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Determinants of land take at the regional scale: a study concerning Sardinia (Italy)

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ABSTRACT

In its "Roadmap to a Resource Efficient Europe" (Communication COM(2011) 571 of 20 September 2011), the European Commission (EC) established an ambitious goal for the European Union (EU), that of achieving no land take by 2050; towards this aim, a key milestone for the year 2020 was set, by stating that European policies in the programming period 2014–2020 ought to consider both their direct and their indirect impacts on land use in the EU. Within this framework, this paper builds upon the findings of a previous paper (Zoppi and Lai, 2014), in which we estimated the magnitude of land take over a short period of time (2003–2008) in Sardinia, an Italian NUTS2 region, and we assessed whether and how land take is related to a set of variables that are regarded as important determinants in the literature, such as parcel size, accessibility, and proximity to main cities and towns, to the coastline, or to protected areas.

In this paper we study the land-taking process taking Sardinia as a case study, in two larger time periods, 1960–1990 and 1990–2008. We assess if, and to what extent, these factors reveal similar, or different, effects in the two periods, and try to identify consistencies concerning the determinants of land take.

1. Introduction

We define land take as the "change of the amount of agriculture, forest and other semi-natural and natural land taken by urban and other artificial land development" (European Environment Agency, 2013a).

To assess the global relevance of land take is rather difficult, since only a few global land-cover datasets are currently available.[2] Among these, (i) a study carried out at the University of Maryland, which estimated that in 1992–1993 urban and built-up areas amounted to 0.18% of the world land area (Hansen et al., 2000:1350); (ii) the "Global Land Cover 2000" project (European Commission, Joint Research Centre, 2003), which assessed artificial land cover as 0.20% of the world land area in the year 2000; (iii) a series of maps produced by the European Spatial Agency (ESA Climate Change Initiative, 2014), which suggest that urban areas corresponded to approximately 0.54% of the world land area between 1998 and 2012; and (iv) Chen et al. (2014), according to whom the artificial land surface in 2010 equaled approximately a 0.88% of the total land surface. These studies and datasets differ in many important aspects such as definition of land cover classes, data sources, classification methodologies, and spatial resolution; such differences make it quite problematic to compare land cover over time at the global scale so as to assess land take worldwide.

In the European Union (EU), where datasets on land cover were consistently produced by the European Environment Agency for the time period 1990–2006 (European Environment Agency, 2013b), annual land take has been assessed at approximately 1000 km^2 per year between 1990 and 2000, slowly decreasing at about 920 km^2 between 2000 and 2006 (European Commission, 2011); artificial land has been estimated to amount to approximately 4% in 2006 (European Environment Agency, 2010:10), rather unevenly distributed.

In Italy, land take shows a trend pattern similar to that of the EU in that, according to a recent report produced by the National Research Institute for the Protection of the Environment (ISPRA, 2015, p. 10), the rate at which land is being taken has slowly decreased from approximately 250 km^2 per year between 1989 and 1998 to about 200 km^2 per year between 1990 and 2014. The same report (ISPRA, 2015, p. 10) also estimates that in 2014 a 7.0% of the Italian land area was artificial.

Within this context, our analysis relates to Sardinia, one of the two major Italian islands and a NUTS2 region. Findings and discussion proposed in this paper build upon the results of a previous paper (Zoppi and Lai, 2014) in which we estimated the magnitude of land take over a short period of time (2003–2008) in Sardinia. Here, consistently with our previous paper, we do not consider land take in ethical terms; rather, we assess what factors influence land take by looking at a set of variables that are regarded as important determinants in the literature (such as parcel size, accessibility, proximity to main cities and towns, to the coastline, or to protected areas) and estimate their quantitative impacts.

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[2] A list of available global land cover datasets, together with some information (e.g. year and resolution) is provided by Giri et al. (2013).

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In this paper we study the determinants of the dynamics of the land-taking process taking Sardinia as a case study, in two larger time periods, 1960–1990 and 1990–2008, and assess these processes in terms of variables influencing land take. We therefore evaluate if, and to what extent, these factors reveal similar, or different, effects in the two time periods, and try to identify consistencies concerning the determinants of land take.

The identification of the most significant physical, socio-economic and planning-related determinants (among which are parcel size, accessibility, population density and presence of nature conservation areas) is relevant in policy terms, since the European Commission (EC), in the "Roadmap to a Resource Efficient Europe" (Communication COM(2011) 571 of 20 September 2011), identifies no net land take as one of the objectives to be achieved by 2050, and sets a key milestone for the year 2020, by establishing that the EU 2014–2020 cohesion policy should consider both its direct and its indirect impacts on land use.

The second section starts by describing how we calculate land take and what set of factors we consider as determinants of Sardinian land take, and goes on to discuss the spatial representation and correlations of the land take variable and its covariates.

Findings from the implemented econometric model related to the correlations between land take and its determinants are presented in the third section, and qualitative and quantitative inferences are discussed. The paper concludes by proposing recommendations and suggestions concerning the definition and implementation of planning policies aimed at limiting or preventing land-taking processes, which may possibly be effective in addressing the EC recommendation on zero-land take by 2050.

2. Determinants of land-taking processes: data, correlations and spatial layouts

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 maps 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:

i. two vector layers belonging to the dataset of the Sardinian Regional Landscape Plan (RLP) (produced in 2006 and available from the regional geoportal) that respectively describe historic settlements, defined as artificial 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;
ii. 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 200 m apart" and are identified on the basis of a selection of appropriate subclasses of the CLC class "artificial surfaces" that characterize the urban fabric and layout;
iii. 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 Fig. 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.

In the Corine Land Cover (CLC) taxonomy, first-level (that is, general and broad) land cover categories of non-artificial surfaces are as follows: i. agricultural areas; ii. forests and semi-natural areas; iii. wetlands; and iv. waterbodies. We assume that land take occurs if an area changes its non-artificial condition, 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 concerning Sardinia shows that artificial land increased from 0.54% in 1960 (13,090 ha) to 1.59% in 1990 (38,182 ha), to 3.25% in 2008 (78,379 ha).[3]

We tentatively assume that land take, generated by demand for urbanization of non-artificial land (CRCS, 2012), depends on physical and planning rule-related factors, and on a social variable, that is residential density (Sklenicka et al., 2013; Huang et al., 2006).

We use the same covariates used by Zoppi and Lai (2014), classed in Table 1, which shows the definitions of the variables and the descriptive statistics concerning non-artificial and artificial land cover for all of the 377 Sardinian municipalities.

i. Physical factors:
   a. average size, slope and distance from the nearest town of a municipality's non-artificial-land areas in 1960 or in 1990, which became artificial in 1990 or in 2008 (Sklenicka et al., 2013; Cheshire and Sheppard, 1995; Palmquist and Danielson, 1989);
   b. accessibility, that is (Stewart and Libby, 1998), (i) endowment of roads connecting towns and cities of regional importance, classed by the Italian Code concerning Road Regulation (Italian law enacted by Decree n. 1992/285) as "Highways", "Main extra-urban roads" and "Secondary extra-urban roads;" (ii) proximity to the city of Cagliari, the regional administrative capital center and the most prominent regional metropolitan area; and (iii) proximity to the closest city or town hosting the headquarters of intermediate tiers of government (that is, in the Italian system, provinces);
   c. distance from the coast, since in Sardinia the-so called "coastal-strip" (CS) is considered a "strategic resource, vital for the achievement of sustainable development in Sardinia, that requires integrated planning and management" by art. 19 of the Planning Implementation Code (PIC) of the Regional Landscape Plan of Sardinia[4] (RLP); since the CS is subject to very strict conservative rules, a proximity effect related to land take could possibly be detected, as Dewi et al. (2013) put in evidence with reference to Asian and African protected forest areas.

ii. Planning-rule-related factors:
   a. endowment of protected areas; it would be expected that conservative policies which entail the presence of great amounts of protected areas could possibly limit or mostly prevent land-taking processes;
   b. areas classed as "landscape components with an environmental value, defined as natural and seminatural areas" and as "agricultural and forestry areas" by the PIC of the RLP; it would be expected that the change of the status of an area from non-artificial to artificial should be comparatively more difficult in such areas;
   c. areas located in the CS; in these areas the change from non-artificial to artificial land cover should be particularly unlikely, as already discussed;

[3] Due to differences in data sources and methodology, these findings are only partly consistent with data on land take provided by ISPRA, the National Agency for Environmental Protection and available at http://www.isprambiente.gov.it/files/comunicati-stampa/2014/Tabelle_consumo_di_suolo.pdf/at_download/file [accessed March 12, 2015].

[4] Available at: http://www.sardegnaterritorio.it/paesaggio/pianopaesaggistico.html [accessed March 12, 2015], which includes the PIC of the RLP, its cartography cartographical zoning classes and spatial dataset.