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LAND QUALITY, DEVELOPMENT AND SPACE: DOES SCALE MATTER?

Abstract: This study analyzes empirically the relationship between land quality decline and the spatial distribution of *per capita* income observed in Italy at different spatial scales and geographical divisions. The aim of this contribution is to verify if a decline in land quality has higher probability to occur in economically disadvantaged areas and if scale may influence this relationship. *Per capita* income was considered a proxy indicator for the level of socio-economic development and life quality in the investigated area. Changes over time (1990–2000) of a composite index of land quality and *per capita* income in Italy were regressed at four spatial scales: (i) 20 NUTS-2 regions, (ii) 103 NUTS-3 prefectures, (iii) 784 local districts designed as Local Labour Market Areas (LLMAs), and (iv) 8,101 LAU-1 municipalities. Different specifications were tested, including first, second and third order polynomial equations. Linear models allowed the best fit for data examined at all spatial scales. However, elasticity of the dependent variable to *per capita* income varied considerably according to scale suggesting that developmental policies may have ~~a~~ limited impact on land quality in vulnerable southern Italian areas compared to northern and central Italy. This study suggests that geographically disaggregated data simulating different spatial levels of governance may offer further insights compared to cross-country datasets indicating targets for multi-scale policies possibly preventing a poverty-desertification spiral.
Key words: land degradation, income distribution, spatial scale, Italy.

1. INTRODUCTION

The rise of economic and social disparities in developed countries coupled with increasing spatial polarization of natural capital causes alterations in the distribution of ecosystem services between healthy and economically-disadvantaged regions with a growing concern in sustainable development matters (Dasgupta

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et al., 2006; Kahuthu, 2006; Galeotti, 2007; Zuindeau, 2007). One of the most important questions in ecological economics is if a continued economic growth is a sufficient precondition for reducing the pressures on the environment, maybe even without policy intervention (Spangenberg, 2001; Stern, 2004; Mukherjee and Kathuria, 2006). This point is particularly tricky to ascertain, since several environmental degradation processes are the result of multi-scale interactions between the socio-economic systems – growing at a reduced pace compared to the past, but changing dramatically in structure and functions – and the ecosystems experiencing high anthropogenic pressures at the local scale (Chowdhury and Moran, 2012).

While economic growth can effectively promote environmental conservation policies, this effect was observed for defined environmental issues only and the geographical implications of this process are still poorly explored (Franceschi and Kahn, 2003). Although scholars continue disputing on such issues, indicators of 'de-coupling' and 're-linking' between income and environmental degradation became increasingly popular to detect and measure improvements in natural resource efficiency with respect to the socio-economic context (Cavlovic *et al.*, 2000; Deacon and Norman, 2006; Mukherjee and Kathuria, 2006; Papyrakis and Gerlach, 2007; Caviglia-Harris *et al.*, 2009).

The hypothesis of an U-shaped relationship between environmental degradation and the level of income was developed to answer such complex questions. As a natural extension of de-coupling analysis, the so-called Environmental Kuznets Curve (EKC), arose increasing interest for scientists and politicians for the (supposed) beneficial role of a rising income on the environmental quality at large. Studies on EKC tried to disentangle this topic from a development perspective (Dasgupta *et al.*, 2002, 2006; Dinda, 2004; Stern, 2004; Kahuthu, 2006 and references therein) and recent contributions have started showing how it may be included in formalized economic models (Andreoni and Levinson, 2001; Hill and Magnani, 2002; Bruvoll *et al.*, 2003). According to the EKC hypothesis, accelerated wealth creation by economic growth is a precondition for the technological progress that in turn would provide a better environment (Magnani, 2001; Bimonte, 2002; Dinda, 2004; Aldy, 2005; but see also Jha and Murthy, 2003). Unfortunately, EKC studies concentrated on air pollution (Dinda, 2004; Stern, 2004; Galeotti, 2007 for reviews). Relatively few studies concern deforestation (Koop and Tole, 1999), clearcutting (Lantz, 2002), water pollution (Paudel *et al.*, 2005), hazardous waste sites (Wang *et al.*, 1998), and farmland conversion (James, 1999). Finally, only a restricted number of papers addressed the relationship between composite indexes of environmental quality and the income level. Examples of such studies have been provided by Zaim and Taskin (2000), Mukherjee and Kathuria (2006) and Caviglia-Harris *et al.* (2009), but see also a recently published special issue on EKC (e.g. Chowdhury and Moran, 2012).

Since EKC has received critical responses (Heerink *et al.*, 2001; Spangerberg 2001; Harbaugh *et al.*, 2002; Chimeli, 2007; Müller-Furstenberger and Wagner 2007), its contribution to the ecological economics debate should be seen just to underline the role of the public policies, that are usually more ambitious in high-income contexts. In other words, the inverted-U relationship is only indirectly linked to income through an 'induced policy response' (Munasinghe, 1999; Dinda, 2004; Stern, 2004). Unfortunately, few papers have dealt extensively with the geographical scale in EKC relationships. On the contrary, it was widely assumed that similar rules apply irrespective of the spatial scale, leading to the use of the same framework to explore (and sometimes of the same model to explain) spatial agglomeration, territorial specialization, and the negative externalities of the production processes impacting the environment at different scales.

As a global phenomenon induced by joint bio-physical and socio-economic drivers, land quality depletion is an interesting environmental issue to be examined in terms of EKC relationships at various geographical scales. This process limits soil fertility and produces worse environmental conditions reducing landscape, vegetation, and water quality, inducing habitat and land fragmentation and sometimes evolving in irreversible phenomena of desertification (Salvati and Zitti, 2008). The economic impact of this process is being increased in the developed regions of the world (Salvati and Zitti, 2007). The Mediterranean basin is an example of this pattern since it is becoming 'hot spot' for land quality depletion because of growing human pressures, climate change, and land consumption. Apart from the contribution from Salvati *et al.* (2011), no studies verify in the Mediterranean basin the EKC relationship for land quality depletion.

The problem is multifaceted since it can be interpreted within three lines of arguments: (i) the normative sphere (e.g. verifying the impact of various territorial organization levels on land quality depletion and the potential effect of multi-scale policies mitigating land degradation), (ii) the information sphere (e.g. identifying the indicators more suited to describe the socio-economic context responsible for land quality depletion) and (iii) the technical sphere (e.g. testing the stability of the EKC relationship at different spatial scales in the light of the Modifiable Area Unit Problem, MAUP).

With a focus on scalar effects, this paper examines the relationship between land quality depletion and the *per capita* income level taken as a *proxy* of socio-economic development. The study was carried out in Italy, a southern European country with wide regional disparities in the level of land vulnerability to degradation and socio-economic development. The effect of the spatial scale was addressed by simulating the impact of four institutional levels progressively (Yamamoto, 2008), moving from a centralized level (the administrative region, the province) to decentralized environmental-economic interactions involving the local sphere (and observable at the district and municipal scales).

While regions and provinces are the administrative decentralized units mainly responsible for environmental policies in Italy, local districts and municipalities play an important role in urban planning and economic development policies and represent also the highest resolution scale suitable to contrast environmental indicators and economic variables (e.g. income) estimated from the national accounting system and from the population census (Istat, 2006). Since land quality depletion is an 'on-site' process of environmental degradation which is determined by territorial disparities, the difference in the level of local and regional *per capita* income seems an appropriate *proxy* for processes depending on the geographical scale (Salvati *et al.*, 2011). The performed analysis should therefore capture the major changes of the localized relationship that have occurred over time.

2. METHODS

2.1. Logical Framework

According to the EKC hypothesis, land quality depletion should be associated to increasing income, having a peak at intermediate (country/regional) income levels. This is likely due to increasing human pressure on the environment when income rises due to the effect of crop intensification, population growth, urban sprawl, forest conversion to agricultural and urban land uses, industrial and tourism concentration, and other minor factors (Salvati *et al.*, 2009). However, at higher income levels, land quality depletion could decrease, as the economy itself change (increasing share of services in total product with a consequent reduction in agricultural and industrial impacts on the environment). Site-specific determinants generally complicate the evaluation at the local scale (Wilson and Juntti, 2005). In this context, geographical scale may also represents a proxy of the scale of production, especially in the agricultural and tourism sectors, traditionally associated to land quality and possible degradation (Briassoulis, 2005).

Such a relation could be linear (de-coupling hypothesis) or polynomial (re-linking hypothesis). In the former case, economic growth has beneficial effects on land quality depletion over the entire range of possible income. In the latter case, economic growth shows a beneficial effects on land quality depletion at lower/intermediate income levels, then a 're-linking' process is expected at higher income. In this case, income shows a two-fold effects: it is associated with an increase in land quality over time at lower levels, whereas at higher levels it could indirectly cause a significant decrease in the same variable. More complex patterns (e.g. third or higher order polynomials) may highlight site-specific responses of land quality, as income rises (Galeotti, 2007).

Since mechanisms through which development and wealth acts (positively or negatively, directly or indirectly) are not completely clear by now, *per capita* income has selected as a proxy for the level of socio-economic development measured at different scales (Salvati *et al.*, 2011). In the present study, different specifications are estimated for *per capita* income, including linear income descriptor only (de-coupling baseline case), linear and squared income terms (EKC most usual case), and finally, linear, squared and cubic income terms (Dinda, 2004; Mukherjee and Kathuria, 2006; Maddison, 2006). The best form was chosen checking for standard diagnostics, including R^2, *F*-test~~,~~ and *t*-tests on equation coefficients.

2.2. Study Area

Italy (301,330 km^2 with coastline extending for 7,375 km) is an intriguing case study from both the environmental and socio-economic perspectives, as it shows a complex spatial distribution of natural and economic capital. This partly reflects on social inequalities and territorial polarization between northern and southern areas (Salvati and Zitti, 2008). Particularly southern Italy shows low income levels and a higher share of agriculture in total product compared to the European average. From the administrative point of view, the country is divided (in 2000) into three geographical divisions (table 1): twenty NUTS-2 administrative regions, 103 NUTS-3 provinces, 784 local districts (conceptually similar to the Travel to Work Areas, LLMAs) and 8,101 NUTS-5 municipalities (Istat, 2006).

Table 1. Classification and number of spatial units by scale and geographical area in Italy

Spatial level	Italy	Geographical divisions
NUTS-2 regions	20	–
NUTS-3 provinces	103	North + centre: 67; South: 36
TTWA districts	784	North + centre: 419; South: 365
LAU-1 municipalities	8,101	North + centre: 4,556; South: 2,606

Source: own elaboration.

2.3. Data and Indicators

The four geographical partitions considered in this paper represent economically- and institutionally-relevant spatial units suited to relate environmental indicators with socio-economic variables estimated from statistical sources. These partitions also reflect the availability of economic (disaggregated) data provided from national accounts. The chosen spatial domains have economic meaning, but indicate also the possible impact of environmental policies carried out at both regional and local levels. As scale may be interpreted as a crucial variable in both monitoring programs and policy strategies, its influence on EKC relationship may contribute to cost-benefits analysis in environmental assessment.

A standard, composite index estimating the potential land quality depletion (Land Vulnerability Index: LVI) was considered in this study as dependent variable. While land quality depletion regards environmental management, the endowments of land resources are mostly driven by geographical location and prevailing territorial and ecological context (Salvati and Zitti, 2008). Therefore, the percent change in the LVI over time was computed in order to infer about land quality depletion, land degradation processes and their possible impact on land conservation practices. The LVI, originally proposed by Salvati *et al.* (2009) and based on integrated information about climate, soil vegetation, and land-use, is suitable to account for some peculiar characteristics of the Italian landscape and circumvents data limitations at high-resolution scales. The LVI ranges from 0 (the highest land quality) to 1 (the lowest land quality) and can be easily calculated at different spatial scales using geographic information system tools. In this study, LVI was computed for two time slices (1990 and 2000) and the score difference was used as the dependent variable (LQD).

Per capita income was derived at the four selected scales from national accounting statistics provided by the Italian National Institute of Statistics (Istat 2006) and from further estimations carried out by Istituto Guglielmo Tagliacarne and CENSIS referring to years 2000 or 2001. This scale specification appears suitable in high heterogeneity datasets (like that used here) in order to analyze possible decentralized, local-level interactions between environment and economic drivers and related policy strategies (Briassoulis, 2005).

2.4. Statistical Analyzes

EKC hypothesis was tested here by specifying different (reduced) forms which include, in its simplest form, (i) change in LVI over the investigated period as dependent variable (LQD) and (ii) district *per capita* value added (or its logarithm) as the main economic driver (GDP). This selection was in accordance with the results found by Salvati *et al.* (2011) in the same study area. Table 2 reports the possible hypotheses on the form of the relationship depicted in figure 1. At the first stage, the following equations were estimated:

$$\text{LQD} = b_0 + b_1(\text{GDP}) + \mathbf{e} \tag{1}$$

$$\text{LQD} = b_0 + b_1(\text{GDP}) + b_2(\text{GDP})^2 + \mathbf{e} \tag{2}$$

$$\text{LQD} = b_0 + b_1(\text{GDP}) + b_2(\text{GDP})^2 + b_3(\text{GDP})^3 + \mathbf{e} \tag{3}$$

where the first term (b_0) is an intercept parameter and $b_{(1)} \dots b_{(n)}$ are the coefficient terms. In order to reduce the possible departure from normality, *per capita* income was transformed using logarithmic function before entering the regression model. The most significant form was chosen among equations (1–3) based on diagnostic statistics (R^2, F-test). Collinearity among variables was checked throughout by the way of variance inflation factor and condition index. Durbin-Watson test was applied to the series observed in order to detect serial autocorrelation in the data. Outputs report variables entered each model with significant coefficients and standard errors.

Elasticity of LQD to GDP was calculated, based on the linear form:

$$\text{LQD} = b_0 + b_1(\text{GDP}) \tag{4}$$

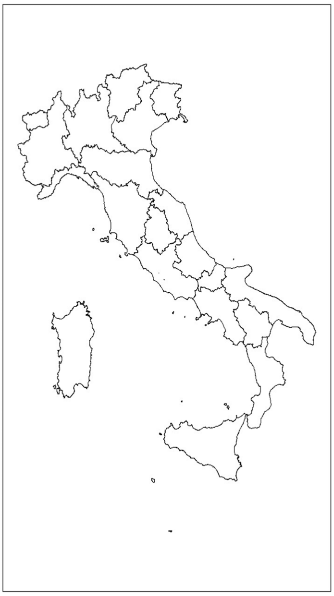
taken the first derivative of LQD term, which is:

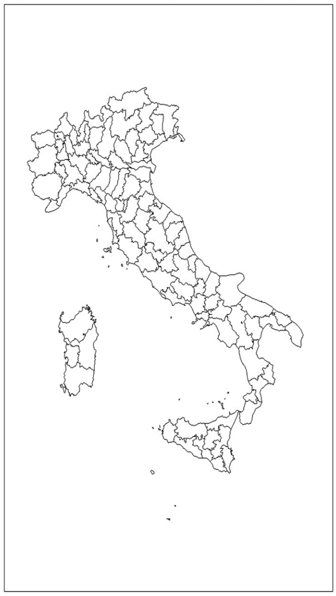
$$\frac{\partial LQD}{\partial GDP} = \frac{b_1}{GDP} \tag{5}$$

by substitution, the elasticity of LQD to GDP (ηLQD/GDP) was derived by substitution in (5) as:

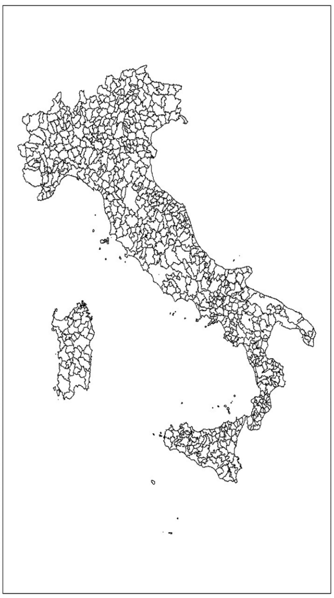
$$\eta_{ld\,/\,gdp} = \frac{\dfrac{\partial LQD}{\partial GDP}}{\dfrac{LQD}{GDP}} = \frac{b_1}{GDP} \bullet \frac{GDP}{D} = \frac{b_1}{b_0 + b_1 GDP} \tag{6}$$

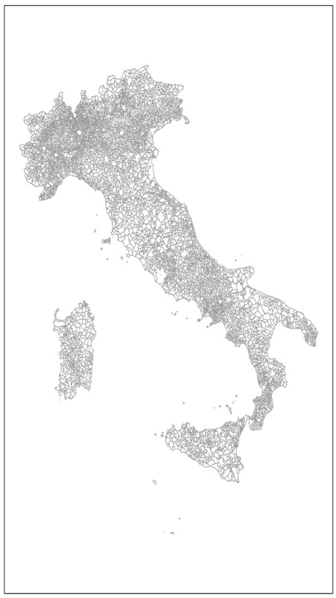
and calculated at three levels (high, intermediate, low) of income. High, intermediate and lower income coincide with the average *per capita* income respectively observed in northern/central area (nearly 18,500 euros), the whole Italy (nearly 14,500 euros), and southern area (nearly 9,500 euros). Income figures referring to 2000 are computed as *per capita*, logarithmic values.





NUTS-2 regions (n = 20) *NUTS-3 prefectures (n = 103)*





Local districts (n = 784) *LAU-1 municipalities (n = 8,101)*

Fig. 1. The four geographical divisions of Italy
Source: own elaboration

3. RESULTS

The relationship between land quality depletion (LQD) and *per capita* income (GDP) in Italy was described in table 2 by using different specifications and spatial scales of analysis. Based on log-income, squared and third-order polynomial regressions between LQD and GDP gave a goodness of fit comparable to (or lower than) the linear form. Lower values of *per capita* income were negatively associated to a higher land quality depletion rate with a coefficient ranging from –0.066 to –0.028, according to the tested scales. The ratio of b_0 to GDP coefficient ranged from 0.204 at region level to 0.173 at municipal level.

The coefficient estimates for the same equations applied to the different geographical divisions of Italy are presented in table 3. An inverse, linear relationship between GDP and LQD was observed at all explored scales. On average, high-income districts experienced lower rates of land quality depletion. Income coefficients are relatively stable in all spatial aggregations considered, ranging from –0.067 to –0.021 in northern/central Italy and from –0.048 to –0.025 in southern Italy.

Elasticity of LQD to GDP ranged from 1.35 to 0.61 in Italy, according to the scale considered (table 4), being higher, on average, in northern/central Italy than in southern regions. However, the ratio in elasticity ratio between northern/central and southern regions declines moving from centralized scales (i.e. provinces) to decentralized scales (i.e. municipalities). The ratio between elasticity observed at the provincial and municipal level is also higher in northern/central (2.54) than in southern Italy (1.87).

Table 4. Elasticity of LQD to GDP in Italy based on the linear regression models reported in tables 2 and 3 by geographical division

Spatial scale	Italy	Northern-central Italy	Southern Italy
Nuts-2 regions	–1.35	–	–
Nuts-3 provinces	–1.24	–1.32	–0.99
TTWA districts	–0.88	–0.73	–0.60
Nuts-5 municipalities	–0.61	–0.52	–0.53

Source: own elaboration.

Table 2. Results of the regression analysis among Land Quality Depletion (LQD) and income (GDP) by different spatial scales in Italy

Variable	Linear				Squared				Cubic			
	NUTS-2	NUTS-3	TTWA	NUTS-5	NUTS-2	NUTS-3	TTWA	NUTS-5	NUTS-2	NUTS-3	TTWA	NUTS-5
b_o	0.323(0.065)**	0.283(0.035)**	0.201(0.031)**	0.162(0.005)**	0.184(0.033)**	–0.882(1.425)	0.104(0.011)*	4.291(0.991)	–0.091(2.504)	–0.483(0.948)	–3.571(0.850)	4.282(2.363)
GDP	–0.066(0.015)**	–0.057(0.008)**	–0.038(0.002)**	–0.028(0.001)**		0.497(0.678)	0.009(0.002)*	–3.004(0.817)	0.081(0.891)	0.216(0.338)	2.725(0.795)	–1.069(0.526)
GDP^2					–0.008(0.002)**	–0.066(0.081)	–0.005(0.002)	2.654(0.799)			–0.673(0.315)	–54.69(9.4)
GDP^3									–0.003(0.017)	–0.005(0.006)	0.054	418.7(97.2)
Adj-R^2	0.480	0.312	0.263	0.079	0.481	0.309	0.263	0.078	0.451	0.309	0.263	0.081
F	18.6**	47.2**	278.0**	692.3**	18.6**	23.8**	277.0*	689.1*	8.8*	23.8**	276.8*	691.2*
df	1,19	1,101	1,782	1,8099	1,19	2,100	2,781	2,8098	2,18	2,100	3,780	3,8097

Note: in brackets, the probability level of *t* and *F* test associated to each regression coefficient was reported: * $0.01 < p < 0.001$, ** $p < 0.001$.

Source: own elaboration.

Table 3. Results of the regression analysis among LQD and GDP by sing different spatial scales in Italy

Variable	Northern/Central Italy			Southern Italy		
	NUTS-3	TTWA	NUTS-5	NUTS-3	TTWA	NUTS-5
b_o	0.329(0.094)*	0.161(0.042)*	0.128(0.007)**	0.248(0.106)*	0.154(0.035)*	0.151(0.009)**
GDP	–0.067(0.022)*	–0.029(0.009)*	–0.021(0.002)**	–0.048(0.026)*	–0.026(0.007)*	–0.025(0.002)**
Adj-R^2	0.114	0.061	0.032	0.067	0.100	0.047
F	9.5*	26.7*	181.1**	3.5*	40.2*	128.9**
df	1,65	1,414	1,5491	1,34	1,362	1,2606

Note: in brackets, the probability level of *t* and *F* test associated to each regression coefficient was reported: * $0.01 < p < 0.001$, ** $p < 0.001$.

Source: own elaboration.

4. DISCUSSION

The present study analyzes the EKC relationship in land quality depletion at different spatial scales, from regional to local levels. Although related to the EKC literature, the illustrated approach differs from previous studies concentrating on the spatial dimension of development-environment relationship. Investigating the role of geographical scale could contribute to clarify (i) the impact of socio-economic and environmental gradients on land quality depletion, (ii) the role of economic polarization and territorial disparities on the environment, (iii) the importance of the production scale seen from a spatial perspective, and (iv) the potential role of decentralized multi-scale and multi-tasking policies possibly mitigating the risk of desertification. In this study, the relation is exemplified by a complex process of environmental degradation which is influenced by country- and regional-wide determinants and relevant local dynamics. The aim of the paper is thus to test a ‘spatially’ adapted environment-development hypothesis at four scales simulating a set of governance levels ranging from a centralized level (administrative regions) to a decentralized level (municipalities).

Results indicate that a relationship exists among land quality depletion and economic growth, providing indirect evidences in favour of EKC. The best fit was a linear form where GDP result is associated to decreasing LVI over time. The second order polynomial form, traditionally used in EKC studies, does not increase significantly the goodness of fit. Changing geographical partition of analysis have only limited influence on regression coefficients indicating stability in the general form of the relationship between LCQ and GDP. Interestingly, LCQ-GDP relationship seems to be not complicated by ‘re-linking’ process observed at higher income levels as observed for other similar environmental problems. This appears particularly important in the policy perspective, as the results are obtained through a regional cross-section analysis of a developed country rather than a cross country analysis, confirming that a disaggregated within country analysis is meaningful in economic terms, and also provide a robust statistical ground (North, 2005; Papyrakis and Gerlagh, 2007; Auffhammer and Carson, 2008; Ordas Criado, 2008).

Using regression coefficient, the analysis of elasticity also provides original insights in the study of LCQ-GDP relationship. While an induced policy response could be possible at the income levels observed in Italy, the different elasticity of the EKC relationship observed in northern and southern Italy suggests that the environmental measures impact variously on land quality and vulnerability in the two areas. This is likely due to the different development paths which have characterized the two regions in the past and corroborates previous findings proposed by Salvati and Zitti (2008). In fact, externalities play crucial, but quite differentiated, roles at regional and local scales (Khanna and Plassmann, 2004). The structure of underlying production system, the interaction itself between drivers acting at different geographical scales, and the differentiated policy responses carried out by regional governments account for such differences and claim for further work going on this direction. While tending to be more innovative in terms of new institutional settings and policy approaches, richest districts – especially in northern Italy – could experience more land degradation due to the higher feedback effects of the economic drivers (Salvati *et al.*, 2009). However, due to higher elasticity to income, these areas could benefit more from developmental policies in terms of land quality improvements. The opposite pattern was observed in southern Italy, a vulnerable area to desertification and a traditional targets for both socio-economic and environmental policies.

As a conclusion, while structural changes reflected in higher income positively affect land quality (Neumayer, 2001; Rupasingha *et al.*, 2004; Dasgupta *et al.*, 2006), developmental policies alone cannot be considered as sufficient to mitigate desertification processes, as additional drivers act to reverse the positive effect of income rise. Implementing the coordination of specific measures (e.g. environmental, social, economic) at different governance scales with the final aim to avoid a downward spiral between environmental degradation and (lower) income or rural poverty may correctly address the problem in drylands.

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