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Linking trajectories of land change, land degradation processes and ecosystem services

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ABSTRACT

Land Degradation (LD) is a complex phenomenon resulting in a progressive reduction in the capacity of providing ecosystem services (ES). Landscape transformations promoting an unsustainable use of land often reveal latent processes of LD. An evaluation carried out in respect to the different ecosystem services is nowadays regarded as the most appropriate approach for assessing the effects of LD. The aim of this study is to develop an evaluation framework for identifying the linkages between land changes, LD processes and ES and suggesting Sustainable Land Management (SLM) options suited to reverse (or mitigate) LD impact. A SWOT analysis was carried out with the aim to identify internal and external factors that are favorable (or unfavorable) to achieve the proposed SLM actions. The study areas are the Fortore valley and the Valpadana, in Italy. The main trajectory identified for the Fortore valley is related to land abandonment due to population aging and the progressive emigration started in the 1950s. The most relevant LD processes are soil erosion and geomorphological instability, affecting regulating services such as natural hazard and erosion control. SLM options should consider interventions to contrast geomorphological instability, the promotion of climate smart agriculture and of typical products, and an efficient water resources management. The main trajectories identified for Valpadana are related to urban expansion and farmland abandonment and, as a consequence, land take due to anthropogenic pressure and woodland expansion as the main LD process. The reduction of food production was identified as the most relevant provisioning service affected. SLM should envisage best practices finalized to water saving and soil consumption reduction: efficient irrigation solutions, climate smart agriculture and zero sealing practices. This study highlights the diagnostic value of the suggested approach where LD processes are elicited from land change trajectories determining specific impacts on ES and providing operational support for the implementation of SLM options.

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1. Introduction

Land Degradation (LD) is one of the major forms of environmental degradation all over the world. It is a complex process involving multiple causal factors, among which climate variability, soil quality and land management play a significant role (Reynolds and Stafford, 2002). LD is a process which entails a reduction in the capacity of providing ecosystem goods and services by cropland, rangeland, and woodlands: it becomes irreversible when

reaching the last stage of desertification. The European Parliament (EC, 2002) identified eight degradation processes to which soils in the EU are confronted with: erosion, organic matter decline, contamination, salinisation, compaction, soil biodiversity loss, sealing, landslides and flooding. More processes related not only to soils but to landscape at large, such as loss of local culture, rural traditions, typical agricultural products and biodiversity, should also be taken into consideration.

Land use and land cover (LULC) changes have been identified as key drivers of global change with major impacts on ecosystems, climate and the human sphere (Foley et al., 2005). Landscape transformations represent the visible result of human interaction with land (Conacher and Sala, 1998). Land changes, intended as land use, population dynamics and ecosystem variations, can be

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analyzed and interpreted in terms of “trajectories” as typified, for instance, by the European Environment Agency (EEA) in the system for “Land and Ecosystem Accounts” (Gómez and Páramo, 2005).

Land changes often reveal latent LD processes, e.g. when associated with unsustainable use of land (Geist and Lambin, 2006; Hill et al., 2008; Schellnhuber et al., 1997). For example, the LD processes which are more directly associated to urban expansion, are land take and soil sealing, often occurring on fertile agricultural areas. In the case of deforestation, the related LD processes involved could be biodiversity loss and carbon stock capacity reduction. A better understanding of land trajectories associated with LD contributes to the assessment of past changes and to run short-term scenario analysis with reliable prediction rules.

As highlighted in the background document for the 2nd UNCCD Scientific Conference, Ecosystem Services (ES) are the base for the assessment of measurable outcomes of LD. An evaluation conducted in respect to the different ES is nowadays regarded as the most appropriate framework for assessing the environmental effects of LD (Helfenstein and Kienast, 2014; Nkonya et al., 2011). A variety of ES have been recognized and classified (MEA, 2005). The relationship between ES, LULC trajectories and ecological setting has been fully investigated with the aim to identify the provision and spatial distribution of ES and to evaluate environmental costs and benefits of different land planning decisions (e.g. De Fries et al., 2004; Feng et al., 2012; Mendoza-Gonzalez et al., 2012; Nahuelhual et al., 2014; Schirpke et al., 2013). Given the difficulty to take into consideration the wide range of ES (supporting, provisioning, regulating and cultural) in a territory, the identification of the main trajectories of land change and related LD processes provides a framework to focus on the key ES affected (Barral and Maceira, 2012).

The aim of this study is to develop an evaluation framework for identifying the linkages between land change, LD processes and ES. The procedure relates the trajectories of land change to LD processes which in turn can affect ES provision, suggesting Sustainable Land Management (SLM) options suited to reverse (or mitigate) LD impact. Despite the importance attributed to land use planning in contrasting unsustainable land cover changes, often ES provision is not taken into consideration (Cowling et al., 2008). The procedure presented in this paper incorporates the analysis of ES in the identification of the most appropriate SLM solutions evaluating changes in LULC, the environmental sensitivity to LD and population dynamics.

The procedure was developed at local scale in two areas in Italy traditionally used for agricultural purposes, which differ substantially in terms of environmental heterogeneity, rural development and land cover dynamics: the Fortore valley in southern Italy and the Valpadana, a portion of the Po plain, in northern Italy. The development of the procedure at local level can help to shed light on important issues and to a better understanding of the local context, priorities and values (Potschin and Haines-Young, 2013), also in relation to ES and sustainability (Turner et al., 2007). While the national scale meets the needs for monitoring and forecasting to support broad management strategies, it is at the regional/local scale that environmental policies and management would be best implemented and applied (Wilson, 2009).

As typically observed in Italy, as well as in other European areas, the period analyzed, of about 50 years, is characterized by the rapid industrialization, urbanization and agricultural intensification of the lowland areas (Antrop, 2000; European Environment Agency, 2006; Lambin and Geist, 2006; Serra et al., 2014) and the abandonment of hilly and mountainous areas (Ferrara et al., 2014; MacDonald et al., 2000) with considerable changes in the local economic structure (Cowell, 2010).

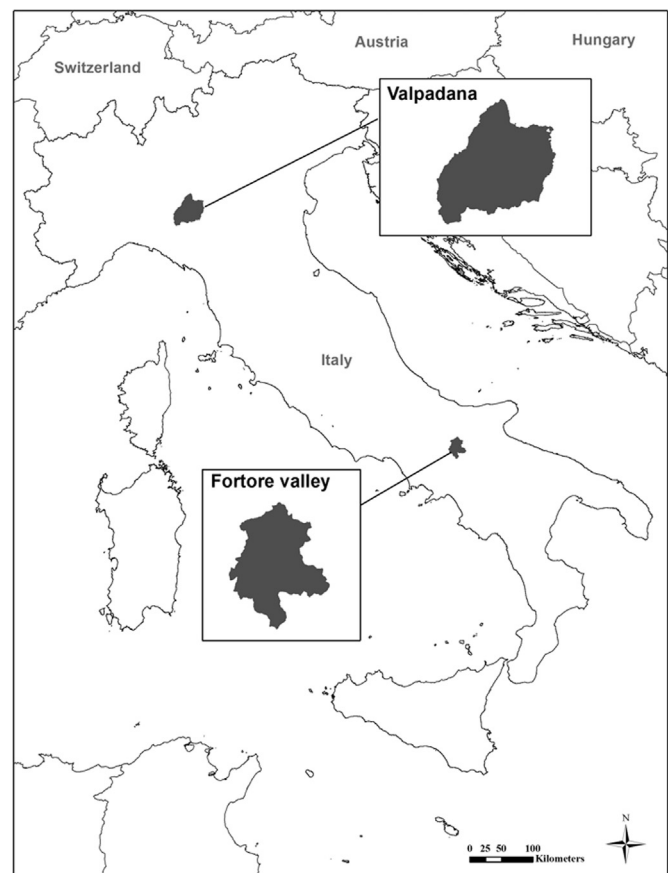


Fig. 1. Location of the study areas (the Valpadana and the Fortore valley).

2. Study areas

2.1. Fortore valley

The Fortore valley is located in southern Italy (Fig. 1), and extends around 472 km². The area is mainly mountainous (55%) and hilly (39%), covering between 400 and 900 m above sea level. Being part of the Apennine mountain range of southern Italy, the valley experienced a progressive depopulation in the last decades. The flysch substratum makes the area particularly sensitive to the risk of soil erosion. Nearly 1600 landslides have been surveyed in the study area (<http://www.sinanet.isprambiente.it/progettoiffi>). Land is primarily used for cropping (82%), especially wheat. Natural and semi-natural areas cover 17% of the study area and the artificial surfaces occupy only 1% of the valley.

2.2. Valpadana

The study area is situated in the provinces of Parma and Piacenza, in the Emilia Romagna region, northern Italy (Fig. 1), covering a surface of around 1423 km². The area is mainly characterized by the alluvial plain of the Po River, which is sensitive to both rapid urban expansion and agricultural development. The hilly landscape of the Apennine mountain range represents a part of the study area and is mostly occupied by natural and semi-natural areas. The land cover is dominated by agricultural areas (73%), mainly wheat, but also maize and meadows. The natural and semi-natural areas cover about 18%. Artificial areas, which cover almost 7%, are primarily located in the flat district.

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