



## Analysis

## Towards sustainability in agro-forest systems? Grazing intensity, soil degradation and the socioeconomic profile of rural communities in Italy

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## ABSTRACT

Overgrazing is a common form of land degradation at the global scale with negative impact on ecosystem functioning, natural capital stocks, socio-ecological systems and economic development. Although most of the regions in Mediterranean Europe are affected by soil degradation driven by unsustainable grazing, information on the spatial relationship among overgrazing, the economic structure and socio-spatial attributes of rural communities is limited. The present study explores the relationship between an index of grazing pressure and a set of indicators assessing six thematic domains (Population dynamics and human settlement, Labour market and human capital, Economic specialization and competitiveness, Quality of life, Agriculture and rural development, Territory and environment) at the municipal scale in Italy. An exploratory data analysis based on non-parametric inference, multiple regression models, Principal Component Analysis and Hierarchical Clustering was developed with the aim to profile municipalities exposed to high or low degree of grazing pressure. An index of overgrazing-driven soil degradation risk which integrates grazing intensity and soil erosion risk was finally proposed. The analysis contributes to identify socioeconomic factors influencing soil degradation in areas with unsustainable grazing possibly leading to desertification risk. Results indicate that the socioeconomic profile of municipalities with high grazing pressure is characterized by specific socio-spatial and economic attributes, traditional cropping systems and a typical land-use structure. Our results may support the development of sustainable land management strategies in areas sensitive to land degradation in the Mediterranean region.

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## 1. Introduction

Soil quality plays a key role in the process of land degradation and desertification in dry and semi-arid regions, especially in cases where increased human pressure negatively impacts natural resources owing to climate changes and landscape transformations (Rubio and Bochet, 1998; Geist, 2005; Helldén and Tottrup, 2008; Abu Hammad and Tumeizi, 2012). The ultimate determinants of soil degradation include inappropriate agricultural practices, deforestation, overgrazing, forest fires and the competition with urban uses of land (Zdruli, 2014). These factors may selectively influence degradation processes such as soil erosion, salinization, sealing, compaction, contamination and loss in organic carbon or affect landscapes in an indirect way (Montanarella, 2007; Costantini et al., 2009; Salvati, 2014).

Unsustainable grazing is one of the most diffused problem in land management at the global scale and is regarded as a serious pressure on natural landscapes (Rowntree et al., 2004; Eichhorn et al., 2006; Ibáñez et al., 2007, 2014; Vetter and Bond, 2012). According to Röder et al. (2007, p. 387), “despite their long history of utilization, recent

changes in socioeconomic frameworks and the intensification of grazing systems have frequently caused rangeland ecosystems to depart from equilibrium states and initiated degradation processes”. Overgrazing is a powerful factor shaping desertification risk especially in areas where land morphology, climate, vegetation cover and soil attributes are unsuitable for intensive agricultural use (Peco et al., 2006; Kéfi et al., 2007; Zhou et al., 2010; Carmona et al., 2012, 2013). While economic development and the higher level of technology in agriculture have accelerated the decline of the number of employees in the livestock sector (Bernués et al., 2011), the local increase in animal density and the shift towards more intensive production systems increased the environmental concerns for unsustainable grazing (Hadjigeorgiou et al., 2002). Moreover, climate changes have been demonstrated to severely impact Mediterranean rangeland ecosystems (Fleischer and Sternberg, 2006). These conditions also create uncertainty in the sustainable management of rangeland (Quaas et al., 2007).

With evolving socioeconomic and environmental conditions at the local scale, revised agricultural policies and changing international market forces (Lambin and Meyfroidt, 2010; Romm, 2011; Abu Hammad and Tumeizi, 2012; Salvati and Carlucci, 2011), unsustainable grazing is considered a key factor in the degradation of Mediterranean agro-forest landscape (Conacher and Sala, 1998). Grazing intensity is

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sensitive to land-use and conservation practices at farm level and to external factors including climate changes, water shortage and socioeconomic forces (Montanarella, 2007). It has also been demonstrated (Barbayannis et al., 2011) that the European Union Common Agricultural Policy measures adopted for Less Favoured Areas stimulate grazing intensification based on financial supports whose effectiveness is largely variable according to the socioeconomic local context. In some economically-disadvantaged, marginal and mountain areas, the characteristics of rural communities may partly reflect the dependence on subsidies from the state or from the European Union (e.g., Salvati and Carlucci, 2011). At the same time, pasture-based livestock farming systems are considered priority habitats preserving traditional and high natural value farmlands in Mediterranean Europe (Bernués et al., 2011). A sustainable management of pastures may also contribute to contain soil erosion and to mitigate land degradation creating, at the same time, favourable conditions for vegetation and thus improving soil fertility (Peco et al., 2006).

The diffusion of sustainable grazing is a process where farmers' and rural entrepreneurs' knowledge, motivations and values play an important role, involving changes in the decision-making behaviour of farmers, in the institutional framework conditions, as well as innovations in agricultural technologies. However, as noted in the extensive review by Tey and Brindal (2012), the literature provide contrasting findings on the 'trigger' factors of the actions carried out by individual farmers, resulting in multifaceted behaviour. Moreover, due to the complex and intensive data gathering required, this line of investigation is better suited to hotspots field studies (Lamarque et al., 2013) than to a country-wide analysis.

Despite that some relevant relations between grazing and basic environmental conditions have been documented in southern Europe, the interactions between rural development, local communities and the territorial context were poorly explored in relation to grazing pressure and the possible consequences for soil degradation were assessed only in specific case-studies using indirect approaches (Kosmas et al., 2003; Iosifides and Politidis, 2005; Ibáñez et al., 2007; Imeson, 2012). Rowntree et al. (2004) discussed the complex relationship between soil erosion and overgrazing. Kéfi et al. (2007) investigated the vegetation patchiness when desertification is imminent and its relation with progressively higher levels of grazing pressure. Ibáñez et al. (2014) and Vetter and Bond (2012) introduced models estimating stocking rate and vulnerability to soil degradation at different grazing intensity and addressing the environmental characteristics of the Mediterranean region. Papanastasis (2009) argued that severe effects on forests are caused by free and uncontrolled grazing by livestock coupled with frequent pastoral wildfires. Forest conversion of wildland to farms, olive orchards and residential areas has a considerable impact on the landscape and the impact of pastoral wildfires is well known in various Mediterranean regions, from Portugal to Turkey (see Bajocco et al., 2011 and references therein).

From the socioeconomic perspective, Kosmas et al. (in press) evaluated the role of various factors shaping the risk of desertification at the continental scale in Europe identifying specific drivers of land abandonment associated with unsustainable grazing in the Mediterranean region. Abu Hammad and Tumeizi (2012) presented a local-scale analysis corroborating Kosmas and co-workers' results. Imeson (2012) debated on the effect of selected overgrazing drivers on land degradation and provides evidence in line with what found by Kosmas et al. (in press). Lorent et al. (2008) demonstrated that macro-economic policies (including agricultural subsidies) are a driving force of land degradation in marginal regions of Mediterranean Europe. Unfortunately, most of these studies have dealt with specific territorial contexts and the description of the socioeconomic conditions associated with grazing intensity (or intensification) was developed using a quite restricted set of territorial indicators.

The inherent difficulties that could arise in linking specific environmental characteristics, such as grazing pressure, to the socioeconomic

attributes of Mediterranean rural communities – due to the lack of a specific theoretical or even empirical background – may be overcome by the use of a large set of socioeconomic indicators analyzed through an exploratory approach based on multivariate statistics. Such approaches proved to be suited to represent the complexity of local-scale socio-environmental interactions (see Hargrove and Hoffman, 2005; Salvati and Zitti, 2009 and references therein), avoiding the risk of substantive inadequacy (Spanos, 2010) that could arise when economic theories are foisted on the data as in traditional econometric models (Salvati, 2014). In other words, the working hypothesis of this study is that an 'operational definition' (quantitatively measured) of sustainability through indicators and indices – in some sense decoupled from an a priori theoretical framework – is a prerequisite for the adequate design, implementation and monitoring of multi-domain policies aiming at a more sustainable rural development sector (Gómez-Limón and Sanchez-Fernandez, 2010). The final objective of this study is to identify if a higher grazing intensity will be associated with a specific socioeconomic profile at the local scale (e.g., based on rural poverty, economic backwardness, low accessibility, extensive agriculture, land abandonment, population aging). These results contribute to design fine-tuned rural development policies for agro-pastoral systems which are truly based on the three pillars (environment, society, economy) of sustainability (Sarkar, 1998).

Based on these premises, the present study proposes an exploratory analysis of the spatial distribution of a proxy indicator evaluating grazing pressure at the local scale compared with 132 indicators illustrating a comprehensive set of territorial and socioeconomic attributes of rural communities in Italy. Municipalities were considered a suitable spatial unit to explore, and possibly clarify, the nexus between the local socioeconomic context and environmental degradation processes using indicators derived from official data sources (Salvati, 2014). An index of soil degradation risk integrating grazing intensity and soil erosion estimates was finally proposed with the aim to inform a sustainable land management strategy in sensitive areas to soil and land degradation.

## 2. Methodology

### 2.1. The Investigated Area

The study area includes the whole Italian country covering 301,330 km<sup>2</sup> of which 23% are flat, 42% are hilly and 35% are mountainous. Italy is characterized by a traditional north–south divide in both environmental conditions (climate, landscape, vegetation, soil and agricultural systems) and socioeconomic variables (income and wealth, labour market and demography). Italy – and especially southern Italy – is considered a hotspot for land degradation and desertification risk in the northern Mediterranean region (Costantini et al., 2009). Italian land is administered by twenty regions and more than 8000 local municipalities. The administrative asset of 2001 was chosen in this study as the reference spatial unit (8101 local municipalities) to enable an effective matching between environmental and socioeconomic data derived from official sources (Istat, 2006). The local governance system changed only moderately in the last decade with nearly 8070 municipalities administering the Italian territory in 2013.

### 2.2. Assessing Grazing Intensity

Grazing pressure was estimated according to Perini et al. (2008) through a proxy indicator: the ratio of the surface area of pastures available in each municipality (hectares) to livestock density (expressed in a standardized weight unit called Livestock Unit: see Trisorio, 2005). The Livestock Unit (LU) quantifies livestock density with reference to the average farm dairy cow (corresponding to one LU) by weighting the different livestock species using a coefficient system (cattle and buffalo [0.8 LU], horses [0.6 LU], pigs [0.4], sheep and goats [0.1 LU] and poultry [0.016 LU]). Livestock consistency by species and municipality and the

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