Retro-diagnosis methodology for land consumption analysis towards sustainable future scenarios: Application to a mediterranean coastal area

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ABSTRACT

Land consumption is a good indicator to directly diagnose present and future imbalances in territories, and indirectly, possible issues associated to the management of other resources. Therefore, after reaching the target of standardizing urban research that makes it possible to build healthier and greener cities, the real challenge for the future is to make the leap from urban scale to regional scale and deploy these policies in an integrated manner, in so-called “smart territories”.

In that context, this paper presents a model of multidisciplinary analysis through indicators based in land consumption and transformation rates. The model, called GIS-LiDAR retrospective analysis, is implemented through territorial information tools in order to simulate and diagnose possible future imbalances based on past and current trends. This innovative methodology will be applied in a Spanish Mediterranean coastal area called the Campo de Cartagena, a territory with issues related to low-density urban sprawl, intensive agriculture and mass tourism coastal urbanization. This territory of high economic activity and with important environmental protected areas like the Mar Menor lagoon as well as complex interrelated phenomena will be “retrohistorically” diagnosed from the perspective of land transformation over 60 years. The method, designed to advance future scenarios and help planners in decision-making, will show dangerous current trends leading to imbalances in this area so that future planning can be implemented with smart (sustainable) criteria.

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1. Introduction

A frequent controversial issue in developed countries refers to the influence of human activities on territory and its consumption of resources (Allais et al., 2015). Maintaining a careful balance between actions required for economic development, such as construction, agriculture or tourism, and the adequate conservation of the natural assets of territory is at times a complex equation difficult to solve (McCormick et al., 2013). The governance of the territory and the correct management of economic activities in relation to land consumption and its impact is one of the challenges of the future in modern societies, where economic activity must coexist inexorably with the environment (Zhang et al., 2015). In this context, one important field in the study of the impact of human activities is the determination of the behaviour pattern and the areas of influence of such activities to implement sustainable management of existing resources (Ben Letaifa, 2016).

The many variables that shape the development of territory require analysis in very different fields (economic, political, social, etc.). Decisions such as the pattern of urban growth, building infrastructure or landscape transformation for boosting economic activities are all issues to be addressed by assessing resource consumption with sustainability criteria (Callaway, 2016). Therefore, a large number of interrelated parameters that influence an iterative process which usually feeds on itself must be taken into account (Hashem et al., 2016).

In the last two decades, numerous initiatives encompassed under the concept of “smart city” have been developed aimed at providing a more sustainable framework for the improvement of metropolitan areas. However, this concept, implemented through innovation, the use of information technologies or optimization in the management of resources for example has widely diversified its meaning and scope in recent years (De Jong et al., 2015). During this time, the rather “classic” concept of smart city (Hollands, 2008; Nam and Pardo, 2011) has been evolving, being the subject of
reflection and analysis by various authors (Deakin and Al Wear, 2011; Lee et al., 2013 or Zygiaris, 2013). The smart city was focused initially toward an integrated vision of multiple solutions to manage a city’s assets (Mahzhan, 1999; Odendaal, 2003), although the breadth of technologies that have been implemented under the smart city label have made it currently more difficult to pin down a concrete definition of the actual concept. Nowadays, usual approaches to a smart city concept address various topics such as energy efficiency, information technology, transport infrastructure, resource consumption, environmental impacts or even hazards, among others (Neirotti, 2014; Fraker, 2013). However, as many authors have recently postulated, the smart city concept (of strong and innovative theoretical charge) has been materialized in practice very often over the last years through isolated ideas or disjointed projects (Anthopoulos, 2017). On occasions it has even become simple political slogans or commercial marketing products with no chance of implementation, or without constituting a response to an actual need for real improvement in the city (Grossi and Pianezi, 2017).

An aspect which policy-makers should pay attention to is the implementation of integrated territorial actions in these processes of transforming urban areas into real smart cities (Thite, 2011). Cases that are limited in range are readily available in the literature (Carter, 2013; Wey and Hsu, 2014). In this context, it is essential to perform a realistic proposal to introduce constraints and boundary conditions imposed by the territorial or sectoral regulations (O’Connell, 2009). In the field of enabling proposals to promote sustainable development, a common problem is very often the need to establish a spatial framework to address a coherent scope for action (a building, a neighbourhood, a specific parameter for the whole city, etc.). It is not difficult to find different successful examples in the specific literature, both pilot projects as well as material achievements (Walravens, 2015; De Jong et al., 2016). However, as some recent authors suggest, the current concept of smart city needs to evolve in a context where sustainability is an increasingly complex and evolving concept (Kummitha and Crutzen, 2017), if we seek to avoid many interesting proposals becoming isolated actions that cannot be incarnated in a suitable spatial framework to reach the target pursued. Current issues related to the sustainable management of resource consumption, transport or urban governance for example are not truly helpful if they approach only the geographical scope of a building or a neighbourhood (La Greca et al., 2011). The results obtained by this approach may lead to merely isolated actions with no connection to the rest of the city or the territory really affected by the issue analysed.

In this line, an aim to achieve in the transformation of these isolated actions into a true comprehensive performance (that would enable more sustainable and healthier areas) involves extending the classical concept of “smart cities” towards a wider idea of “smart territories”. In developing this idea, the need to implement multidisciplinary assessment must be taken into account to provide government expertise in global planning (urban sprawl, industry development, infrastructure investments, etc.) with sustainable criteria (Anato et al., 2015). This work should be carried out through instruments that could diagnose and monitor management issues to facilitate decision-making for territorial governance beyond the simple geographical context of a classical administrative urban delimitation (Hader and Rodzi, 2009). This is a qualitative target that would allow societies to enhance the concept of Smart City, improving it into a more comprehensive framework such as Smart Territory. The framework of Smart Territory could actually be in some cases more consistent with the original purpose of sustainability and efficiency from the concept of smart city.

In this context, the use of GIS (Geographic Information Systems designed to capture, store, manipulate, analyse, manage, and represent spatial data) and LiDAR (surveying methods based on 3D technology to represent high precision cartography by laser) tools can be very helpful. These instruments are able to simulate future scenarios, thus allowing decision makers to restrain trends oriented towards unsustainability in the context of territory and resources management (Pozoukidou and Ntriankos, 2017). With that intention, this article presents an innovative method of multidisciplinary analysis based on indicators obtained through territorial information systems. The method, called GIS-LiDAR retrospective analysis, is designed to help decision-makers and authorities in territorial management. This way it will allow cities’ land use policies to be optimized, generating synergies in planning and development with sustainable criteria for land consumption and other resources use. The methodology presents multiple applications since it allows to study how phenomena belonging to different disciplines (tourism, urban planning, environmental impacts or hazard risks, for example) can feed each other, giving rise to more complex problems. A situation of these characteristics (which requires methodologies such as these to be properly analysed), is presented for a Mediterranean coastal area, whose case will be diagnosed and evaluated through the simulation of future scenarios.

2. GIS-LiDAR analysis methodology

Land consumption is a very interesting indicator for the purposes of establishing growth and evolution patterns of a territory. Furthermore, it allows to homogeneously evaluate growth forecasts of factors such as population, resource consumption, the need for infrastructure development or landscape transformation (Steinitz, 2000). Through inertial interpolation matrices of process behaviour, forward-looking statements of these factors can be set based on the trends observed in the different land types and the existing urban planning in a territory. To achieve this goal, a methodology based on four stages that will use various GIS and LiDAR tools (SDIMED, CartoMur, SitMurcia and IDERM) is proposed. However, the methodology is not restricted to these specific instruments, therefore researchers need not use these particular tools but can choose their own tools based on the best adaptation to the analysed territory.

To start with, the diagnosis towards the future must be made taking into account the various interconnected issues that make up the current scenario (driving forces, pressures of activities, impact on human well-being, impact on ecosystemic services and state-changes of the social ecosystem). Therefore, this work requires a prior analysis adapted to the specific case of study in order to select the appropriate variables (see Fig. 1 as a standard example).

This process is the first step of an integrated analysis set out in four phases. After selecting all analysis factors, they must be implemented in a GIS tool to permit their numerical evaluation. The tool should enable them to be studied in the context of a “retrohistorical” analysis. This analysis introduces the trends of land transformation in a limited time frame from a starting date until today. The analysis must meet certain minimum
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