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LAND DEGRADATION STUDY IN MEDITERRANEAN AREAS AT DIFFERENT SCALES: RESULTS OF TWO YEARS OF ACTIVITIES IN THE FRAMEWORK OF MILDMAP-MEDIA PROJECT

M. MACCHIATO[1,2], M.T. CARONE[1], R. COPPOLA[3], M. D'EMILIO[1,3], M.L. GIANNOSSI[3], V. IMBRENDA[1], M. LANFREDI[1,3], M. LIBERTI[3], S. MARGIOTTA[3], S. PIGNATTI[3], T. SIMONIELLO[1,3] AND V. SUMMA[3]

[1]*Consorzio Interuniversitario per la Fisica della Materia (CNISM) UdR-NA, Naples, Italy*
[2]*Università degli Studi "Federico II"-Dip. di Scienze Fisiche (DSF), Naples, Italy*
[3]*Istituto di Metodologie per l'Analisi Ambientale (IMAA-CNR), Tito Scalo (PZ), Italy*
phone: +39971427256 e-mail: simoniello@imaa.cnr.it

Summary

MILDMAP-MEDIA Project is inserted in the ArchiMed INTERREG IIIB, an EU-funded programme that promotes Europe's regions to work together on common projects for developing new solutions to economic, social and environmental challenges. In particular the aim of the project was to define a common decision support system and procedures to be shared and applied by the institutions involved in territory management in Mediterranean areas. In the framework of this project, the activities presented in this paper were devoted to the development and evaluation of indexes capable to provide information for studying land degradation phenomena at different spatial scales. For such a purpose, a methodology carried out starting from remote sensing observations, in situ collected measurements, and modelling procedures, was adopted. The result of our work was the development of a methodology able to identify critical areas within the territory and to support the definition of policies and intervention strategies for land degradation control. The flexibility of the implemented approach allows for being applied to different areas affected by similar criticises, such as land cover fragmentation, biomass reduction, soil loss and erosion.

Introduction

The United Nations Environmental Program (UNEP) and the European Commission (EC) environmental programme recognize the Mediterranean basin as one of the most critical environments. Indeed, in Europe, the United Nation Convention to Combat Desertification (UNCCD) identified Portugal, Spain, Italy, Greece and Turkey as countries actually or potentially affected by land degradation as a result of both natural (e.g. climate change, soil vulnerable features) and anthropogenic (e.g. overgrazing, intensive agricultural practices) causes. In particular, land mismanagement has accelerated the spreading rate of such phenomena during the last 50 years making the Mediterranean countries much more vulnerable to land degradation phenomena.

This paper deals with the results we obtained in the framework of "Methodology integration of EO techniques as operative tool for land degradation management and planning in Mediterranean areas" (MILDMAP-MEDIA) project. For characterizing land degradation processes, we followed a multiscale approach, which integrates remote and in situ data at different spatial resolutions. For each spatial scale, we selected land degradation indicators appropriate to study the area characteristics. We started our study by focusing on European Mediterranean countries. At this scale, AVHRR satellite data were used to study vegetation dynamics by means of a Normalized Difference Vegetation Index (NDVI) time series. To identify areas affected by vegetation degradation, trend persistence in photosynthetic activity was estimated. In a second step, at Southern Italy scale, we analyzed the land cover structure by applying a set of landscape metrics to investigate the spatial dimension of the ecological processes and the relationship between natural and human environment.

Then, at subregional scale, we focused on soil erosion processes. In particular, we developed a methodology for identifying badland formations occurring in a vulnerable site of Basilicata region by means of high resolution TM satellite imagery. We used these images also to perform a screening with a recently introduced satellite multispectral index (GSI-Grain Size Index), whose values are linked to fine sand content in topsoil. Our aim was to assess the potential of this index to monitor topsoil properties linked to erosion processes. Therefore, we carried out field surveys for collecting soil samples and soil radiance spectra. Granulometric distributions obtained from laboratory measurements as well as GSI values computed on in situ and laboratory spectra were compared to GSI values derived from satellite.

Materials and Methods

In order to analyze vegetation dynamics for European Mediterranean countries, we adopted the 8-km AVHRR-NDVI time series (1982-2003) gathered from the Global Inventory Modelling and Mapping Studies (GIMMS). The NDVI is proportional to vegetation vigour and density since it is based on the normalized difference between near-infrared and red radiance. From such a dataset, we estimated the persistence of positive and negative trends by applying the sign-time distribution concept. The presence of persistent NDVI negative trends provides information on prolonged/severe vegetation stress; on the contrary, persistent positive trends give hints of vegetation growth (expansion/recovery) (Lanfredi et al., 2004; Simoniello et al., 2008).

The Corine land cover map was adopted for analyzing land cover structure (composition and configuration) at Southern Italy scale. The analysis was performed by applying a set of landscape ecology metrics selected to take into account the ecological implication of land degradation processes (ShDI, ShEI, NP, MPS, CA, AWMPFD, IJI, Cohesion, Contagion) (Simoniello et al., 2006). Two Landsat scenes, one acquired in 1998 by TM and one in 2002 by ETM, having 30m spatial resolution were elaborated for soil characterization at subregional scale. In particular, for the remote identification of eroded areas (badlands), we developed a methodology based on the combined classification of spectral bands (including thermal channel) and morphological data (slope and aspect) derived from a DEM (Liberti et al., 2006). For the grain topsoil characterization, we studied the Grain Size Index (GSI) (Xiao et al., 2006) that is defined as follows: GSI = (R-B)/(R+G+B), where R, G, and B are red, green and blue Landsat bands. GSI value is negative or nearly 0 for water bodies and vegetation cover and increases (up to ~0.2) when fine sand content in topsoil increases.

In order to compare calculated GSI values with soil granulometry, we carried out field surveys for collecting topsoil samples over the study area. Soil was sampled by following the scheme in Fig.1 to obtain an average value for each selected Landsat pixel.

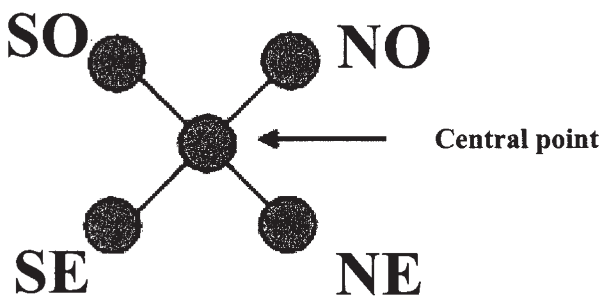

Figure 1. Soil sampling scheme

Grain-size analysis was carried out using a *Malvern MasterSizerE* laser particle sizer with a 100 mm lens, which identifies grain-size intervals from 0.5 to 100 μm. Samples were dispersed in distilled water for 15 minutes, stirred and immersed in an ultrasonic bath, for complete dispersion of aggregates. The clay fraction (<2 μm) was separated in distilled water (Summa et al., 2007). Granulometric distributions obtained from laboratory measurements were compared to GSI derived both from satellite data and from ground measurements of soil spectral signatures. Soil signatures were acquired by a portable spectroradiometer *FieldSpec FR Pro* both in situ, following the scheme of soil sampling, and in laboratory in order to evaluate the environmental effects that can affect satellite measurements.

Results and Discussion

The total persistence map of NDVI trends derived from GIMMS time series showed that there are many areas of clustered vegetation activity decrease. The existence of aggregated negative trends testifies a vegetation degradation that is not linked to local events (e.g. forest cutting, land cover change), but could be due instead to general climatic conditions and land mismanagement. In order to make the information on vegetation dynamics integrable with other structural land degradation indexes, we reclassified the obtained map in a common range (1-2) from very low to very high sensitivity (Fig. 2).

Results obtained from evenness and diversity metrics showed that Southern Italy landscape has a medium level of land cover diversity (ShDI 2.60) with a quite even distribution (SEI 0.70) and interdispersion among classes (IJI 68.19). The territory is strongly characterized by covers connected to agriculture; also broad leaved forests is a dominant class with an interdispersion level of about 70% and a shape complexity of 1.55 (Fig.3). Natural covers that are more closely vulnerable to land degradation, such as sparsely vegetated areas and natural grassland, showed a connection with other cover higher than 60%, but their shapes provide hints of high anthropic influence.

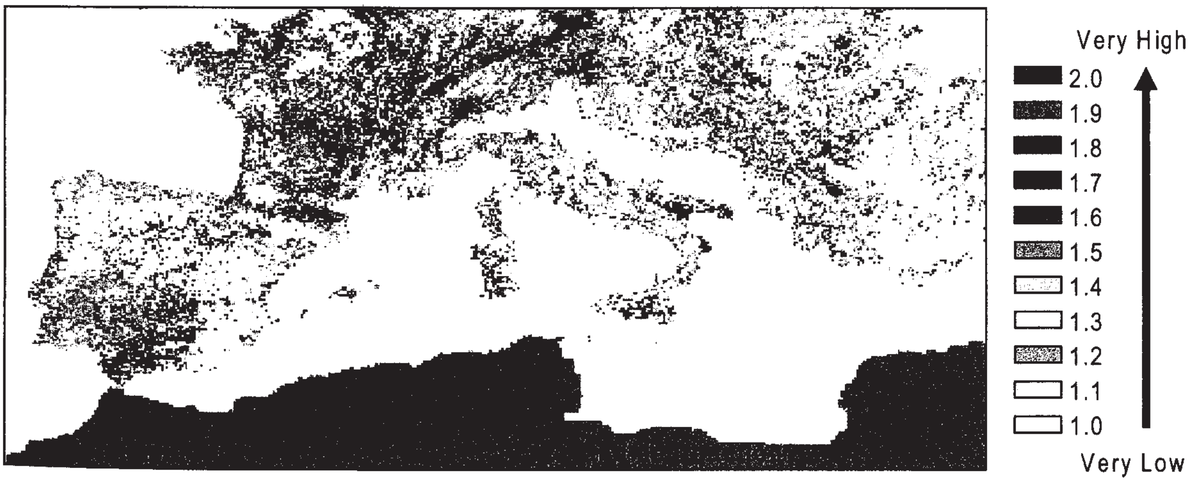

Figure 2. Map of vegetation sensitivity to land degradation based on the time length of decrements in photosynthetic activity derived from AVHRR satellite time series.

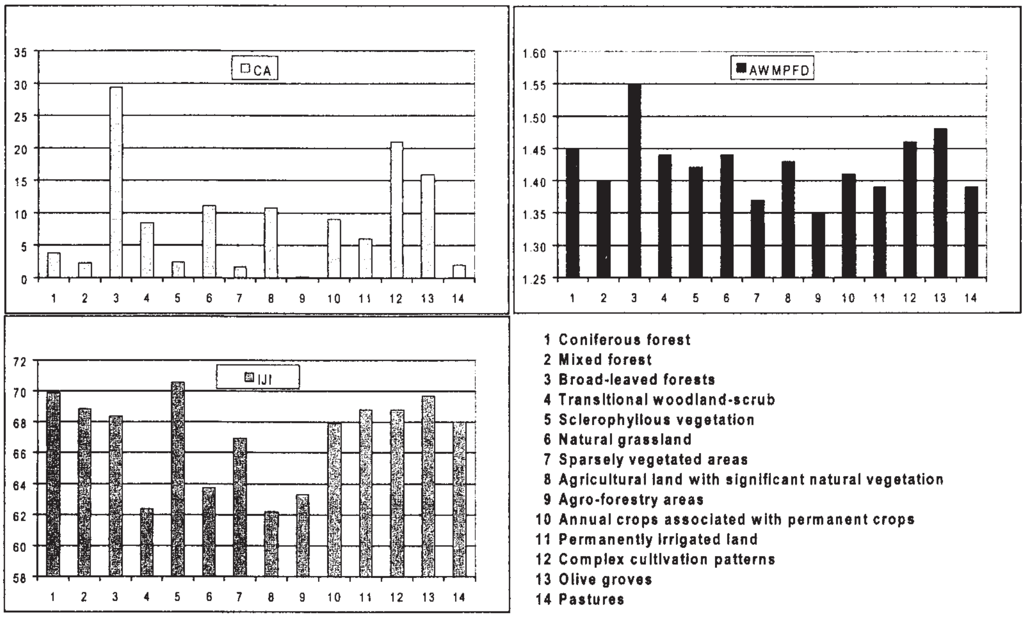

Figure 3. Results of landscape metrics at class level for some covers of Southern Italy

As far as the identification of badland formations at subregional level, we found that the use of morphological data strongly improve data classifications by reducing commission errors. The most performing result was achieved by using Maximum Likelihood Classifier on all TM/ETM bands integrated with slope and aspect maps (Fig.4a). Results form the error matrix showed an overall accuracy higher than 85 %.

At the same scale, the analysis of GSI showed that such an index has to be used very carefully in areas where land degradation is in progress. The presence of vegetation cover, even if poor, biases satellite-derived values; in particular, green vegetation lowers such values, while withered vegetation tends to increase them. Therefore, we recommend a careful image selection (e.g. summer image with low vegetation presence) and the use of vegetation mask to eliminate contaminated pixels. The GSI map shown in Fig.4b is characterized by many rather coherent structures of high index values; they are made up of central clusters contoured by ever smaller fragments, that is the typical patch distribution of rising land degradation processes.

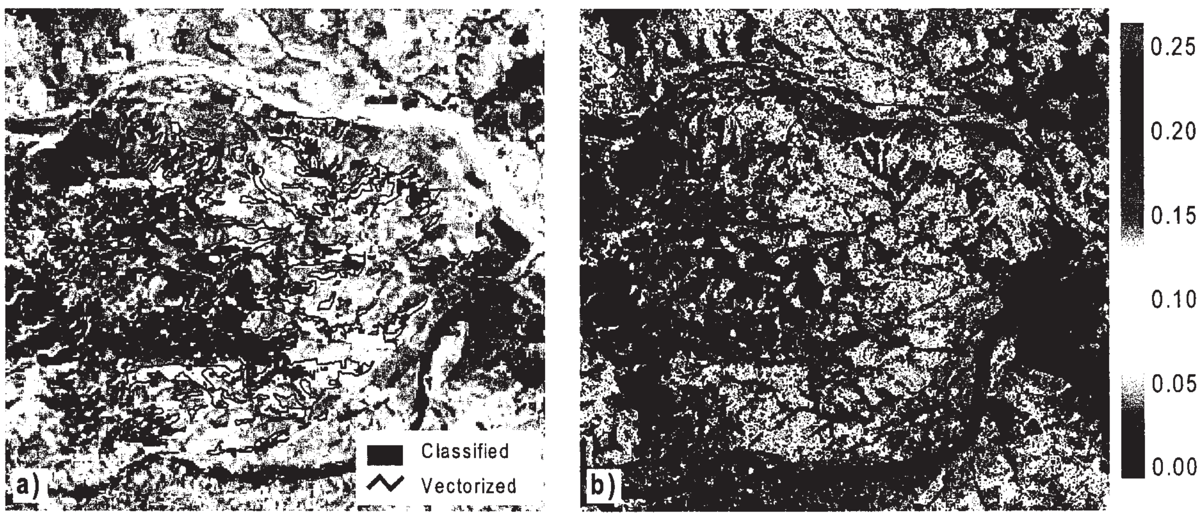

Figure 4. Map of badland formations (a) and grain size index (b) obtained form the elaboration of Landsat TM satellite data.

Conclusions

The adopted multiscale approach seems to be particularly suitable for the characterization of land degradation phenomena. Such an approach, structured in successive "zooming in" steps, allowed us to identify anomalies linked to degradation processes at different operative levels.

Starting from the analysis at large spatial scales, we searched for indexes capable to enhance the territory vulnerability by analyzing the persistence of negative trends in vegetation activity and the level of fragmentation of vegetation covers. At higher spatial scale, we focused on soil degradation processes by testing speditive methods for badland area mapping and soil grain size characterization.

Altogether, the proposed approach seems to be very versatile, because it is based on integrable and independent methodologies. Although such methodologies were applied in cascade, each of them is robust for its scale of investigation to support the definition of policies and intervention strategies at different operational levels.

Acknowledgments

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References

Lanfredi M, T. Simoniello, M. Macchiato, Temporal persistence in vegetation cover changes observed from satellite: development of an estimation procedure in the test site of the Mediterranean Italy, *Remote Sensing of Environment*, 93(4), 565-576, 2004

Liberti M., T. Simoniello, M. Carone, R. Coppola, M. D'emilio, M. Lanfredi, and M. Macchiato, *Badlands area mapping from Landsat-ETM data.* In "Proceedings of 2nd EARSeL Workshop on Remote Sensing of Land Use and Land Cover", Ed. M. Braun, ISBN-10 3-00-020518-7, pp.434-440, 2006.

Simonello T., Carone M.T., Coppola R., D'Emilio M., Grippa A., Lanfredi M, Liberti M. and Macchiato M., *Preliminary study to monitor land degradation phenomena through landscape metrics.* In "Proceedings of 2nd EARSeL Workshop on Remote Sensing of Land Use and Land Cover", Ed. M. Braun, ISBN-10 3-00-020518-7, pp.408-414, 2006.

Simoniello T., Lanfredi M., Liberti M., Coppola R., and Macchiato M. Estimation of vegetation cover resilience from satellite time series, in Special Issue "Climate-soil and vegetation interactions in ecological-hydrological processes", Eds: V. Iacobellis, S. Manfreda, and M. Sivapalan, *Hydrol. Earth Syst. Sci. Discuss.*, 5, 511–546, 2008.

Summa V., Tateo, F., Medici, L., & Giannossi, M.L. (2007). The role of mineralogy, geochemestry and grain size in badland development in Pisticci (Basilicata, Southern Italy). *Earth Surface Processes and Landforms*, 32, 980-997.

Xiao J., Shen Y., Tateishi R. and W. Bayaer, 2006. " Development of topsoil grain size index for monitoring desertification in arid land using remote sensing". *International Journal of Remote Sensing*. Vol. 27, pp. 2411–2422.