AGRICULTURAL PROFITABILITY AND SUSCEPTIBILITY TO SOIL DEGRADATION IN A CHANGING MEDITERRANEAN LANDSCAPE

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Biographical Notes

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Abstract

This study explores at the local scale the possible linkages observed in recent years between the level of land vulnerability to degradation and selected agricultural systems in Italy. By analyzing
agricultural added value and land productivity in combination with additional socioeconomic indicators available at the district scale, we found different environment-economy relationships depending on the local context. The analysis was undertaken in both the early-1990s and early-2000s on 784 districts with different land degradation vulnerability. Results indicate that, in the early-1990s, land productivity in northern Italy was positively correlated to labour productivity in agriculture, agriculture’s share in total product, and level of land vulnerability. However, during the following years, the increase in land productivity was not associated to a parallel increase in the level of land vulnerability. A contrasting pattern was observed in southern Italy: here, the observed increase in land productivity was accompanied by a rising proportion of land classified as vulnerable to degradation. Based on these results, agro-environmental measures supporting sustainable agriculture in marginal inland areas and contrasting land degradation risk are discussed.

**Keywords:** Land vulnerability, Land profitability, Agriculture, Geographical scale, Southern Europe.

**JEL Classification:** Q15, Q24, R14, R52.

1. **Introduction**

Coupled with soil degradation, biodiversity erosion, climate and land-use changes, Land Degradation (LD) is a complex phenomenon determined by the joint action of several bio-physical and socioeconomic drivers (Geist and Lambin 2004). The United Nations Convention to Combat Desertification describes ‘land’ as a “terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system”, and its ‘degradation’ as a “reduction or loss of the biological and economic productivity” resulting from land mismanagement, soil quality reduction, and long-term loss of natural vegetation (Brandt et al 2003).


The Mediterranean region is characterized by structural landscape fragility, human pressure, important regional disparities and unstable socioeconomic conditions (Iosifides and Politidis 2005, Montanarella 2007, Salvati 2010). This region is also considered an hot-spot for climate change, forest fires and desertification risk. Following climate aridity, soil deterioration, and land-use
changes an increasing level of land vulnerability to degradation was observed along the northern Mediterranean basin over the last decades (Simeonakis et al 2007, Lavado Contador et al 2009, Salvati and Bajocco 2011). In this area LD impacted the primary sector determining, at local scale, a land productivity decrease and changes in the geographical distribution of crops at regional scale. The scarcity of water and the ever more frequent heat waves and severe drought episodes are possible drivers for such processes (e.g. Olesen and Bindi 2002, Thomas 2006, Salvati and Carlucci 2011). Climate aridity may also determine a reduction of irrigated areas in regions where the agriculture is most heavily affected by competition with industrial and urban uses of water (Perez-Sirvent et al 2003, Rodriguez Diaz et al 2007, Sivakumar 2007). As a result, some of the low-input, marginal farming systems may be severely affected by climate variations and LD (Lorent et al 2008).

In this context there is certainly scope to study extensively the impact of LD on the economic system. The relationship between land productivity and LD, assessed in some previous studies at farm scale (Boellstorff and Benito 2005, Atis 2006, Danfeng et al 2007, Hein 2007), should be investigated at wider scales in order to highlight the possible linkages with regional-based processes such as agricultural intensification (or land abandonment), soil deterioration, climate and land-use changes. Meso-scale approaches, even if empirical and cross-sectional, may stimulate fine scale, in-depth studies designed to address the complexity of the environment-agriculture relationship in a climate change context (Mendelsohn and Dinar 2003, Midmore and Whittaker 2000, Thomas 2006, Veeman et al 2008, Smith et al 2010).

To contribute to this deserving issue, the present paper analyzes over time the linkages, if any, between an indicator of the level of LD vulnerability covering a Mediterranean country and selected agricultural performance variables estimated at regional scale. We chose economic districts as the analysis unit scale and Italy as a paradigmatic case of the environment-economy complexity typical of the Mediterranean basin. In Italy local districts represent the finest scale to correlate macro-economic variables with environmental, social, and agricultural variables (Salvati and Zitti 2008).

Even if preliminary, this study provides an empirical background for testing hypotheses on the possible impact of LD on the rural development of economically disadvantaged regions. We adopted two approaches here: the first one was based on a simplified quantitative approach and used economic and environmental indicators derived from official data sources to explore the potential relationship between agricultural productivity and land degradation susceptibility. The second one relies on an expert-based analysis following a qualitative approach and focusing on the highest LD-vulnerable region in Italy.
The results presented in this paper may stimulate the integrated analysis of the environment-economy interaction at a disaggregated scale. Such analysis provides evidence on the linking (or delinking) processes among agricultural productivity, the creation of added value in the primary sector, and the (possibly increasing) land vulnerability to degradation in susceptible and non-susceptible land. Effective strategies coping with two apparently divergent targets (reducing the agriculture’s impact on the Mediterranean environment and preserving the economic viability of the primary sector especially in marginal, inland areas) are finally discussed.

2. Methods

2.1 Logical framework

To evaluate the level of land susceptibility to degradation we used selected environmental and socioeconomic indicators estimated on the 784 districts that reflect Local Labour Market Areas (LLMAs) covering the entire Italy (301,330 km²). To assure temporal and spatial comparability among the selected variables, these districts were identified on daily data of labour mobility utilising Population Census data (Istat 2006). LLMAs have been also used to analyze the level of land vulnerability to degradation (Salvati and Zitti 2008), the performance of the primary sector (Giusti and Grassini 2007), and the relationship between economic competitiveness and environmental sustainability (Salvati and Carlucci 2010).

The level of LD vulnerability was quantified in early 1990s and early 2000s through the Environmentally Sensitive Area Index (ESAI) procedure which composes several climate, soil properties, vegetation, and human pressure variables into a summary indicator. The selection of the two time points considered in this study was due to the restricted data availability at local scale (Salvati 2010).

Various interdisciplinary EU research projects carried out extensive evaluations of LD vulnerability using the ESA framework (e.g. Brandt et al 2003). Results of the procedure were validated on the field in several Mediterranean areas by analysing the correlation between the ESAI and some indicators of soil quality and physical degradation (Kosmas et al 2011], Basso et al 2000, Lavado Contador et al 2009). The methodology is based on more than ten variables covering the geological, topographical and climatic conditions, as well as the typical features of land cover for Mediterranean Europe (Salvati and Bajocco 2011). A statistical analysis was performed for each variable in order to define (i) the correlation of the variable to the level of LD, (ii) the correlations within the data matrix, and (iii) the contribution of each variable to the estimation of land vulnerability (Basso et al 2000). To each variable a set of vulnerability scores was assigned (Brandt
et al 2003). Scores derived from the statistical analysis and from additional information gathered from the available literature (Lavado Contador et al 2009). A sensitivity analysis was undertaken in order to indicate the most valid, low-cost, and efficient set of key variables and scores by theme (Kosmas et al 2011). For each theme, a quality indicator was calculated by averaging the vulnerability scores of the selected variables. A composite index was then calculated by averaging the values of the quality indicators (Salvati and Bajocco 2011).

2.2 Environmental data and indicators
All variables selected in this study match a number of requirements which influence the reliability of the outcome including the (i) availability and regularity of time series, (ii) quality and reliability of data sources, and (iii) easy computing of integrated alphanumeric and cartographic data (Salvati and Zitti 2008). Climate quality was described here by considering the average annual rainfall rate, the aridity index (defined as the ratio between rainfall and reference evapotranspiration, both measured over a thirty years period), and aspect (Basso et al 2000). These indicators were calculated using basic information available in the National Agro-meteorological Database of the Italian Ministry of Agriculture (Salvati and Carlucci 2010). The database relates to data collected from nearly 3,000 gauging stations since 1951. To ensure the homogeneous territorial coverage, the meteorological data were spatially interpolated through kriging or co-kriging procedures (with elevation, latitude, and distance to the sea as ancillary variables) in order to create a grid of 544 points with daily data of temperature, precipitation, humidity, solar radiation, and wind. Two analysis periods were selected: 1961-1990, and 1971-2000. The reference evapotranspiration rate was calculated using the Penman-Monteith formula (Salvati and Bajocco 2011).

Soil data were obtained from the soil quality map produced in the framework of DISMED project (Brandt et al 2003) and derived from the European Soil Database at a 1 km² pixel resolution (Joint Research Center, JRC). An Italian database of soil characteristics (‘Map of the water capacity in agricultural soils’), generated by the Ministry of Agriculture and based on nearly 18,000 soil samples, thematic cartographies (Land system map, Ecopedological map, and Geological map of Italy, respectively obtained from the National Centre of Pedological Cartography, JRC-Ispra, and the Italian Geological Service), and a Digital Elevation Model provided by the Ministry of the Environment with 70 m resolution were used as ancillary information (Salvati and Carlucci 2011). These datasets can be considered as the standard soil information available at regional level and are presented for use at the scale of 1:500,000. This scale is adequate for the level of analysis adopted in this paper (Salvati and Bajocco 2011). Soil texture, depth, slope, and parent material, regarded as
proxies for additional soil structure influencing factors (e.g. organic matter, compaction), were selected as input variables (Kosmas et al 2011). These variables were considered as static during the investigated time period since they change slowly or rarely and by their nature are infrequently measured or mapped (Salvati and Zitti 2008).

Land cover changes and LD were quantified through four standard ESA variables: fire risk, vegetation protection against soil erosion, vegetation resistance to drought, and vegetation cover (Basso et al 2000). Such indicators were obtained from the CORINE (COoRdinate INformation on the Environment) cartography in both 1990 and 2000. The Corine Land Cover (CLC) project coordinated by the European Environment Agency (EEA) provided diachronic, pan-European land cover maps (Salvati and Bajocco 2011). The CLC inventory is based on satellite images as the primary information source. The choice of scale (1:100.000), Minimum Mapping Unit (MMU) (25 hectares) and minimum width of linear elements (100 metres) for CLC mapping represents a trade-off between production costs and land cover information details (Eea 2007). The standard CLC nomenclature includes 44 land cover classes. These are grouped in a three-level hierarchy. The five main (level-one) categories are: i) urban fabric, ii) agricultural areas, iii) forests and semi-natural areas, iv) wetlands, and v) water bodies. According to Kosmas et al 1999, a weight was attributed to each cover category in order to obtain a land classification based on the different vulnerability level of its vegetation. Finally, human pressure was assessed using population density and demographic variation. Both variables were measured at municipal scale in 1991 and 2001 on the basis of the National Census of Households (Salvati and Zitti 2008). Population growth rate was calculated for two defined time horizons (1981-1991 and 1991-2001).

Since severe LD processes result mainly from unsustainable land management coupled with a particular set of soil, climate, and vegetation conditions, four thematic indicators, quantifying the environmental quality in terms of climate (Climate Quality Index, CQI), soil (Soil Quality Index, SQI), vegetation (Vegetation Quality Index, VQI) and land management (Land Management Quality Index, MQI), were estimated as the geometric mean of the different scores for each considered variable. The scores of each thematic indicator ranges from 1 (the lowest contribution to land vulnerability to degradation) to 2 (the highest contribution to vulnerability to degradation). The ESAI was estimated in each i-th spatial unit and j-th year as the geometric mean of the four partial indicators (Brandt et al 2003): The index ranges from 1 (the lowest land vulnerability to degradation) to 2 (the highest vulnerability to degradation). According to the ESAI range, four land classes were identified (Basso et al 2000): (i) non-affected land (ESAI < 1.17), (ii) potentially affected land (1.17 < ESAI < 1.225), (iii) ‘fragile’ land (1.225 < ESAI < 1.375), and (iv) ‘critical’
land (ESAI > 1.375). Intermediate and final maps were produced after the various layers were referenced to the elementary spatial unit having a resolution of 1 km². An average ESAI value was assigned to each district on the basis of the ‘zonal statistics’ tool provided with the software ArcGIS (Salvati and Carlucci 2010). This procedure computes a weighted average of the ESAI values belonging to each district.

2.3 **Socioeconomic variables**

The economic variables considered in this analysis were: *per capita* district added value (INC), agriculture’s and industry’s share in total district product (respectively AGR and IND), land profitability (LP), and labour profitability of the agriculture (FP). All variables, derived from the national account statistics and the agricultural censuses carried out by the Italian National Institute of Statistics (Istat) referred to the early-1990s and early-2000s (see Table 1). LP and FP were respectively obtained as the agriculture’s added value *per* hectare of utilised agricultural area (UAA) and the ratio of agriculture’s added value to work units (Trisorio 2005). A crop intensity index was computed according to Salvati and Bajocco 2011.

Table 1. Selected economic and environmental variables by geographical region in Italy (2000).

<table>
<thead>
<tr>
<th></th>
<th>North</th>
<th>Centre</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture’s share in total product (%)</td>
<td>2.5</td>
<td>1.9</td>
<td>4.6</td>
</tr>
<tr>
<td>Land profitability (1,000 euros <em>per</em> hectare of UAA)</td>
<td>2.8</td>
<td>1.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Land profitability (1990-2000 change, %)</td>
<td>2.5</td>
<td>1.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Labour profitability in agriculture (1000 euros <em>per</em> work unit)</td>
<td>28.2</td>
<td>25.1</td>
<td>17.9</td>
</tr>
<tr>
<td>Labour profitability in agriculture (1990-2000 change, %)</td>
<td>4.8</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Population living in rural municipalities (%)</td>
<td>20.2</td>
<td>12.6</td>
<td>56.7</td>
</tr>
<tr>
<td>Workers employed in primary sector (% on total workforce)</td>
<td>3.8</td>
<td>3.6</td>
<td>9.4</td>
</tr>
<tr>
<td>Crop intensification (1990-2000, %)</td>
<td>0.1</td>
<td>1.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Environmental Sensitive Area Index (ESAI score)</td>
<td>1.22</td>
<td>1.25</td>
<td>1.28</td>
</tr>
<tr>
<td>ESAI (1990-2000 change, %)</td>
<td>2.2</td>
<td>2.5</td>
<td>2.3</td>
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</table>

2.4 **Statistical analyses**

The possible linkage observed at regional scale between the profitability of agriculture and the (increasing) land vulnerability to degradation is influenced by different driving forces (Mendelsohn and Dinar 2003). The agriculture is, among others, a factor with a two-side relationship with LD. On the one hand, rural development influences land quality *sensu lato* (Mendelsohn et al 2007) because the growth of the primary sector is usually accompanied by crop intensification determining unsustainable mechanisation, poor water management, and soil pollution phenomena (Cacho 2001). The abandonment of lands, where depopulation and economic marginalization take
place represents the other side of the coin (Wiebe 2003). The contribution (positive or negative) of the agriculture to LD hence depends on the ability to balance these two opposite interactions (Le Houerou 1993).

In turn LD impacts the primary sector in a multifaceted way (Pender 1998], Cuffaro 2001, Pender et al 2004). Since the agricultural production is sensitive to losses in soil fertility and recurrent water shortage, output and productivity of man-made capital and labour in the primary sector were influenced by LD (Shortle and Abler 1999). The effect of LD on the agricultural profitability may be masked by the use of inputs that increase the yields, but they do not stop the negative trend in yields due to the degradation of natural capital (Salvati and Carlucci 2010). The relationship between LD and the agricultural system would be also influenced by exogenous variables such as traditional production factors, local differences in prices, policies, and site-specific variables, making more difficult the exploration of the possible linkages existing between these two dimensions (Salvati 2010).

We therefore analyzed the available indicators through an exploratory approach which includes linear regression and multivariate analysis such as the Multiway Factor Analysis (MFA). The rationale of using the MFA coupled with linear regression is to provide an overview of the relationships among all considered variables, since regression mainly concentrates on the most significant relationships among them. First, we specified two regression equations for the dependent variable (LP) according to a simplified model as follows:

\[
\begin{align*}
\log (LP_t) &= a + b_1 (AGR_t) + b_2 \log (FP_t) + b_3 \log (ESAI_t) + e \\
\log (LP_{t+1} / LP_t) &= a + b_4 (AGR_{t+1} - AGR_t) + b_5 \log (FP_{t+1} / FP_t) + b_6 \log (ESAI_{t+1} / ESAI_t) + e
\end{align*}
\]

In these specifications LP at the initial time and its change in output is function of labour productivity and, indirectly, of the technological progress in the primary sector, its share in total product (taken as a proxy of the level of per capita added value), and land vulnerability to degradation (which specifies the aggregate effect of climate variability, soil quality, and other biophysical variables possibly impacting LP). The simplified specification reflects data availability at the detailed spatial level considered in this paper (Mendelsohn and Dinar 2003).

Equations were separately estimated for three geographical domains (northern, central, and southern Italy, see Figure 1) using a stepwise linear regression weighted by the surface area of each district. Regression coefficients were indicated by \( b_1, \ldots, b_6 \). Predictors entered each model according to the results of \( F \) tests with a probability level fixed to 0.01; \( e \) represents the regression error term.
Results report the variables entered each model with significant coefficients. Collinearity among variables was checked throughout by way of variance inflation factor and condition index. A MFA was then carried out in order to explore changes in LP in those districts where LD is potentially more severe (i.e. all districts belonging to the southern Italian region: Salvati and Bajocco 2011). The procedure was applied separately for the two study years to the matrix composed by six variables (INC, AGR, IND, AP, FP, and ESAI) measured on 365 local districts. Six dummies identifying the administrative region to whom each district belongs to (Abr: Abruzzo; Mol: Molise; Cam: Campania; Apu: Apulia, Bas: Basilicata; Cal: Calabria; Sic: Sicily; Sar: Sardinia) were included in the analysis as supplementary variables. The six dummies were introduced to control the disparities existing in the agricultural variables coupled with regional-based differences in the environmental and economic policies possibly mitigating LD risk.

The MFA is a generalisation of the Principal Components Analysis (PCA) whose goal is to analyse sets of variables collected on the same set of observations (Coppi and Bolasco 1989). The objectives of the MFA are i) to analyse diachronically the relationship between the different data sets, ii) to combine them into a common structure called ‘compromise’ which is then analysed via PCA to reveal the common structure between the observations and finally, iii) to project each of the original data sets into the compromise in order to analyse communalities and discrepancies. The
weights used to compute the compromise are chosen to make it as representative of all data sets as possible (Lavit et al 1994). The MFA allows (i) to evaluate if the position of the observations (i.e. districts or administrative regions) is stable or changing over time and (ii) to determine the conjoint trajectories of the considered economic variables. Changes in the different variables were described by projecting them into the same plane formed by the two main MFA axes. Points (i.e. economic variables) placed close to each other in the factorial plane indicate spatial association, while points placed far from each other indicate spatial segregation (Coppi and Bolasco 1989).

2.5 Qualitative analysis

Based on quantitative analyses and additional information taken from reference works, a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was implemented for the two Italian regions that have been investigated in the present study: northern and central Italy (together) vs southern Italy. The SWOT framework is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats of defined economic contexts by contrasting their socioeconomic and environmental features (Hill and Westbrook 1997). This framework allows identifying the internal and external forces that are favourable or unfavourable to achieving a target (in this case, sustainable rural development). Strength and Weaknesses are attributes of the system that are respectively helpful or harmful to achieve the objective. Opportunities and Threats are external conditions that are respectively helpful or harmful to achieve the objective.

3. Results

The analysis of economic indicators reveals the complex pattern of rural development in Italy and its possible linkage with LD (Table 1). Although decreasing in time, the agriculture’s share in total product was found relatively high in southern Italy. The low profitability of the two production factors considered here (land and labour) indicates that an higher resource efficiency in agriculture could be gained in the short-term. This pattern could influence land quality possibly triggering LD via crop intensification (Figure 2). A generally low crop intensity observed in southern Italy as compared to the central and northern Italy (Figure 3) confirms that local-scale intensification processes are still possible in that area.

As a result of the different development paths that occurred during the last years in Italy, a really contrasting pattern was observed in the three investigated regions. As the regression analysis indicates (Table 2), in the early 1990s the LP was found positively associated to FP in all geographical areas (Equation 1). Interestingly, the regression coefficients clearly increased from
northern to southern Italy. In the economically-developed districts of northern and central Italy, the LP was also found positively correlated with AGR. Only in northern Italy, however, a higher level of the LP was also found correlated to higher levels of land vulnerability to degradation.
Figure 2. An estimation of crop intensity at the local scale in Italy using a proxy indicator in 2000 (left) and crop intensification (in percentage) between 1990 and 2000.

Figure 3. The loading plot of the Multiway Factor Analysis.
Table 2. Estimates of exploratory stepwise regressions among the agricultural profitability (taken as the dependent variable) and selected economic variables in Italy by geographical area (standard errors are reported in brackets; one and two stars indicate significance at $p < 0.01$ and $p < 0.001$, respectively).

<table>
<thead>
<tr>
<th></th>
<th>Northern Italy</th>
<th>Central Italy</th>
<th>Southern Italy</th>
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<tbody>
<tr>
<td></td>
<td>Eq. 1</td>
<td>Eq. 2</td>
<td>Eq. 1</td>
</tr>
<tr>
<td>log(FP)</td>
<td>4.11(0.73)</td>
<td>4.81(1.18)</td>
<td>7.51(1.58)</td>
</tr>
<tr>
<td>$\Delta$ log(FP)</td>
<td>0.55(0.21)</td>
<td>3.29(0.87)</td>
<td>0.78(0.23)</td>
</tr>
<tr>
<td>log (ESAI)</td>
<td>2.60(0.50)</td>
<td></td>
<td>2.73(0.61)</td>
</tr>
<tr>
<td>$\Delta$ (AGR)</td>
<td>-0.09(0.04)</td>
<td>-0.01(0.00)</td>
<td>-0.01(0.00)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.09(0.04)</td>
<td>-0.01(0.00)</td>
<td>-0.01(0.00)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.27*</td>
<td>0.41*</td>
<td>0.24*</td>
</tr>
<tr>
<td>N</td>
<td>283</td>
<td>136</td>
<td>365</td>
</tr>
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</table>

During the investigated time period (Equation 2), the increasing LP was found throughout associated to a parallel increase of both FP and AGR. However, in southern Italy only the increasing LP was found associated to a consistent increase in the level of land vulnerability to degradation. In other words, the increasing LP was found associated to the level of land vulnerability in both northern and southern Italy, although in northern Italy the correlation was found significant only in the absolute values observed in the early 1990s, while in southern Italy the correlation was found significant only when the difference between the beginning and the end of the study period was considered. This suggests that, on average, the increase in LP may influence the environmental conditions leading to LD, despite this pattern was differentiated in northern and southern Italy because of the contrasting environmental conditions found in these regions.

The results of the MFA confirm this pattern. The first axis (Figure 4) accounted for nearly 16% of total variance and illustrates the increasing land vulnerability to degradation in dry regions like Apulia, Sicily, and Sardinia, as the positive loading of the ESAI testifies. The second axis explained 15% of total variance and is taken as a proxy of rural development. Notably, INC was associated to the positive values of this axis and AGR, a variable widely used to indicate disadvantaged economic conditions, showed the opposite pattern. Arrows indicate, on a time basis, the most important changes in the considered variables. The ESAI showed a positive shift along the first axis suggesting that the conditions determining LD became worse during the last years in the most LD-vulnerable districts. Land profitability showed a similar pattern compared with the ESAI. Finally, AGR moved along the first axis suggesting that the agriculture’s share in total product was high and relatively stable in the most vulnerable areas of southern Italy, while decreasing in less vulnerable and more developed districts.
Figure 4. Examples of rural landscapes associated to specific LD problems in vulnerable areas of Southern Italy.

4. Discussion

The present article illustrates an exploratory procedure appropriate for analyzing the economic dynamics of rural systems suffering soil deterioration, human pressure, climate and land-use changes. The results presented here well depict the complexity of the environment-economy relationships especially observed in the disadvantaged (and LD-vulnerable) southern Italian region. This complexity, partly due to the multi-faceted linkages observed between the rural system and the level of vulnerability to degradation, was traditionally attributed to the different long-term growth paths observed in northern and southern Italy (Salvati and Carlucci 2011). However, the present study points out also the role of local-scale factors that may influence the sustainable rural development path more than regional-wide variables (Brunori and Rossi 2007).
In northern Italy a higher LP was found associated, on average, with increasing levels of LD in the early 1990s. Evidence from previous studies, however, indicates that LD occurs in northern Italy only on restricted land and depends primarily on human drivers, since the ecological conditions (e.g. climate, soil, water availability) are generally optimal for crop (Salvati and Bajocco 2011). In addition, since the agriculture’s share in total product was found low and decreasing over time, to measure the aggregate impact of LD on the profitability of agriculture is a relatively difficult exercise (Tanrivermis 2003). Although in the 1970s and 1980s several lowland areas underwent a crop intensification process (Salvati and Zitti 2008) that contributed to the increase of land vulnerability (results of the regression analysis illustrated here reflect this pattern), the increasing level of LP was not associated to the increase of land vulnerability in the most recent years, as this study testifies.

A contrasting picture was observed in southern Italy, an economically-disadvantaged region subsidized by the European Union and with large surface areas suffering LD and climate aridity (Juntti and Wilson 2004). In this region (i) the level of crop intensity is lower than the Italian average; (ii) labour profitability in agriculture was found correlated to LP (with a higher coefficient than those observed respectively in northern and central Italy, see Table 2); (iii) the agriculture’s share in total product and the percentage of workers in the primary sector were found higher compared to the Italian average (Table 1); and, finally, (iv) the increasing LP correlated to the increase in land vulnerability to degradation during the investigated period.

In this context, the intensification of the agriculture may accelerate LD through multi-faceted, long-term processes impacting land quality (heavy mechanisation and irrigation, unsustainable water management, and growing livestock pressure). Figure 4 depicts some examples of these processes from southern Italy. These processes may increase the risk of soil salinisation, erosion, compaction, and pollution which are regarded as LD drivers in the Mediterranean basin (Simeonakis et al 2007). Coupled with high (and increasing) population density, exurban development, and tourism growth along the ecologically-fragile coastal areas, crop intensification also exacerbates the environmental conditions in terms of water shortage, possibly reflecting a reduction of land productivity in the short-term (Tanrivermis 2003, Atis 2006, Hein 2007) (see Table 3).

These findings suggest that the intensification of the agriculture observed in the last years in several areas of southern Italy could be only partially sustainable in the long term. Following Olesen and Bindi 2002, two contrasting paths are possible in the coming future: (i) land abandonment associated to losses in rural income and marginalisation of inland agricultural districts, and (ii)
agricultural intensification based on the diffusion of unsustainable farming practices. Unfortunately, both paths, if poorly controlled, may trigger LD (Salvati and Bajocco 2011).
Table 3. The agricultural system and LD context in Italy: a SWOT analysis.

<table>
<thead>
<tr>
<th></th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Threats</th>
</tr>
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</table>
| **Northern and central Italy** | High per-capita income  
High land productivity  
High technological and human capital  
Increasing multi-functional farms | Increasing soil pollution, sealing, and compaction  
Urban sprawl in high-quality agricultural areas  
Increasing drought severity and water shortage during the growing season |  
Increasing land vulnerability associated to significant losses in crop productivity |
| **Opportunities**    | High-quality natural capital (in central Italy)  
High economic potential for organic farming (especially in central Italy)  
Rural hospitality around cities |  
| **Strengths**        | Increasing land profitability  
High proportion of rural population  
High employment rate in the primary sector | Low per-capita income  
High share of the agriculture in total product  
Low crop productivity and technological progress  
Restricted water availability for irrigation |
| **Opportunities**    | Low crop intensity and high-quality agriculture  
Potential for tourism development  
Potential for organic farming  
High-quality natural capital | Land Degradation especially in some rural hot-spots |
| **Weaknesses**       | Low per-capita income  
High share of the agriculture in total product  
Low crop productivity and technological progress  
Restricted water availability for irrigation |  

In the present context, policy is increasingly concerned with the reduction of the negative externalities coming from the agricultural production (Hubacek and van der Bergh 2006). However, further efforts are needed to approach more strictly the multifunctional role of agriculture and its potential impact on the environment (Vercammen 2011). This cannot be possible without striking a balance between the economic, environmental, and social functions at different spatial scales, especially the regional and local scales (Briassoulis 2011). The possible strategies to be undertaken in order to mitigate the negative externalities of the agriculture on LD include both in situ actions and measures applicable at regional level (Zalidis et al 2002). The former actions includes, among others, technical measures (e.g. crop rotation, tillage techniques, diversification of irrigation methods) that will be useful to mitigate specific soil degradation processes (Jayasuriya 2003, Tanrivermis 2003, Atis 2006). The latter group includes financial resources aimed at encouraging the active involvement of farmers in soil conservation, especially in marginal areas undergoing soil erosion (Hein 2007). Penalties to discourage unsustainable soil conservation practices can be considered as incentives to motivate efforts against LD (Wiebe 2003).

Since LD is a dynamic process in both time and space, research should investigate if a complex policy strategy like the one described earlier is effective from the environmental perspective and sustainable from the economic point of view in both the short- and the long-term (Shortle and Abler 1999). The goal of such an analysis should be to mitigate a possible downward spiral between agricultural intensification (or land abandonment) and LD in ecologically-fragile Mediterranean
areas (Salvati and Zitti 2008). The present paper provides evidence that southern Italy may enter such a spiral. First, in southern Italy LD was locally severe and the level of land vulnerability was found increasing over the last years (Salvati and Bajocco 2011). Second, crop intensity is generally lower than in northern and central Italy while LP is rapidly increasing. Third, the sensitivity of LP to FP is the highest observed in Italy; and forth, the increasing levels of LP affected the level of land vulnerability. Multi-scale monitoring and qualitative enquiries (Onate and Peco 2007) are thus needed to more precisely disentangle the economic paths of the agriculture and the interrelations with the environment in LD-vulnerable southern Italian region.

References


