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Detecting multi-scale urban growth patterns and processes in the Algarve region (Southern Portugal)

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A B S T R A C T

The importance of urban growth processes and their spatial characteristics has led to a growing interest in monitoring these phenomena. Spatial metrics are widely employed for this purpose, appearing in an increasing number of studies where they are used to characterise growth patterns and their evolution over time. This paper presents an analysis of urban growth patterns using spatial metrics in the Algarve (southern Portugal), an area of considerable urban dynamics associated with tourism. Two datasets were used (CORINE 1:100,000 maps and COS 1:25,000 maps) and two time periods (1990 and 2006–2007) in order to compare the different urban land use patterns detected and their evolution over time. The results show differences in urban land use patterns and associated processes at each scale, with stable land use patterns predominating at the 1:100,000 scale whereas the 1:25,000 scale showed a move towards more dispersed patterns. These results have enabled an assessment of the principal differences in urban growth patterns observed at both scales, and the implications for planning these entail.

Introduction

Processes of change in land use and urban growth are important components of the global changes currently taking place in Europe (EEA, 2006a) and worldwide (Grimm et al., 2008). Today, more than half of the world's population lives in cities (Botequilha-Leitão, 2012; Grimm et al., 2008; Seto & Fragkias, 2005), and one important aspect of these is the type of growth pattern they present, whether in the Iberian Peninsula (e.g. Catalán, Saurí, & Serra, 2008; Vaz, Nijkamp, Paínho, & Caetano, 2012), the rest of Europe, (e.g. Kasanko et al., 2006; Schwarz, 2010), the United States (e.g. Kaza, 2013; Song & Knaap, 2004; Wu, Jenerette, Buyantuyev, & Redman, 2011) or Asia (Taubenbock, Wegmann, Roth, Mehl, & Dech, 2009; Yu & Ng, 2007).

The concept of “urban land use pattern” is used to refer to the spatial characteristics of land use in cities (Grimm et al., 2008), usually distinguishing between “urban sprawl” (Camagni, Gibelli, & Rigamonti, 2002; EEA, 2006a), a more or less dispersed expansion that commonly occurs in American and European cities (EEA, 2006a), and the idealised “compact city” of the Mediterranean (Dematteis, 1998; Kasanko et al., 2006; Schwarz, 2010), with a higher density and smaller extent, as being two opposing urban land use patterns (Dieleman & Wegener, 2004; Frenkel & Ashkenazi, 2008).

There is widespread debate about the spatial characteristics of these two patterns of urban growth and the consequences or impact that each of them has on their surrounding landscapes (Antrop, 2000; DiBari, 2007), transport systems and energy efficiency (Kenworthy, 2006), or on global change (Grimm et al., 2008). Therefore, characterisation of the spatial pattern of urban growth is of great interest (Wu et al., 2011) for urban and metropolitan planning, especially in Europe (EEA, 2006a), given the different legislative characteristics and contexts of member countries.

This interest is even higher in those countries where urban growth is very rapid (Barredo, Demicheli, Lavalle, Kasanko, & Mccormick, 2004; Tian, Jiang, Yang, & Zhang, 2011; Yue, Liu, & Fan, 2013), or where there has been a marked shift to coastal urbanisation (EEA, 2006b), as is the case of Portugal (Caetano, Carrão, & Painho, 2005; Ferrão, 2002; Freire & Caetano, 2005) and particularly of the Algarve Region. Much of the urban growth in this region has occurred along the coastline (CCDR, 2007), which in the Algarve constitutes a very sensitive space in terms of the landscape, with many areas of considerable environmental value (Cancela d'Abreu, Pinto Correia, & Oliveira, 2004).

A wide range of tools are available for exploring urban growth patterns in all these areas. However, among those most frequently

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mentioned in the literature are spatial metrics (Buyantuyev, Wu, & Gries, 2010; Dietzel, Herold, Hemphill, & Clarke, 2005; Hepinstall-Cymerman, Coe, & Hutyra, 2011; Herold, Couclelis, & Clarke, 2005; Kaza, 2013; Seto & Fragkias, 2005; Wu et al., 2011). Most of these studies have used the term spatial metrics to more clearly differentiate these from landscape metrics. Spatial metrics can be defined as “measurements derived from the digital analysis of thematic-categorical maps exhibiting spatial heterogeneity at a specific scale and resolution” (Herold, Goldstein, & Clarke, 2003). They are used to characterise urban patterns (Dietzel et al., 2005) whereas in ecological landscape studies, landscape metrics are explicitly linked to ecological functions (DiBari, 2007; Gustafson, 1998; Luck & Wu, 2002).

One important aspect of implementing spatial metrics is the question of scale (Diaz-Varela, Álvarez-López, & Marey-Pérez, 2009; Turner, 2005; Wu et al., 2011). In this regard, the use of different resolutions, or even different scale maps, permits identification of different types of urban growth patterns. While many papers have addressed the scale effect by upscaling or downscaling the dataset (e.g. Buyantuyev et al., 2010; Wu et al., 2011), it is also important to analyse the urban growth patterns appearing in the different maps available. This may have important implications for monitoring specific processes or for land use planning, since the omission of some growth patterns at certain scales (e.g. dispersed growth) may indicate the unsuitability of using a particular map for a given purpose.

Another aspect of interest is related to the existence of pull factor gradients in growth processes, for example, the attraction of town centres (Seto & Fragkias, 2005; Taubenbock et al., 2009; Tian et al., 2011, etc.). For coastal areas, one of the main determinants of urban growth processes and patterns is the coastline (Botequilha-Leitão, Cruz, & Aguilera, 2011; Ferrão, 2002; Petrov, Lavalle, & Kasanko, 2009), and it is thus helpful to consider possible coastal-inland gradients in the study of these processes.

It is therefore important to explore changes in urban growth patterns associated with possible *urban sprawl* processes and identify the existence of pull factor gradients, at different scales. Focussing on a sector of the Algarve region in Portugal, this paper presents an analysis of urban growth patterns associated with coastal areas that can be detected with spatial metrics in two different maps: the CLC map at a scale of 1: 100,000 (*CORINE Land Cover* maps covering Europe) (EEA, 2007), and the COS map at a scale of 1: 25,000 (*Carta de Ocupação do Solo* maps available for Portugal) (IGP, 2011). On the basis of the patterns identified, the processes of pattern change associated with each scale can be inferred and compared, evaluating the possible planning implications of the different processes identified in each of them.

Thus, this study tested the following working hypothesis: There are differences in the urban growth patterns that can be detected at two scales (CLC and COS maps) using spatial metrics, for two more or less similar time periods; as well as in the urban growth processes inferred.

This article is organised as follows: (i) characterisation of the study area (section Study area); baseline data and methodology (sections Datasets and Methodology); (ii) division of the study area into sectors (section Identification of sectors using buffer zones); (iii) calculation of a set of spatial metrics to characterise the growth patterns in each of the sectors at the two scales (section Results of spatial metrics and FA); (iv) the results of a factor analysis and cluster analysis to classify urban land use patterns in the different sectors and their evolution over time (section Cluster analysis and identification of urban growth patterns at the selected scales); (v) interpretation of urban growth pattern changes as urban growth processes; (vi) discussion of the results (Section Discussion); and (vii) conclusions (section Conclusions).

Materials and methods

Study area

The study area is located in the Algarve region, in the south of Portugal (Fig. 1). With 451,000 inhabitants, this region has experienced significant demographic and land use change in recent decades (Aguilera & Botequilha-Leitão, 2012; Botequilha-Leitão, 2009; Botequilha-Leitão et al., 2011; INE, 2012; Vaz et al., 2012). This is mainly due to tourism, the most important and largely predominant economic activity (Petrov et al., 2009).

At regional level, three main landscape units can be identified from north to south: the “*Serra*”, the “*Barrocal*”, and the “*Litoral*”. More than 70% of the Algarve's population lives in the *Litoral*, mainly in the Algarve's western-central part known as the “*Barlavento*” (CCDR, 2007). This landscape unit also contains some large agricultural areas, together with almost all the region's urban areas, including its resorts. However, increasing urban pressure is extending from the “*Litoral*” towards the “*Barrocal*”.

The study area was defined on the basis of the following considerations: (1) coastal areas exert a strong attraction, (2) the Algarve's population and economic activities are concentrated in the “*Litoral*”, (3) natural parks are barriers to tourist and urban development, thus pushing development into the remaining coastal areas (in our case the central Algarve, located in the “*Barlavento*”), and (4) development pressure is moving towards more inland areas such as the “*Barrocal*”.

Datasets

The maps of urban land use at two scales employed in this study come from two different sources. The first of these was the European CORINE Land Cover (CLC) mapping project (EEA, 2007). As is well known, the CLC mapping data at European level are at 1:100,000 scale with a minimum mappable unit (MMU) of 25 ha. For the present study, we used the CLC 1990 map and the CLC 2006 map.

The second source was the map of land use in Portugal (*Carta de Ocupação do Solo de Portugal* – COS), a mapping project carried out by the Portuguese Geographic Institute (IGP, 2011) which complements the CLC products available in Portugal. In 1990, the first COS map was drawn up (COS 1990) using a spatial resolution of 1:25,000, a MMU of 1 ha (IGP, 2011) and a legend of its own. The COS 2007 map was created in 2007 with the same legend as that of the CLC map. To render the legends of the two COS maps comparable, the COS 1990 legend has been equated to that of COS 2007, and thus also to that of the CLC. This process has implied the aggregation of 8 urban land use categories in COS 1990 to form 4 urban land use categories existing on the second level of disaggregation in the CLC legend (1.1 urban fabric; 1.2 industrial areas and infrastructures; 1.3 areas under construction; and 1.4 sports and cultural areas).

At this level, of the four land use categories related to urban aspects of the landscape, Category 1.1 (urban fabric) was selected in the four available maps (COS 1990, COS 2007, CLC 1990 and CLC 2006). This is the category with the greatest spatial extent (2/3 of the surface area of artificial areas) that best represents urban growth processes, especially residential growth related to tourism.

Methodology

The proposed methodology consisted of four main steps (Fig. 2): (i) analysis of the coastal-inland urban land use gradient across the selected datasets to identify urban sectors; (ii) selection of a set of spatial metrics; (iii) cluster analysis to identify urban patterns