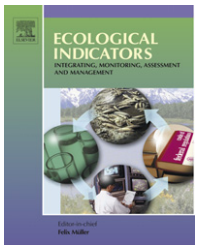
available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ecolind



Case study

Assessing the impact of ecological and economic factors on land degradation vulnerability through multiway analysis☆

Luca Salvati [a,b,*], *Marco Zitti* [c]

[a] *Italian National Institute of Statistics (ISTAT), Viale Liegi 13, I-00198 Rome, Italy*
[b] *c/o Department of National Accounting and Analysis of Social Processes, Faculty of Statistics, University of Rome 'La Sapienza', Piazzale A. Moro 5, I-00185 Rome, Italy*
[c] *Consultant of Central Office for Crop Ecology, National Research Council in Agriculture (CRA-UCEA), Via del Caravita 7a, I-00186 Rome, Italy*

ARTICLE INFO

Article history:
Received 26 December 2007
Received in revised form
31 March 2008
Accepted 3 April 2008

Keywords:
Land degradation
Indicators
Multiway analysis
Composite index
Weighting system
Mediterranean basin

ABSTRACT

Land degradation (LD) is a global problem which involves climate, soil, vegetation, economic, and population conditions. In Mediterranean Europe climatic variability and human pressure combine to produce soil sealing, erosion, salinisation, fire risk, and landscape fragmentation, all regarded as important factors to start LD. The aim of this paper is to introduce a time-series evaluation of land vulnerability to degradation based on nine ecological and economic variables. The analysis was carried out over 1970–2000 at the municipality level in Latium (central Italy), a region which has shown increasing land vulnerability in the last years. A multiway data analysis (MDA) was applied in order to explore the relationship among indicators over the study period. Their importance in determining LD vulnerability was estimated through a weighting system based on MDA results. A composite index of land vulnerability (LVI) was obtained as the weighted average of the nine variables transformed into single indicators, according to their relationship with LD. Considerable increases in LVI were observed in dry coastal and lowland municipalities close to Rome, thus indicating that climate aridity, population growth, and land use changes are important determinants of land vulnerability in Latium. LVI was positively correlated to the environmental sensitive area index (ESAI) measured on the same spatial and time scales, thus suggesting that a sound evaluation of land vulnerability is possible through LVI score.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

The term land degradation (LD) is often used to describe an environmental phenomenon affecting dry lands, sometimes without a clear understanding of the involved processes (Le Houerou, 1993; Thornes and Brandt, 1995; Puigdefabregas and Mendizabal, 1998). LD usually means reduction or temporary loss of the biological and economic productivity of irrigated and non-irrigated agricultural land, pastures, rangeland, and woodlands (Brandt et al., 2003; Tanrivermis, 2003; Salvati et al., 2008). It results from various factors, including climatic dryness, poor soil and vegetation quality, pressure due to agriculture intensification, population growth, urban sprawl, and industrial concentration (Kosmas et al., 2000a; Garcia

☆ This paper reflects the ideas and research activities of the authors. Findings, interpretations, and conclusions should not be attributed to ISTAT or CRA.

* *Corresponding author at*: Piazza F. Morosini 12, I-00136 Rome, Italy. Fax: +39 06 69 53 12 14.
E-mail addresses: bayes00@yahoo.it (L. Salvati), mzitti@ucea.it (M. Zitti).

1470-160X/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecolind.2008.04.001

Latorre et al., 2001; Salvati and Zitti, 2005). Coastal and lowland areas in the Mediterranean basin are generally depicted as vulnerable to LD due to both anthropogenic factors (e.g. Loumou et al., 2000; Tanrivermis, 2003; Salvati et al., 2008) and the impact of climate change (e.g. Sharma, 1998; Incerti et al., 2007; Sivakumar, 2007). Although the environmental characteristics of vulnerable areas are similar to those of degraded land, some factors (e.g. vegetation, agriculture, irrigation, and policy strategies) mitigate this process in the short term (Thornes and Brandt, 1995; Montanarella, 2007).

The complexity of LD represents a limitation for monitoring, modelling, and projection approaches (Rubio and Bochet, 1998; D'Angelo et al., 2000; Feoli et al., 2003). In the Mediterranean basin the assessment of vulnerable land was conducted mainly through the use of *proxy* indicators depicting climate, soil, and vegetation at an adequate spatial scale (Rubio and Bochet, 1998; Feoli et al., 2002; Salvati and Zitti, 2008a and references therein). These indicators were usually aggregated into a composite index of land vulnerability by standard procedures (e.g. environmental sensitive area index, ESAI, see Basso et al., 2000). However, time-series analyses focusing trends in both land vulnerability and its main drivers are generally lacking in this area (e.g. Montanarella, 2007). An integrated approach based on multivariate time-series analysis may better explore latent patterns and trends of the main factors affecting LD (e.g. Feoli et al., 2002; Salvati and Zitti, 2008a). Such approaches are meaningful because they make clear that land vulnerability should not be treated as something static but as something that changes over time (e.g. Salvati and Zitti, 2008b). Moreover, the choice of relevant indicators, the method used to normalise the indicators themselves, and the weighting technique have a considerable influence on the estimate of land vulnerability and need to be further studied (Basso et al., 2000; Salvati and Zitti, 2005).

The aim of this work is to built-up a regional vulnerability evaluation model (VEM) able to assess land vulnerability over time by way of a composite index integrating ecological and economic indicators of LD vulnerability. The following steps were implemented in order to achieve this goal: (i) selecting environmental, economic, and social indicators, and integrating the information associated to those research dimensions; (ii) determining a weight for each indicator through a multivariate time-series approach; (iii) estimating trends in land vulnerability from 1970 to 2000 by way of a composite index (LVI) aggregating indicators on the basis of their weight.

VEM was built-up at local scale (i.e. municipalities) in order to provide politicians and other stakeholders with a simple monitoring tool (e.g. Nader et al., 2008). We believe that an empirical framework like the one introduced here provides valuable results stimulating more sophisticated approaches to the problem (e.g. Salvati et al., 2008).

2. Materials and methods

The study area includes the administrative region of Latium, one of the twenty NUTS-2 Italian regions. In 2000, it includes five provinces (Viterbo, Rieti, Rome, Latina, and Frosinone) and 377 municipalities (Salvati and Zitti, 2007). It covers an area of approximately 17,065 km^2 featuring a complex topography and various climatic zones according to elevation (Salvati et al., 2007). In the last 30 years the study area has been subjected to a number of land use changes due to urban growth, crop intensification, forest fires, and tourism concentration. Moreover, climate conditions became drier especially along the coastal rim, and severe drought episodes occurred more frequently over the whole region.

2.1. Data and indicators

An indirect estimation of LD in the Mediterranean basin was developed through the use of indicators describing the impact of different factors on land vulnerability to degradation (Puigdefabregas and Mendizabal, 1998; Rubio and Bochet, 1998; Basso et al., 2000; Salvati et al., 2008). A number of indicators is commonly used which especially describes including those describing climate, soil characteristics and erosion risk, vegetation quality and plant productivity, fire risk, land fragmentation and management (Kosmas et al., 2000a, 2000b; Salvati and Zitti, 2005). However, it should be noted that few indicators are available over a long time, thus representing a serious constraint for the objective of this study. We therefore identified a restricted number of variables which cover the whole national territory and are continuously available from the statistical sources: (i) over the last 30 years at least and (ii) at an adequate geographical scale (i.e. municipalities). We believe that variables selected represent an acceptable compromise between accuracy and time/space resolution (e.g. Yli-Viikari et al., 2007).

According to the regional scale of this study three main research themes were identified (Salvati and Zitti, 2008b): (i) climate–soil, (ii) landscape, and (iii) human pressure. The climate–soil dimension was described by three factors (Diodato and Ceccarelli, 2004): the (i) bioclimatic, (ii) pedologic, and (iii) geomorphologic. These factors regard respectively with climate aridity, available water capacity of the soil, and soil erosion (Kosmas et al., 2000a; Venezian Scarascia et al., 2006; Incerti et al., 2007). The landscape dimension includes three variables linked to natural and agriculture land use (e.g. Kosmas et al., 2000b; Tanrivermis, 2003; Salvati et al., 2007): crop intensification, woodland cover, and loss of agricultural surface. The impact of human pressure was finally described by three variables concerning population density and growth (Salvati and Zitti, 2007), as well as concentration of industrial activities with a potential impact on soil (Salvati and Zitti, 2005; Salvati et al., 2008). Variables used in this work and related data sources were described in Salvati and Zitti (2005, 2007, 2008b) and Salvati et al. (2007, 2008). All the variables were made available at 4 years: 1970, 1980, 1990, and 2000. According to Basso et al. (2000) some variables can be considered static as they change slowly and by their nature are infrequently measured. This was the case for AWC, which was regarded as constant in the following analyses (Salvati and Zitti, 2008a,b).

Variables were then transformed into indicators ranging from 0 to 1 as follows:

$$X_{t,i,j} = \frac{x'_{i,j} - x'_{\min,j}}{x'_{\max,j} - x'_{\min,j}} \quad (1)$$

Download English Version:

https://daneshyari.com/en/article/4374454

Download Persian Version:

https://daneshyari.com/article/4374454

Daneshyari.com