Cities 40 (2014) 99–110

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

A method for detecting and describing land use transformations: An examination of Madrid's southern urban–rural gradient between 1990 and 2006

Susana Díaz-Palacios-Sisternes, Francisco Ayuga *, Ana I. García

BIPREE Research Group, Universidad Politécnica de Madrid, Spain

ARTICLE INFO

Article history:
Received 24 May 2013
Received in revised form 27 March 2014
Accepted 28 March 2014
Available online 24 April 2014

Keywords:
Land use
Gradient analysis
Urban dynamics
Urbanization
Corine Land Cover

ABSTRACT

The growth of large cities often involves changes in territorial and landscape structures. Modern procedures for classifying land cover, based on mapping involving territorial databases (such as the European CORINE database) and geographic information systems, allow changes in land use, the spatial distribution of land use, and territorial dynamics to be examined. The present study identifies and quantifies the urban–rural transformation processes that occurred over the period 1990–2006 towards the south of Madrid. The results obtained show urbanization to have been the predominant transformation process. The speed of transformation towards urban land use has been enormous, increasing the urbanized area by over 100% between 1990 (29,914 ha) and 2006 (70,095 ha). Characterizing the transformation processes that take place along urban–rural gradients provides a means of quantifying the impact of urbanization on the landscape.

Introduction

The planning and management of urban areas from the point of view of sustainable development and smart growth, relies upon the analysis of urban dynamics associated with land use changes and the forces driving them. Urban dynamics should be analysed from the perspective of the relationship between urban and territorial phenomena, always remembering that towns, and the infrastructures that connect them, depend upon, and profoundly transform, the surrounding territory.

A number of studies have examined the diffusion of urban uses over urban–rural gradients (URG) from a landscape perspective (Catalán, Saurí, & Serra, 2008; Dietzel, Herold, Hemphill, & Clarke, 2005; Robinson, Newell, & Marzluff, 2005; Frondoni, Mollo, & Capotorti, 2011; Herold, Couclelis, & Clarke, 2005; Herold, Goldstein, & Clarke, 2003; Hewitt & Escobar, 2011; Solon 2009; Weng, 2007; Zhang, Wu, Zhen, & Shu, 2004; Luck & Wu, 2002). Modern tools, such as geographic information systems (GIS), and the greater availability of different types of data, now allow this type of analysis to be more easily undertaken. For example, Hernández-Blanco, García-Moruno, and Ayuga (2004) studied how to choose the best locations for agricultural and industrial activities, examining the surrounding landscape using a GIS. More recently, Jeong, García-Moruno, and Hernández-Blanco (2012) improved this procedure using on-line tools and a multi-criteria spatial decision support system (MC-SDSS). Tassinari and Torreggiani (2006) similarly studied the location of cheese factories, while Thapa and Murayama (2008) combined GIS with an analytical hierarchical process (AHP) to study the suitability of peri-urban land for agricultural purposes. More recently, Akinci et al. (2013) used similar techniques when studying a territory affected by the construction of three dams. Domingo-Santos, Fernández de Villarán, Rapp-Arrarás, and Corral-Pazos de Provens (2011) focused on the visibility of elements in a viewshed, while Sarvestani et al. (2001) used satellite images taken over time to study the urban growth of Shiraz (Iran). Paudel and Yuan (2012) studied the ecological effects of urbanization from multi-temporal classification maps and through the use of a GEOMOD model, while Papadimitriou (2012) used artificial intelligence techniques to study landscape transformations.

Researchers across the globe have studied landscape from different perspectives. From an environmental psychology point of view, Galindo and Corraliza (2000) analysed the well-being associated with the everyday contemplation of landscapes. Bishop (2003) reviewed the procedures available for enhancing the use of computer visualization and 3D models in landscape

* Corresponding author. Address: BIPREE Research Group, School of Agricultural Engineering, Universidad Politécnica de Madrid, Spain. Tel./fax: +34 913365625.
E-mail addresses: susanadps@hamadryades.es (S. Díaz-Palacios-Sisternes), francisco.ayuga@upm.es (F. Ayuga), ai.garcia@upm.es (A.I. García).
URL: http://www.bipree.es (F. Ayuga).

http://dx.doi.org/10.1016/j.cities.2014.03.010
0264-2751/

analysis, while Tress, Tress, and Fry (2005) reviewed the problems arising during multidisciplinary landscape studies. García and Ayuga (2007) examined the effect of redundant buildings on rural landscapes in Spain, while in northern Italy, Tassinari, Carfagna, Benni, and Torreggiani (2008) did the same taking into account all man-made features. Picuno, Tortora, and Capobianco (2011) also studied the landscape effects of crop shelters in Basilicata and Apulia (Italy), as did Arcidiacono and Porto (2010) in Sicily (Italy). Cañas, Ayuga, and Ayuga (2009) developed assessment methods for evaluating rural landscapes based on people's preferences. This was later simplified by Ramírez, Ayuga-Téllez, Gallego, Fuentes, and García (2011). Tasser, Ruffini, and Tappeiner (2009) proposed the use of indicators for landscape evaluation in northern Italy, including land use changes and urban sprawl. Later, Schirpke, Tasser, and Tappeiner (2013) made use of a GIS and landscape metrics to examine the same region. Finally, de Vries, de Groot, and Boers (2012) studied the impact of man-made elements and impact mitigation measures on landscape perception in the Netherlands, while Grammatikopoulou, Pouta, Salmiovirta, and Soini (2012), in southern Finland, took into account people's preferences in agricultural landscape perception as part of landscape assessment.

Via the analysis of urban dynamics, the present paper reports a study of land use changes over two periods of the recent past – 1990–2000 and 2000–2006 – in the south Madrid (Spain) area (Fig. 1). The aim was to characterize the changes in urban structure, identifying the transformation processes that took place, along with their spatial distribution, and to establish the intensity of transformation gradients with respect to distance from Madrid.

Methods

Characteristics of the study area

The study area occupies some 9973 km^2. It covers the area to the south of Madrid's 1990 urban land area, and takes in the south-east of the NUTS 2 region (ES30) of the *Comunidad de Madrid* (CM, or the Madrid Autonomous Region), plus all the municipal areas of the NUTS 2 region (ES42) of *Castilla–La Mancha* (CCLM, or the Castilla–La Mancha Autonomous Region) directly influenced by the expansion of Madrid (Junta de Comunidades de Castilla – La Mancha., 2010). This includes the cities of Guadalajara and Toledo. Madrid's expansion beyond its administrative frontiers could not have occurred towards the north since the Guadarrama Mountain Range acts as a natural barrier to such a process (De Santiago Rodríguez, 2011b). The study area is composed of 211 municipalities, of which 66 belong administratively to the CM (2992 km^2; 30% of the study area) and 145 to the CCLM (6981 km^2; 70% of the study area). Agricultural land uses are mainly cereal crops (46% of the study area), woody crops (mostly olive trees −16% of the study area – and vineyards −6% of the study area). Agriculture represents just 0.1% of its gross domestic product (Comunidad de Madrid. Dirección General de Agricultura y Desarrollo Rural. Consejería de Economía y Turismo., 2008; Junta de Comunidades de Castilla–La Mancha, 2008). The study area is crossed by five main corridors (consolidated in the 18th century) connecting Madrid with Barcelona towards the northeast (served by the A2 freeway), Valencia towards the southeast (served by the A3), Cordoba to the south (served by the A4), Toledo slightly to the

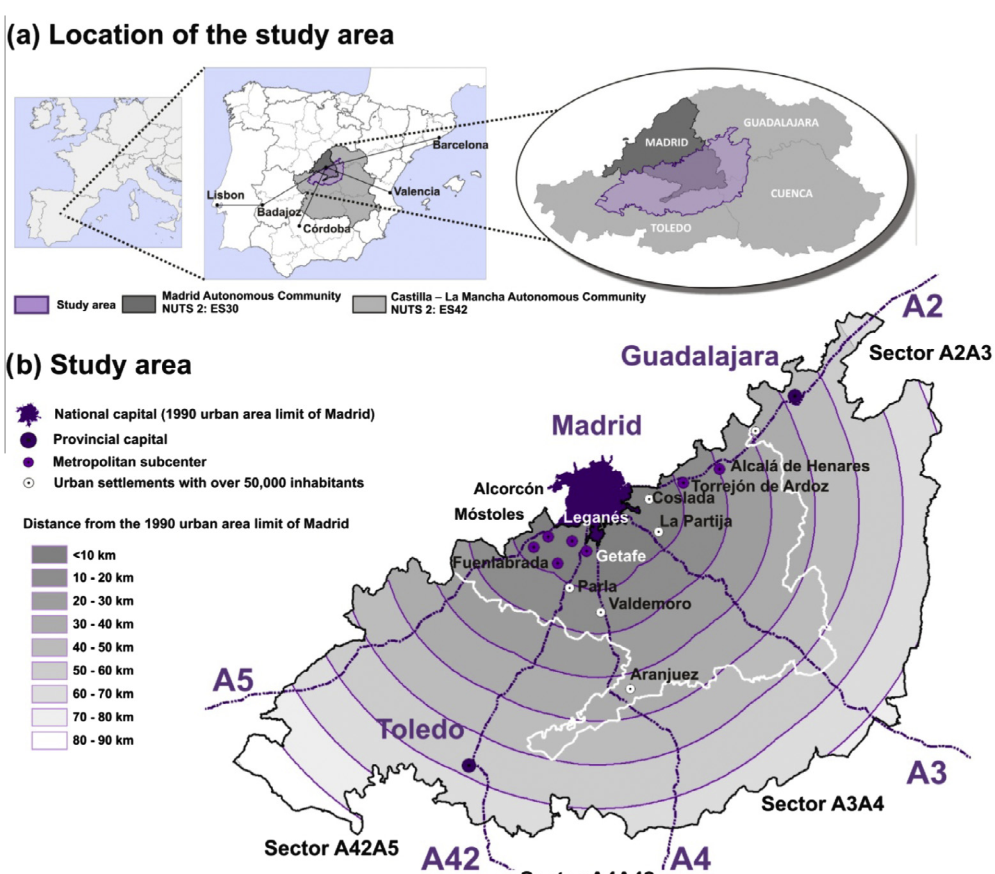

Fig. 1. The map shows the study area with its main cities (national capital, provincial capitals, metropolitan centers and urban settlements with over 50,000 inhabitants), and the major freeways forming the boundaries between the different sectors.