Study of the Relationship of Processes of Socio-Economic and Spatial Development of the City with the Help of Information and Analysis System Based on PROGNOZ Platform

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1 ABSTRACT

Information technology has become the best direction in all branches of activity in developed and developing countries - from the optimization and automation of manufacturing industry to the electronic database for schools and universities, and urban planning sphere is no exception.

In Russia there is a comprehensive database of development areas – the information system for urban development (ISOGD). The main goal of ISOGD is to provide public authorities, local governments, individuals and legal entities with relevant and reliable information, necessary for the implementation of urban planning projects, investment and other economic activities. At the moment this data is not used for the analysis of urban areas and to support the adoption of urban planning decisions. In connection with this aspect, we have begun to develop a software product – information-analytical system (IAS). This analytical software combines overall socio-economic statistics, the data of the state cadastre of real estate, legal and regulatory framework of the federal and municipal level in the field of urban planning, GIS and PROGNOZ-PLATFORM software.

This article presents the results of research and practical work considering the case of Novye Lyady microdistrict, which represent a part of comprehensive test problem of functional development (public and residential functions) forecasting of the selected areas throughout urban territory.

Within this article the solution to the benchmark problem using the IAS and Perm ISOGD is shown: investigation the possibility of development consolidation taking into account the maximum feasible housing density.

2 INTRODUCTION

Looking at developed and developing countries today, information technology is best direction in all branches of activity - from the optimization and automation of manufacturing industry to the electronic database for schools and universities. Urban planning as a filed also has information support. In Russia, in Perm particularly, there is a comprehensive database of development areas – the information system for urban development (ISOGD). The objective of ISOGD is to provide public authorities, local governments, individuals and legal entities with relevant and reliable information, necessary for the implementation of urban planning projects, investment and other economic and general service activities, land-use system management.

ISOGD contains following information:

(1) Perm land use and development regulations;

(2) Regulation lines plans, boundary-setting plans and supporting data (the official title is «Area planning documentation»);

(3) State of exploration of natural and man-made conditions materials;

(4) The documents and materials of withdrawal and reservation of land for public use;

(5) Documents and materials about the built-up and prospective built-up plots;

(6) Geodetic and cartographic materials;

(7) The documents and materials on the provision of land for purposes not related to construction;

(8) Documents and materials of the state real estate cadastre;

(9) Documents monitoring processes of urban planning activities;

(10) Documents and materials of public hearings;

(11) Information and analysis materials on various aspects of the city of Perm and urban development activities [1].

Despite the fact that ISOGD is an extensive database of urban data, it is not used to analyze the built development, to justify urban planning decisions, to develop a strategy for the territory, due to the lack of analytical tools.

However, achievements of the last decade in the field of information technology in the world practice have contributed to the development of the urban environment analysis different methods integration (Space matrix, Space sintax, Mixed Use Index (MXI) [Y.Ye, A. Van Nes, 2014]) with geographic information systems to quantitatively describe and classify the spatial properties development and identify their relationship with the socio-economic processes.

Over the past two years, the author attempted to develop an analytical software tool - information-analytical system (IAS), which would allow the city to explore different processes in relation to the socio-economic development of the city [Maximova, Zavylov and other 2013].

The opportunities of BI-platform PROGNOZ-PLATFORM were applied as an analytical tool. The IAS database is formed to solve this complex problem and, together with the data of the municipal ISOGD includes federal, regional and municipal socio-economic statistics, the legal framework of the federal and municipal level in the field of urban development. Special software tool working with maps allows to analyze ARCGIS mapping data, contained in ISOGD.

This structure makes possible to collect and analyze data and to investigate the relationship of socio-economic and spatial development processes in the city.

Currently the IAS is tested through traditional town planning calculations, which are mandatory in accordance with federal and local regulations. This procedure will work to debug the IAS and verify the results received with its help. Data obtained with the help of the IAS is compared with calculations performed manually. Testing of the IAS is based on solving simple benchmark problems. First and the simpliest one, focusing on plot selection for the new school construction within Perm, was described in a study [5] based on approaches developed by A. Golovin [2013].

The problem considered in this paper is a part of comprehensive benchmark problem of functional development (public and residential functions) forecasting of the urban territory selected areas.

Fig. 1: General view of Novye Lyady

3 CASE STUDY

New Lyady – Perm remote residential area, was selected as an object of investigation area.

The area represents 40-50s development of the last century, therefore its layout was formed during the Soviet era with the fingerprints of the time: string development, 12 m fire spacing with number of storeys 1 to 5.

The bulk of the population lives in the multi-storey residential buildings neighborhood area, where all the schools, kindergardens, shops and the main objects of the cultural life of the village are located (Figure 1).

Currently, we plan to develop the area with an increase in the number of residents to 15 thousand people by 2020.

On the one hand New Lyady microdistrict has fairly simple and coherent types of layout, on the other – there is a real spatial development plan formed and approved for the area, so it was chosen as the most suitable for testing the IAS.

The verification was carried out on the multi-storey building typical '60s territory, where the buildings are located meridianally. Typology and building parameters for 5 quarters are shown in Table 1.

№ of block	Number of buildings in the block	Building material	Number of floors (n)	Building height (H), m	Width of buildings (B), m
1	5	Reinforced concrete panel	5	15,0	
5	8	Brickwork	3	9,4	
17	4				12,0
22	1	Reinforced concrete panel	5	15,0	
33	3				

Table 1: Typology and parameters of buildings in the blocks in Novye Lyady microdistrict

Fig. 2: The scheme of residential plots development marked in Table 3

The testing objective was to study the possibility of development consolidation within the block taking into account the maximum feasible density, established by the federal health standards. Method of calculation is set out N.S. Rusakova, V.A. Sosnowski [2006] and is based on a comparison of the maximum feasible current density and housing.

The maximum feasible density of housing (net) is determined by the conditions to ensure a standard insolation time for residential areas (not less than 2.5 hours per day from April 22 to August 22 for the northern zone (to the north of 58o north latitude), not less than 2 hours per day from 22 March to 22 September for the central zone (58o north latitude - 48o north latitude), not less than 1.5 hours per day from February 22 October 22 for the southern zone (to the south of 48o north latitude)) and ensure regulatory area of vegetation (the minimum area of open space should be not less than 6 meters per person).

Insolation is provided in compliance with the gaps (2H – between meridianal oriented buildings, H – between latitude oriented buildings), hence, if the building density P1 satisfies the inequation:

$$P_1 \leq P_2 \quad (1)$$

$$P_2 = \frac{\sum BL}{\sum (B + 2H)(L + 1)}, \% \quad (2)$$

Where:

B – width of the building;

H - height of the building;

L – distance between the buildings;

Housing stock density P_1 is calculated according to the formula:

$$\Delta_{net} = \frac{10^4 \cdot m}{c + \frac{2m}{\alpha \cdot n}}, sq. \frac{m}{ha} \quad (3)$$

Where:

m – residential security rate (entered by the user or accepted by local regulations – 20 sq. m. for new development);

c - area occupied by vegetation (entered by the user or accepted by local regulations – 6 sq. m. per person);

α - coefficient characterizing the proportion of residential buildings of the total area of the square is taken, depending on the number of stores of the building;

n – number of stores.

The relation between n and α is given in Table. 2.

n, floors	α, value
2-5	0.59
6-30	0.53

Table 2: value of α

Limitary building density P_1:

$$P_1 = \frac{\Delta_{net}}{n \cdot \alpha \cdot 100}, \% \quad (4)$$

The values of the design parameters and target functions for the blocks indicated in Figure 1 are shown in Table. 3.

№ of block	Parameters							Values of the target functions for existing buildings	
	c	m	α	n	B	H	$S_{уч}$	P_1	P_2
	sq.m/person	sq.m/person	-		m	m	sq.m.	%	%
1							33553	34,66	35,71
5							16365	34,66	35,71
17	6 (variable)	20	0.59	5	12	15	31932	34,66	35,71
22							16739	34,66	35,71
33				3		9.4	25195	39,51	45,98

Table 3: The values of blocks calculated parameters and target functions

With the use of ISOGD the IAS allows to determine the c value specifically for each quarter, which helps to accurately identify the reserves for construction consolidation or for open spaces land forming.

3.1 Algorithm of solving the test task

Parameters highlighted in Table 3 (c, m and α) are introduced into the calculation of the standard block of the IAS database tools.

Values c, B, H and Sq were obtained using carthographic data entered into the IAS from ISOGD. The boundaries of the districts were identified by the regulatory lines of Novye Lyady planning documentation. The IAS receives them from ISOGD database.

(1) Identification of existing and planned Δnet1 and Δneti density of housing, with variable values mi, ni, αi by the formula (3);

(2) Calculation of P1 (the formula (4) and P2 (2) at different values of parameters calculated;

(3) Comparison of objective functions according to the formula (1).

Using this algorithm Novye Lyady Area technical and economic indicators were defined in stages of development until 2030. The calculations have shown the possibility of consolidating buildings in some neighborhoods in the considered area for the planned by municipality main enterprise increase in the number of inhabitants in 2030 (Table 5).

Phase	№ of block	Square of block	The volume of the existing residential development, m^3	The volume of the existing non-residential development, m^3	The volume of projected residential development, m^3	The volume of the projected social infrastructure, m^3
1ˢᵗ phase	9	5975			14460	
	10	11862			20368	2036
	11	6340			14860	
	14	3789		100		1500
	15	52168				1000
	20	11571				
	21	2474				
	32	9396				
	35	1843				
1ˢᵗ phase sub-total		105418	0	100	49688	4536
2ⁿᵈ phase	6	4185				
	7	13923	11160			
	8	2888				
	16	33619		11508		15364
	17	31932	25315		12235	
	22	16739				
	31	6544		4509		1000
	34	17643	6605		10125	
	36	2596				
	38	41036		3100		1400
2ⁿᵈ phase sub-total		171105	43080	19117	22360	17764
3ᵈ phase (perspective development)	4	13997			20547	
	5*	16365	15048			
	12*	18629	18374			
	23	5558				
	25	19190	10210		7232	
	29	7222			2772	
	30	5363			5676	
	33	25193	23865		18085	
	37*	32195	22860			
3ᵈ phase sub-total		143712	60992		54312	

Table 5: Technical and economic parameters for projected residential and non-residential buildings. * Highlighted blocks are the blocks selected for verification.

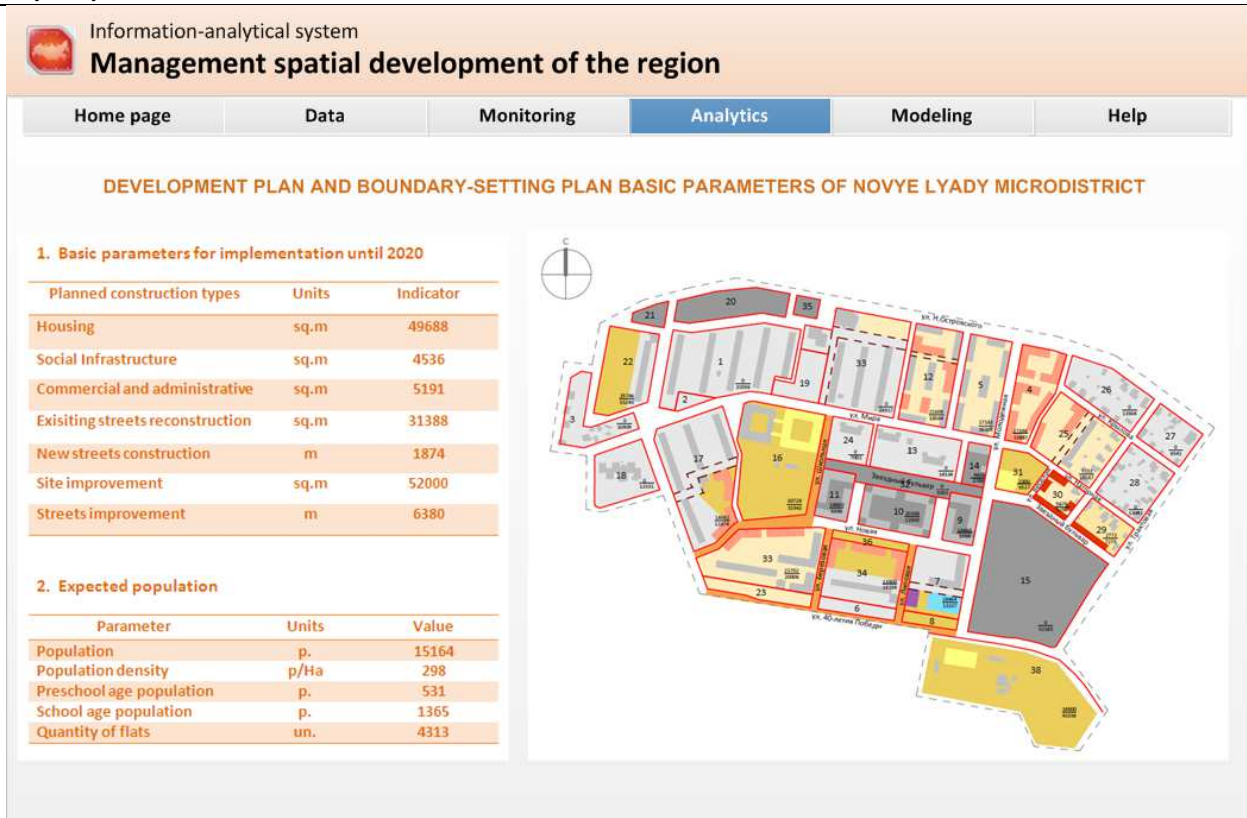The IAS interface for solving the village of Novye Lyady task shown in Fig. 3.

Fig. 3: Interface of technical and economic assessment in the IAS page

4 LIST OF ECONOMETRIC AND ADAPTIVE METHODS USED IN SOLVING THE TASK

1. Regression models:

1.1. Linear Regression (Instrumental Variables Estimation);

1.2. Nonlinear Regression (Nonlinear OLS Estimation);

1.3. Error Correction Model

2. Time Series Analysis:

2.1. Trend With Functional Dependency Estimation;

2.2. Smoothing Models (Median Smoothing, Exponential Smoothing);

2.3. X11;

2.4. ARIMA

3. Determinate Equation;

4. Panel Data Model;

5. System of Nonlinear Equations.

5 CONCLUSIONS

(1) The IAS is well compatible with ISOGD of Perm. The IAS decision subsystem has successfully used the built-in tools for test problem modeling to work with maps that support the following functions:

- Map scale change;
- Selecting an arbitrary region on the map;
- Map layers view;
- View information about objects on the map.

(2) Comparison of the results obtained in the IAS calculation and manually, showed a high reproducibility. The program works correctly and properly handles the data.

(3) Test problems showed the ability to analyze balance/imbalance function areas using the PROGNOZ-PLATFORM analytical framework.

(4) The practical result of the test problems solving is seen in the possibility for giving off land for the new housing allocation in the long term, as the sanitary quality of the old and new buildings is provided and there are reserves for consolidation the development.

(5) City planning documentation in chart form, as an integral part of ISOGD is good and, most importantly, affordable base for the comprehensive integrated platform of scientific planning of urban development creation. Created in the ArcGIS format, cartographic master plan materials (Land use and development regulations and Local standards of urban planning), if they represent an analytical tool like PROGNOZ-PLATFORM, can be used for spatial analysis and study of the interaction of processes of socio-economic and spatial development of the city.

6   ACKNOWLEDGMENTS

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