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Land use change and forest routing in a rural context: The relevance of the community-based management and planning framework

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A B S T R A C T

Land-use change processes present a variety of trajectories depending on local conditions, the regional context and external influences. This study is an in-depth analysis of spatial and temporal land-use change in a rural mountain area for the data period 1965–2010. It concerns a rural area with partially mountainous characteristics and a high prevalence of forest land, in which both the processes of peri-urbanisation and a common land management system involving the state and the community can be observed. Supported by a collection of five periods of image analysis (the 1965, 1974, 1983, 1995, and 2010 maps), the transformation indicators were analysed in terms of the stability grade (SG), which expresses the total proportion of the landscape that has not experienced any transition, the rate of forest transformation (FS) and artificialisation processes (AS). In the area as a whole, the spatial and temporal transitions involve a significant increase in urban areas with a discontinuous fabric, a reduction in agricultural areas, and significant routing of forest occupation with typology and pattern transition. In the common lands, the major transformations occur between forests and semi-natural areas, with a general temporal increase in broad-leaved forest and degraded forest areas and a decrease in agricultural and agro-forestry areas, showing improvements to forest land through the introduction of new species and forest maintenance reflected in smaller subdivisions of patterns of land use. The methods enabled four periods to be identified revealing a distinctive evolution in land use, in which urban consolidation is present consistently, together with rotation of the forest typology – involving forest degradation, gains from agro-forest land or sparsely vegetated areas and the appearance of burnt areas. The results highlight the importance of public policies in the dynamics of land-use change, either in the form of planning or regulatory instruments closely linked to local communities and based on agriculture and forest resources. The management of common land, even in an informal way, introduces differences to land-use trajectories and forest maintenance and greater benefits for the communities.

Introduction

Understanding the processes of land-use change and their forcers has made a territorial approach possible, highlighting traditional values, cultural practices and the political framework within the usual management practices. As pointed out by Verburg, van Berkel, van Doorn, van Eupen, and van den Heiligenberg (2010), land-use changes present a variety of trajectories depending on local conditions, the regional context and external influences. Moreover, studies of land use and cover change are important in examining the viability of community-based programmes (Dalle, Blois, Caballero, & Johns, 2006), some of which emphasise processes and interactions involving socio-economic driving forces and biophysical conditions (Aspinall, 2004; Barrico et al., 2012; Braimoh & Onishi, 2007; Lee, Hertel, Rose, & Avestisyan, 2008; Lee, Huang, & Chan, 2008; Changhong et al., 2011; Li, Zhou, & Ouyang, 2013; Pontius, Shusas, & McEachern, 2004).

As emphasised by Hietel, Waldhardt, and Otte (2004), land-use change in rural areas takes place within the physical constraints of the landscape and presupposes a knowledge of the ongoing dynamics and their resulting characteristics (Claessens, Schoortl, Verburg, Geraedts, & Veldkamp, 2009; Domon, 2011). Conversely, Rounsevell et al. (2006) identify competition between land uses, in

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which physical, economic or political characteristics may determine land-use decisions and change, involving weak relationships with past developments and supported by competition for resources. Changes in land use based on territorial differences, such as those resulting from different development strategies or from specific features or vulnerabilities, represent a common assumption (Fu et al. 2006; Hara, Takeuchi, & Okubo, 2005; Mehaffey et al., 2008; Robinson, Newell, & Marzluff, 2005). Several studies aim to evaluate rural landscape dynamics through pattern representation and the evolution of indicators (Bodesmo, Pacicco, Romano, & Ranfa, 2012; Hasse & Lathrop, 2003; Stein, Riley, & Halberg, 2001; Veldkamp & Lambin, 2001) but few have dealt with their relationship to social determinants (Pan, Domon, de Blois, & Bouchard, 1999; Serra, Pons, & Saurí, 2008; Simpson et al., 1994; Su et al., 2011; Valbuena, Verburg, Bregt, & Ligtenberg, 2010). Although Verburg et al. (2010) consider that land-use typologies based on current landscape and ruralities are poor indicators of regional land-use dynamics, other authors have pointed out that land-use trajectories emerge from competition between agricultural and forest land, as emphasised by Abdullah & Nakagoshi (2008) and Lasanta, González-Hidalgo, Vicente-Serrano, and Sferi (2006). This is related to income and improvements in manufacturing or, as stressed by Barrico et al. (2012) and Reidsma, Tekelenburg, van den Berg, and Alkemade (2006), agricultural landscapes and biodiversity values as planning vectors for human benefit.

As shown by Easterling, Brandle, Hays, Guo, and Guertin (2001), forest evolution takes place over a long period of time but modelling is a powerful tool for simulating forest succession. The competition between agricultural areas and forest corridors is affected by social and environmental factors and, in turn, affects successional processes and biodiversity. Similarly, in studying land use in Europe Rounsevell et al. (2006) assumed that forests have a long rotation period, leading to the conclusion that rapid social changes do not affect forests immediately but may take decades to materialise. Rudel et al. (2005) consider that forest transitions, even when rare, may not occur at all unless governments create effective forestation programmes, and stimulate forest fragmentation (Lira, Tambosi, Ewers, & Metzger, 2012).

Several authors have analysed land-use changes through a comparative evaluation of land-cover image sources (Aspinall, 2004; Braimoh, 2006; Lee, Hertel et al., 2008; Wentz, Stefanov, Gries, & Hope, 2006), using detection techniques which involve different images and sources. The photo-interpretation of digital images is a widely-used and relatively effective method of evaluating landscape metrics (Hara et al., 2005; Mas, 1999; Pan & Zhao, 2007; Rozenstein & Karnieli, 2011). The use of satellite imagery for interpretation has made it possible to integrate sets of images from several observation periods obtained from different sources and using different scales. The reconstitution of the transformation path using aerial photographs and satellite images in accordance with uniform classification principles and field validation capabilities has been explored by several authors, including Catalan et al. (2008), Deng, Wang, Hong, and Qi (2009), Kolios and Stylios (2013), Tapiador and Casanova (2003) and Van Vlient et al. (2011), to reveal the dynamics of land-use transformation. In addition, forest monitoring analysis using satellite images has been applied with good results by Niraula, Gilani, Pokharel, and Qamer (2013), Persson and Azar (2006) and Qamer et al. (2012).

The detection of temporal transformation dynamics in land use and occupation can be divided into three main categories: unitary pre-classification (single image classification); comparative classification (image to image classification) and post-classification (overall image comparison), as demonstrated by Manandhar, Odeh, and Pontius (2010) and Tavares, Pato, and Magalhães (2012). Several studies of rural and forest transformation dynamics have been explored by Käyhkö and Skånes (2008), demonstrating the importance of empirical local knowledge in analysing land-use trajectories and understanding forest management and conservation processes (Dalle et al., 2006; DeFries, Hansen, Turner, Reid, & Liu, 2007; Lambin & Meyfroidt, 2010; Schmitz, Matos, De Aranzabal, Ruiz-Labourdette, & Pineda, 2012). Some authors identify an understanding of cultural perceptions as a means of improving forest conservation, specifically by using the influence of community practices (Chen, Shivakoti, Zhu, & Maddox, 2012; Fagerholm, Käyhkö, & Van Eetvelde, 2013). Recognising the process involved in rural land-use change and its driving factors is crucial to effective management and conservation which values ecological and social impacts. This is reinforced by Schwilch et al. (2012), with regard to the importance of stakeholder association and participation. A conservation planning framework (Cowling & Pressey, 2003; Pierce et al., 2005) makes it possible to empower local associations and create in-depth communications, as well as a systematic assessment of conservation planning and conservation security.

With regard to mountain landscapes, Mottet, Ladet, Coqué, and Gibon (2006) stress that land-use change factors cannot be separated from local drivers, since adjacent areas may have different trajectories According to Nelson et al. (2008), local communities are playing an increasingly prominent role in forest conservation strategies. In some regions a community-based conflict surrounding management has been identified (Hayes, 2006), in which local gains oppose conservation of biodiversity (Brechin, Wilshusen, Fortwangler, & West, 2002; Ellis & Porter-Bolland, 2008). For Niraula et al. (2013), the involvement of forest stakeholders across the state and private sectors and local community is the only way to strengthen the capacity of balanced community-based organisations in situations where significant improvements to the conservation of forest resources and financial incomes are possible, but depend on greater participation (Carmona, Nahuelhual, Echeverria, & Baez, 2010; Chen et al., 2012). In particular, there is a growing interest in identifying the local practices and decision-making processes that could strengthen participatory models of resource management, whilst also allowing for social and economic gains, thereby increasing the community's resilience to risk, as well as developing policies for protecting biodiversity (García-Barrios, 2012; Matthews, Gilbert, Roach, Polhill, & Gotts, 2007; Scott, 2011; ; Young et al., 2005).

In Portugal, where the study area is located, land-use changes in rural areas has become a significant debate, specifically in mountain territories associated with human abandonment which affects the structure of the landscape (Azevedo, Moreira, Castro, & Loureiro, 2011; Nunes, Almeida, & Coelho, 2011; Pôças, Cunha, & Pereira, 2011) although, as pointed out by Diogo and Koomen (2012), the driving forces in question have remained stable over time despite an increase in the rate of land-use change. However, rural land-use changes related to wildfire forcers are considered significant (Moreira, Rego, & Ferreira, 2001; Nunes et al., 2005; Tedim, Remelgado, Borges, Carvalho, & Martins, 2013) and have a recognised impact on forest management (Carvalho-Ribeiro, Lovett, & O'Riordan, 2010; Schwilch et al., 2012) and ecosystem services (Barrico et al., 2012; Pereira, Queiroz, Pereira, & Vicente, 2005; Pinto-Correia, 2000).

The objective of this study is to assess the spatial dynamics of land use over time in a mountainous region of Portugal during the period 1965–2010. Specifically, the paper investigates publicly managed forests over two distinct policy regimes. To this end, the paper charts the shifting land-use patterns and practices that characterised pre- (prior to 1974) and post-revolution (1974–present) Portugal.