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Integrated monitoring and trans national coordination to support sustainable land management strategies: Ideas for new joint Euro-Mediterranean initiatives

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Introduction

Any human activity inevitably implies land use and changes in land use. Indeed the first human induced land use changes are associated with the burning practices of indigenous peoples, for example in Australia (Yibarbuk *et al.*, 2001) and North America (MacCleery, 1999). In the late Pleistocene and early Holocene altered fire regimes, whereby aboriginal mosaic burning replaced infrequent intense lightning-induced fires, are considered responsible for displacement of forests by woodlands and grasslands, and thus a reduction in carbon stocks. Subsequently, the first agricultural revolution of the Neolithic (Mazoyer and Roudart, 1997) with extensive deforestation phenomena due to "slash and burn" technologies that dominated for thousands of years, substantially affected land use patterns in many parts of the world.

The detailed analysis of Neolithic land-use on worldwide migration patterns and technology evolution were recently addressed by Wirtz and Lemmen (2002), who for the first time suggested a deterministic mathematical model able to generate the spatio-temporal pattern of subsistence style alteration in a realistic and robust way. Did such drastic changes during the mid-Holocene shift already affect climate patterns globally? Recent definitions of the Anthropocene (Crutzen, 2002) place the start of the Anthropocene in the late eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane. Certainly the early impacts of Neolithic agriculture were negligible on climate, but already detectable on early land degradation phenomena, like erosion and decline of organic matter content in soils.

Most of the land degradation phenomena in the Mediterranean basin commenced in the Neolithic, reaching a peak during the Roman times (Lowdermilk, 1953), with extensive erosion by water in the Apennines of Central Italy that could be considered as an early form of desertification in the area.

Over the past 50 years to meet the demands for resources humans have changed ecosystems more rapidly than in past ages. It is increasingly clear that environmental degradation and resource depletion play an important role in creating or exacerbating human insecurities (Dabelko *et al.*, 2002). There is growing understanding that environmental degradation, especially when coupled to inequitable access to critical natural resources, increases the probability of conflict and instability and exposes a substantial risk to human security.

The challenge of reversing and limiting degradation while meeting increasing demands for services involves changes in policies and in institutional strategies. A main issue in any strategy aimed at safeguarding the nations' environmental security, (and therefore social and economic security) should be based on the technical and institutional capability to study environmental degradation processes and natural catastrophes through assessing, quantifying and monitoring phenomena during the time and prevention through adequate intervention.

In fact a leading role is played by the environmental emergencies linked to desertification, as stated by the Millennium Ecosystem Assessment (MA, 2005) that is a complex process involving the interaction of various components: the socio-economic issues, such as food security, poverty, migratory flows and political stability, and different environmental issues, such as climate change, biodiversity and water supply. The UNCCD (1994) emphasises the need for coordinating all efforts towards sustainable development, through the implementation of widely supported Action Programmes (National, Regional, Sub-Regional).

From the technical point of view, the realisation of the above-mentioned objectives requires making assessment and forecasting of the phenomena through adequate tools (Enne *et al.*, 2003a). Countries involved in the fight against desertification have to establish specific information systems based on quantitative approaches, such as the Desertification Monitoring System (DMS). DMS must be able to provide a monitoring-based diagnosis of the state of natural resources and of populations in the affected regions and support the decision-making process. In particular, they should help actors at all levels to review their progress, analyse the weaknesses of the implemented policies and determine priority actions (UNCCD, 1994).

As defined by UNCCD, desertification indicators are "*integrated series of physical, biological, social and economic indicators* " aimed at achieving "*systematic observation of land degradation in affected areas and at gaining a better understanding of the processes and the effects of drought and desertification*". The international community has understood that it is impossible to define a universal set of indicators, but rather that it is necessary to come up with some common approaches and methodologies.

The implementation of DMS through the development of benchmarks and indicators poses relevant technical and institutional challenges. Among the main open technical issues are (Jauffret, 2005):

- Organisation of structured sets of Benchmarks and Indicators (B&I) able to represent the land degradation systems;
- Integration of different disciplines and as well as spatial and temporal scales involved in the process;
- Evaluation and quantification of effectiveness and benefits of mitigation interventions, including the socio economic ones.

From the institutional point of view, the main difficulties at the national and local levels are linked to inter-sectoral coordination, whereas at the supranational level methodological harmonisation is urgently needed.

The aim of this paper is double:
1. To discuss and comment some of the achievement reached by the MEDCOASTLAND Thematic Network in relation to desertification indicators;
2. To present some initiatives, recently accomplished or currently on-going at the European/Mediterranean level, which could be used as examples, or exported, in the frame of new, integrated joint Euro-Mediterranean initiatives which could be promoted with reference to the European Commission's 7th Framework Programme (7th FP). The projects considered are MEDRAP, related to "international and regional coordination and harmonisation" and DESERTWATCH, related to "data based operational monitoring system".

Discussion

Improving international and regional coordination and harmonisation

The Terms of Reference (ToR) of the Regional Action Programme (RAP) of the Annex IV suggested the need for developing a platform for a mutual cooperation among the northern Mediterranean countries in order to improve the effectiveness of the fight against desertification at national level. It has become very clear that Northern Mediterranean countries need to better coordinate and harmonize their adopted methodologies.

In particular, the ToR highlighted the need to work on relevant and trans-national priority issues, such as the identification of common benchmarks and indicators, the definition of desertification sensitive areas and the exchange of data through the scientific community involvement (Enne *et al.*, 2003b).

The MEDRAP project has been proposed to the European Commission by Nucleo Ricerca Desertificazione (NRD) to define the state of the art of the most relevant desertification issues and to contribute in the identification of strategies and priorities to reverse desertification trends. The MEDRAP Concerted Action, which has run from 2001 until 2004, had the main objective to support the elaboration of a truly common Sub-Regional Action Programme (involving some of the Annex IV countries: *i.e.* France, Greece, Italy, Portugal, Spain, Turkey) to combat desertification by favouring the establishment of a better link between the scientific community and other actors in relevant areas. Such objectives have been achieved through the establishment of a wide network aimed at the exchange of knowledge and data between scientific community and the stakeholders. For the whole of its duration MEDRAP organised five thematic workshops. They dealt thoroughly with the following topics:

1. Sustainable management of soil and water resources;
2. Identification of sensitive areas;
3. Political and socio-economic aspects of desertification;
4. Desertification mitigation in sensitive areas;
5. Regional strategies to combat desertification.

Starting from the state of the art, the workshops focused on finding solution and providing options to decisions makers taking into account their real needs and successful experiences adopted in similar contexts. Almost in all workshops it was possible to attain the participation of representatives from UNCCD Annex I and III countries, thanks to the financial support provided by the Global Mechanism.

The project was very successful and produced a rich set of scientific documents as well as conclusions and recommendations shared by all the partners (Enne *et al.*, 2004). In particular, the strengthening of the link between scientific community and actors and their direct involvement allowed the identification of desertification-related common priorities.

The project approach provided an excellent example on how to work on the implementation of each ToR, starting from the identification of the existing gaps. A revision of the ToR in the light of the obtained results was necessary and yet a recommended step towards the elaboration of a realistic and effective Plan of Action to combat desertification in the northern Mediterranean area.

The bottom-up approach and the local consultations demonstrated the validity in the identification of mitigation measures. In particular, EASW[1] was considered as a possible common methodology to achieve local participation, also for non-EU Countries, where it has not yet been used. Hence,

the experience highlighted the importance to establish linkages among the Countries of UNCCD Annexes I, III and IV in order to build synergies among the people and to achieve reliable results through their concrete participation and approach application. Furthermore, MEDRAP representsa great direct contribution on indicators and benchmarks especially for the results obtained by the second and the third workshops.

[1] The European Awareness Scenario Workshop (EASW) Initiative was launched by the European Commission in 1994 to explore actions and experiments for the promotion of a social environment. Its methodology was created by the Danish Board of Technology, in order to understand the improvements that can be achieved in ecology and in the dissemination using participatory approach. It is based on dialogue between groups of local actors to create a balanced relationship between society, technology and environment.

The complexity of the problem and the need to harmonize methodologies for the identification of sensitive areas has been enhanced by the second workshop. The work started from the presentationof the knowledge acquired on the identification of sensitive areas by different EU research projects. The results underlined the will to work together, taking into account both biophysical and socio and economic indicators for the identification of a common methodology to assess sensitive areas. The obtained results can be used to compare the indicators used by the European Mediterranean Countries for mapping desertification sensitive areas. Some methodological divergences have been observed however, mainly due to heterogeneity of the approaches, to the use of different indexes and parameters and to the difficulty in the implementation of the same methodology for such a wide context as the Mediterranean Basin.

Nevertheless, Greece, Italy, Portugal, Spain and Turkey, generally have considered indicators related to some main categories: climate, soil, vegetation and anthropic pressure conditions. In particular, MEDRAP suggested that such affinities could constitute the starting point for the elaboration of common indicators at Mediterranean level, aiming at developing and implementing a common SRAP for the Annex IV Countries.

The role of socio-economic indicators to better characterise sensitive areas and implement mitigation strategies was highlighted during the third workshop. The workshop enhanced the need for using *social, economic and biophysical indicators* within a simplified methodology taking into consideration the existing standards of EU reporting and the contributions deriving from socio-economic indicators elaborated from other projects. Data availability although is limited by institutional constraints and by economic and technical factors, thus data standardisation is necessary for comparing results. Successful relevant experiences on benchmarks and indicators utilization in pilot areas must be improved and adopted in sub-regional areas. Moreover, a platform is required to ensure the use of developed indicators and monitoring systems after the end of the projects. The activities carried out enhanced how science on desertification indicators could constitute support for decision-makers in mitigating desertification and towards the sustainable development by building integrated indicators with more attention on socio-economic ones.

International cooperation has showed an increase in activities and efficiency over the last decade. It has shown also the importance of education, training and capacity building as necessary means to bridge the gap between administrators and community users by consulting and involving all stakeholders, including decision makers since the beginning of the definition of the appropriate approaches to establish benchmarks and indicators. From the institutional point of view, the linkage between the NAP and other national strategic frames must be strengthened and efforts must be made to integrate NAPs into other national strategies.

Integrated sets of indicators

National and international agencies have emphasised the need for knowledge structuring and facilitation of the communication on indicators as a reliable tools for decision support. They have proposed several solutions. To be able to identify real problems and provide a simple model for decision-making, indicators could be grouped in a logical framework according to different criteria.

In particular, the DPSIR model, proposed by the European Environmental Agency EEA (Gentile, 1998) as an evolution of the well-known PSR (OECD, 1993) enables an integrated vision of desertification by enhancing the "cause-effect" interactions between indicators. Such model, which is the most widespread also at international level, demonstrates some limitations due to its static structure. It consists of 5 strictly defined phases (Driving Forces, Pressures, State, Impact, Responses). Hence, it doesn't consider the multi-scale approach that must characterize studies dealing with the desertification process.

Thus, the DPSIR model could produce different results, if it is used with different spatial scales and methodologies. Such limitations imply that in some cases the results could not be compared to each other. Therefore, at the lowest degree of details, the causal relationships become weak and the representation looses effectiveness.

Some case studies from southern Mediterranean basin analysed in the frame of the MEDCOASTLAND.NET Project[2] by several Mediterranean partners, prove that the application of the model could become more effective if DPSIR is used on homogeneous land units such as the agro-ecological zones, in which typical processes and related causal relationships could develop.

Agro-ecosystems were selected by the Moroccan partners (Badraoui *et al.*, 2004) to propose the implementation of suitable management measures. The Moroccan agro-ecosystems, identified at the national scale through several studies and research, were subdivided on the basis of the biological, climatic, landscape and land use characteristics. The application of the DPSIR proved efficient in the harmonisation of approaches and evaluations derived by different case studies dealing with similar desertification problems.

In other cases, DPSIR has been applied partially, without considering the establishment of indicators for each component involved in the process. In Jordan for example, (Al-Qudah, 2004) the same causes have been often linked to different processes and this transversal use of DPSIR can generate a confusing interpretation of the methodology.

In Palestine (Dudeen, 2004) the biophysical processes have been substituted to the "State", not always in the correct way. "Responses" are not referred to a possible monitoring system for the actual responses, but as a proposal framework for the future actions.

Starting from the above-mentioned considerations about DPSIR, the NRD elaborated a proposal for a model, which intends to fill the gaps of DPSIR, by:

1. Integrating natural vulnerability of environment with biophysical processes;
2. Linking indicators typologies to specific operational objectives;

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[2] *MEDCOASTLAND is a thematic network project funded by the European Commission, within the international cooperation with Mediterranean countries. It aims at coordination and dissemination of land conservation management to combat land degradation for the sustainable use of natural resources in the Mediterranean. The overall objective is to contribute to sustainable development in Mediterranean coastal areas, with particular regard to Land and Soil Degradation and Conservation Management*

3. Integrating different spatial scales involved in the desertification process;
4. Highlighting mutual interactions between scales and phase of the process.

The following changes were considered in relation to the abovementioned considerations:
1. Vulnerability indicators (V) have been added to the model as an element that cannot be considered by the traditional DPSIR, but that contributes to define prevention strategies with D (Driving Forces) and P (Pressures). This class of indicators refers to the natural vulnerability to land to degradation processes. The causes of a desertification process (normally described by both Driving forces and Pressures) have been grouped. Thus the user can define different causes according to the detail of the representation desired and without forcing a two-level distinction (however, the levels could be more than two...). In addition another element was introduced, or the "biophysical degradation processes" (PR), merging together Pressure and State to highlight and monitor any kind of causal mechanisms.
2. The DPSIR elements can be associated with strategic objectives (such as Prevention, Monitoring, Mitigation/Adaptation), where: Monitoring means "observation of bio-physical processes"; Mitigation/Adaptation means "observation of implemented actions and their effects and consequences also at the socio-economical level"; Prevention means "observation of the elements that must be considered to prevent a process ".
3. The elements of the model have been linked to specific spatial scales, which they can refer to. The scale ranges proposed are fully described and elaborated in an earlier paper by Enne and Zucca (2000).
4. A dynamic representation enhances inter-scale and intra-scale relationships, as discussed below.

In order to systematize indicators, strategic objectives, DPSIR elements and spatial scales have been combined in a bi-dimensional table within which the indicators can be placed (Table 1). The table highlights that in order to achieve a "Prevention" action the use of V, D and P indicators must be over stressed. In order to carry out a "Mitigation" action PR and S indicators will be preferred, and finally I and R indicators will be considered to carry out a "Mitigation/Adaptation" intervention.

The spatial scales defined in the table suggest that in a given geographical and socio-economic context, the factors considered in the 6 columns can be observed at different scales. This does not imply that the representations at the different scales are independent from each other; on the contrary it highlights that given phenomena can be more efficaciously observed at different scales and with *ad hoc* instruments and information.

Such scheme was developed by Zucca (2004) to describe some sets of indicators that were tested in a pilot area of the DESERTNET project (Zucca and Della Peruta, 2005).

A dynamic representation (Fig. 1) that enhances inter-scale and intra-scale relationships has been proposed in order to highlight that some "cause" factors at a given scale can be related with some specific "effects" of the subsequent causal level, but not with others (Colombo *et al.*, 2006). One example is reported about a case study (the pilot area mentioned above) related to the Sardinian agro pastoral context, in Italy, and in which four causal levels have been identified that precede processes and state indicators. A further step to support the dynamic representation of the phenomena consists in highlighting the intra-scale and inter-scale causal relationships (*i.e.*, among phenomena at the same scale and phenomena at different scales) and their importance (e.g. when several pressure factors can be related to a change in state).

Concerning the relationships among the DPSIR phases and the spatial scales, it could be stated that some processes are common to wide areas or they are more easily detectable and interpretable at a given scale. Furthermore, some of them could be more adequately detected at more than just one scale. As an example, all elements in D can be approximately considered common to most of the agro pastoral contexts in Sardinia, similarly to the general increase in the number of sheep (in P1). The way in which such factors influence phenomena in P2 and P3 largely depends on the local or district factors and thus requires indicators at the corresponding level. In turn, the intensity of the biophysical processes identified could be generally quantified only through precise measurements in plot sites and then extrapolated to wider areas, although it is possible to identify indicators that allow approximate estimations at wider scale (e.g. through remote sensing).

From the technical point of view, the system cannot be considered as closed one, because at the levels that correspond to D, I and R also other external factors concur.

Operational remote monitoring systems

One of the main issues in monitoring and managing desertification processes through indicators is due to the subjectivity of the methodologies that can be carried out and applied. The development and the implementation of operational monitoring systems constitute an essential step to limit such subjectivity and to make desertification monitoring reliable and repeatable. Thus, the use of this kind of system could provide the potential users with a tool based on standard framework and methodology that shall serve as common infrastructure.

The DESERTWATCH Project (2004-2007), funded by the European Space Agency (ESA), is focused on land degradation and desertification research on the northern Mediterranean region using the framework developed by the UNCCD. It is not a research project, but a development activity to create a user-tailored system to assess and monitor desertification and its trend over time in the mentioned region on the base of Earth Observation (EO) technology. The project intends to valorise the outcomes of ten years of European research, by integrating the more consolidated procedures and algorithms into an operational highly automatized system. The Desertwatch system aims at supporting national and regional authorities of Annex IV countries by giving an operational response to the needs and requirements of the user community. It is based on the integration of data of different nature (ground data and remote sensing data).

The operational logical framework of the system is shown in Fig 2. On the left there are the data inputs, including DEM (Digital Elevation Model), Socio-economic data, Meteorological data, Soil quality and Management Quality from the users. The most important ones are the Remote Sensing data (Landsat and Meris images).

Table 1. Integrated structured representation of a desertification indicator set.

		phases of fight against land degradation					
		Prevention		**Monitoring**		**Mitigation/Adaptation**	
		V **Vulnerability** (resistance, resilience, etc.)	**D/P** **driving forces** and **pressures:** causes of degradation	**PR** **Process dynamics:** degree and trend of biophysical processes	**S** **State:** quality/ degradation level	**I** **Impact:** consequences on socio-economical components and ecosystem functions	**R** **Response:** society reaction
spatial scale for evaluation, interventions monitoring,	Regional, National, sub-National., etc.						
	"Wide area" or **District** (up to 1:200.000)						
	"Local" (up to 1:50.000)						
	"Plot" or ***detail*** (about 1:5.000)						

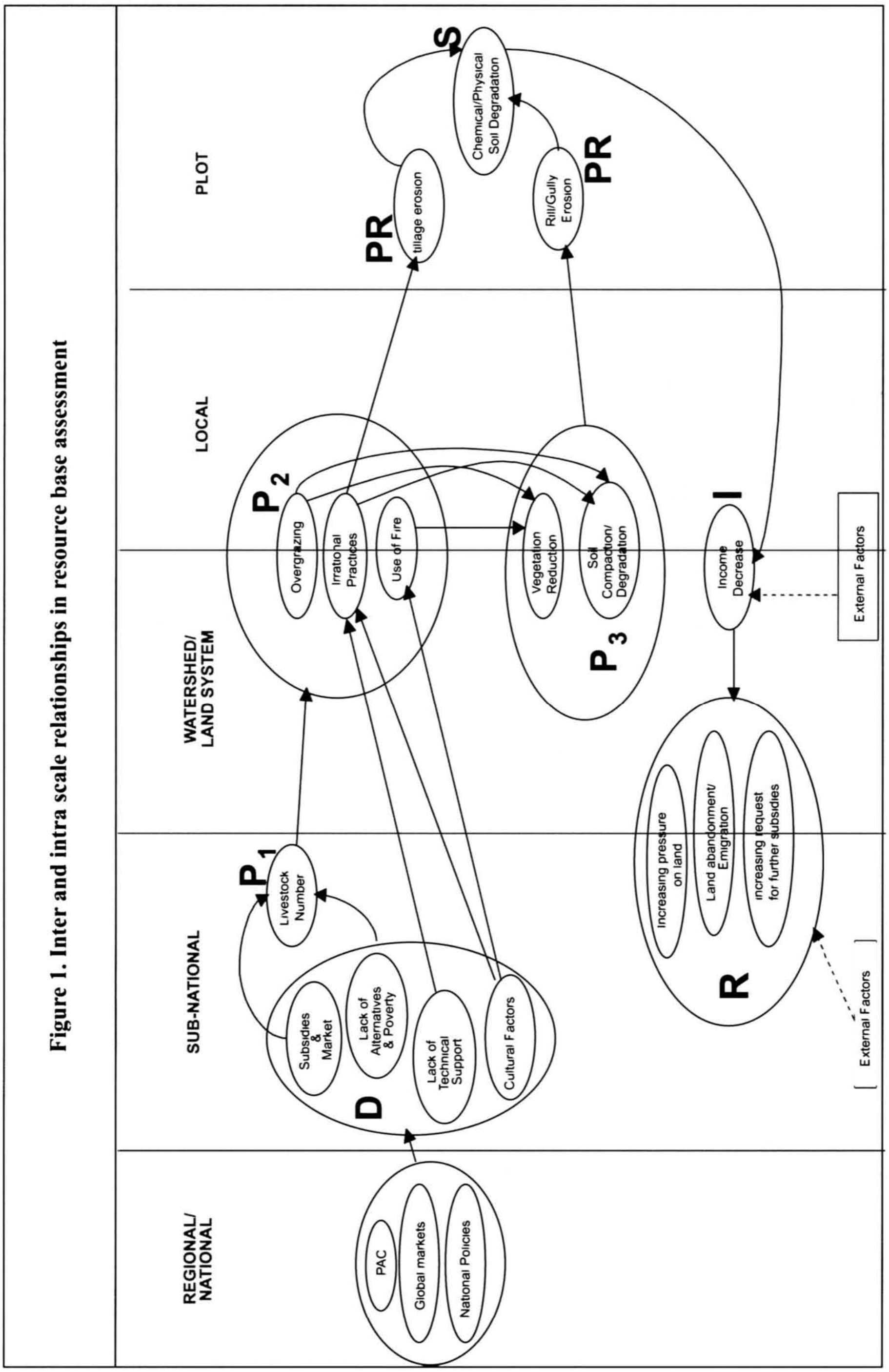

Figure 1. Inter and intra scale relationships in resource base assessment

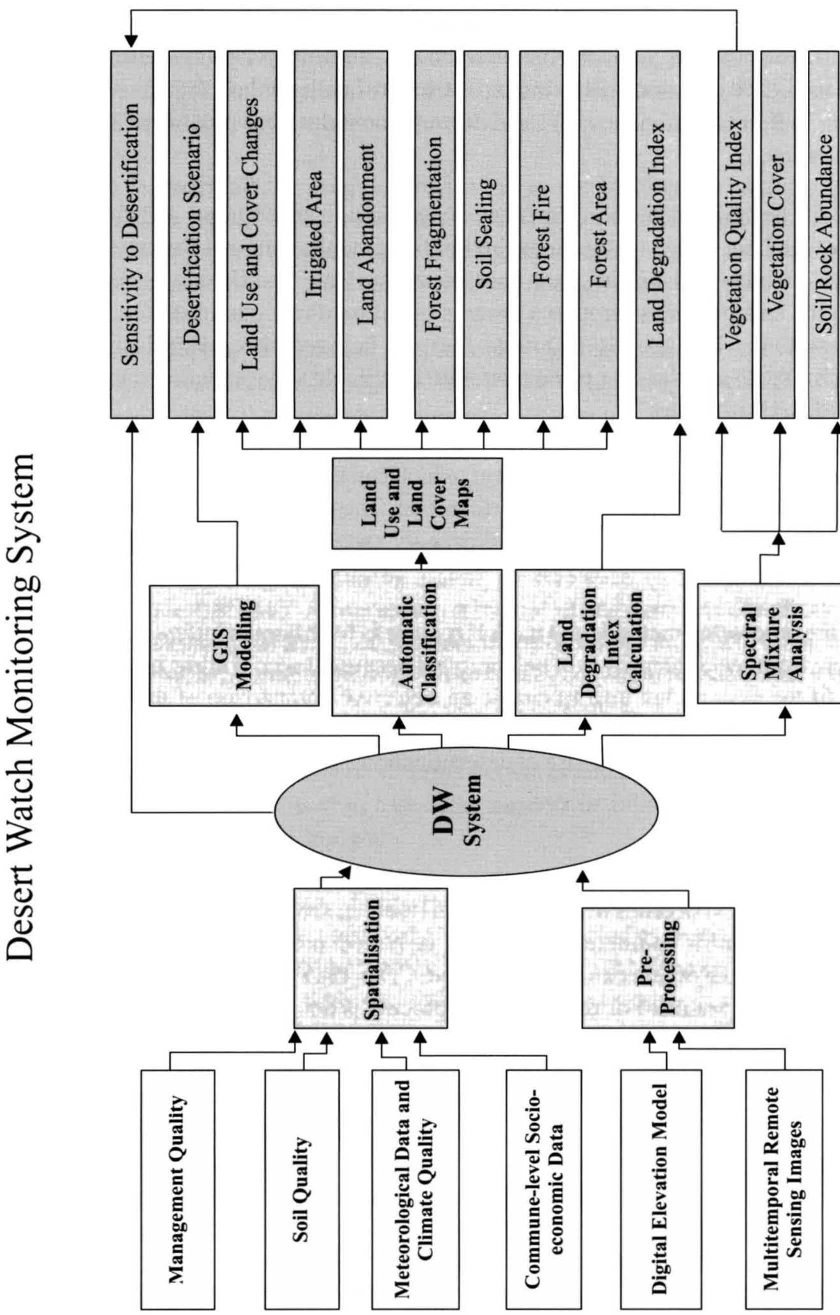

Figure 2. DesertWatch Monitoring System

After pre-processing, all these data are put into a sequence of elaboration procedures, including different Modules such as SMA, LDI, Auto Classification and Scenario Modelling (Blue colour boxes in Fig 2). The products are listed on the right: e.g., 1) Sensitivity to desertification, 2) Soil quality index map; 3) Vegetation quality index; 4) Climate quality index; 5) Soil sealing; 6) Forest fragmentation; 7) Rainfall efficiency; 8) Land degradation index; and finally 9) Change trends of these indexes in time.

The project will be implemented in Portugal, Italy, Greece and Turkey and foresees a close involvement of the User Group (institutional bodies linked to the National Committees to Combat Desertification), which will be the final user of the system. The developed outputs will be transferred to the specific users through a process based on direct demonstration and operation from the consortium. The goal is to bridge the gap between the scientific usage of Earth Observation (EO) data and the set-up and operation of reliable services tailored to specific users needs and validated by the user.

In fact, the users will be provided with a system, which can be routinely used by non-experts, for generating the required indicators about desertification. The system delivers functions that are to the maximum possible extent user simple and friendly and involve as little manual activities as possible.

Furthermore the processing methods and models require as little human interpretation as possible. In this case, environmental security will be improved because it would allow not only to simplify the usability of the system, but also to enable an objective comparison of data generated over different areas. Thus, such approach could permit extending the methodology and outcomes to other arid regions affected by or are at risk of desertification anywhere in the world.

Conclusions

The experience of the last decades in desertification research shows that the process is rather well understood by the scientific community. However, its remediation still remains problematic. The efforts of the international organisations such as UNCCD or the EU-funded research projects have produced considerable results. For the better, the process is not considered anymore as purely a biophysical aspect of land degradation, but more within the ecosystem approach including socio-economic features.

Monitoring the process of desertification has proven difficult and cumbersome. This is a real handicap for the desertification science, as the decision makers at all level need accurate and reliable information. The emergence of sophisticated remote sensing systems has given considerable support to monitor the process. However, it should be made clear that this technology remain by large an excellent tool to monitor vegetation cover changes but not necessarily adequate enough to demonstrate the desertification status, especially when socio-economic consideration are not considered. Thus it is crucially important to combine remote sensing technology with ground checks and field surveys, wherever possible.

Harmonization and standardization of RS data is urgently needed. Standard methods of radiometric and atmospheric corrections are necessary to generalize results of research and enable comparison between different countries. Identification of remotely sensed indices related to land degradation are also needed. Such indices could be further developed to derive for instance food security indicators for the Mediterranean countries.

Assessment of land degradation and desertification in the Mediterranean and especially of its economical damage should be based on *benchmarks and indicators* and on real data derived through collaborative efforts between national and international institutions. The time has come to replace *ad hoc "quick and dirty"* assessments with scientifically proven results.

Developing and adopting a common methodology to make harmonised estimates of land degradation and desertification throughout the Mediterranean region could be a first step to perform and apply regional environmental impact assessments. Addressing different scales and allowing for data compatibility by making the best use of available information should be strongly supported.

Quantitative indicators should be used to assess ecosystem and natural resources degradation in arid and semi-arid areas by identifying points of reference to unify criteria for assessing degradation and desertification. A consensus on the use of standard sets of indicators has not yet been reached. Most standards are based on bioclimatic or aridity index and on indexes related to soil type or soil erosion. In order to perform sustainable ecosystem management it is necessary to integrate the main components of ecosystem functioning, e.g biodiversity and species composition, ecosystem fragmentation, socio-economic driving forces, geochemical cycles and global climate change. Establishing monitoring networks and promoting data collection through common standards should be used to assess the success or failures of actions combating land degradation, desertification and drought.

Completing and updating the Euro-Mediterranean Geographical Soil Database at the scale of 1:1 million (Lambert *et al.*, 2001) is a necessity for additional studies in the region. CIHEAM-IAM Bari in collaboration with the members of the MEDCOASTLAND project should take the lead in finalising this database along with the soil map as it was agreed in the Memorandum of Understanding signed in Bari, Italy in December 1999. This database should be complemented with climate, land use land cover, and other possible data. All sources of funding should be explored to support this effort. The final result of this activity should form the Mediterranean component of the European Soil Data Centre (ESDAC) hosted by the EC JRC, in Ispra, Italy.

Using the 1:1 million-scale soil database could be only the starting point of a long process that would require country-based assessments as scale dependency especially in soil survey is closely related to the national territory of a given country i.e comparing Algeria with Lebanon. The first exercise to be implemented could be the Mediterranean Assessment of Soil Degradation (MEDSOD) as a multidisciplinary integrated assessment of soil degradation to be able to show both "*hot and bright spots*" in natural resources management and conservation. Showing "*bright* *spots*" (C. Licona Manzur *et al.*, 2004) and success stories in ecosystem management is particularly important to demonstrate that investing in sustainable use of natural resources is worthy and should be continued.

The initiatives described by the present contribution, as well as the methodological discussion proposed, could constitute a valuable example and reference to set-up new joint Euro-Mediterranean projects aimed at tackling the difficulties highlighted and to strengthen the scientific and institutional collaboration all around the Mediterranean basin.

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