable development, combined with the strategic requirements of ecological priority and green development in territorial spatial planning, natal-based solutions related indicators can be added to the ecological livable dimension, focusing on carbon emission reduction, green infrastructure construction and other aspects. The index system will be deepened and supplemented from the directions of industrial structure upgrading, urban green construction, and residents' green life .

At the same time, according to the changes in the external environment of urban development, urban landscape style, and the requirements of the upper planning, the city examination and evaluation index system of various places is dynamically adjusted to objectively and completely reflect the different characteristics of each stage of urban development, and provide data support for the research and evaluation of the weak links in the implementation of planning. For large cities with good economic development background, incremental changes should be highlighted in the long-term planning, and micro-indicators such as "new projects" and "new facilities" can be added to the index system as a supplement to macro-economic and social monitoring indicators .

6.3.3 Improve database construction

The desirability and completeness of city data determine whether the city examination is carried out smoothly. Without accurate, complete, continuous and desirable urban data, it is impossible to judge the direction of urban development or the implementation of urban facilities. With reference to the construction mode of London development database, urban construction data of different regions, different levels and different fields of the city should be collected regularly through the city examination data information platform to ensure the desirability and continuity of urban dynamic monitoring data. The city database should be connected with the geographic information system (GIS), and the relevant special visual analysis can be carried out through GIS, and the multi-city data management system can be formed by using other data sources. The urban operation monitoring intelligent platform based on the urban database can monitor the urban operation status and urban disaster early warning in real time, and improve the safety and resilience of the city.

7 CONCLUSION

This article focuses on comparing the planning and evaluation of China and the UK, summarizing the historical evolution and development characteristics of planning monitoring and evaluation in the UK. It also explores the research progress and practical exploration of urban health examination and evaluation in China. By comparing and analyzing the "Monitoring Report" and "Evaluation Regulations", optimization suggestions are provided for urban health examination and evaluation in China.

In the future, China's city examination and evaluation needs to pay more attention to: (1) optimizing the city examination indicator system, and selecting indicators should consider objectivity, accessibility, and operability, which can effectively reflect the strategic direction and overall goals of the city (some indicator data is difficult to obtain). Establish corresponding city examination databases (2) Improve the framework of planning and evaluation content, and enhance the comprehensiveness of planning and evaluation. (3) Clarify the criteria for planning evaluation and analysis, ensure the effectiveness of planning evaluation implementation, and improve the top-level design level of planning. (4) Improve the planning monitoring and evaluation system, and enhance the implementation of planning decisions. (5) Improve the application methods of city examination results, so that planning and evaluation can be effectively monitored and monitoring results can be obtained.

By comparing the development process of planning and evaluation in the UK, the following three aspects of city examination and evaluation experience can be obtained: in terms of evaluation orientation, it is necessary to establish a goal orientation that varies from city to city, establish a clear and identifiable problem orientation, and establish an effective result orientation; In terms of indicator system, the breadth of data sources should be expanded, the depth of indicator judgment should be strengthened, and the validity of comprehensive data should be improved; In terms of evaluation mechanism, it is necessary to consolidate the foundation of real-time monitoring, improve comprehensive judgment ability, improve feedback implementation system, improve urban governance feedback mechanism, and form a closed-loop system from real-time monitoring, comprehensive judgment, feedback implementation to urban governance evaluation.

8 REFERENCES

[1] Zhou Zhutian, Zhai Guofang, Shi yijun. Index Monitoring Framework and Implications of British Spatial Planning[J]. Urban Planning International, 2018(5): 86-93
[2] Zhang Jie. An Empirical Study of Development Planning Under the System of 2004 in the United Kingdom – A Case Study of England [J]. Urban Planning International, 2015(1): 78-83
[3] Wang Jun, Chen Xi. About the mechanism of planning evaluation in the western countries: Conception, content and evolution of solution. Urban Planning International, 2011, 26(6): 78-83
[4] Greater London Authority. The London Plan 2021 [Z]. 2021.
[5] The Ministry of Natural Resources .Procedures for City Examination and Evaluation of Cities in Territorial Space Planning[S].2021
[6] Shang Yanran, Zhao Lin, Feng Yu etc. Methods and practical exploration of assessing the status quo of territorial space development and protection -- A case study of Jingdezhen City, Jiangxi Province [J]. Urban Planning Forum,2020(06):35-42.DOI:10.16361/j.upf.202006005.
[7] Wu Giang, Wang Xin, Chen Ye etc. The challenge of urban city examination in megacities and its practice in Shanghai [J]. Urban Planning Forum,2022(04):28-34.DOI:10.16361/j.upf.202204003.
[8] Zhang Yichun, Tang Chenghui, Xu Shuncai, et al. The Historical Evolution and Spatial Logic of Urban Agglomeration Spatial Planning in China: Based on the New National Spatial Perspective [J]. Urban Planning, 2021 (5): 21-29
[9] Zhou Yanni, Jiang Tao, Song Xiaojie, et al. International experience and inspiration from the annual planning implementation evaluation in the UK [J]. International Urban Planning, 2016 (3): 98-104
[10] Zhan Meixu, Liu Qianqian, Huang Xu, et al. New Mechanisms and Paths for Modernization of Urban Governance from the Perspective of Urban City Examination [J]. Geographic Science, 2021 (10): 1718-1728
[11] Shen Shuai is handsome, Wang Zheng Inspiration of London's annual monitoring report on city examination in China [C]//Urban Planning Society of China, Chengdu Municipal People's Government. Proceedings of 2021 China Urban Planning Annual. China Building Industry Press, 2021: 77-86. DOI: 10.26914/c.cnkihy.2021.026637
[12] Hu Bingxuan Research on optimization strategy of city examination and assessment system from the perspective of holistic governance [D]. China Academy of Urban Planning and Design, 2022. DOI: 10.27482/d.cnki.gzcgs.2022000005
[13] Shan Zhuoran, An Yuehui, Yuan Man, et al. Comparative Analysis and Policy Suggestions on City Examination Evaluation in China and the UK [J]. Planner, 2022,38 (03): 53-60