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Factors Affecting Land-Taking Processes in Italy at the Regional Scale: Empirical Findings from Sardinia



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Layout

1. Introduction
2. Defining land take
3. Factors related to land take
4. Results
5. Discussion and conclusion

Lai S.



Zoppi C.

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Italy at the Regional Scale:
Empirical Findings from Sardinia



1. Introduction

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

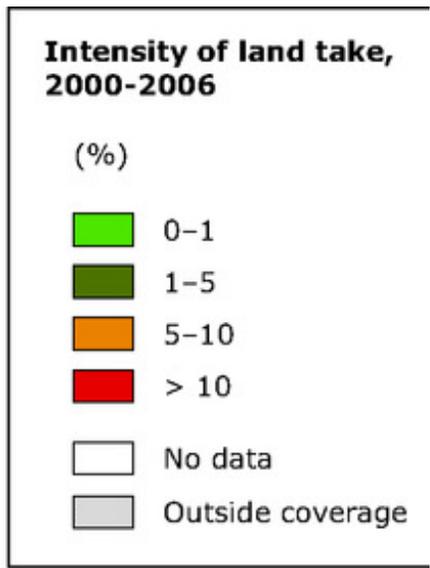
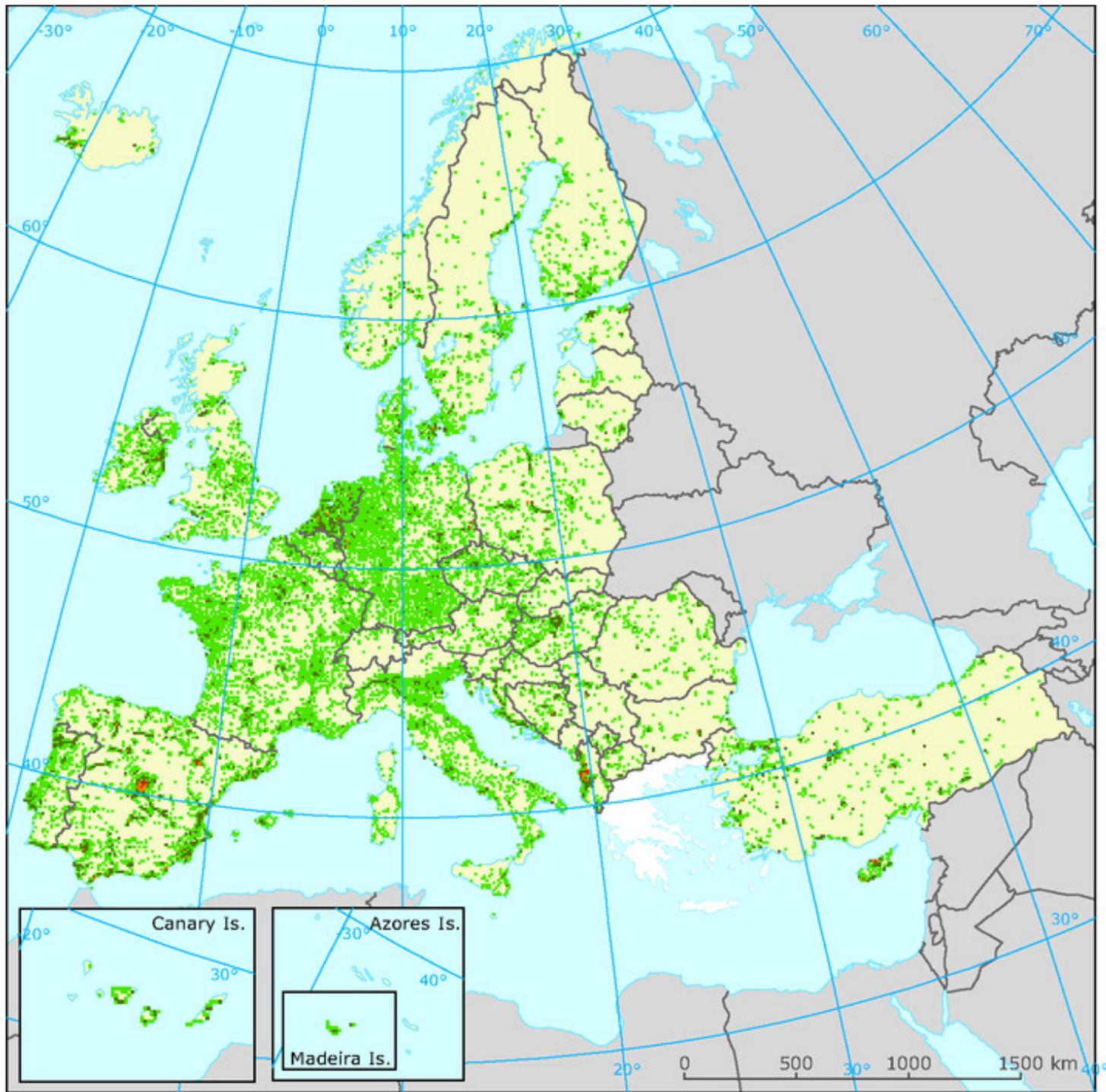
- **goal**: no net land take by 2050
- **impacts** of EU policies on LT to be taken under control in 2014-20

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

In the EU, land take amounted to:

- >1,000 km² /year (1990-2000)
- \simeq 920 km² /year (2000-2006)





<http://www.eea.europa.eu>

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 Europe's 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.**

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2. Defining “land take” (c)

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 (\approx 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.



(from Prokop et al, 2011)

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.

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Italy at the Regional Scale:
Empirical Findings from Sardinia



2. Defining “land take” (d1)

As of today, no detailed maps are available to describe, measure and compare land take over a large period of time in Italy. The European Environment Agency (EEA) does produce and make available land-cover maps but only from 1990 onwards ; moreover, the resolution of the map is not fully appropriate at the regional scale. Therefore, because we aimed at studying the process at the regional scale and by looking at a much larger space of time, we chose to study land take by integrating various sources as follows:

- ▶ two vector layers belonging to the dataset of the Regional Landscape Plan of Sardinia (RLP) (produced in 2006 and available from the regional geoportal) that respectively describe historic settlements, defined as urbanized areas as of the end of the XIX century on the basis of the maps produced by the (then) Royal Geographic Italian Military Institute, and urban developments as of the end of the 1950's, which in Sardinia were usually built adjacent to the historic settlements, preserving their comparatively high density and compactedness together with the characteristics of older urban tissues and of the architectural features of the built environment;

2. Defining “land take” (d2)

- ▶ a vector layer produced by the EEA and describing Urban Morphologic Zones (UMZ) as of 1990; these are defined by the EEA as “sets of urban areas laying less than 200m apart” and are identified on the basis of a selection of appropriate subclasses of the CLC class “artificial surfaces” contributing to the urban tissue and function;
- ▶ the 2008 Corine Land Cover Map produced by the Regional administration of Sardinia and available from the regional geoportal; this is a vector dataset from which we selected only polygons belonging to the first-level CLC class “artificial surfaces”.

The three above datasets differ in aim and resolution and for this reason they were preprocessed to avoid inconsistencies. As Figure 1 shows, such inconsistencies were corrected by means of basic geoprocessing operations. Hence, we use the Sardinian CLC-based land-cover maps for 2008, the EEA’s UMZ for 1990, and the above mentioned layers of the RLP to detect artificial land cover and land take in 1960.



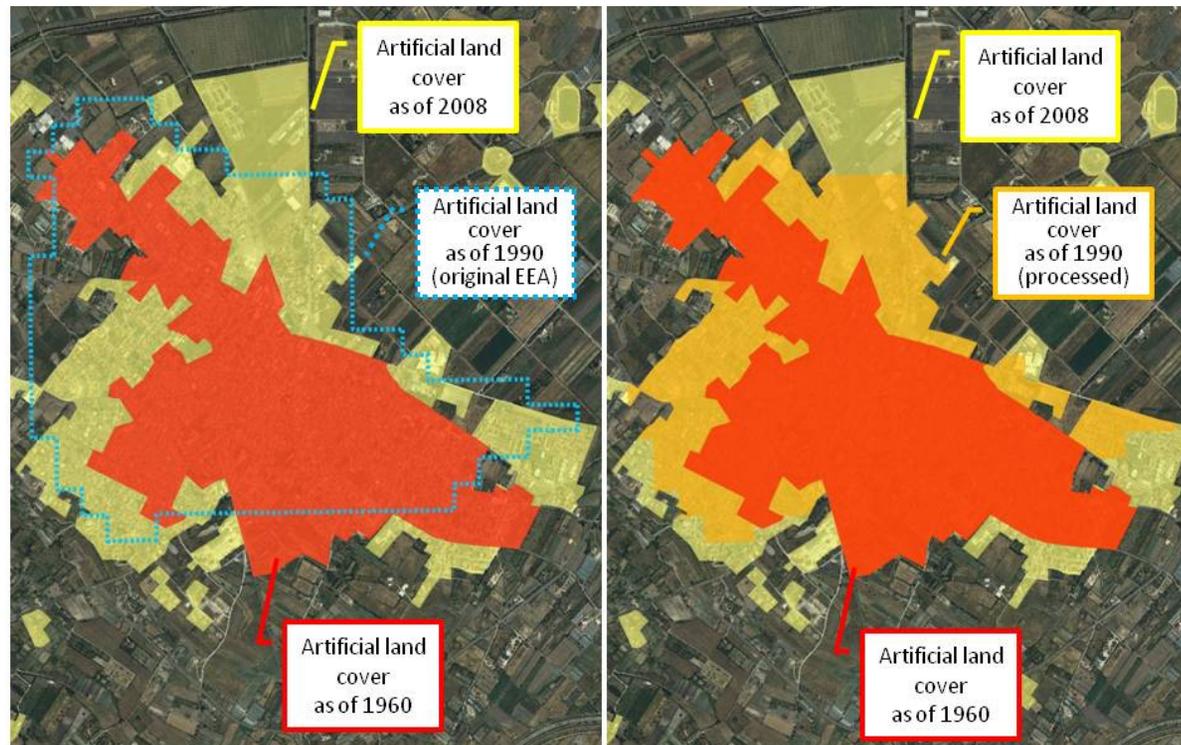
2. Defining “land take” (e)

In the CLC classification, non-artificial surfaces are classed into four classes (at Level 1): i. agricultural areas; ii. forests and semi-natural areas; iii. wetlands; and, iv. waterbodies.

The land-taking process is identified in this study as the passage of areas from non-artificial classes, either in 1960, for the period 1960-1990, or in 1990, for the period 1990-2008, to the artificial land-cover class, either in 1990, for the period 1960-1990, or in 2008, for the period 1990-2008.

Our analysis shows that Sardinia has experienced an increase in artificial land from 0.54 percent in 1960 (13,090 hectares) to 1.59 percent in 1990 (38,182 hectares), to 3.25 percent in 2008 (78,379 hectares)

non artificial classes



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

Variable	Definition	Mean	St.dev.
NURB1960	Municipality’s non-urbanized areas in 1960 (ha) (source: RLP, Spatial Dataset of the Regional Geographic Information System of Sardinia, next SDRGISS)	6,353.51	6,157.73
NURB1990	Municipality’s non-urbanized areas in 1990 (ha) (source: CLC, SDRGISS)	6,286.95	6,081.00
NURB2008	Municipality’s non-urbanized areas in 2008 (ha) (source: Corine Land Cover Map of Sardinia – 2008 Edition, level 1, next CLCMS08, SDRGISS)	6,180.33	5,963.59
PLT6090	Percentage of municipal area whose land cover changed from non-urbanized to urbanized between 1960 and 1990	1.05	2.58
PLT9008	Percentage of municipal area whose land cover changed from non-urbanized to urbanized between 1990 and 2008	1.89	2.35

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Factors Affecting Land-Taking Processes in
Italy at the Regional Scale:
Empirical Findings from Sardinia



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 60-90	St.Dev. 60-90	Mean 90-08	St.Dev. 90-08
Location-related and physical determinants	<i>PSIZ6090</i> <i>PSIZ9008</i>	Municipality's average size of areas classed as non-urbanized in 1960/1990 and urbanized in 1990/2008 (PSIZ6090/PSIZ9008) (ha) (source: RLP, CLC, CLCMS08)	4.60	7.18	2.07	1.25
	<i>SLOP6090</i> <i>SLOP9008</i>	Municipality's weighted average slope of areas classed as non-urbanized in 1960/1990 and urbanized in 1990/2008 (SLOP6090/SLOP9008) (percent); weight = area size (source: RLP, CLC, CLCMS08, Digital Terrain Model of Sardinia)	6.99	7.08	9.56	6.19
	<i>PRS6090</i> <i>PRS9008</i>	Municipality's weighted average distance from the closest urban center to areas classed as non-urbanized in 1960/1990 and urbanized in 1990/2008 (PRS6090/PRS9008) (km); weight = area size (source: RLP, CLC, CLCMS08, SDRGISS)	0.96	1.54	2.43	1.51
	<i>ACCESS</i>	Endowment of roads connecting regional town and city centers per unit of municipal land area (km/km ²) (source: SDRGISS)	Mean	0.96	St.Dev.	0.47
	<i>DISTCAPC</i>	Distance of a municipality from the regional capital city, Cagliari (km) (source: Google Maps)	Mean	126.46	St.Dev.	71.27
	<i>DISTNEAC</i>	Distance of a municipality from the closest province administrative center (km) (source: Google Maps)	Mean	30.99	St.Dev.	16.70
	<i>DISC6090</i> <i>DISC9008</i>	Municipality's weighted average distance from the shoreline to areas classed as non-urbanized in 1960/1990 and urbanized in 1990/2008 (DISC6090/DISC9008) (km); weight = area size (sources: RLP, CLC, CLCMS08, SDRGISS)	17.23	14.98	21.05	13.91
	Planning code determinants	<i>CONSAREA</i>	Municipality's total protected area: parks, reserves, etc. (ha) (sources: SDRGISS)	Mean	1,342.74	St.Dev.
<i>NAT6090</i> <i>NAT9008</i>		Municipality's landscape components with environmental value, defined as natural and seminatural areas, that change from non-urbanized to urbanized between 1960/1990 and 1990/2008 (NAT6090/NAT9008) (ha) (sources: RLP, CLC, CLCMS08)	2.73	13.45	10.79	22.16
<i>AGFO6090</i> <i>AGFO9008</i>		Municipality's landscape components with environmental value, defined as agricultural and forestry areas, that change from non-urbanized to urbanized between 1960/1990 and 1990/2008 (AGFO6090/AGFO9008) (ha) (sources: RLP, CLC, CLCMS08)	3.12	11.25	24.11	47.93
<i>COASTRIP</i>		Percentage of a municipality's area included in the CS (ha) (source: RLP; SDRGISS)	Mean	1.22	St.Dev.	2.41
<i>OLPL6090</i>		Municipality's area classed in the planning code in force before 2006 as areas where	20.35	87.46	36.04	90.98

4. Results (1) – 1990-1960

- 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
<i>Constant</i>	-0.9315	0.2730	-3.413	0.0007
<i>PSIZ6090</i>	0.1122	0.0106	10.627	0.0000
<i>SLOP6090</i>	0.0018	0.0101	0.174	0.8621
<i>PRS6090</i>	-0.0740	0.0495	-1.494	0.1361
<i>ACCESS</i>	0.2315	0.1431	1.618	0.1065
<i>DISTCAPC</i>	-0.0018	0.0009	-1.944	0.0527
<i>DISTNEAC</i>	0.0073	0.0039	1.867	0.0627
<i>DISC6090</i>	0.0066	0.0051	1.299	0.1947
<i>CONSAREA</i>	-4.1E-05	2.5E-05	-1.624	0.1053
<i>NAT6090</i>	0.0337	0.0063	5.359	0.0000
<i>AGFO6090</i>	-0.0290	0.0082	-3.517	0.0005
<i>COASTRIP</i>	0.1483	0.0330	4.499	0.0000
<i>OLPL6090</i>	0.0037	0.0008	4.397	0.0000
<i>DENS1961</i>	0.0075	0.0004	17.616	0.0000
<i>AUTC6090</i>	0.4777	0.0547	8.727	0.0000

Adjusted R-squared= 0.8024



4. Results (2) – 2008-1990

- ▶ 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
<i>Constant</i>	-1.7298	0.4922	-3.514	0.0005
<i>PSIZ9008</i>	0.8553	0.0679	12.588	0.0000
<i>SLOP9008</i>	-0.0150	0.0139	-1.073	0.2839
<i>PRS9008</i>	-0.0232	0.0691	-0.336	0.7372
<i>ACCESS</i>	0.7924	0.1869	4.239	0.0000
<i>DISTCAPC</i>	0.0011	0.0012	0.890	0.3741
<i>DISTNEAC</i>	0.0050	0.0054	0.917	0.3596
<i>DISC9008</i>	-0.0023	0.0076	-0.302	0.7626
<i>CONSAREA</i>	-7.0E-05	3.2E-05	-2.189	0.0293
<i>NAT9008</i>	-0.0024	0.0053	-0.450	0.6532
<i>AGFO9008</i>	0.0018	0.0021	0.841	0.4011
<i>COASTRIP</i>	0.1201	0.0443	2.712	0.0070
<i>OLPL9008</i>	0.0006	0.0013	0.447	0.6553
<i>DENS1990</i>	0.0026	0.0004	6.261	0.0000
<i>AUTC9008</i>	0.4222	0.0941	4.489	0.0000

Adjusted R-squared= 0.6289



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

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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 and, the lower a municipality's proximity to the nearest province administrative center (DISTNEAC) , the less the municipality is suitable to land take, which is an argument in favor of balancing accessibility as well

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:

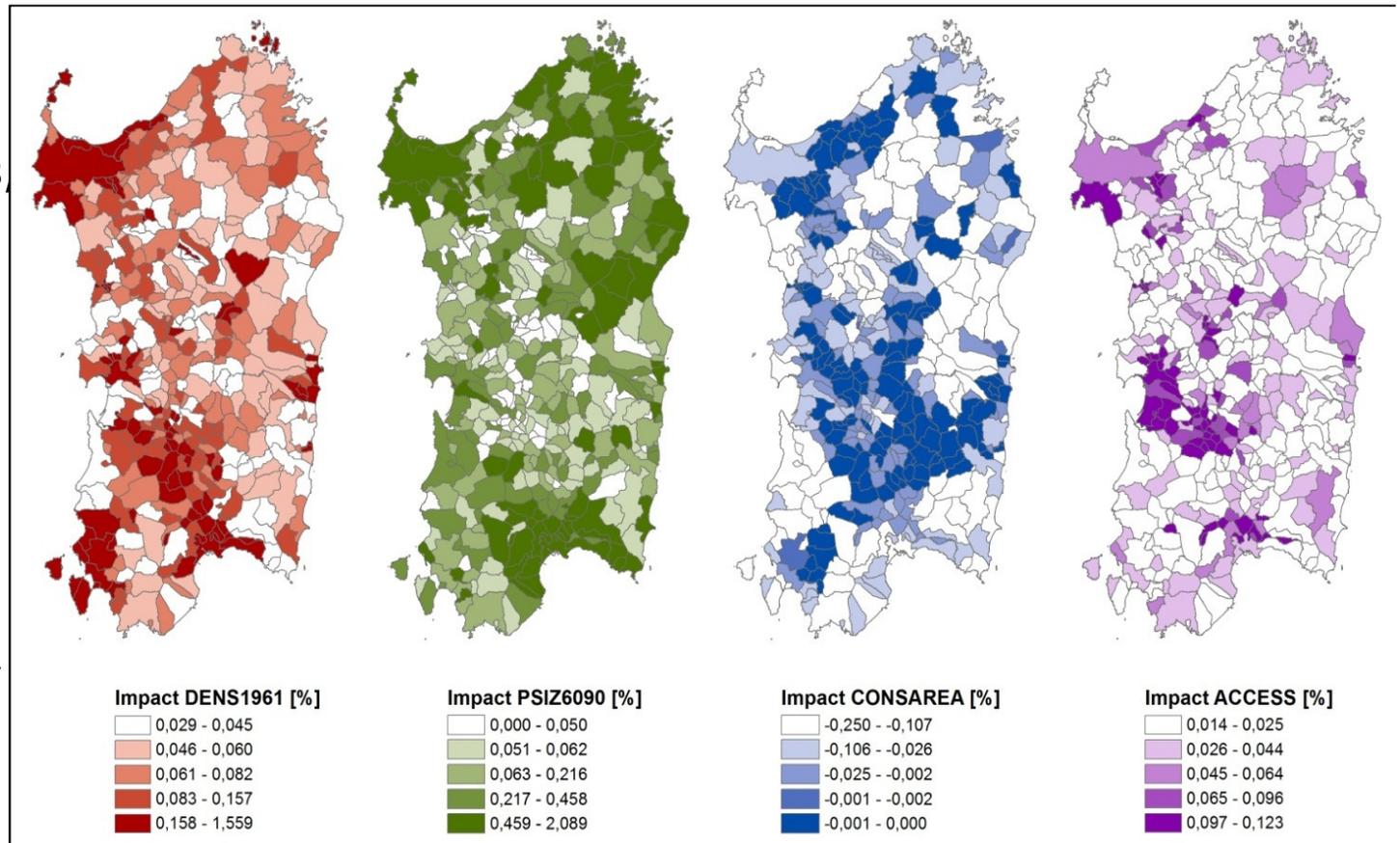
- **conservation of natural resources (incl. habitats & species)**

5. Discussion and conclusion (3)

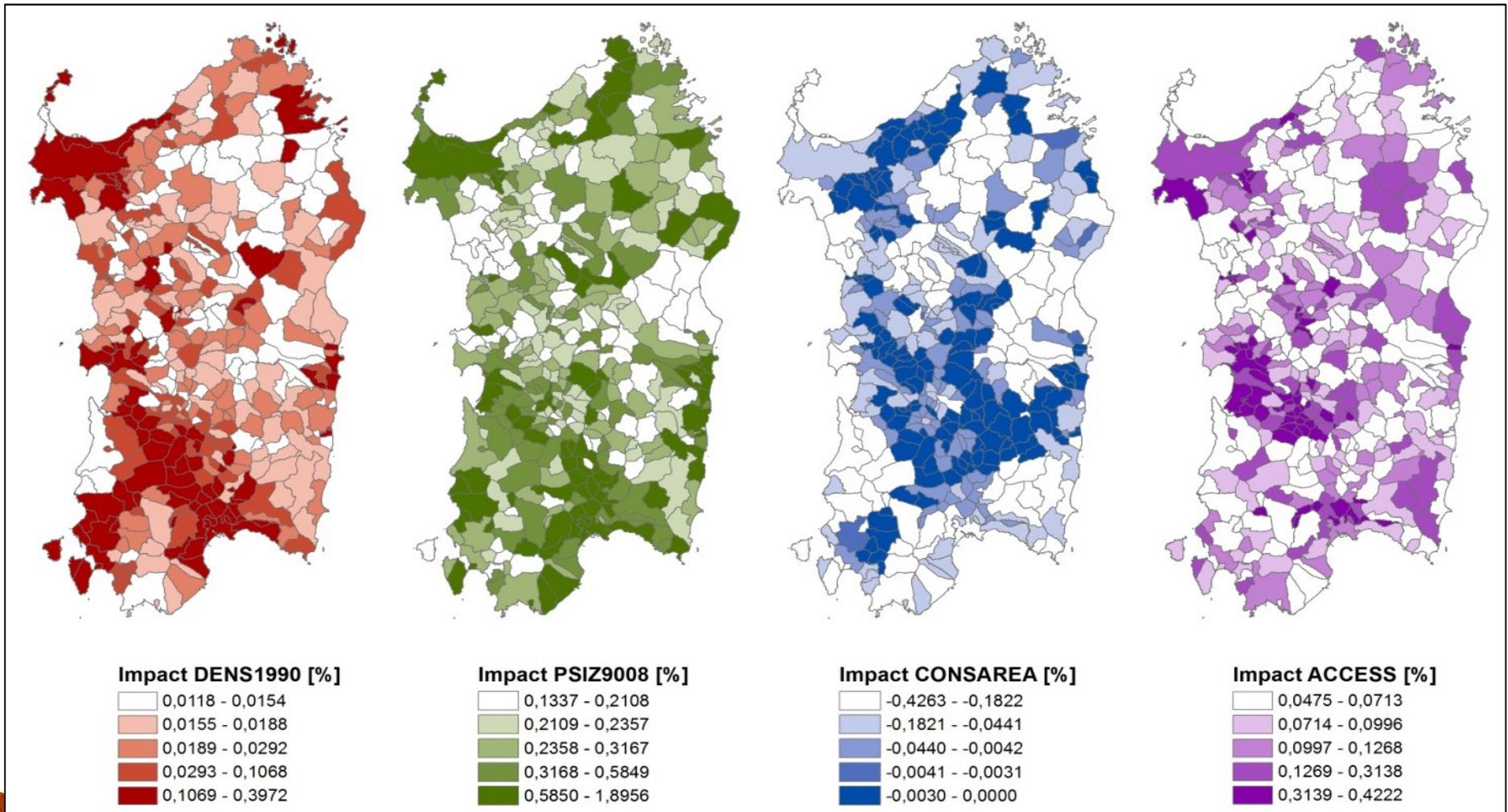
4. OLPL6090 and OLPL9008, and NAT6090 and NAT9008 are positively correlated to land take: the more conservative planning rules are weakened, the more land-taking processes occur.
5. The fact that protection of nature, environment and natural resources matters is also put in evidence by the absence of correlation between land-taking processes and the variable DISC9008, in the 1990-2008 time period, and the evidence of an impact of the variable DISC6090 on land take in the 1960-1990 time period. Since in the Sixties, Seventies and Eighties regional land-taking processes in Sardinia were almost exclusively concentrated in coastal municipalities, as the positive correlations between the variable COASTRIP and land take put in evidence in both periods, the non-coastal characterization of land take in the 1990-2008 period could only be related to the conservative planning rules that the regional landscape plans in force from 1990 to 2006 and the RLP, from year 2006 on, have implemented

5. Discussion and conclusion (4)

- ▶ GIS-based discussion of policy implications
- ▶ “What-if” scenario
- ▶ What would the magnitude of the impacts on PLT6090 and PLT9008 be if a single explanatory variable increased by a given quantity?



5. Discussion and conclusion (5)



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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.

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