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Regional land-taking processes in Italy: a study concerning Sardinia

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1. Introduction

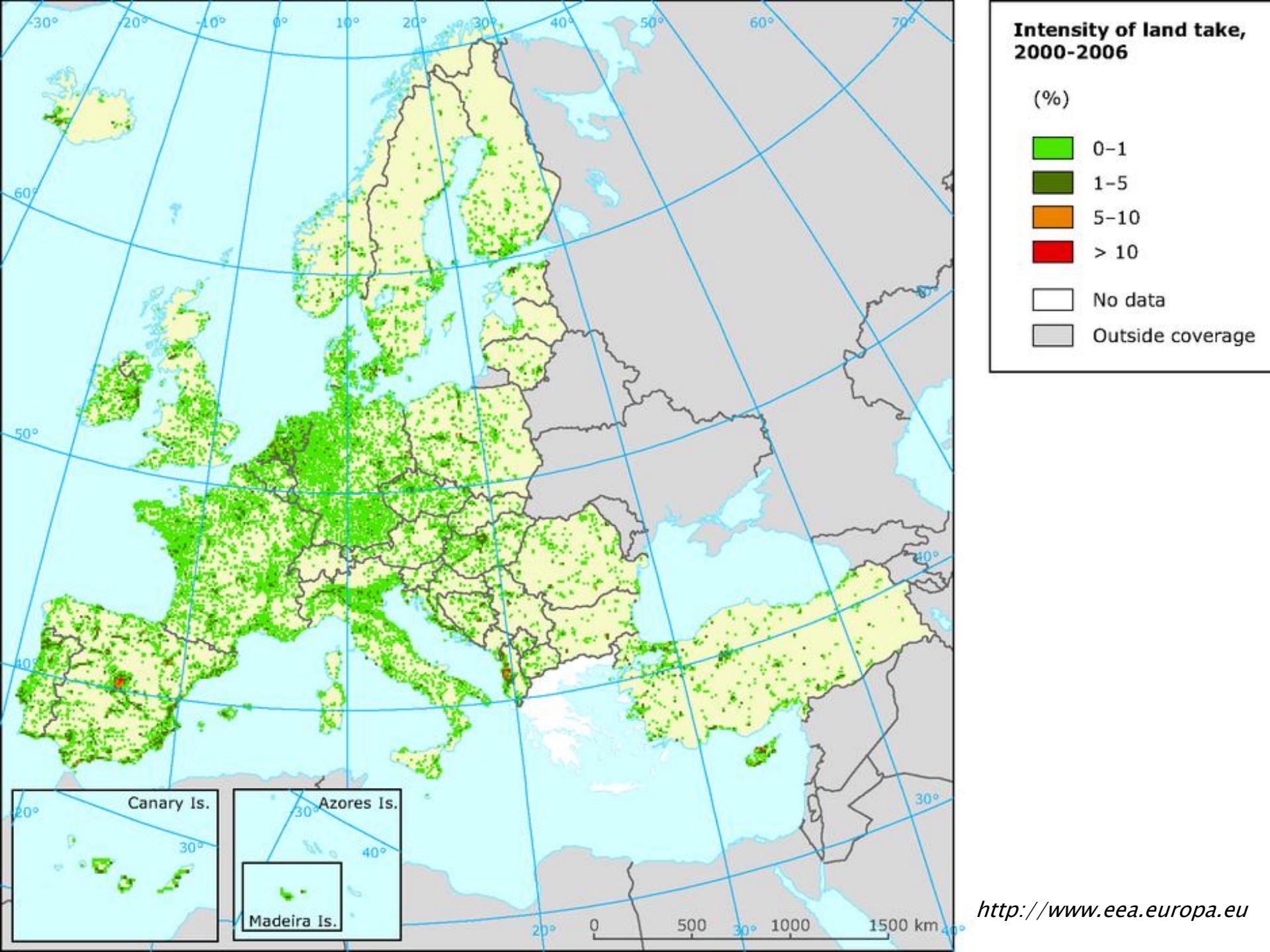
Land take is a process of significant relevance in the EU:

- **goal**: no net land take by 2050
- **impacts** of EU policies on LT to be taken under control in 2014-20

(Communication of the EC to the European Parliament no. 571 /2011)

In the EU, land take amounted to:

- >1,000 km^2 /year (1990-2000)
- ≃920 km^2 /year (2000-2006)



http://www.eea.europa.eu

1. Introduction

In Italy:

- In 2009: artificial land cover 7.3%
- Average growth rate: 1990-2000 ≃6%
  2000-2006 ≃3%

- No systemic information at the national level
- But … some regional geographic information systems in place

- Sardinia: 2003 and 2008 land cover maps of Sardinia
- Possible to relate land take with spatial, economic and planning/ policy-related variables
- Results and inferences can be easily generalized to other EU regions if geographic databases are available.

2. Defining "land take" (a)

To reach no net land take by 2050 is regarded by the EC as an important milestone for a resource-efficient Europe because of possible consequences of land take:

- Soil sealing
- Soil contamination and erosion
- Decrease in soil organic content
- Decrease in agricultural production and productivity

- Impacts on the carbon cycle
- Impacts on water cycle and microclimate
- Impacts on biodiversity
- Impacts on agricultural production

2. Defining "land take" (b)

COM 571 /2011 does not state how to define land take.

- **Land Use and Cover Areas frame Survey (LUCAS)** of EUROSTAT:
  2 types of "**artificial land**" (land *taken* by land-taking processes)
  - "*non built-up*" areas.
  - "*built-up*" areas (further classed according to the no. of floors of their buildings).

- **COoRdination de l'INformation sur l'Environnement (CORINE)** Land Cover vector map (CLC) of the EEA: 4 types of "**artificial surfaces**"
  - Urban fabric.
  - Industrial, commercial and transport units.
  - Mine, dump and construction sites.
  - Artificial, non-agricultural vegetated areas.

LUCAS Surveying Europes Landscape
Land Use / Cover Area Frame Statistical Survey

Corine land cover
European Environment Agency

It is difficult and controversial to identify a precise measure of land take. Therefore, it is difficult to implement rigorous quantitative studies on land take.

2. Defining "land take" (c)

(from Prokop et al, 2011)

At least two relevant general issues:

- First, can we say that land take is always negative?
  - Some types of land take do not generate the listed impacts.
  - E.g.: soil sealing (≃ 50% of the land taken is sealed).

- Second, why existing uses should be preferred over the new ones?
  - Land-take is caused by pressure in favor of settlement development.
  - Heavy taxation could be the most effective means to counter demand for land take.

We do not propose ethic narratives or value judgments on land take.

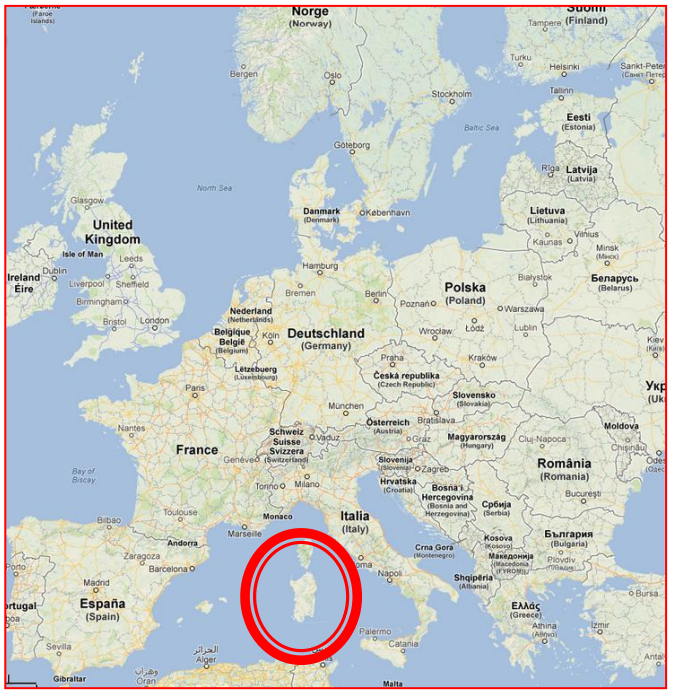
We analyze land-taking processes in order to understand which factors, and possibly to what extent, can be considered relevant to explain the phenomenon.

2. Defining “land take” (d)

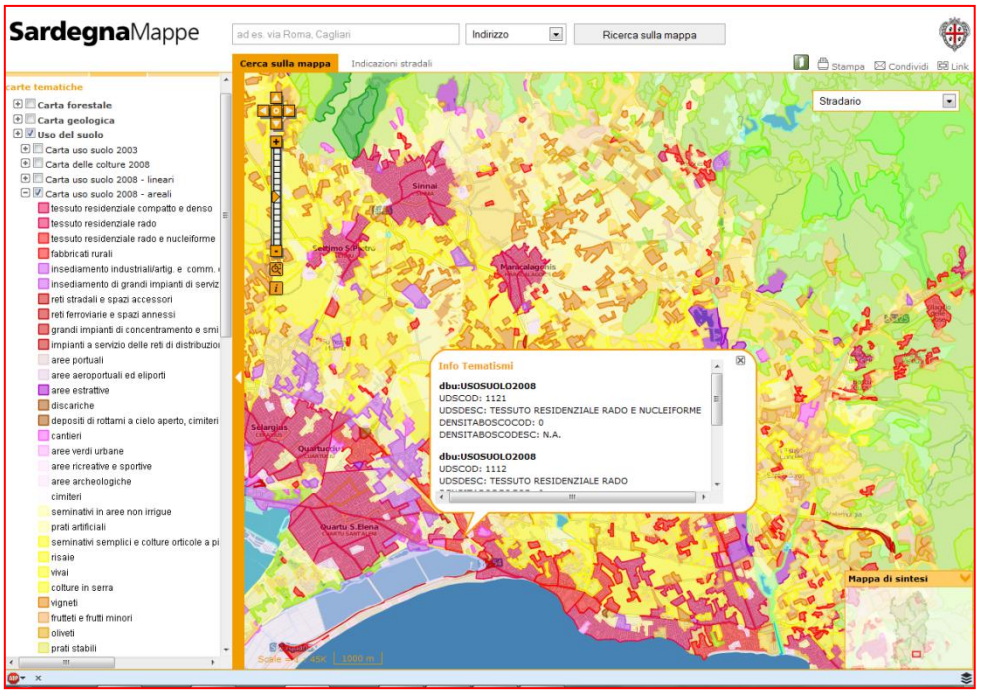
Our analysis is implemented with reference to Sardinia, an Italian autonomous region, and an island in the Mediterranean Sea.

Sardinia has advanced land-cover maps

- based on the CLC classification (4th level)
- available for 2003 and 2008
- that make it possible to analyze land cover changes.



http://maps.google.com/



http://www.sardegnageoportale.it/ webgis/sardegnamappe

2. Defining "land take" (e)

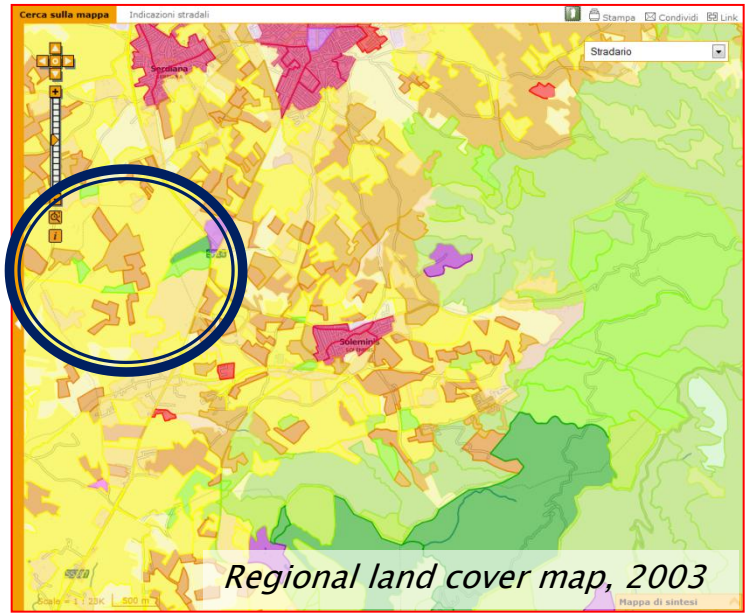
CLC classification (1st level)

- 1. artificial surfaces
- 2. agricultural areas
- 3. forests and semi-natural areas
- 4. wetlands
- 5. waterbodies.

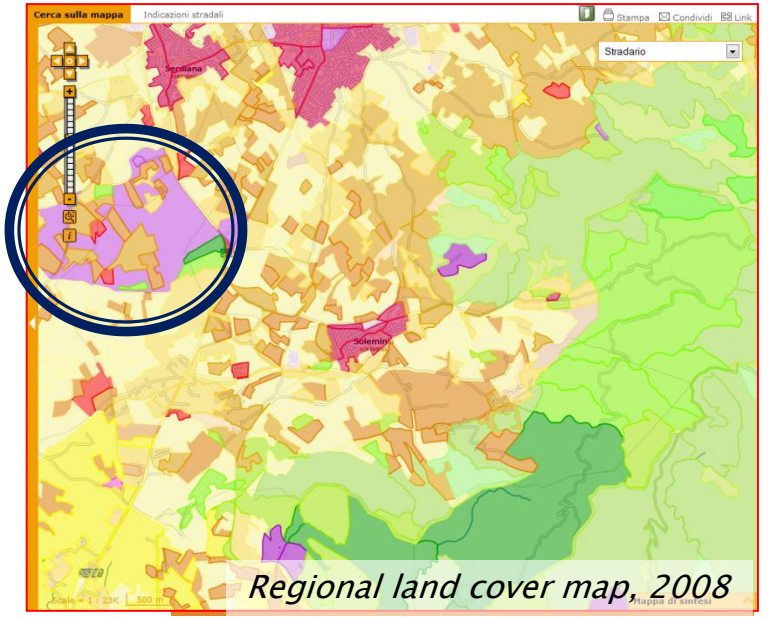
non artificial classes

Land-taking process is here identified as the 'shift'of areas from non artificial classes in the 2003 map to the "artificial surfaces" class in the 2008 map.

Sardinia has experienced an increase in artificial land
from 2.75% in 2003 (66,206 ha)
to 3.22% in 2008 (77,516 ha).



Regional land cover map, 2003



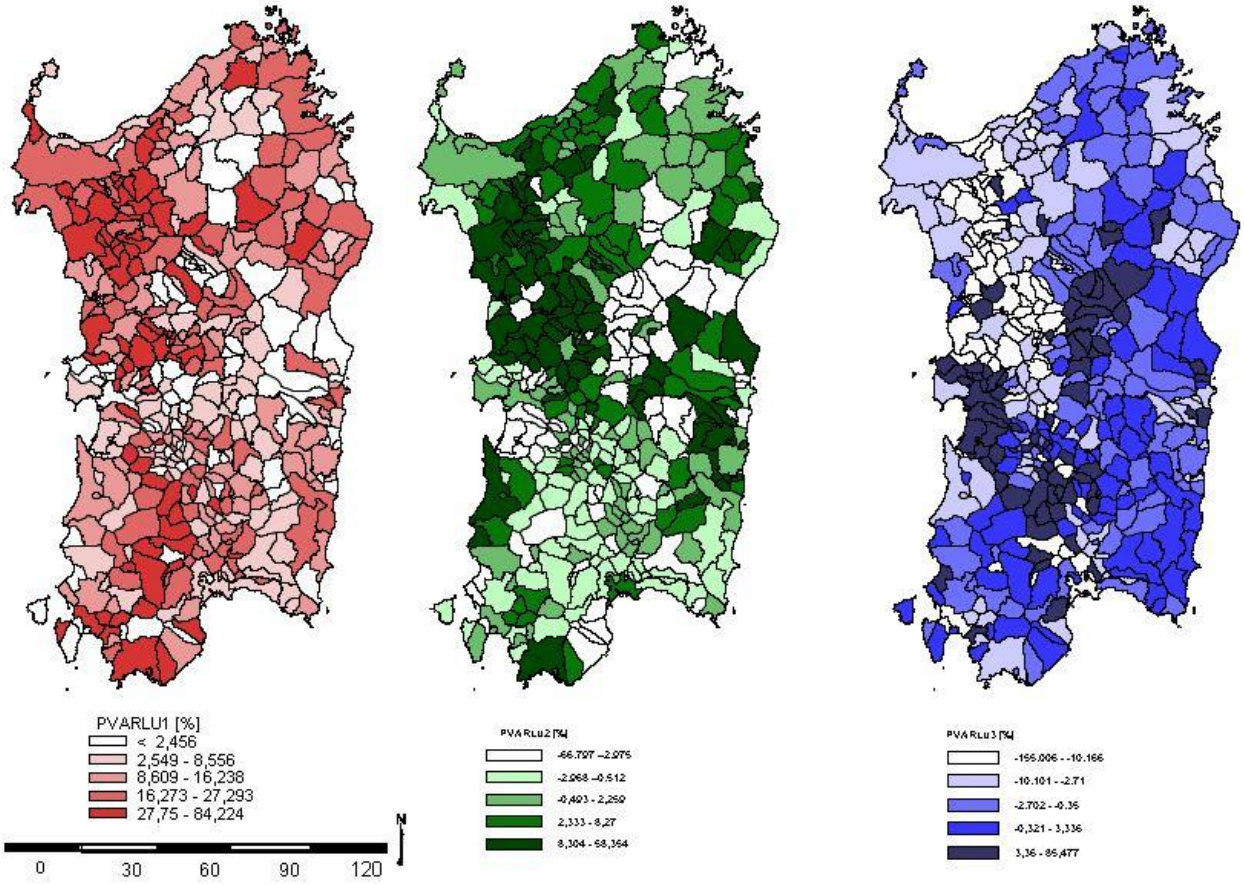
Regional land cover map, 2008

2. Defining "land take" (f):
land-cover variables & descriptive statistics

Variable	Definition	Mean	St.dev.
ARTIF03	Artificial land cover in 2003 (ha)	175.62	318.47
NARTIF03	Non-artificial land cover in 2003 (ha)	6,212.60	5,993.52
NARTIF08	Non-artificial land cover in 2008 (ha)	6,181.76	5,956.36
PERLTAKE	2003-2008 percent change from non-artificial to artificial land cover	0.53	0.99
PVARLU1	2003-2008 percent change in artificial land cover	13.55	18.81
PVARLU2	2003-2008 percent change in non-artificial land cover, agricultural areas	2.39	12.57
PVARLU3	2003-2008 percent change in non-artificial land cover, forests and semi-natural areas	-4.65	24.32
PVARLU4	2003-2008 percent change in non-artificial land cover, wetlands	0.96	32.57
PVARLU5	2003-2008 percent change in non-artificial land cover, waterbodies	11.51	59.69

The analysis is carried out at the municipal level.

2. Defining "land take" (g): spatial representation



Spatial representation of the variables PVARLU1, PVARLU2 and PVARLU3 at the municipal level (20th, 40th, 60th, and 80th percentiles).

3. Factors related to land take

Land take is related to physical, socio-economic and planning determinants (Sklenicka et al., 2013; Huang et al., 2006), and it is a consequence of pressure for future land development (CRCS, 2012).

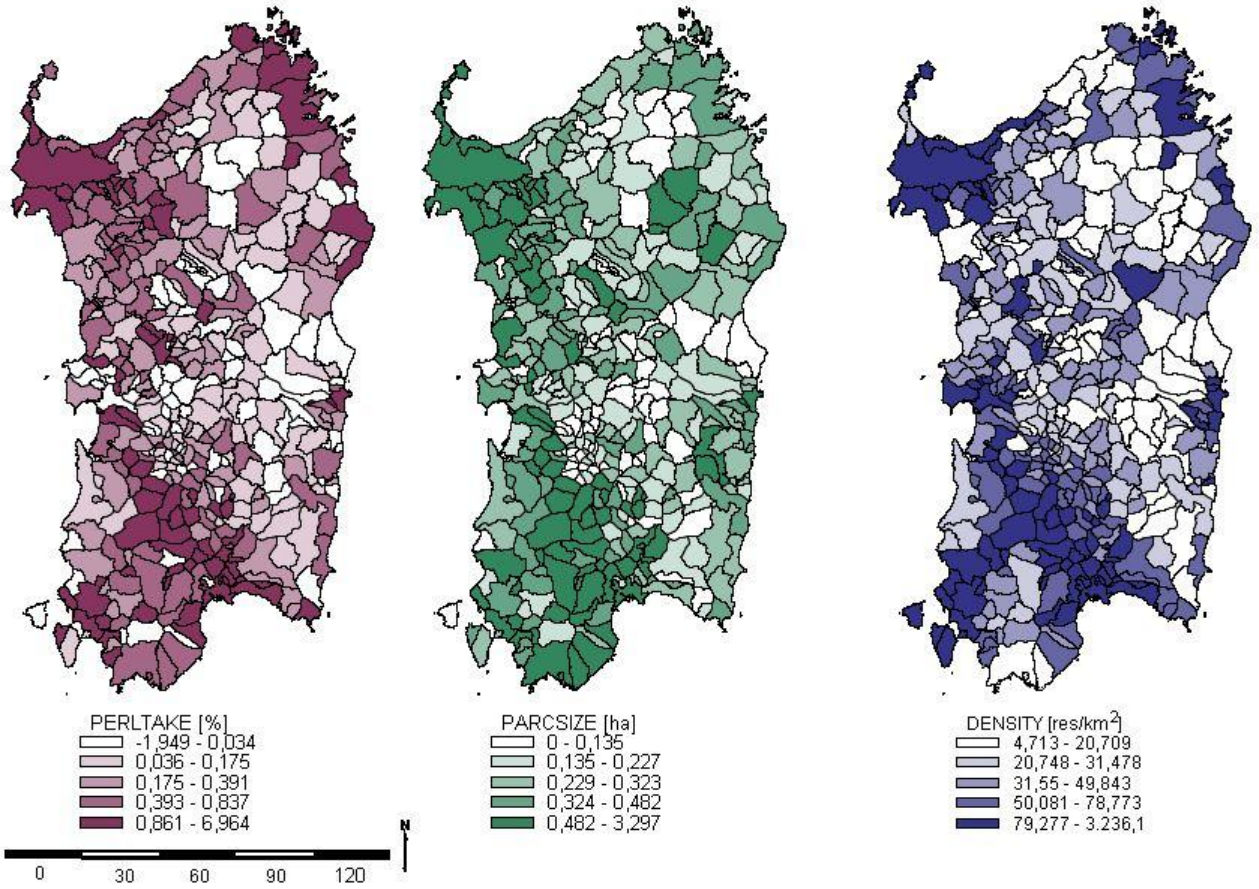
	Variable	Definition	Mean	St.dev.
Location-related and physical determinants	*PARCSIZE*	Municipality's average size of areas classified as non-artificial in 2003 and artificial in 2008 (ha)	0.33	0.29
	SLOPE	Municipality's average slope of areas classified as non-artificial in 2003 and artificial in 2008 (%)	8.97	6.60
	PROXSETL	Municipality's weighted average distance from areas classified as non-artificial in 2003 and artificial in 2008 CLC to the closest urban center (km); weight = area size	2.62	1.64
	ACCESS	Endowment of roads connecting regional town and city centers per unit of municipal land area (km/km^2)	0.95	0.47
	DISTCAPC	Distance of a municipality from the regional capital city, Cagliari (km)	126.45	71.17
	DISTNEAC	Distance of a municipality from the closest province administrative center (km)	30.98	16.67
	DISCOAST	Municipality's weighted average distance of areas classified as non-artificial in 2003 and artificial in 2008 from the shoreline (km); weight = area size	21.02	13.99
Planning code determinants	*CONSAREA*	Municipality's total protected area in 2008: parks, reserves, etc. (ha)	1,342.74	2,632.62
	NATAR	Municipality's landscape components with an environmental value, defined as natural and seminatural areas that change from non-artificial to artificial land cover in 2003-2008 (ha)	11.67	26.05
	AGRFORAR	Municipality's landscape components with an environmental value, defined as agricultural and forestry areas that change from non-artificial to artificial land cover in 2003-2008 (ha)	25,70	50.83
	COASTRIP	Percentage of a municipality's area included in the CS	11.18	24.96
	OLDPLAN	Municipality's area classed under the planning code in force before 2006 as area where land transformations and new developments are almost totally forbidden that changes from non-artificial to artificial land cover in 2003-2008 (ha)	14.85	43.06
Socio-econ.	*DENSITY*	Municipality's population density in 2008 (residents/km^2)	77.42	209.25
	INC2008	Municipality's real per-capita income in 2008 (euros; 2008 consumer price index = 1)	9,212.95	1,391.61

3. Factors related to land take: correlations

- High and positive correlation between PERLTAKE and PARCSIZE.
- Lower, and yet relevant, positive correlation between PERLTAKE on the one hand and DENSITY, NATAR, AGRFORAR and INC2008 on the other hand.
- Highest negative values of the correlation coefficient: between PERLTAKE on the one hand and the variables SLOPE, DISTNEAC and DISTCOAST on the other hand, although the linear correlation is not very relevant.

Variable	Pearson's ρ
PARCSIZE	0.68
DENSITY	0.40
NATAR	0.36
AGRFORAR	0.33
INC2008	0.32
OLDPLAN	0.21
COASTRIP	0.19
ACCESS	0.12
PROXSETL	0.06
CONSAREA	-0.06
DISTCAPC	-0.08
DISTCOAST	-0.20
DISTNEAC	-0.21
SLOPE	-0.22

3. Factors related to land take: spatial representation



Spatial representation of the variables PERTAKE, PARCSIZE and DENSITY at the municipal level (20th, 40th, 60th, and 80th percentiles).

4. Results (1)

- Do factors cited in the literature relate to land-take processes?
- If so, to what extent?
- Ordinary Least Square model (dependent variable: PERLTAKE)

Variable	Coefficient$_i$	Stand.error	t-statistic	Hypothesis test: coeff.=0
Constant	-1.1696	0.3047	-3.839	-0.0001
PARCSIZE	2.3516	0.1443	16.300	0.0000
SLOPE	0.0018	0.0056	0.327	0.7436
PROXSETL	-0.0111	0.0261	-0.427	0.6696
ACCESS	0.2378	0.0833	2.855	0.0046
DISTCAPC	0.0013	0.0005	2.437	0.0153
DISTNEAC	0.0025	0.0023	1.107	0.2690
DISTCOAST	0.0015	0.0031	0.476	0.6347
CONSAREA	-2E-05	1E-05	-1.754	0.0803
NATAR	-0.0026	0.0021	-1.214	0.2256
AGRFORAR	0.0003	0.0009	0.347	0.7291
COASTRIP	-9E-05	0.0018	-0.048	0.9617
OLDPLAN	0.0021	0.0011	1.878	0.0612
DENSITY	0.0016	0.0002	8.889	0.0000
INC2008	4E-05	3E-05	1.202	0.2301
Adjusted R-squared= 0.5918				

4. Results (2)

- Next, an OLS-regression model is run, including only covariates whose coefficients are significant at 30% in the OLS model.
- The model with a reduced set of explanatory variables confirms the estimates of the OLS model.

Variable	Coefficient$_i$	Stand.error	t-statistic	Hypothesis test: coeff.=0
Constant	-1.1068	0.2664	-4.1540	0.0000
PARCSIZE	2.3407	0.1379	16.9780	0.0000
ACCESS	0.2400	0.0759	3.1630	0.0017
DISTCAPC	0.0012	0.0005	2.3550	0.0191
DISTNEAC	0.0028	0.0021	1.3380	0.1817
CONSAREA	-3E-05	1E-05	-1.9350	0.0537
NATAR	-0.0023	0.0019	-1.1830	0.2378
OLDPLAN	0.0020	0.0010	1.8990	0.0583
DENSITY	0.0016	0.0002	9.0300	0.0000
INC2008	3E-05	3E-05	1.1450	0.2528
Adjusted R-squared= 0.5964				

4. Results (3)

- Finally, a censored-regression model (Tobit) is run in order to check the robustness of the OLS estimates. This is justifiable because about 80% values of PERLTAKE take values in the interval (0,1).
- The model's estimates confirm the results of the OLS model, with the exception of the variable NATAR, which is less significant than in the case of the OLS.

Variable	Coefficient$_i$	Stand.error	t-statistic	Hypothesis test: coeff.=0
Constant	-0.5120	0.1330	-3.849	0.0001
PARCSIZE	1.4791	0.0940	15.736	0.0000
ACCESS	0.1309	0.0372	3.521	0.0004
DISTCAPC	0.0004	0.0003	1.395	0.1630
DISTNEAC	0.0014	0.0010	1.364	0.1726
CONSAREA	-2E-05	6E-06	-3.405	0.0007
NATAR	0.0029	0.0012	2.347	0.0189
OLDPLAN	0.0004	0.0006	0.653	0.5138
DENSITY	0.0008	0.0002	3.352	0.0008
INC2008	2E-05	1E-05	1.208	0.2269
Decomposition-based fit measure=0.5266				

5. Discussion and conclusion (intro)

- The analysis of land-taking processes has been carried out
  - by looking at variables whose relevance has been put forward in several studies concerning land take
  - through censored and OLS regression models.

- The set of variables here considered includes location-related and physical determinants, planning code rules, and socio-economic factors.

5. Discussion and conclusion (1)

1. A double agglomeration effect is highlighted, since land-taking processes are positively and significantly related to

- high population density
- high concentration of land which changes its status from non-artificial to artificial.

Policy implications:

- **low-density settlements**
- **extensive and light land-taking processes**

5. Discussion and conclusion (2)

2. The more a municipality is accessible, the more it is suitable to land-taking processes.

Policy implication:

- **To balance accessibility opportunities at the regional level**

3. The presence and size of protected areas is negatively and significantly connected to land take.

Policy implication:

- **conservation of natural resources (incl. habitats & species)**

5. Discussion and conclusion (3)

4. OLDPLAN is positively correlated to land take: The more conservative planning rules are weakened, the more land-taking processes occur.

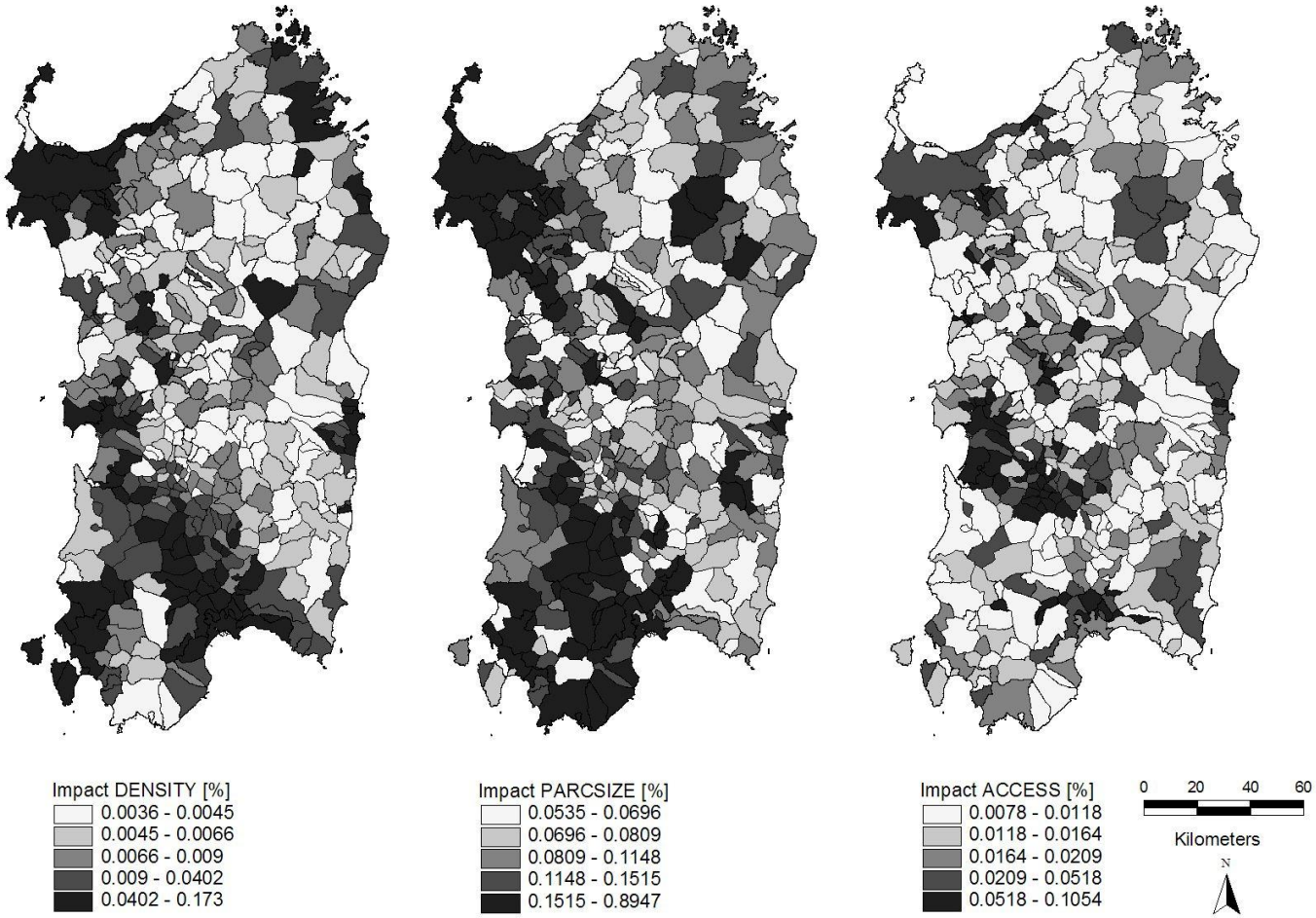
5. No correlation between land-taking processes and the variables COASTRIP and DISCOAST: land take was not a coastal phenomenon in 2003-2008.

In the '80s & '90 it was, so this could only be related to conservative planning rules (landscape planning).

6. A slight, statistically-significant at 25% only, positive income effect indicates that a more balanced income distribution could help limit spatial concentration of land-taking processes.

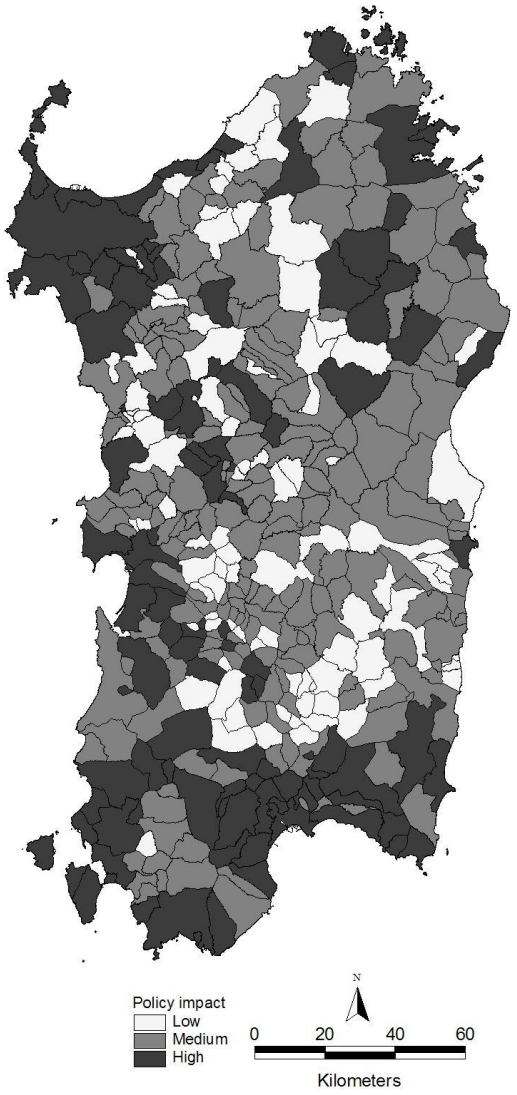
5. Discussion and conclusion (4)

- GIS-based discussion of policy implications,
- "What-if" scenario
- What would the magnitude of the impact on PERLTAKE be if a single explanatory variable increased by a given quantity?



5. Discussion and conclusion (5)

- Cumulative impacts can also be estimated.



5. Discussion and conclusion (6)

- The methodology can be easily replicated and exported with reference to other Italian and European contexts and results could be straightforwardly comparable.

- Policy implications of the findings could be a point of reference for future Italian and European land-use and planning policies which entail a careful consideration of the negative impacts of artificialization of land.