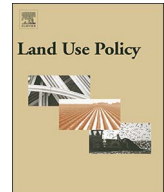




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Land and farming system dynamics and their drivers in the Mediterranean Basin

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ABSTRACT

Given the heterogeneity and richness of Mediterranean farming systems, it is difficult to assess the nature and causes of observed dynamics based on single case studies. This research identifies case studies conducted on the north and south of the Mediterranean basin to provide a comprehensive overview of the current land and farming system dynamics and their main drivers. We analyze 80 papers published in international journals from 1985 to 2015. The studies vary in spatial scale, from 4 km² in the case of peri-urban regions and small agricultural areas to more than 500,000 km² in the case of national-based analyses. Most of the papers focus on mountainous rural areas, whereas only a few case studies are located in mixed regions or peri-urban inland regions. We analyze the farm trajectories behind the general dynamics to understand the ongoing processes at the agricultural level and their related drivers. Social and demographic drivers are indicated as particularly relevant for abandonment, which is frequently associated with intensification processes. Intensification dynamics are driven mainly by economic factors, which particularly affect annual crop production. Few papers analyze the dynamics of extensification and more research in this field is needed to understand this process and its eventual transition to the abandonment of agricultural areas. This analysis provides an opportunity for the exchange of ideas and information from a diverse range of disciplines and interest groups, which should be combined to formulate effective land use policies.

1. Introduction

Land and farming system dynamics (LFSD) can be considered as the set of processes which cause changes of land use and land systems. These changes of land use can cause various environmental impacts because they can turn a natural and less intensive system into a more intensive or urbanized one (Foley et al., 2005). Reductions in ecosystem functioning as the biodiversity loss (Haines-Young, 2009), soil organic carbon loss (Edmondson et al., 2014) and soil erosion (Debolini et al., 2013), can impact the well-being of human societies (MEA 2005). How LFSD can be influenced is therefore crucial knowledge for the successful implementation of policies whether it is the Common Agricultural Policy or making progress towards the Sustainable Development Goals.

LFSD are usually identified through land use and land cover change (LULCC) analyses. The identified dynamics can result from local competition between different uses within the agricultural sector, such as the transition from traditional family farming toward corporate agriculture (Bontkes and Van Keulen, 2003) and the intensification of agricultural activities (Temme and Verburg, 2011). LULCC can also result from transitions of agricultural land to other land use types, as in the case of urban sprawl, which in the Mediterranean basin happens particularly in coastal areas (Salvati et al., 2012). These transitions are not independent and act in a feedback chain: farming systems surrounding urban areas are affected by the expansion of cities, often causing the abandonment of agricultural activities and leading in turn to the development of market-oriented agriculture further away from

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the cities (Debolini et al., 2015) or to the niche development of urban agriculture in residual agricultural areas (Opitz et al., 2016). To inform and support sustainable land management, an overall understanding of the feedback mechanisms and the human-environment interactions at the regional level is needed (Foley et al., 2005). This is particularly urgent as specific regions (e.g. Maghreb) are expected to undergo rapid transitions in the coming decade (FAO, 2011). Transitions, such as population density increases, climate change and soil degradation, which may jeopardize food and water security in the region, and therefore overall human well being (Schröter et al., 2005).

In this study, we carried out a systematic literature review of LFSD case studies in the Mediterranean basin published in the last thirty years. Our aim is to provide a comprehensive view of LFSD in the Mediterranean, starting from published case studies, and to understand the drivers linked to the analyzed dynamics. This literature review is the first step toward a multi-scale meta-analysis of Mediterranean landscape management. Moreover, we compare the results concerning LFSD drivers in the Mediterranean with those of similar studies conducted on the whole of Europe (Van Vliet et al., 2015; Hesperger and Bürgi, 2009).

The Mediterranean basin contains a high diversity of farming systems, as well as a high rate of land cover transitions. Environmental challenges are particularly exacerbated in the Mediterranean basin, which is one of 34 global hotspots of biodiversity (Médail and Quézel, 1999). From an agricultural perspective, the Mediterranean basin has a long history of producing food, fodder and fiber for the supply of past civilizations. In parallel, it also resulted in a diversity of land uses and landscapes, sometimes strongly reshaping the environment (e.g., terraces and irrigation canals, hedgerows and agro-silvo-pastoral systems) (Pinto-Correia and Vos, 2004; Blondel, 2006). The context of the Mediterranean Basin, therefore, provides an excellent and challenging opportunity to identify connections between LFSD, related processes and drivers, and to reflect upon how this information can be used to better adapt or implement sustainability policy measures.

For these reasons, current agricultural systems and landscapes are complex and inherited from a long history of agricultural and cultural Mediterranean traditions (Zeder, 2008). Some of the traditional Mediterranean agricultural systems have been recognized to combine the production of food with the supply of other ecosystem services. For instance, the silvo-pastoralism and agroforestry have been known for their supply of regulating soil erosion and maintaining soil fertility in combination with the production of food (Torralba et al., 2016). Some of these agricultural systems were common in the past, but were abandoned in favor of simplified systems aimed at increasing crop yields and farm gross margins during the 20th century (Pinto-Correia and Vos, 2004). Traditional farming systems can sustain biodiversity at the regional level and are still present, although marginally, on both sides of the Mediterranean basin (Bugalho et al., 2011). Traditional Mediterranean farming systems may therefore provide interesting alternatives for an unsustainable growth of the agricultural production sector. Of all LFSD, land abandonment has been investigated deeper in the Mediterranean basin than other LFSD, among other reasons because of its impact on plant and animal species richness (Plieninger et al., 2014).

Recent studies have shown how agroforestry and organic farming have the potential to enhance production and diversify farmers' incomes, which could support the resilience of farms and their food production to climate change and the world market (Daoui and Fatemi, 2014). Besides agroforestry, organic farming and silvo-pastoralism, innovative practices targeting soil conservation and its ability to retain water are increasingly being considered as economically and environmentally sustainable alternatives to high-input conventional practices (Martínez et al., 2006). At the same time, the Mediterranean basin is characterized by limiting conditions for agriculture (poor and shallow soils, steep slopes and dry summers) and a limited availability of resources, mainly water. These conditions can worsen with the

expected climate change on the region, leading to high vulnerability in the supply of ecosystem services in European Mediterranean countries and the wider Mediterranean Basin (Schroter et al., 2005). The social organization in this region also has some distinct features, such as the low level of entrepreneurship in some hilly and mountainous marginal regions, which are mainly characterized by traditional extensive farming systems (Petanidou et al., 2008), a property structure based on family lands that are considered as a heritage more than a production factor and low taxes on land ownership (Otero et al., 2013).

Finally, from an environmental perspective, the Mediterranean climate offers unique conditions for a rich biodiversity to coexist with agricultural production, while future climate changes are expected to shift species' suitable climatic conditions northward (Ruiz-Labourdette et al., 2013). The Mediterranean Basin is projected to become increasingly dry and warm, while inter-annual climate variability is also expected to increase, particularly during the summer. The combined effects of a changing climate and land-use patterns are likely to influence the ecosystems and the services they deliver (Guiot and Cramer, 2016).

The strong heterogeneity and specificity of Mediterranean farming and agricultural systems requires an integrative multi-scale methodology, from local land use to global land cover changes (Lambin et al., 2006). From this perspective, we brought together a multidisciplinary panel of researchers to carry out a comprehensive description of the Mediterranean case studies about LFSD. Concretely, we focused on identifying the main characteristics of the LFSD analyses conducted in the Mediterranean basin, as well as the main proximate and underlying drivers of LFSD. We used the results of the analysis to formulate research needs on LFSD for sustainable development in the Mediterranean basin.

2. Materials and methods

2.1. Literature review and data collection

The systematic literature review has been carried out following the general method formalized by the Centre for Evidence-Based Conservation (2010). In particular, we applied a 7 step method: first of all, we discussed the research question to be explored with the review. In our case, as indicated on the Introduction section, the aim of the review was to provide a comprehensive view of LFSD in the Mediterranean and to understand the drivers linked to the analyzed dynamics. To obtain this information, we developed a standardized form to be filled with the main information we would collect from the papers, namely: the scale of analysis, the location of the case study, the type of region (rural, urban or mixed), the typology of the landscape (e.g. mountainous, coastal or internal hilly), the extension of the case study, the analyzed agricultural systems, the main and secondary type of dynamic, the specific trajectories identified, and the drivers of the dynamics. Then, the authors performed a literature review to select all case studies relating to LFSD in the Mediterranean basin published from 1985 to 2015. We used the ISI Web of Science database (Thomson Reuters, New York, NY, USA) to compose our initial paper selection. The following keywords were used for the bibliographic search: Mediterranean, landscape, land system, farming system, change, dynamic and trajectories. We also selected research areas to avoid studies unrelated to environmental, agricultural or ecological sciences. With this first selection, we obtained 1754 papers. To have select case studies, we screened paper titles, keywords and abstracts on the following criteria: the paper had to (1) present an evidence-based case study; (2) present quantitative and explicit results from an LULCC analysis; (3) include more detailed information on agricultural dynamics than just agricultural/urban transitions.

By applying these criteria to the whole database, we obtained a final selection of 74 papers. Finally, we added six more papers published in non-indexed journals, mainly to improve the coverage of the southern

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