



AIDCCD



European Commission
Research Directorate General

AIDCCD - Active exchange of experience on indicators and development of perspectives in the context of UNCCD



Local & Regional Desertification Indicators in a Global Perspective *Seminar Proceedings*

Edited by
Giuseppe Enne and Maria Yeroyanni



Centro Interdipartimentale di Ateneo
Nucleo Ricerca Desertificazione
Università degli Studi di Sassari



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Local & Regional Desertification Indicators in a Global Perspective

*Proceedings of the International Seminar
Beijing – China
16 to 18 May 2005*

Edited By:
Giuseppe Enne and Maria Yeroyanni



Permanent Interstate Committee
for Drought Control in the Sahel



China National Desertification
Monitoring Centre



Desert Research Foundation of
Namibia



Instituto Argentino De
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2006 – Centro Interdipartimentale di Ateneo – NRD
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AIDCCD is an Accompanying Measure supported by the European Commission DG Research under Framework Programme 5. It contributes to the implementation of the Key Action 2.3.3 “Fighting land degradation and desertification” within the Energy, Environment and Sustainable Development Programme. Contract Number EVK2–CT-2002-80018

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Preface

This volume contains the proceedings of the International Seminar on “*Local and Regional Desertification Indicators in a Global Perspective*” held in Beijing, China, in May 2005. The seminar was organised under the framework of the AIDCCD (Active Exchange of Experience on Indicators and Development of Perspectives in the Context of UNCCD) Accompanying Measure. AIDCCD is a project funded by the European Commission, Research Directorate-General under the Fifth Framework Programme (Natural Resources Management and Services).

Land degradation, desertification and the unsustainable use of natural resources cause severe environmental damages worldwide. The identification and use of desertification indicators and benchmarks constitute a priority issue in all UNCCD Regional Annexes, since they are main tools. They are obtained from the scientific knowledge and contribute to solutions, measures and decisions.

Efforts are currently underway to identify common sets of environmental indicators which take into account environmental factors, socio-economic factors and the complexity of desertification. Although a relevant quantity of data and information has been developed in all Annexes, there have been few opportunities to exchange and compare experiences in order to find common solutions to common problems.

The aim of the seminar was not to produce and present new scientific findings and achievements, but rather to provide a valuable opportunity to exchange information and experiences between representatives of the different UNCCD Annexes, while bringing them together and exploring possible synergies. Participants from Asia, Latin America, Africa and Europe included recognised scientists, stakeholders and representatives of relevant international bodies. The seminar was preceded by the drafting of a report on the *State of the art on existing indicators and CCD implementation in the UNCCD Annexes*. It was published in a separate volume (available upon request at nrd@uniss.it) and it has provided the seminar participants with a global overview on the implementation of indicators. Furthermore, it allowed the organisers to identify main issues that required further discussion at the seminar such as:

- development and use of desertification benchmarks and indicators;
- data gathering for monitoring,
- impact of climate change,
- case studies, cooperation.

A practical approach was adopted through the presentation of concrete examples from all annexes.

We are confident that these proceedings will provide a valuable insight in the activities carried out at global level in the field of desertification regarding benchmarks and indicators and they will contribute to the acquirement and dissemination of valuable initiatives in the area.

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OPENING SESSION

ACTIVE EXCHANGE OF EXPERIENCE ON INDICATORS AND DEVELOPMENT OF PERSPECTIVES IN THE CONTEXT OF UNCCD: THE AID-CCD PROJECT

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1. Introduction: general overview of the project

AIDCCD is a EU Accompanying Measure that was born in the framework of the ENRICH implementation to address the issue of the UNCCD (United Nations Convention to Combat Desertification) implementation in a global perspective, by involving all regional Annexes. Its main objective is to allow the exchange of experience on desertification indicators and on information circulation systems in the different UNCCD regional annexes (Annex I for Africa; Annex II for Asia, Annex III for Latin America and the Caribbean; Annex IV for Northern Mediterranean and Annex V for Eastern Europe).

Desertification indicators and the Information Circulation Systems have been recognised as relevant priority issues and much work has been carried out to address these aspects in all Annexes. All these activities have been developed in parallel and have produced a relevant quantity of data and information but due to a lack of opportunities to meet and discuss the experiences and the activities carried out such information is usually bound to the national and/or regional levels.

The AIDCCD project was conceived as an answer to this need, and in particular to support the development and coordination of the exchange of experiences between scientific institutions involved in the UNCCD implementation. All the project partners (Table 1) are in fact deeply involved in the NAPs and RAP elaboration in their own Annexes and have a great deal of experience on indicators development and use.

To achieve the objectives above, two thematic seminars will be realised on:

- Local and Regional Desertification Indicators in a Global Perspective;
- Role of the Information Circulation Systems in the scientific and practical approach to combat desertification.

The seminars constitute the core activities of the project. Their purpose is to draw up the state of the art, to stimulate exchanges of experience and to identify development perspectives. This should lead to the final objective: showing in a qualitative and whenever quantitative way how science and technology can be used to assist decision-makers in mitigating desertification in a sustainable development perspective.

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Table 1: AIDCCD project partners

In order to provide for the successful outcome of the seminars, the project includes a set of complementary preparatory activities:

- elaboration of a preparatory study/review on “State of Art on existing indicators and their use for the desertification monitoring and CCD implementation in the UNCCD Annexes”,
- realisation of a Think Tank to discuss the results achieved by the studies and elaborate the Terms of Reference for the two seminars.

The studies and the conclusions reached are available on the project web site (<http://nrd.uniss.it/sections/aid-ccd/>) and will be published in a separate volume.

2. The preparatory studies

Their general aim was to make the state of the art on indicators used by the different stakeholders at the local, sub-national, national, sub-regional and regional levels in relation with UNCCD implementation.

The complexity of the regions was taken into account when considering the range and scope of the studies which was obviously reflected in the total number of reviews elaborated (Table 2):

Annex	Studies
Africa	2 studies for Northern Africa and Southern Africa
Asia	2 studies for western and eastern Asia
LAC Countries	2 studies for Central and Southern America
Mediterranean Europe	1study report

Table 2: Overview of the studies elaborated

In order to elaborate homogeneous reports in terms of information required and related contents, the *Terms of Reference* for the study were drawn up and discussed by all project partners. A questionnaire was elaborated to collect information on:

- Main institutions and projects involved in the desertification indicators development and implementation
- State of art on B&I on desertification and/or drought in each project/related activity in the different Countries
- Overview on methodology of B&I in each project/related activity in the different Countries
- Examples on practical use of B&I in each project/related activity in the different Countries

The questionnaire was then distributed among the main stakeholders selected in the different annexes, and particularly the Focal Points. In addition, the authors of the studies referred to existing available documents on the issue.

2.1. Preparatory studies for Annex I: Africa

Three studies were planned, two of which (Northern and Southern Africa) were concluded whereas one (Sub-Saharan region) is under elaboration.

The Countries subjected to close examinations were: Algeria, Egypt, Morocco, Tunisia, Lebanon, Libia (northern Africa); Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe (Southern Africa).

In general, the studies highlight the following:

- Most countries have at least started the process of developing benchmarks and indicators under the framework of the UNCCD.
- There is some confusion about terminology, e.g. what are indicators and benchmarks. Different countries have different definitions or interpretations.
- Most indicators identified are country specific, i.e. only proposed in one or few countries. This suggests that causes and effects of desertification that are considered important in the different countries varies widely, which makes it difficult, if not impossible, to develop one “universal” core set of desertification indicators.
- Only approximately 15% of the indicators have some kind of defined benchmarks.
- Just a few countries have actually implemented their suggested indicators.
- The diversity of indicators proposed by the different countries is striking. Seldom is an indicator used in more than one country.
- Most countries establish some kind of forum or national group of experts that develops a list of potential indicators. However, the only clear example of real participation found in this review is the approach taken by NAPCOD in Namibia where the development of local level indicators was based on the information needs expressed by the local resource users, resulting in local level monitoring systems
- Most stakeholders are apparently working only at local scale.

2.2. Preparatory studies for Annex II: Asia

Two studies were elaborated, one for East and Southern Asia and one for Western and Middle Asia with a total of 10 Countries considered in detail: China, India, Mongolia, Thailand, Japan, Korea, Turkmenistan, Iran, Israel, Syria

Both studies highlighted the following:

- The Asian region is particularly active, a great number of regional and sub-regional meetings were carried out during the last years, many of them relevant to the issue of B & I.
- The Asian Thematic Programme Networks (TPNs), launched during ministerial meetings to support the RAP and the NAPs, constitute a very good platform for the development of coordinated actions throughout the region. Six TPNs have been set up since 1999. Each TPN programme has been dealing with a specific desertification problem in Asia. Particularly relevant is **TPN1: Benchmarks and Indicators Development and Mapping for Desertification Monitoring and Assessment**, hosted by China. The Launching Meeting for the Thematic Programme Network on Desertification Monitoring and Assessment (TPN1) was held in July 1999 at Beijing China. A list of common indicators has been already agreed.
- TPN1 highlighted a very strong interest in RS data; frequent contacts with ESA exist.
- TPN1 proposed an interesting indicator structure based on a zonation related to i) agro-climatic regions; ii) land use; iii) degradation process; and particularly focusing on P, S, I indicators and on Implementation indicators.
- Real application of TPN1 B&I in Countries is still lacking due to financial and capacity problems.

- Also single countries possess relevant experiences:
 - China developed an original classification system for land degradation forms and phenomena and created a National Desertification Monitoring Centre which is accumulating very relevant knowledge and experience also through extensive, multi-scale field surveys;
 - Countries like Mongolia, Turkmenistan, Israel are developing interesting knowledge related to range monitoring through RS;
 - Iran is applying results of the European research (ESA methodology, MEDALUS III project);
- A generalised interest toward exploiting European scientific cooperation in the field of B&I is quite evident.

2.3. Preparatory studies for Annex III: Latin America and the Caribbean

Two studies were also elaborated for Annex III that cover the areas of South America and of the Mesoamerica & the Caribbean. The following Countries were subjected to close examination: Argentina Chile Venezuela Colombia Brazil Peru Uruguay Paraguay Bolivia Ecuador Panama Costa Rica.

The reviews highlighted the following:

- A regional TPN (Technical Programme Network) is taking shape on B&I.
- Very relevant inter-regional cooperation activities on B&I are in progress with Annex I.
- Exchanges with European scientific community established also thanks to MEDRAP are increasingly emphasised as an opportunity and a source of knowledge and methodologies.
- The two regions show very different degree of development on B&I: the Caribbean is just starting to work on the issue and to co-ordinate efforts, while Southern America area already counts on a decade of experience.
- Several regional and sub-regional meetings were held on B&I, particularly in South America and different trans-national pilot projects were carried out involving several countries and in particular Argentina, Chile, Brazil and Mexico.
- A first, very basic data-base for the whole region has been agreed and populated considering few simple indicators.
- Considering the single countries, some of the most interesting experiences belong to Argentina and Chile. In Argentina a practical and applicable methodology was reached. The selected indicators proved useful, not only for establishing desertification degrees, but also for helping awareness of the local population as well as of the decision-makers. Leader indicators were identified per ecosystem, and maps of fragility, human pressure and state of desertification were drawn. Both at local and provincial levels, the methodology includes the temporal scale within the spatial scale (diachronic studies). Chile has created an information system that permits to monitor desertification processes. Its main achievement is the MONITOR system, including a set of indicators and analysis tools. Communities, institutions and authorities are participating in training programs on the use of the System.

2.4. Preparatory studies for Annex IV: Northern Mediterranean

One review was elaborated for the Northern Mediterranean area and it focused on experiences carried out in Greece, Italy, Portugal, Spain, Turkey and Malta highlighting the following main issues:

- Desertification is not a unifying issue: the use of land degradation indicators is very sectorial.
- The elaboration and use of indicators is driven by scientific community and by transnational research activities; a scarce linkage exists with institutional needs.
- Efforts are mainly devoted to risk indicators and mapping and no attempt is made to define and map status of land degradation.
- In Portugal a very interesting experience has been carried out on indicators testing at national scale and in pilot areas, integrated within NAP.
- New countries are still not very active in this field, with the exception of Malta.
- A number of relevant on going research project are raising more and more interest in other annexes, also thanks to AID-CCD.

3.The Think Tank

A Think Tank among the project partners and a small group of selected experts was held in Mendoza (Argentina) in May 2004 to discuss about the results achieved by the studies and to propose Terms of Reference for the realisation of the two AIDCCD seminars.

The conclusions achieved can be grouped into technical and institutional.

At the institutional level, among the others the importance was generally stressed to take in account the reality of the implementation of the NAP process whose speed varies according to the region and to the Country; similarly, efforts must be made to guarantee that a linkage exists between the NAP and the other national strategic frame and to pursue the integration of the NAP in the national strategies.

Several issues were stressed concerning the technical issues, among which are the following:

- to highlight the necessity to have benchmark as reference (giving a meaning to the indicators). Benchmarks must be considered within the context of indicators and indicators are not relevant without benchmarks;
- to develop socio-economic indicators without which the concept of indicators remains incomplete;
- to establish the link between biophysical and socio-economic indicators. The integration of biophysical and socio-economic indicators has not been attempted to the desired extent; relationships/interactions between the two categories of indicators should be studied;
- to define common sets of Benchmarks and Indicators for different levels, from global to local;
- to develop "top-down " and " bottom-up" approaches;
- to develop adequate harmonised information circulation systems using international standards;
- to implement operational Monitoring-Evaluation systems using elaborated benchmarks and indicators;
- to translate the scientific knowledge into useful knowledge to the decision makers;
- to elaborate indicators in response to the decision makers needs.

4. The AIDCCD seminar on “Local and regional desertification indicators in a global perspective”

On the basis of the results achieved, the Terms of Reference for the first AIDCCD seminar were elaborated. Six main priority issues were in fact highlighted by the Think Tank that deserve a deeper analysis during this first seminar; each issue constitutes one session, and in particular:

- Integrated approach for the Development of Desertification B& I
- Integrated Approach for the Use of Desertification B& I
- Data gathering for the development of the reference B& I for monitoring and assessing desertification: A - Traditional approach; B - Remote Sensing
- Climate change impact on Desertification – what B&I should be used
- Reinforcing North-South, South-South cooperation on desertification B&I

A rationale was developed by the project partners for each of the topics above that clearly identifies main priorities and expected results:

SESSION I - Integrated approach for the development of desertification B&I (by E. Abraham)

Problem statement: Desertification is a complex environmental problem. There is a strong need to focus its analysis through methodological tools that may enable to comprehend this complexity.

The Integrated Assessment (I.A.) is a structured process to address complex issues using the knowledge of several scientific disciplines and incorporating local, regional and/or national social actors. The level of social participation depends on the problem assessed, its extent and its interactions with the ecosystem; it also depends on the level of spatial scale at which the problem occurs (local, regional and/or global). The integrated assessment requires the participation of those social actors likely to have an influence on the decisions made by different governments, agencies at various administration levels, and diverse groups of interest.

Although this problem has been acknowledged by some countries, as studies made in the framework of the AID CCD project show, it is notorious that this discussion is far from being held in all of them.. Even today, many countries focus on the same thematic studies that have proven inefficient. Experts and institutions are still very fragmented in their analysis, views, themes; hence they are not able to obtain a systematic, integrated view of the problem that should take into consideration the real needs of the users. In particular, discussion should focus on:

- Consensus on terminology and the reach of the B&I concepts
- Examples of application in the NAP's, SRAP's and RAP's.
- Examples of unified methodologies.
- Indicators based on a logical framework of integration of desertification processes that address the problems in an integrated approach.
- Development of integrated models, based on this logical and systematic framework,
- establishment of relationship between the driving forces, the socioeconomic and the biophysical B&I, analyzing the influence of these mutual relationships.
- The participatory approach and its relation with the integrated approach.
- Design and establishment of systems for desertification assessment and monitoring.
- Successful experiences in sensitization and in the use of B & I by different users like NGO's or community-based organizations.

Purpose: The traditional approach of research on desertification processes addresses biophysical dimensions, lacking of social, economic and cultural perspectives, and thus

providing poor theoretical and methodological contributions that could help to develop an understanding of the multiple variables at work in the production of the same phenomenon.

It is to be expected that the explanatory role of this set of variables may contribute to clarify the multiple relations between the natural and the cultural realms, thus allowing to add up to the knowledge of the causes and consequences of desertification. This would bring new elements to propose alternatives towards sustainable development, better fitted to reality and to the capacity of communities and decision makers.

Considering the above reasons, the need to conduct such discussion at international level is obvious. The transfer of the outcome of this discussion to sub-regional, national and local levels would be mandatory through its incorporation to the NAPs, SRAPs and RAPs.

Anticipated results: Progress in the above mentioned guidelines for discussion, and in particular:

- Improved knowledge of the state of these discussions in the different countries.
- Improved knowledge of the methodologies applied.
- Increased exchange and spreading of the successful experiences.
- Increased sensitization about the need to use an integrated desertification assessment approach and methodology as a working basis.

SESSION II - Integrated approach for the use of desertification B&I (by Y. Brahimi)

Problem statement: Although a great deal of work has been done on indicators in the past, Monitoring & Evaluation of drought and desertification still constitute one of the key issues of the Convention to Combat Desertification (CCD). Drawing lessons from the past experiences all the Countries Parties to the Convention agreed on the necessity to achieve an operational monitoring and evaluation system. In this context different CST/CCD studies proposed guidelines for building up an operational national M&E system which should include, inter alia, a permanent network of representative sites based on agroecological homogeneity, an environmental/desertification information system based on agreed management procedures for database, partnership and scientific cooperation framework, and, last but not least, coordination mechanisms bringing together information users and producers.

As a product of the M&E system, the use of benchmarks and indicators for assessing the implementation and impact of the CCD might help the actors at the different levels to assess their own progress, review their priorities and improve their positions with respect to combating desertification, mitigating the effects of drought and improving the lives of people in affected areas.

Setting up a national M&E system is however a very complex and difficult task. It requires important human, scientific, technical and financial resources, as well as an adapted institutional framework. Although M&E in the countries concerned is lagging well behind the many other undertakings, number of affected countries have undertaken this work by themselves or in cooperation with developed scientific specialised institutions. They did it through specific ways that is interesting to know and analyze since they faced the main same problems or issues, like:

- How is M&E mainstreamed in the NAP process, as a needed tool for decision making at all levels?
- How can the M&E system meet the needs of the various decision makers in terms of indicators?
- How can the M&E system make it possible to combine biophysical and socio-economic indicators?

- What are the synergies with other environmental conventions and with other national initiatives & planning?
- How can the M&E system give a global view of both NAP implementation impact and desertification assessment?
- How does the implementation of the desertification M&E system contribute to strengthening dialogue between the different key stakeholders, especially between scientists and decision makers at all levels?
- How is traditional knowledge taken into account when designing indicators?

Purpose: The main purpose is to have a global state of the art about M & E systems 10 years after the adoption of the Convention.

To reach this goal, experiences have to be exchanged between scientists and decision makers from both developed and affected countries on the different approaches for setting up a M&E system in the context of the CCD, and for providing final users with useful and adequate indicators.

Anticipated results: The anticipated results are:

- a better knowledge of the different experiences and main challenges that the developing countries are facing in the implementation of the M&E system,
- potential opportunities for developing cooperation at the international and regional level, south-south cooperation in particular.

SESSION III A – Data gathering for the development of the reference B&I for monitoring and assessing desertification – traditional approach (by E. Wafa)

Problem statement: The collection and the diffusion of environmental data are of capital importance for the advance of knowledge on our environment. To be able to reach these data quickly is the indispensable condition of the development of effective policies for fighting against desertification in particular and environmental protection, in general. In addition, the rational exploitation of these data requires the existence of a precise documentation on adopted methodologies for data collection. The harmonization of methodologies of data collection is also a significant condition for the realization of diachronic and synchronic studies.

The development of indicators and landmarks making it possible to evaluate the impacts of fighting against desertification very often comes up against the availability and/or the disparity of data and of useful information. The majority of the studies prepared on this subject underline the crucial requirements on this matter.

On the basis of the identification of the indicators aiming to support the decision-making, it is essential to identify the data necessary for their development, to define the methodologies of data collection, treatment and filing. Several technical difficulties are related to the data-gathering enabling the identification of these indicators: scale of the data, precision, validity. In the same way, one often notes that the data of various sources are not always comparable. The coherence and the comparability of not harmonized data can raise problems.

Harmonization of the definitions and nomenclatures, training, and development of data and metadata bases are as many tools which would make it possible to make fruitful the investments granted for the data-gathering and to make an optimized use of it.

The update of the data is also relevant. The category to which the data belong determines the frequency of their collection. Lastly, it is significant to understand the used methodology for data-gathering and to define later the description through duly documenting the data (in the form of metadata base).

Purpose: The scientists working on this subject in the various parts of the world, although in different contexts, are confronted with the same types of problems. This is

why it is extremely important to be able to take note of the international experiences as regards data acquisition useful for the development of indicators of fighting against desertification, and to learn the useful lessons from them. The stress will be laid on the difficulties that the institutions in charge of the data-gathering meet to satisfy the needs of the decision makers at various levels, and the difficulties encountered by the users to have access to the relevant data.

With a little precaution at the stage of planning and owing to a greater synergy between the various scientific and non-scientific institutions engaged in the fight against desertification, the data can be exact, relevant and useful for all kinds of users.

Anticipated results: The seminar aims at the following results:

- a state of knowledge in the field shared by all,
- a better knowledge of the main successful experiences (successful stories) and main challenges with which are confronted the developing countries in the control of the data necessary to the production of monitoring indicators of fighting against desertification,
- potential identified axes of co-operation.

SESSION III B - Data gathering for the development of the reference B&I for monitoring and assessing desertification – Remote Sensing (by S. Siheng)

Problem statement: Remote sensing has been a very useful tool for monitoring and assessing the present and dynamic situations of desertification and drought at local, regional and global scales for decades. Many countries and institutions have achieved very good results in this area. Some of the results have helped the elaboration of relevant NAP's, and RAP's. But up to now many other countries and institutions still have not really or widely use remote sensing as a technological tool for the above mentioned purpose. Data collection and processing methodologies and tools are often very different from one project to another. Data from the various stakeholders are often difficult to combine and possibilities for information and data exchange are weak, both at the national and the regional level.

This is why the global or regional figures of desertification used by UNCCD or other international as well as regional organizations are rough estimations and could not be broken down to a lower scale, such as each specific country, etc.

Desertification data, world maps do exist, but they are too general since the mapping scale are too small. In most situations, countries have a poor regular information collection. Existing data and maps in most situations are not compatible with each other. This is not an ideal situation and does not favour making and adjusting NAP's and RAP's. That is why it is necessary to exchange experiences on the topic of Remote Sensing to monitor and assess desertification at the global level by experienced experts from all Annexes.

Purpose: The overall purpose is:

- To discuss the topic aspects mentioned above and achieve an agreement to set up recommendations to UNCCD,
- To share experiences on and results of the Remote Sensing technology in monitoring and assessing different aspects of desertification, especially those that have been proven operational use and adopted by national focal points.

The key aspects that need to be discussed and/or deepened are:

- Do we need to set up an unified and consistent indicator set which should be endorsed by UNCCD, other related UN organizations, regional organizations, focal point of countries? If so how can we do?

- Which kind of indicators (such as indicators of driving factors, state, pressure, impact, response; Geo-physics and socio-economic factors etc.) and which specific indicators could be detected by Remote Sensing technology and which specific earth observation satellite data have been used for the purpose? Which indicators are the most relevant? How can they be collected in an operational way? How can they be used in operational systems? How can results be taken into account by decision makers?
- Which specific and limited sets of indicators with each specified mapping scales could be selected by using Remote Sensing technology (alone or in conjunction with *in situ* data)?
- Technical methodology assisted by Remote Sensing technology for monitoring and assessing climate change (for instance UNCCD using CMI-Climate Moisture Index as indicator for assessing local as well as regional, global climatic situation and change especially climatic drought in desertification affected areas) should allow deriving such information as soil moisture, land use and land cover, wind and water erosion etc.;
- The best innovative methodology and operational systems using Remote Sensing technology for monitoring and assessing different aspects of desertification which have been used for NAP's, RAP's implementation and decision making should be made available and worldwide used in a coherent way.

Anticipated results: Participants to the seminar should recognize and make their national focal points and other relevant experts aware that:

- The modern Remote Sensing technology is a very good tool and have great potential capacity for serving and contributing to the local and global fight against desertification. It will thus be a priority for them to make the better use of it for monitoring-evaluation in their national action programmes;
- It is necessary to focus on drawing and setting up a consensus on a limited set of operational indicator for monitoring and assessing desertification that could be derived from Remote Sensing technology and could be applied in different specific mapping scales. Proper efforts have to be led in order to have them widely endorsed by UNCCD. This implies an effort in standardizing information content and exchange procedures (interoperability);
- It is necessary to promote the application of Remote Sensing technology in monitoring and assessing desertification at local, regional and global levels.

SESSION IV – Climate Change impact on desertification: what B&I should be used? ***(by G. Begni)***

Problem statement: One of the main features of climate change are changes in average temperatures and rainfall and occurrence of extreme events. Even if no anthropic interference occurs, the response of ecosystems to climate change is complex, highly non-linear, presents bifurcation points and memory effects. Both slow trends and extreme events may lead to severe changes, which may be irreversible, among which desertification. The case of the evolution of Sahara during the past millenniums is a good example. In addition, due to dramatic increase in human population and activity, interferences between anthropic and climatic impacts become more and more severe and may be quite difficult to separate in spite of their theoretically different temporal and spatial scales. It might happen for instance that key anthropic interferences occur when the ecosystem is in an unstable state or bifurcation point, or that complex couplings between extreme events and anthropic pressure occur on similar time scales.

In addition, there may be feedbacks of desertification on climate change (changes in albedo and hence energy balance, in water cycle, etc.)

Climate changes have a global signature, but also exhibit strong regional and sub-regional heterogeneities. Downscaling from the global scales to the regional and sub-regional scales is an active domain of research. Addressing these scales is mandatory when addressing desertification issues.

Policy makers are more and more aware of possible adverse impacts of climate change and the urgent need to define mitigation measures. On the other hand, policy makers are also aware of the need to combat desertification, which can be one of these negative impacts. How do these approaches could be linked?

- how do climate changes affect arid and semi-arid ecosystems?
- how do anthropic activity impacts couple with climate change to affect such ecosystems?
- what are the main features and results of IPCC endorsed scenarios (including accuracy)?
- what is the state-of-art and results in downscaling climate change scenarios to the proper time and spatial scales in arid and semi-arid regions?
- What is the leading scheme to address desertification as an impact of global change (this should be anthropic activity dependent)?
- The following points should be addressed in order to focus on B & I:
- what are the main indicators used to characterize global change and its impacts?
- How could these indicators be coupled to other ones in order to improve the relevance and accuracy of the discussed desertification indicators?
- Is it possible to set up a coherent set of indicators for policy makers who have to address simultaneously climate change, lost of biodiversity and desertification impact in arid and semi-arid regions?

Purpose: The purpose of the session is to bring answers to the above questions. It should be kept in mind that these issues are highly complex from a scientific point of view, and sometimes unpredictable (interaction between ecosystems, anthropic pressure and critical aspects of climate change). Scenarios have to be used as guidelines, but nevertheless the issue remains highly complex. The leading idea is to leave scientific issues behind the scene and put forward which indicators and associated benchmarks can be produced and be relevant to address these issues from various decision makers points of view. Also, any practical relevant caveat about the practical use of these indicators should be put forward.

Anticipated results:

- Behind the scene: have a clear idea of the scientific background of the recommended indicators and benchmarks. Nevertheless, this could include side recommendations about implementation of ad hoc research programmes, operational measurement networks and data handling facilities.
- On the forefront: answers to the practical questions listed above and definition of a relevant set of indicators of desertification that could take into account climate change within a decision makers perspective.

SESSION V – Reinforcing North-South, South-South cooperation on desertification B&I (by F. Tapsoba)

Problem statement: The activities undertaken at the international level to follow up the various decisions of the Conference of Parties to the CCD obviously show that there is a wide range of tools and methods to monitor and assess land degradation processes in arid, semi-arid and dry sub-humid areas. All these tools are designed to supply

managers of natural resources at regional, national and local scales with a much better access to scientific knowledge, so that they can make decisions with full understanding of the facts. However, for several reasons, no consensus has been achieved up to now within the scope of the CCD on the tools to be used.

Among the factors that hinder a consensus on these issues, the following have to be taken into proper account:

- The fact that most NAP processes do not take enough into account the existing situations. It seems that the involved actors do not all agree on the fact that the CCD, far from being the starting point of the combat against desertification, is rather the beginning of a better organisation of the efforts previously undertaken and of the intensification of such attempts. In some cases, initiatives are launched to develop new tools and products, instead of using the tools and methods that have proved their worth in former decision-making processes.
- The large number of monitoring and information systems, as well as their costs of development and/or acquisition. At the international and national levels (mainly in the affected developing countries), such constraints clearly handicap the harmonisation of methodologies to collect and process information.
- The technical and institutional difficulties to produce results that can be used by decision-makers. In developed countries, institutes specialised in providing indicators generally use networks of statistics databases or other databases that are already operational. These institutes are seldom requested to generate – or to finance the generation of – all the data necessary to produce the indicators of interest. If we consider for instance indicators of sustainable development, we realise that in developed countries, such indicators are already generated in various forms by specialised organisations. This does not apply to developing countries, where, in order to obtain a given indicator, it is usually necessary to carry out all the steps required to produce it.
- The insufficient knowledge (mainly in the South) of existing monitoring and assessment tools and products.
- The insufficient organisation (in the South again) of data information.

Purpose: The workshop aims at setting up an international operative system of scientific, technologic, technical and politic cooperation to improve the performance of systems put in place by affected countries. Specially, it aims at :

- enhancing the exchange of experience between different countries, especially between countries subject to desertification;
- publicising the original solutions implemented by some countries in order to solve various shared problems regarding the production and use of indicators for the monitoring and assessment of action programmes and desertification;
- identifying the prospects of transferring successful experiments to other affected countries, within the scope of South-South or North-South co-operation;
- determining the possibilities of carrying out co-operative capacity building programmes for Southern countries to manage the various aspects of monitoring and assessment within the framework of the CCD.

Anticipated results:

- Identification of the specific needs by annex or by sub-region regarding capacity building (strengthening of skills and expertise of individuals and institutions);
- Identification of capacity building offers / opportunities (access to tools, techniques and scientific models; access to the data and indicators in use);

- designing and circulating new methods so as to link local skills and assessments on the one hand with national, regional and global skills and assessments on the other hand.

SESSION VI – Case studies of B&I operational monitoring initiatives at various scales (by P. Klintonberg)

Problem statement: According to the findings of the studies carried out in preparation for this seminar it was revealed that many countries have developed indicators and have the intention to monitor either the extent of desertification or the process of UNCCD implementation. However, there are not many examples of operation implementation; Usually desertification monitoring in different scale has been designed by user's different requirement, using different indicator system and receiving different results.

The desertification monitoring indicator system in larger scale may be more general; the monitoring results will be not break down to small areas and mainly serve to NAP, Regional Action Plan or at most provincial as well as state Action Plan; Methodology in this scale will involve more remote sensing technology and use the image with a range from 30m to 1000m resolution;

The desertification monitoring indicator system in middle scale maybe has more specific indicators and index; the monitoring results will be broken down to relatively small areas and mainly serve to District or county level for specific project planning an design of combating desertification; this scale will involve both remote sensing and field survey technologies and use the image with 10m-30m resolution;

The desertification monitoring indicator system in small scale will has many detailed specific indicators and index; the monitoring results will be used to reveal and analyze the desertification process and evaluate the efficiency of desertification combating efforts in small areas such as township area or typical desertification field for pilot research or new technique demonstrating application; this scale will involve mainly field survey and measuring technologies and if employ remote sensing technique the image will has high resolution of about meters.

Purpose: To present and discuss the processes and results from the various monitoring initiatives presented as case studies and other initiatives experienced among participants.

This session would focus on presenting case studies from initiatives that actually have taken the step from the drawing board to actual implementation. The session would try to answer the question: What are the lessons learnt from presented case studies, that contributes towards successful implementation of indicator based monitoring of desertification and/or the process of UNCCD implementation?

Anticipated results: Clearer identification of obstacles and successful solutions that can be applied to facilitate other monitoring initiatives elsewhere.

Participants will learn operational experiences of monitoring desertification in different scale from each other to improve their practical works and have an outreach policy about it.

5. Conclusions

AIDCCD constitutes the first attempt to deal with the desertification indicators and the mitigation actions systematically and at a global level.

The exchange of experience among the Annexes and between scientific community and stakeholders contributes to implement the UNCCD and to provide stakeholders with the necessary tools and information to implement the UNCCD at the different levels.

The AIDCCD seminar on *Local and Regional Desertification Indicators in a Global Perspective* constitutes therefore a relevant opportunity to exchange information and experiences matured in the activities carried out to implement the Convention.

A general consensus on indicators and methodological approaches is not an immediate and realistic objective, but it should be taken into account as a general aim in future perspective. This seminar wishes to provide a support in this direction not only through the relevant papers that have been presented but also through the results achieved during the discussions that provided interesting results, as reported in the seminar conclusions.

SESSION I

Integrated approach for the Development of Desertification B&I

INTEGRATED APPROACH FOR THE DEVELOPMENT OF DESERTIFICATION B& I: ADDRESSING THE SESSION TOPIC IN THE AID-CCD PERSPECTIVE

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Abstract

The treatment of complex systems and an integrated evaluation are considered as a new approach to the study of desertification. A procedure for obtaining desertification indicators and benchmarks is presented, based on these concepts and on participative planning, to accomplish a system of desertification assessment and monitoring orientated towards problem solving and towards an action plan directed to final users and decision makers.

Key words: Desertification, complex systems, integrated assessment procedure, B & I

1. Desertification: a complex problem

Desertification is a complex issue, systemic by nature, affecting the structure and operation of ecosystems in drylands. It takes in the multiple relations among those processes involving biophysical, socio-economical, political and institutional factors, always taking into account the spatial and temporal scales of this phenomenon. The combat against desertification concentrates on the consequences these processes produce on mitigating life conditions in affected areas, on their production losses and limitations and above all, on the reciprocal relations they keep with poverty, marginality, exclusion and the need to carry out alternatives of sustainable development in arid zones.

2. Traditional versus integrated approach

Traditionally, research on desertification processes has been approached from a sectorial vision, especially the biophysical dimensions, with deficiencies in the social, economic and cultural perspectives, providing weak theoretical and methodological contributions that help enhance comprehension of social variables. The explanatory role of this complex of variables may contribute to clarify the multiple relations within the natural and the cultural range, while adding up to the knowledge of the causes and consequences of desertification, thus contributing with new elements to the proposal of alternatives of sustainable development better fitted to reality and to the capacity of communities and decision makers. In practice this means dealing with desertification issues from the environmental point of view going beyond sectorial assessment.

Comprehending the environmental problematic of desertification requires a theoretical-methodological treatment in transdisciplinary terms that would contain the uncertainty levels typical of complex systems, surpassing simple approaches of reality referred to classificatory structures of thematic variables (land, water, vegetation, demography, etc). Hence, learning what is aleatory and building up the Integrated Assessment System is feasible.

3. Complex systems

A new focus on the ecosystemic approach was consolidated by the International Council for Researchers in the Great Lakes (Allen et al, 1991). This is a conceptual and

managerial issue integrating the two theories of the complex systems: the chaos theory and the hierarchy theory. The hierarchic nature of these systems requires a presentation of studies from different perspectives and spatial scales. The ecosystemic structure shows holistic – transcending any sectorial perspective – being its focal point the relations among the ecosystem attributes for man. The ecosystemic approach considers environmental issues within their geographical, historical, biological, cultural, political, social, economical and anthropological complex range. It is an interdisciplinary and intersectorial view essential for assessing degradation of ecosystems, thus the prompt to search for solutions to guarantee sustainability.

As stated by Ciurana (2001) and Castoradis (1997): *“Every complex phenomenon is made up of linearly and non-linearly interrelated elements that occur in only one or in different spatial and temporal planes”*. In terms of social relations, this phenomenon and its complexity are defined as *“a quality of relations between the system and its observer”* (Rosen, 1985). This theoretical-methodological treatment generates an integrated assessment system of desertification based on indicators and the support of participative strategic planning, valid for decision makers under circumstances where reality is in permanent growth.

4. Integrated Assessment

Integrated Assessment (IA) is a process meant to treat complex issues through various scientific disciplines while incorporating local, regional and / or national social actors. Participation levels depend on the issue assessed its range and interaction with the ecosystem, as well as the spatial scale where the issue develops (local, regional and/or global). The aim is to enhance the vision of society towards environmental interactions and contribute to catalyze socio-environmental changes, thus aiding the communication channels between science and politics. Committing decision makers to consider the results in compliance with those affected by the decisions made is the ultimate solution. This methodology is to be conducted throughout a transparent process open to those engaged in it.

IA must provide the scientific technical support necessary for formulating political decisions, including social, technical and political management. This information has to be properly adapted so as to reach the comprehension levels of decision makers and of social actors involved in the process. To this extent, IA is known as the intersection between a vertical integration of actors and interests and a horizontal integration of disciplines and sources of knowledge to confront the multiple dimensions of the problem at engaging natural and social sciences to dispose of integrated scenarios viable of considering simultaneously economical, social, ecological and political issues (Freitas, 2002). The intersection of vertical and horizontal integration is part of an interactive information process in need of permanent feedback as the socio-environmental scenario takes shape. This should not be understood as a series of linear processes that reach a final decision process separately. To add up, socio-environmental impacts derived from alterations in one part of the system could originate multiple direct and /or indirect effects in other parts of the system.

5. International experience on IA

Organization for Economic Cooperation and Development (OECD), UN (United Nations), DIB (Development Interamerican Bank), WB (The World Bank) and EPA (Environmental Protection Agency) among others, have developed integrated methodologies in the last decades, in search of an integration between the economic and the environmental problematic sectors. OECD was the first to present a proposal

concerning the environment in 1979, which was complemented in 1989 with a program on indicators (OECD, 1991). Since then on, OECD is devoted to the enhancement of sectorial indicators based on their political relevance, analytical depth and measurability. In the 90's a project named "Report on the state of the Environment" was developed in holistic and integrated terms, with the support of *Environment Canada*; RIVM – The National Institute for Public Health and the Environment, and UNEP – The United Nations Program for the Environment (UNEP) (UNEP/DEIA, 1996). Studies were carried out on environmental indicators in the 90's, with Countries Parties of OECD. The priorities were:

- To use the Pressure – State – Response (PSR) model in accordance to significant environmental issues occurring in OECD countries.
- To identify and define various indicators under different criteria: political pertinence, assessment accuracy and measurability.
- To confer benchmarks to these indicators.
- To publish these indicators for a certain group of countries.

The PSR model sets up what contaminating emissions or land changes exercise *pressure* on the environment. At this rate, the *state* of the environment could be affected by variations in the levels of environmental contamination, habitat diversity, water flows, etc. In view of the foregoing, society will get an *answer* in respect to these alterations in the shape of economical environmental policies and programs to prevent, reduce or at least alleviate environmental pressures (damage) (OECD, 1998). New developments have arisen since the introduction of this model –regarding driving forces. Likewise have the impact of the project and the scale to measure the state variation as a consequence of feedback answers. These models have been adopted by UNCCD through various contributions, highlighting those advances between OSS (Sahara and Sahel Observatory) and GTZ (German Technical Cooperation) for monitoring and assessing NAPS (National Action Programs) with the development of a "Monitoring and Evaluation for Action Programmes to Combat Desertification Training Manual" (2002). The M&E system counts with three components: state and desertification dynamics, NAPS implementation quality and NAPS impact. This training program is being implemented in Africa and in LAC.

6. Indicators usage

Agenda 21 highly stimulated indicators usage, specifically in chapter 40, at highlighting the importance of creating and using sustainable development indicators. The latter are a mere tool of assessment among others and should be translated into scientific and political terms. They are to be complemented with scientific and qualitative information as well as integrated under an M&E system.

7. An instance of a Procedure towards an Integrated Assessment of Desertification

Supported by a field work carried out with communities living in the drylands of Argentina, a methodological procedure was developed to articulate different desertification processes, multiple interrelated factors and a great number of scales to be approached (Abraham, Montaña, Torres, 2003). Simultaneously, this procedure leads to defining problems and objectives within the desertification combat frame and identifying indicators for proceeding to measuring and monitoring.

The procedure is based on participative planning, approach and integrated assessment to incorporate actors, mainly local communities and decision makers in desertification affected lands. It may be directed to local, regional and / or national levels, being highly effective in the latter for gaining indicators, giving priority to problems and objectives,

identifying action and impact hypotheses and defining actions in an assessment and monitoring system. It is made up of five stages or working phases within the frame of which concrete desertification combat actions are defined.

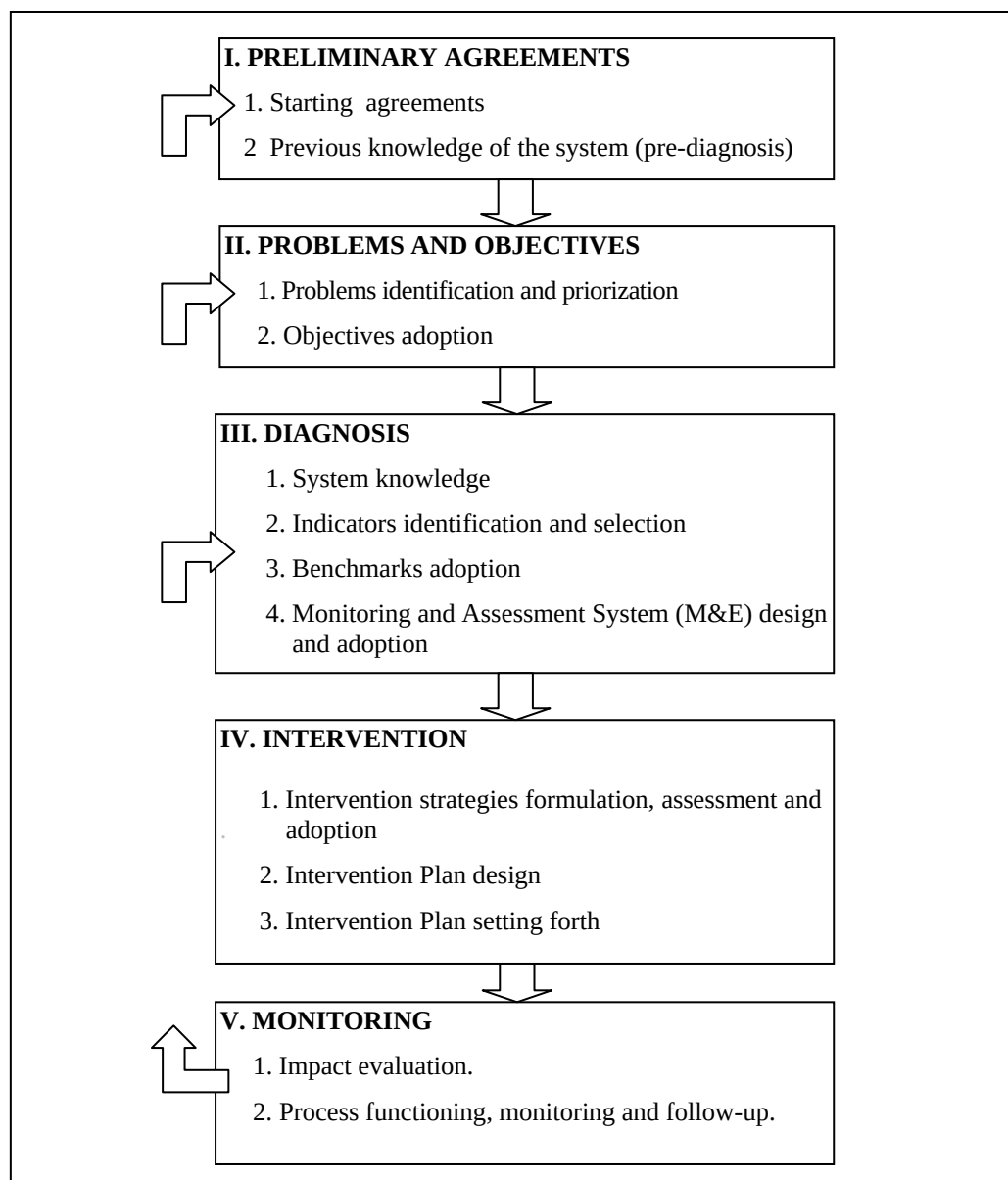


Figure 1: Five Stages Procedure to develop an Desertification Integrated Monitoring and Evaluation System

This general statement is outlined as follows:

Stage I. Preliminary agreements comprising two components:

1. *Starting agreement*, with the identification of general problems, needs, demands; preliminary idea of ambits to be covered (geographical, institutional, problems); preliminary identification of actors and roles in the different stages and levels of participation of the process; basic consensus on expectations, needs and feasible strategies; general outlines on the handling of the project information and the adoption of general communicative and spreading strategies.

2. *Preliminary knowledge of the system, with pre-diagnosis*: general knowledge of the system and of the desertification processes affecting it; selection of the intervention area; agreement on spatial and temporal assessment scales to be adopted.

Stage II. Problems and objectives, comprising three components:

1. *Problems identification and hierarchies* (taking in: Problems identification, hierarchies and priorities)
2. *Objectives adoption* (identification and selection of objectives to be adopted)
3. *Identification of impact and action hypotheses*

Stage III. Diagnosis, comprising four components:

1. *Knowledge of the desertification system and processes that affect it* (processes and driving forces; knowledge of the present state (identification of ERUs (Environmental Reference Units); causes and effects of desertification (knowledge of the base line state from which changes initiate (environmental history); assessment of desertification fragility, pressure and state by of environmental units of reference; potentialities and restrictions.
2. *Indicators identification and selection* (identification of feasible indicators; presentation and discussion of assessment criteria and selection of indicators and their evaluation; selection of indicators to be used by each problem and by each environmental unit of reference; building up of data models: monitoring and assessment; identification/implementation of pilot sites, study cases or measuring stations in representative sites; agreements on information handling: collection, processing and data gathering procedures.
3. *Adoption of benchmarks* (background on accepted benchmarks; discussion on benchmarks to be adopted; baselines setting up; adoption of recommended benchmarks).
4. *Design and adoption of the Monitoring and Evaluation System (MES)*: actors summoning; definition of activities, tasks, roles and levels of participation; sensitization and partnership building; drawing of the Monitoring and Assessment Plan; formal agreements and commitments; adoption of the System: assessment.

Stage IV. Intervention, comprising three components:

1. *Formulation, assessment and adoption of strategies of intervention* (formulating specific alternatives of intervention, impact hypothesis assessment, selection of strategies of intervention).
2. *Design of the Intervention Plan*, on the basis of MES (new actors summoning, definition of activities, tasks, roles and levels of participation; sensitization and new partnership building; drawing of the Intervention Plan; formal agreements and commitments).
3. *Implementation of the Intervention Plan* (Intervention Plan set off).

Stage V. Monitoring, comprising two components:

1. *Impacts assessment* (impact indicators adjustment, impact indicators assessment by means of the Monitoring and Evaluation System; transfer and spreading of the results of desertification combat project).
2. *Functioning, monitoring and assessment process* (fulfillment of activities and functions previewed in the Intervention Plan and in MES; detection of problems at various levels and adjustments; permanent updating of objectives, hypothesis; re-summoning and roles of actors; re-programming).

From the very beginning (Abraham and Prieto, 1988, 1991; Kharin and Abraham, 1992; Abraham, 1989, 1995, 2003; Abraham, Montaña and Torres, 2003; Torres, Montaña, Abraham, Torres and Pastor, 2003; Abraham, Tomasini and Macaggno, 2003; Abraham and Macaggno, 2005), this procedure has been experienced and validated in the drylands of the Argentine west, thus consolidating its phases. It is worth mentioning the adoption of this working method on the side of national and international projects. One of them being “Combat against desertification and mitigation of drought effects in South America”, financed by DIB (Development Interamerican Bank) and executed by IICA (2002-2006), has adopted this procedure for study cases held in six South American countries: Argentina, Chile, Equator, Peru, Bolivia and Brazil, its application being countersigned by the Natal Compromise (November 2004). Argentina Pilot Country LADA (Land Degradation Assessment in Drylands) Project, also has adopted this Procedure in the four pilot sites under study at national / local level. The implementation process of one Service and Production Experimental Unit has been started with the support of GTZ, within the frame of NAP Argentina. It comprises small caprine producers around a project of productive diversification and assessment of desertification processes in Lavalle desert, Mendoza, Argentina.

These experiences are learnt lessons, thus contributing to reduce the gap between the generation of scientific knowledge and its application in the real world. Hence, indicators are quite useful but when used as a means and mainly in integrated assessment systems. Benchmarks and Indicators are not developed in this Procedure as technocratic processes but aim at socially sustainable processes.

8. Why has this issue been incorporated to the AID CCD Project?

Although this problem has been recognized by some countries, as appears from the studies made in the framework of the AID CCD project, it is notorious that in not all of them is this discussion held. Many countries are, even today, focused on the same thematic studies that have proven inefficient. Experts and institutions are still very fragmented in their analysis, views and themes; hence they are not able to obtain a systematic, integrated view of the problem that should take into consideration the real needs of the users.

What do we expect with your participation in this Seminar: to focus discussions and contributions for obtaining:

- Consensus on terminology and the reach of the B+I concepts
- Examples of application in the NAPS, SRAPS and RAPS.
- Examples of unified methodologies.
- Indicators based on a logical framework of integration of desertification processes that face the problems in an integrated approach.
- Development of integrated models, based on this logical and systematic framework, establishment of a relation between the driving forces, the socioeconomic, and the biophysical B+I, analyzing the influence of those reciprocal relations.
- The participatory approach and its relation with the integrated approach.
- Design and establishment of Systems for Desertification Monitoring and Evaluation. Successful experiences.
- Successful experiences in sensitization and the use of B & I by different users like NGOs or community-based organizations.

On account of the above reasons, the need to conduct such discussions at international levels is evident. The purpose of this introduction is therefore, to act as a trigger to

conduct this high level discussion and identify the mechanisms to transfer the outcome of these proposals to regional, national and local levels, paving the way to its incorporation to PANs, SRAPs and RAPs.

It is to be expected that the explanatory role of this complex of variables may contribute to clarify the multiple relations between the natural and the cultural range, thus allowing to add up to the knowledge of the causes and consequences of desertification, and bringing new elements to the proposal of alternatives of sustainable development, better fitted to reality and to the capacity of communities and decision makers.

How can we make it?

Focusing our work on the progress in the above mentioned lines of discussion, and in particular

- Improved knowledge about the state of these discussions in the different countries.
- Improved knowledge about the methodologies applied.
- Increased exchange and spreading of the successful experiences.
- Increased sensitization about the need to work upon the basis of the approach and methodology of an integrated assessment of desertification.

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DESERTIFICATION MONITORING AND EVALUATION INDICATORS APPLIED IN CHINA

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Abstract

China is one of the countries seriously affected by desertification in the world. Desertification is widely distributed in arid, semi-arid and dry sub-humid areas of the Northwest China, northern part of the North China and the Western part of the Northeast China. China had carried out two times of desertification monitoring in 1994-1995 and 1999-2000 respectively. The Law on Combating Desertification was passed in 2001, and came into effect on Jan. 1, 2002. The third time of desertification monitoring have been carried out from 2004 to 2005 in light of the request of the law. This paper introduces the three times of desertification monitoring in China in detail, including monitoring system, methods and main results. The first and second time of desertification monitoring result revealed desertification land area expansion durative. In accordance with the second time of desertification monitoring result, desertification land area was 2,674,000 square kilometers, accounting for 28 percent of the total territorial area of China. Sandy desertification land expansion speed is 3,436 square kilometers per year, but it was 2,100 square kilometers per year in 1980's and 1,560 square kilometers per year in 1960's-1970's. Because of the difference of relief, topography and climate, the main types of desertification in China include desertification caused by wind erosion, desertification caused by water erosion, desertification caused by salinization and alkalization, desertification caused by frozen and melting. Genesis and distribution of four types of desertification are explained firstly in this article, then it introduces the monitoring evaluation indicators of this four types of desertification. Because desertification land can be divided into desertified farmland, desertified grassland, desertified woodland and desertified non-reclaimed land in view of land-use types in China, the main monitoring methods is ground measurement and the remote sensing technology, evaluation indicators of four types of desertification are expounded from the point of view of the monitoring method and desertification land use type respectively. Over 20 orientation stations have been established in north China to monitor the cause, development and evolvement of desertification land and to provide information for decision-making. At the end of the article, orientation desertification evaluation indicators, including desertified land indicators, combating desertification benefit, sand and dust storm, weather data, statistics data, are explained too.

Key word: Desertification, monitoring, indicator, China

China is one of the countries seriously affected by desertification in the world. With the daily-increasing pressure of population, the situation of land degradation/desertification is accelerating and becoming worse from bad, and this negative fact brings serious threats and damages to the regional/local environment and social-economical development and to local people's life and existence. Now desertification has become the obstacle of China's development, especially when China turn its economic development strategic focus into middle-west parts.

1. Desertification monitoring in China

1.1 The first time of desertification and sandification survey in China

The first time of desertification and sandification survey in China had been completed from 1994 to 1995. The desertification and sandification survey had been completed with involvement 841 counties of 29 provinces, autonomous regions and municipal cities to the exclusion of Taiwan Province and Shanghai Municipal City. Totally 4,570,000 square kilometers, occupying 48% of the total territorial area of China have been surveyed and investigated. During the Survey, ground observation and field outlining were combined with interpretation of the newest TM images of 1:100,000 scale, and the total overlaid area is approximately 93% of the total surveyed area. China national desertification monitoring centre acquired the desertification data, including desertification caused by wind erosion, desertification caused by water erosion, desertification caused by salinization and alkalization, desertification cause by frozen and melting. CNDMC has completed the compilation of Desertification Map of China with a scale of 1:2.5 million. This survey is the first overall, systematic and objective survey and inventories of the affected area, distributions, patterns resources potential of desert, Gobi and desertization impacted land in China. The final result of the survey will be a baseline for desertification monitoring in the future.

1.2 The second time of desertification monitoring in China

The second time of desertification monitoring had been carried out from 1999 to 2000. In light of UNCCD, the total area of arid, semi-arid and dry sub-humid areas, the geographic scope where the occurrence of desertification is possible and humidity index ranges from 0.05 to 0.65, is approximately 3,317,000 square kilometers, occupying 34.6% of the total territorial area of China. In which, the arid area is 1,427,000 square kilometers, the semi-arid area is 1,139,000 square kilometers, and dry sub-humid area is 751,000 square kilometers respectively (Table 1).

Types	Arid area	Semi-arid area	Dry sub-humid area	Total
Area	1427	1139	751	3317
% in total of affected area	43.1	34.4	22.5	100
% in total of China territory	14.9	11.9	7.8	34.6

Table 1. The area of arid, semi-arid and dry sub-humid area of China unit: 10³km²

The arid, semi-arid and dry sub-humid areas in China are widely distributed in most part or some parts of 497 counties of Xinjiang Uygur Autonomous Region, Inner Mongolia Autonomous Region, Qinhai Province, Gansu Province, Hebei Province, Ningxia Hui Autonomous Region, Shanxi Province, Shanxi Province, Xizang Autonomous Region, Shandong Province, Liaoning Province, Jilin Province, Helongjiang Province,

Sichuan Province, Yunnan Province, Henan Province, Hainan Province, Beijing Municipal City.

Classification systems includes mainly the classification of land use, the classification of desertification patterns and their grading of severity. Classification of land use are divided into six patterns, namely farmland, grassland, woodland, resident settlement & industry/transport facilities and mining pots, water area and non-reclaimed lands. In order to indicate objectively the severity of desertification in China and to operate in a comparative easy way to implement the classification, the following four grading classes have been adopted, namely slight desertification, medium desertification, severe desertification and the most severe desertification.

The system of this time of desertification monitoring has three levels, namely national macro-level monitoring, critical region monitoring and orientation station monitoring.

National macro-level monitoring

The aim of national macro-level monitoring is to acquire different types of desertification data every province and provide information for making policy. The method is laying out of permanent sample plots to monitor desertification status and changing. Over 30,000 permanent sample plots were laid out in China for the second time of desertification monitoring. Different types of desertification area were estimated in accordance with the investigation data from every sample plot. At the same time, statistics data, weather data, hydrologic data have been collected to analyze the genesis and development of the desertification lands in China.

Critical region monitoring

Critical region means desertification land centralized and severely affects social and economic development. 214 counties had been ascertained the critical regions. The monitoring method is ground measurement combined with the remote sensing technology, according to the type of desertification land to plot. The area of desertification land and distribution was acquired, which will provide information for combating desertification engineering programming and designing.

Orientation station monitoring

The aim of orientation station monitoring is to observe and accumulate desertification data of genesis and combating effect for a long time, and to provide information for desertification combat. 20 orientation stations have been established for the second time of desertification and 30 orientation stations will be established in north China in the future.

Technical characteristic Based on the experience of the first time of desertification monitoring, the second time of desertification monitoring adopt some advanced technique as followed:

- The method of laying out of permanent sample plots was applied to the monitoring to save cost and time.
- The RS, GIS and GPS technology was applied to the monitoring to enhance efficiency and quality.
- A great deal of ground measurement was carried out to ensure the reliability of the monitoring result.

Main results

- Total area of desertification land is about 2,674,000 square kilometers, accounting for 28 percent of the total territorial area of China. Desertification land was distributed in Xinjiang Uygur Autonomous Region, Inner Mongolia Autonomous Region, Qinghai Province, Gansu Province and Xizang Autonomous Region. Sandy desertification land expansion speed was 3,436 square kilometers per year, but it was

2,100 square kilometers per year in 1980's and 1,560 square kilometers per year in 1960's-1970's.

- Desertification land monitoring information system has been established. It can manage information such as desertified land data, attribute data, statistics data to provide information for making policy.
- Genesis of the desertification lands in China included natural factors and human activities. The physical geographical conditions and climatic variation are a certain conditions to cause desertification, but the desertification process is slow. Human activities have accelerated and promoted the desertification processes as the leading factors to cause desertification.
- China national desertification monitoring center put forward some beneficial suggestions and advices to combat desertification in China.

1.3 The third time of desertification monitoring in China

The third time of desertification monitoring had been carried out from 2003 to 2004. The monitoring methods is ground measurement combined with the remote sensing technology. Based on the result of the second monitoring and this time monitoring, the dynamic change of desertification land will be obtained. The desertification result will publicize in the near future.

2. Desertification monitoring evaluation indicators

Because of the difference of relief, topography and climate, the main types of desertification in China include desertification caused by wind erosion, desertification caused by water erosion, desertification by caused salinization and alkalization, desertification caused by frozen and melting in light of classification of leading natural factors. Every type of desertification evaluation indicators are illuminated in detail as followed.

2.1 Desertification caused by wind erosion evaluation indicators

Desertification caused by wind erosion means land degradation resulting from wind erosion, which resulted from the movement and deposition of soil particles by wind. Desertification caused by wind erosion can be divided into desertified farmland, grassland, woodland and non-reclaimed land in view of land-use types. Different types of desertification caused by wind erosion have a set of different evaluation indicators.

Desertified farmland evaluation indicators

Crop product reduction rate, soil texture and effective soil thickness are the grading indicators to evaluate the severity of desertified farmland.

Desertified grassland, woodland and non-reclaimed land evaluation indicators

Ground measurement indicators include vegetation coverage, soil texture, covered sand thickness and relief. Vegetation coverage and relief are the indicators by means of the remote sensing technology.

2.2 Desertification caused by water erosion evaluation indicators

Desertification caused by water erosion means land degradation resulting from water erosion, which resulted from the movement and deposition of soil particles mainly by precipitation. Desertification caused by water erosion can be divided into desertified farmland, grassland, woodland and un-utilized land in view of land-use types too.

Desertified farmland evaluation indicators

Crop product reduction rate, gradient and engineering measures are the grading indicators to evaluate the severity of desertified farmland.

Desertified grassland, woodland and non-reclaimed land evaluation indicators

Ground measurement indicators include vegetation coverage, gradient and corrasive gully area proportion. Vegetation coverage, gradient and corrasive gully area proportion are the indicators by means of the remote sensing technology.

2.3 Desertification caused by salinization and alkalization evaluation indicators

Desertification caused by salinization and alkalization means land degradation resulting from salinization and alkalization, which resulted from soluble salt and alkali accumulated in soil. Desertification caused by salinization and alkalization can be divided into desertified farmland, grassland, woodland and un-utilized land in viewpoint of land-use types. Different types of desertification caused by salinization and alkalization have a set of different evaluation indicator.

Desertified farmland evaluation indicators

Ground measurement indicators include the content of salt in soil, salina percent and crop product reduction rate. Salina percent and crop growing status are the indicators by means of the remote sensing technology.

Desertified grassland, woodland and non-reclaimed land evaluation indicators

Ground measurement indicators include the content of salt in soil, salina percent and vegetation coverage. Salina percent and vegetation coverage are the indicators by means of the remote sensing technology.

2.4 Desertification caused by frozen and melting evaluation indicators

Desertification caused by frozen and melting means land degradation resulted from soil mechanical destroyed caused by temperature changing under zero degree or about zero degree. Desertification caused by frozen and melting is a special desertification land in China, distributed in Qinghai-Xizang Plateau. It is very difficult for us to field measure because the distribution of desertification caused by frozen and melting is main in the depopulated areas. The monitoring evaluation indicators are relief and vegetation coverage by means of remote sensing.

2.5 Orientation station monitoring evaluation indicators

The aim of orientation station monitoring

The weather data, soil, vegetation and statistics data, related with the formation, development and evolvement of desertification, have been collected to analyze the genesis and combating desertification benefit through a long period of observation and collection. The result of orientation station monitoring can provide basic information for combating desertification for all levels government and provide scientific foundation for the analysis of result and improvement of monitoring methods of national macro-level desertification monitoring. The contents of orientation monitoring include desertified land monitoring, combating desertification benefit monitoring, sand and dust storm monitoring, collection of weather data and statistics data simultaneously.

Desertified land monitoring

The method of orientation station monitoring is laying out of permanent sample plots to monitor desertified land. Monitoring evaluation indicators include soil, vegetation, wind erosion and deposition indicators. Soil indicators include soil type, humus thickness, soil texture, organic matter, soil water content, etc. Vegetation indicators include vegetation type, vegetation coverage, biomass, etc. Wind erosion and deposition indicators include soil erosion amount, soil deposition amount and dune moving rate.

Combating desertification benefit monitoring

The methods is laying out of permanent sample plots to monitor combating desertification benefit. Evaluation indicators include planting survival rate, preservation rate, vegetation coverage, biomass, soil water content, organic matter, dune moving rate, soil erosion quantity, etc.

Sand and dust storm monitoring

Sand and dust storm is a natural/man-made disaster and often occurred in north China, it will cause a great deal of loss of agriculture and forestry, and at the same time sand and dust storm affect transportation and human health. Weather data and economic loss evaluation indicator will be collected through field observation and investigation when sand and dust storm is happening.

Weather data and statistics data

Weather data and statistics data will be used for analysis of desertification formation, development and combating desertification. Usually, it is purchased from the concerned department.

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ASIAN REGIONAL DESERTIFICATION MAPPING OBJECTIVES AND METHODOLOGIES

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Abstract

The proposed Asian Regional Desertification Status Map will serve users at national, regional and international levels for understanding causes and progress of desertification and ecosystem vulnerability to desertification and land degradation. By applying remote sensing techniques to the Asian regional, the applied study of satellite image in desertification monitoring and assessment is conducted. The desertification status map of Asia now have been completed the first raw map, the indicator system and classification system is raised, and its working process is described.

Keywords: Desertification maps, Scale, Regional level, land degradation, Classification.

1. Objectives

The general objective is to put forth to TPN1 member countries a common set of benchmarks and indicators (B&I) system for desertification monitoring and assessment (DMA) in Asian region for comments and suggestions. The B&I system, once finalized based on the comments and suggestions from the member countries, could be used for DMA for the Asian region.

2. Benchmarks

According to the opinion from General Assembly of the Intergovernmental Negotiating Committee for the Elaboration of UNCCD, Tenth Session, New York, 6-17 January 1997: "Benchmarks are used to develop correlations between various parameters and to provide a baseline for monitoring at the local, national and regional levels."

Benchmarks are the baselines that serve as the starting point for evaluation and monitoring and thus provides a point of reference from which the land starts to degrade/improve. Benchmarks are standards against which decertified land can be compared in order to determine degradation trends. The benchmarks are also used to quantify the severity/degree of degradation. Different benchmarks are to be established for different agro climatic regions and different land uses.

Benchmarks can be determined by identifying non-degraded land ecosystems (representative sites) under the same agro climatic zone and natural conditions. The benchmarks can also be established based on existing researches, historical data and field investigation.

3. Indicator system

The proposed indicator system includes four aspects: pressure, state, desertification impact and implementation.

3.1 Pressure indicators

Characterize driving forces both natural and man-made, affecting the status of natural resources and leading to desertification. Pressure indicators are used to assess desertification trends and make an early warning for desertification. Natural indicators describe natural factors, mainly climatic conditions, natural disasters, which promote

the occurrence and development of desertification. Non-natural indicators describe the pressure on land/ecosystems leading to land degradation from human activities.

3.2 State indicators

Characterize the status of natural resources including land. The physical and biological features of desertified land ecosystem are the main factors to be considered. Physical indicators describe the land characteristics, physical and chemical properties of soil and hydrological features of the land ecosystem. Biological indicators are used to describe biological characteristics of the land ecosystem.

3.3 Impact indicators

Desertification impact indicators are used to evaluate the effects of desertification on human beings and environment.

3.4 Implementation indicators

Implementation indicators are used to assess the actions taken for combating desertification and to assess its impacts on natural resources and human beings. Such impacts refer to improvements of socio-economic and natural conditions.

4. Asian regional desertification Status Mapping

Desertification maps is a kind of useful and visible reference for the prognosis of desertification and for planning preventive or combative measures against it by showing the causes and dynamics of desertification with respect to the process itself and environmental vulnerability to desertification.

Before practically starting desertification mapping a series of technical aspects that are related to the scale, the minimum map able unit, classification system, projection system, datum, accuracy, map composition and format should be clarified. Technically, preparation of desertification mapping includes availabilities of the prescription of mapping standard, relevant data and technological capacity. It is necessary to collect some information from the involved countries, such as availabilities of climatic data and national maps for the purpose of desertification monitoring.

The delivered questionnaire is expected to provide necessary information on these issues. The desertification mapping is moved forward by forming a framework of regional desertification mapping. The main technical details were discussed and defined in the “Thematic Programme Network on Desertification Monitoring & Assessment (TPN1)” meeting in 2003. Based on the B&I adopted, the Chinese Academy of Forestry undertook the work of developing the Desertification Status Map of Asia in 2004, and has now completed its first raw map.

4.1 Methodologies

4.1.1 Data

MODIS (or Moderate Resolution Imaging Spectra-radiometer) is a key instrument aboard the [Terra \(EOS AM\)](#) and [Aqua \(EOS PM\)](#) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths. These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere.

4.1.2 Image processing

500-meter resolution satellite image (band 1~7) was acquired in 2003, by the Moderate resolution Imaging Spectroradiometer (MODIS). Image Processing and mapping by Asian Thematic Programme Network on Desertification Monitoring & Assessment (TPN1). The MODIS Image Processing have been done on the ENVI and ERDAS Image Processing system. The Projection system is Albers Conical Equal Area, to keep the data in continuity and systematizing. The Albers Conical Equal Area projection is mathematically based on a cone that is conceptually secant on two parallels. There is no areal deformation. This projection produces very accurate area and distance measurements in the middle latitudes. Thus, Albers Conical Equal Area is well-suited to countries or continents where north-south depth is about 3/5 the breadth of east-west and used for thematic maps.

Parameter detail:

Latitude of 1st standard: 15° 00' 00" N

Latitude of 2nd standard: 47° 00' 00" N

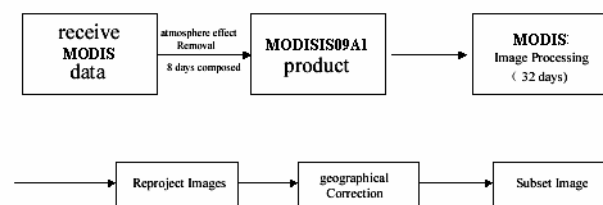
Longitude of central meridian: 90° 00' 00" N

Longitude of origin of projection: 0.0

Datum: WGS 84 (World Geodetic System);

Band combination: 4,3,2

MODIS Image Processing flow chart:



4.1.3 Classification system

Multispectral classification process the sorting of pixels into a finite number of individual classes, the Land use map is a classified image, showing vegetation, bare land, pasture, urban, etc. In order to confirm the land use classification system in the project area, the guideline should be set up. Land resources and land use (Land resources character, specialty and the land use pattern) to reflect the actuality of land resources and land use. The precision in classification, classify investigating to the land resource by using remote sensing technology. Every indicator in the classification system must be reached the anticipated precision of MODIS data. Adapted the land resources investigation in large-scale using remote sensing technology.

According to the guideline, the classification system is established as follow:

- Land use: Farmland; Forest; Meadow; Water; construction; have not utilized land;
- Forest and Meadow: In accordance with the land use pattern, the characteristic of land coverage, the management prescription of land resources, the secondly class is for Meadow and Forest;
- Farmland;
- Water;
- Urban, factory, inhabitation;
- Sandy land, Gobi, salinization-alkalization land;

To classify desertification degree, the basal land use pattern were used as the evaluate indicator, and to evaluate the degree of desertification respectively. The dictators

include: forest, Meadow, Farmland, otherwise. For farmland, the classification was in accordance with the surface features of the project area, and the crop reflects to the depth and homogeneity of the image. For forest, Meadow and otherwise, the NDVI indices method were adopted.

Indices are used to create output images by mathematically combining the DN values of different bands. It is used extensively in vegetation analyses to bring out small differences between various vegetation classes. In many cases, judiciously chosen indices can highlight and enhance difference, which cannot be observed in the display of the original color bands. The Normalized Difference Vegetation Index (NDVI) is a combination of addition, subtraction, and division:

$$\text{Vegetation Index} = \frac{IR-R}{IR+R}$$

4.1.4 Classification

Supervised Classification, it is usually appropriate when the user wants identify relatively few classes, and when the user can identify distinct, homogeneous regions that represent each class. On some regions that the objects in a feature space are obvious, the pattern recognition skills and a knowledge of the data to help the system determine the statistical criteria for data classification. About the rest, the classes are determined by spectral distinctions that are inherent in the data, and then define the class. Unsupervised classification enables to define many classes easily, and identify classes that are not in contiguous, easily recognize regions. Unsupervised Classification uses the ISODATA clustering method (Iterative Self-Organizing Data Analysis Technique), and uses spectral distance as in the sequential method, but interactively classifies the pixels, redefines the criteria for each class, and classifies again.

4.1.5 Classify result



	Classification	%
1	Forest	18.98
2	Farmland	19.60
3	Meadow	34.24
4	Water	2.71
5	Urban	0.09
6	Gobi	10.50
7	Firm and Ice	0.20
8	Low-Desertification	4.47
9	Mod-Desertification	3.14
10	High- Desertification	6.06

5. Conclusion

Remote sensing has been widely used for monitoring and assessing in the present and dynamic situations of desertification and drought at local, regional and global scales. Many countries and institutions have made achievement in this area. Since 1999 the “Asian Thematic Programme Network on Desertification Monitoring & Assessment (TPN1)” has made delightful progress by the joint efforts of all the TPN1 member countries but we still have hard work to do. There are now 20 TPN1 member countries. The desertification Status map of Asia now have been completed the first raw map .The next step aims at conducting ground control by gathering ground truth and provide training to those countries not yet able to be fully involved in image interpretation and monitoring processes. We appeal to sequential and more supports and assists from international, regional and sub-regional organizations, developed countries and all interested countries. All of the efforts and results will undoubtedly contribute to combat desertification, the serious hazard to our planet. Fruitful and successful implementation of TPN1 will assuredly facilitate Asian countries’ actions for combating desertification and improve Asian natural environment toward sustainable development.

DESERTIFICATION INDICATOR SYSTEM FOR MEDITERRANEAN EUROPE (DIS4ME)

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Abstract

A desertification indicator system for Mediterranean Europe (DIS4ME) has been developed by the EU-funded research project DESERTLINKS as a contribution to the work of the UNCCD, particularly in the Annex IV Sub-Region¹. A vital element of the project was the link with stakeholders at national and local levels. DIS4ME contains around 150 indicator descriptions. The indicators came from: the NAPs for Portugal, Spain, Italy and Greece; over a decade of European research; and the people who live in desertification-affected areas. Each indicator is fully described using a common format. A database allows indicator selection according to various logical frameworks, temporal and spatial scales. Within Europe there are many causes and consequences of desertification and wide-ranging local variability. A different set of indicators is required to understand the bigger picture in each situation. Reports and documents from the NAPs and a workshop with local stakeholders identified the main desertification issues for Europe as: land abandonment; intensive irrigated farming; overgrazing; deforestation; littoralisation; inappropriate agricultural practices; changes in the economic activity; degradation of the physical environment; availability of water resources; changes in the social structure; capacity of institutional organisations to combat desertification. Each of these issues is explored separately in DIS4ME bringing together a synthesis of knowledge about desertification processes and how they are known to affect different parts of Mediterranean Europe. DIS4ME also contains several examples of indices calculated by combining a number of different indicators. The expert system for evaluating the Environmental Sensitivity Index of a local area is calculated from 13 different indicators. It allows the land user to analyse the properties of his land and identify which of the factors under his control could be altered to improve the situation. The expert system, and the accompanying method for mapping environmental sensitivity to desertification, is an example of unified methodology which has already been applied at municipality, national and Mediterranean-wide scales as part of the national and regional action programmes. A participatory as well as a scientific approach has been taken. Stakeholders from national, regional and local organisations took part in four workshops and the results were used in the development and evaluation of DIS4ME. Feedback indicates that, through DIS4ME, we have had great success in promoting sensitisation to the issue of desertification and the use of indicators by different groups such as NGOs and community-based organisations. Although DIS4ME has been specifically developed to provide indicators of relevance in Mediterranean Europe it is expected that some of the indicators included and approaches taken will be transferable to other regions.

Key words: indicators, database, composite indicators, desertification issues, stakeholders, Mediterranean Europe

¹ DIS4ME is available online at www.kcl.ac.uk/desertlinks. Details of how to obtain the necessary password to access the site are given.

1. Introduction

The EU-funded DESERTLINKS Project began in 2001 with the aim of developing a desertification indicator system for Mediterranean Europe². It was planned to be a contribution by the European Commission to the work of the UNCCD and in particular the Annex IV sub-region countries of Portugal, Spain, Italy and Greece. A vital element of the project was the link with stakeholders at a local level, to discover their perception of desertification and their needs for indicators. Each country had begun work on their National Action Programmes so collaboration with the National Committees and local stakeholders in four desertification-affected study areas was the first step to establish the specifications for a useful indicator system. Because past research activities had built up a considerable body of information about them, DESERTLINKS focused on study areas in the Alentejo region of Portugal, the Guadalentín basin of Spain, the Agri basin in Italy and the Greek island of Lesbos.

The completed indicator system, DIS4ME, is available on line at www.kcl.ac.uk/desertlinks. This paper presents some of the highlights of DIS4ME.



Figure 1: DIS4ME introduction page

The site is divided into four main sections:

- **Desertification and DIS4ME:** providing general information about desertification, an invitation to provide feedback on the contents of the site and the site map.

² Combating Desertification in Mediterranean Europe: Linking Science with Stakeholders (DESERTLINKS). Contract Number EVK2-CT-2001-00109 (November 2001 to March 2005)

- **Indicators:** providing background information about indicators, access to the database of indicator descriptions, and descriptions of how sub-sets of indicators relate to specific desertification issues.
- **Using and combining indicators:** showing how indicators can be aggregated to map desertification or degradation risk over large areas, and provide an assessment of the risk of erosion or salinisation.
- **Linking science with stakeholders:** describing the work done with the stakeholders and how DIS4ME has been used and evaluated.

2. Indicator data base

At the heart of DIS4ME is the database of indicator descriptions. A list of some 220 candidate indicators was compiled, gathering information from the following sources.

- Indicators already used to map desertification at a national scale by the Annex IV Focal Points, as described in their reports to the Second MEDRAP Workshop, 6 to 8 June 2002³. These indicators tend to be those for which data is available at the national scale (such as Wild-fire incidence, Drought index, Land use index).
- All indicators described by Enne and Zucca (2000) in *Desertification indicators for the Europe Mediterranean region: state of the art and possible methodological approaches*⁴.
- All indicators described in Kosmas et al., (1999) in *Manual on key indicators of desertification and mapping environmentally sensitive areas to desertification*⁵
- All indicators listed in Greeuw et al., (2001) in *Factors, actors, sectors and indicators: the concepts and application in MedAction. Report #1 from the MedAction Project*⁶.
- Indicators suggested by the expert knowledge of members of the DESERTLINKS project. These have come from over a decade of European research into the causes and consequences of desertification in Mediterranean Europe. These indicators range from the Mediterranean-wide scale (Vegetation cover from remote sensing, Regional degradation index) to the sub-national (Employment index, Deforested area, Effective precipitation) to the plot scale (Soil depth, Tillage operations).
- Indicators suggested by the expert knowledge of local stakeholders who themselves live in desertification-affected areas. These indicators include some of the more pragmatic ones (Land abandoned from agriculture, Fragmentation of land parcels, Groundwater exploitation and Net farm income).

Also a review of other environmental indicator systems was undertaken, including:

- Commission on Sustainable Development (CSD)
- Organisation for Economic Cooperation and Development (OECD)
- European Environment Agency (EEA)
- Indicator Report on the Integrated Environmental Concerns into Agricultural policy (IRENA)
- Towards European Pressure Indicators (TEPI)

³ MEDRAP: Concerted Action to support the northern mediterranean regional action programme to combat desertification. <http://www.uniss.it/nrd/medrap>

⁴ Enne, G. and Zucca, C. 2000. Desertification indicators for the European Mediterranean region: state of the art and possible methodological approaches. ANPA, Roma and NRD, Sassari, 261 p

⁵ C. Kosmas, M. Kirkby and N. Geeson, 1999. The MEDALUS Project: Mediterranean desertification and land use. Manual on key indicators of desertification and mapping environmentally sensitive areas to desertification. European Commission Project Report, EUR 18882

⁶ <http://www.icis.unimaas.nl/medaction>

- Land Degradation Assessment of Drylands (FAO-LADA)
- Agri-environmental indicators for sustainable development in Europe (ELISA)
- Proposal on agri-environmental indicators (PAIS)
- International Institute for Sustainable Development (iisd)

According to the OECD⁷ an indicator should be specific, measurable, achievable, relevant, and time-bound. The European Environment Agency suggests that indicators should demonstrate policy relevance and utility for users, and analytical soundness as well as measurability⁸. It should be cost effective to compile the necessary data. Indicators should also be comprehensible, easy to interpret and suitable for indicating changes over time. With these criteria in mind, an iterative review of the candidate list was conducted. Indicators that could not be either described, measured or used in a practical way were abandoned. The exercise also revealed gaps which were filled with new indicators. The indicator list has been optimised, retaining about 150, most of which have now been fully described.

PHYSICAL AND ECOLOGICAL INDICATORS	
Climate	Air temperature
	Aridity index (1)
	Aridity index (2)
	Climate quality index
	Drought
	Drought index
	Effective precipitation
	Potential evapotranspiration
	Rainfall
	Rainfall erosivity
	Rainfall seasonality
	Wind speed
Water	Groundwater depth (change in)
	Water quality
Runoff	Area of impervious surface
	Dam sedimentation
	Drainage density
	Erosivity (RDI)
	Flooding frequency
	Floodplain and channel morphology
	Rainfall-runoff relationship
	Runoff threshold (RDI)
	Soil permeability
Soils	Acidified area
	Drainage
	Erosion risk (RDI)
	Infiltration capacity
	Organic matter in surface soil
	Organic matter in surface soil
	Organic matter mixing with depth
	Parent material
	Rock fragments
	Salinization potential
	Slope aspect

⁷ Environmental Indicators for Agriculture, Volume 3: Methods and Results, OECD, Paris March 2001.
www.oecd.org/agr/env/indicators.htm

⁸ Gentile, A.R. From national monitoring to European reporting: the EEA framework for policy relevant environmental indicators. <http://www.desertification.it/asv/ASINARA%20WEB/04gentile.htm>

	Slope gradient
	Soil crusting
	Soil depth
	Soil erosion (USLE)
	Soil erosion (measured)
	Soil loss index
	Soil quality index
	Soil structure
	Soil surface stability
	Soil texture
	Soil type
	Water storage capacity
Vegetation	Area of matorral
	Biodiversity conservation
	Deforested area
	Drought resistance
	Ecosystem resilience
	Erosion protection
	Forest fragmentation
	Vegetation cover
	Vegetation cover rs
	Vegetation cover type
	Vegetation quality index
Fire	Burned Area
	Fire Frequency
	Fire Risk
	Forest and wild fires
	Fuel models
	Wild fire incidence
ECONOMIC INDICATORS	
Agriculture	Expenditure on water
	Family size
	Farmer's age
	Farm ownership
	Farm size
	Forest productivity
	Fragmentation of land parcels
	Gross margin index
	Traditional agricultural products
	Net farm income
	Parallel employment
Land management	Agri-environmental management
	Fire Protection
	Forest management quality
	Management quality index
	Organic farming
	Reclamation of affected soils
	Reclamation of mining areas
	Soil erosion control measures
	Soil water conservation measures
	Sustainable farming
	Terraces (presence of)
Land use	Area of cultivated & semi-natural vegetation (rs)
	Area of marginal soil used
	Land abandoned from agriculture
	Land use evolution
	Land use intensity
	Land use type

	Natural vegetation
	Period of existing land use type
	Shannon's diversity index
	Urban sprawl
Cultivation	Area of hillslope cultivated
	Fertilizer application
	Mechanisation index
	Tillage direction
	Tillage depth
	Tillage operations
Husbandry	Grazing
	Grazing control
	Grazing impact
	Grazing intensity
	Husbandry intensity
Water use	Aquifer over exploitation
	External water resources
	Groundwater exploitation
	Hydrological regulation (artificial)
	Irrigated area
	Irrigation intensity and seawater intrusion
	Irrigation percentage of arable land
	Irrigation potential realised
	Runoff water storage
	Water consumption by sector
	Water leakage
	Wastewater recycling
	Water scarcity
	Water availability
Tourism	Penetration of tourist eco-labels
	Tourism contribution to local GDP
	Tourism change
	Tourism intensity
Macro economics	Employment index
	GDP per capita
	Accessibility
	Unemployment rate
	Value added by sector
SOCIAL INDICATORS	
	Adult education level
	Depopulation caused by degradation
	GINI index
	Human poverty index
	Number of technicians with a knowledge of desertification
	Old age index
	Population density
	Population growth rate
	Public perception of desertification
INSTITUTIONAL INDICATORS	
	EU production subsidies
	Hydrological and forestry plans
	Internal resources mobilisation
	Local agenda 21
	NGO contribution
	Policy enforcement
	Protected areas
	Recycled waste
	R & D expenditure

	River basin management plan
	Water use policy/law
COMPOSITE INDICATORS	
	ESI

Table 1: Indicators in the DIS4ME database

Each indicator is described using the same format as that used by Enne and Zucca (2000)⁹ and the description includes:

- definition,
- position within DPSIR logical framework,
- target and political pertinence,
- methodological description and basic definitions (including the levels of any relevant benchmarks),
- evaluation of data needs and availability,
- author,
- bibliography,

More powerfully, the indicators will also be available in a database, allowing the user to select indicators according to various logical frameworks, temporal and spatial scales.

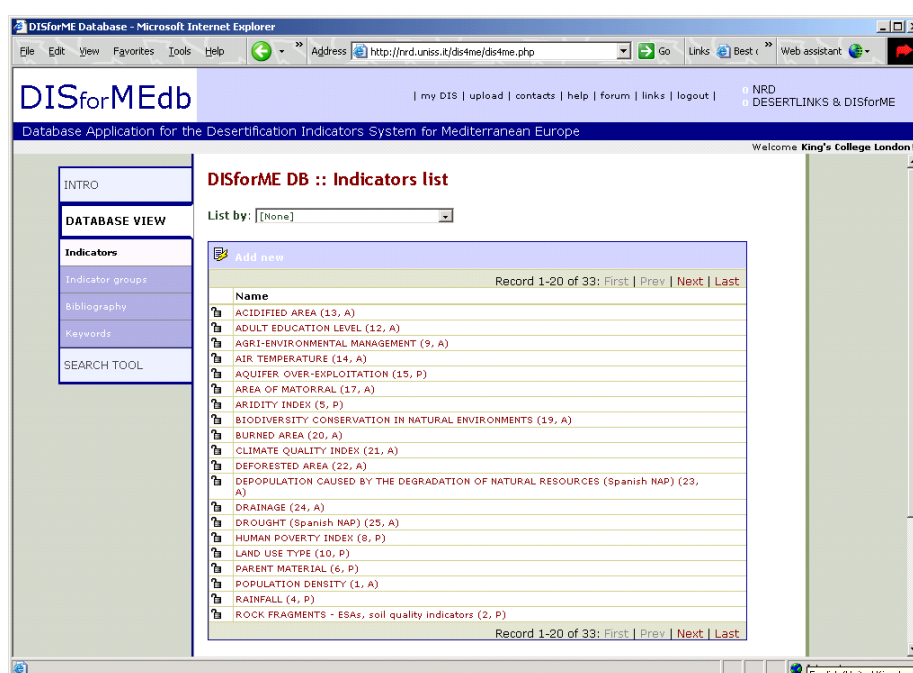


Figure 2: DIS4ME database

3. Different indicators for different issues

Within Europe the causes and consequences of desertification and land degradation are manifold, with wide-ranging local variability. For example, a particular issue associated with desertification in the Alentejo is rural depopulation driven by the search of the young for better incomes and standards of living in the cities. This is resulting in an ageing rural population. In the Guadalentín the issues relate to changing land uses in

⁹ Enne, G. and Zucca, C. 2000. Desertification indicators for the European Mediterranean region: state of the art and possible methodological approaches. ANPA, Roma and NRD, Sassari, 261 pp

response to available EU subsidies, resulting in large-scale, easily erodible contouring of hillslopes and planting of almond trees. The land degradation in these two situations has different causes and consequences. A different set of indicators is required to understand the bigger picture in each.



Figure 3: Desertification issues featured in DIS4ME

Examination of reports and documents from the National Action Programmes¹⁰ and a survey and workshop in which local stakeholders were asked what their perception of desertification was, and how it affected them, highlighted the main desertification issues for which indicators were required.

Issues	Sub-themes
Land abandonment	Climatic conditions, Soil conditions, Water availability, Employment opportunities in agriculture and elsewhere, Income from land, Changing rural population, Availability of alternative choices, Change in land management, Change in vegetation cover
Increase in intensive irrigated farming	Climatic conditions, Soil conditions, Water availability, Income from land, Soil salinization, Deterioration of water availability, Change in cultivation techniques
Overgrazing	Climatic conditions, Number of animals, Soil and vegetation conditions, Land tenure, EU subsidy policies pre agenda 2000
Deforestation	Climatic conditions, Drought tolerance of forest, Forest destruction by fire, Forest productivity, Impact of grazing on deforestation, Role of forest management, Impact of human population, Change in erosion risk
Littoralisation	Economy by sectors (coast), GDP inland/ coast and rate of change,

¹⁰ <http://www.unccd.int/actionprogrammes/northmed/national/2001/greece-eng.pdf>

<http://www.unccd.int/actionprogrammes/northmed/national/2000/italy-eng.pdf>

<http://www.unccd.int/actionprogrammes/northmed/national/2000/portugal-eng.pdf>

MEDRAP: Concerted Action to support the northern Mediterranean regional action programme to combat desertification. <http://www.uniss.it/nrd/medrap>

(concentration of economic and social activity in coastal areas)	Tourism development (coast), Population and rate of change (inland/coast), Agriculture development (coast), Expansion of artificial areas and tourism settlements in coastal zones, Role of planning and land use policy (coast), Employment opportunities (inland/coast), Existence of subsidies for economic activities (coast), Tourism demand (housing, services etc) (coast), Tourism and irrigation demand for water (coast), Land abandonment (inland), Water consumption (coast), Soil consumption due to urban expansion (coast), Biodiversity loss (coast), Water pollution (coast), Land/land use change (inland), Sustainable policies
Inappropriate dry farming agricultural practices on marginally productive land	Farm income, including subsidies, Income from off-farm employment, Land management changes, Climate conditions, Soil conditions, Economic and socio-economic conditions, Farming practices, Land use, Land abandonment, Soil degradation, Policy enforcement, Agri-environmental management
Changes in the economic activity in desertification-affected areas	Climatic conditions, Ecosystem conditions, Benefits and subsidies, Change in farm income, Development of tourism, Changing rural population, Expansion of use of irrigation, Exploitation of resources, Progressive decline in traditional agriculture, Development of new activities (apart from irrigated agriculture)
Degradation of the physical environment	Off-site impacts, Changing land use, Vegetation cover, Soil conditions, Control of erosion, Fire, Water availability, Population, Biodiversity change, Climate conditions, Production methods, Productivity change, Salinisation
Changes in the availability of water resources	Climatic conditions, Soil conditions, Changes in land use, Increase in urban water use, Increase in irrigated agriculture, Intensification of agriculture, Reduction in water reserves and quality, Change in flooding frequency, Farm income
Changes in the social structure	Changing agricultural system, Changing opportunities outside agriculture, Changes in the rural population, Littoralisation and urbanisation, Changing land use
Capacity of institutional organisations to combat desertification	National assessment of desertification risk, National policy and strategy framework, Local capacity for combating desertification, Local use of best practices

Table 2: The most important issues in desertification in Mediterranean Europe.

For each main issue, a number of sub-themes were also identified from the same data and information sources. These broadly relate to processes or state dynamics affecting the particular issue, reasons for its occurrence (or factors influencing the issue or driving forces and pressures); and its consequences (or impacts and responses).

Each of these issues, with their sub-themes, is explored separately in DIS4ME. For example, in the land abandonment section:

- abandoned land is described as an "area previously cultivated but where farming has ceased and the natural vegetation has been allowed to grow under various intensities of grazing."
- Information is given on the reasons for land abandonment. These tend to be because the land no longer provides a sufficient income for the farmer, sometimes because the land has become degraded, sometimes because there is insufficient labour to maintain the cultivation structures such as terraces, but more often because the traditional grazing is not profitable.
- Examples of reasons for land abandonment in each of the study areas are given. For example, in Portugal intensive cereal production begun in 1900 caused such extensive soil degradation that by 1950 agricultural productivity started to decline, and there were large scale population migrations to the cities and abroad. Similar examples are given for the other study areas.

- Finally, an overview of which of the indicators in the database are of particular relevance to land degradation is given, together with a discussion about how they inter-relate. For example indicators of relevance to land abandonment fall in four groups, relating to soil, climate, socio-economic and management conditions.

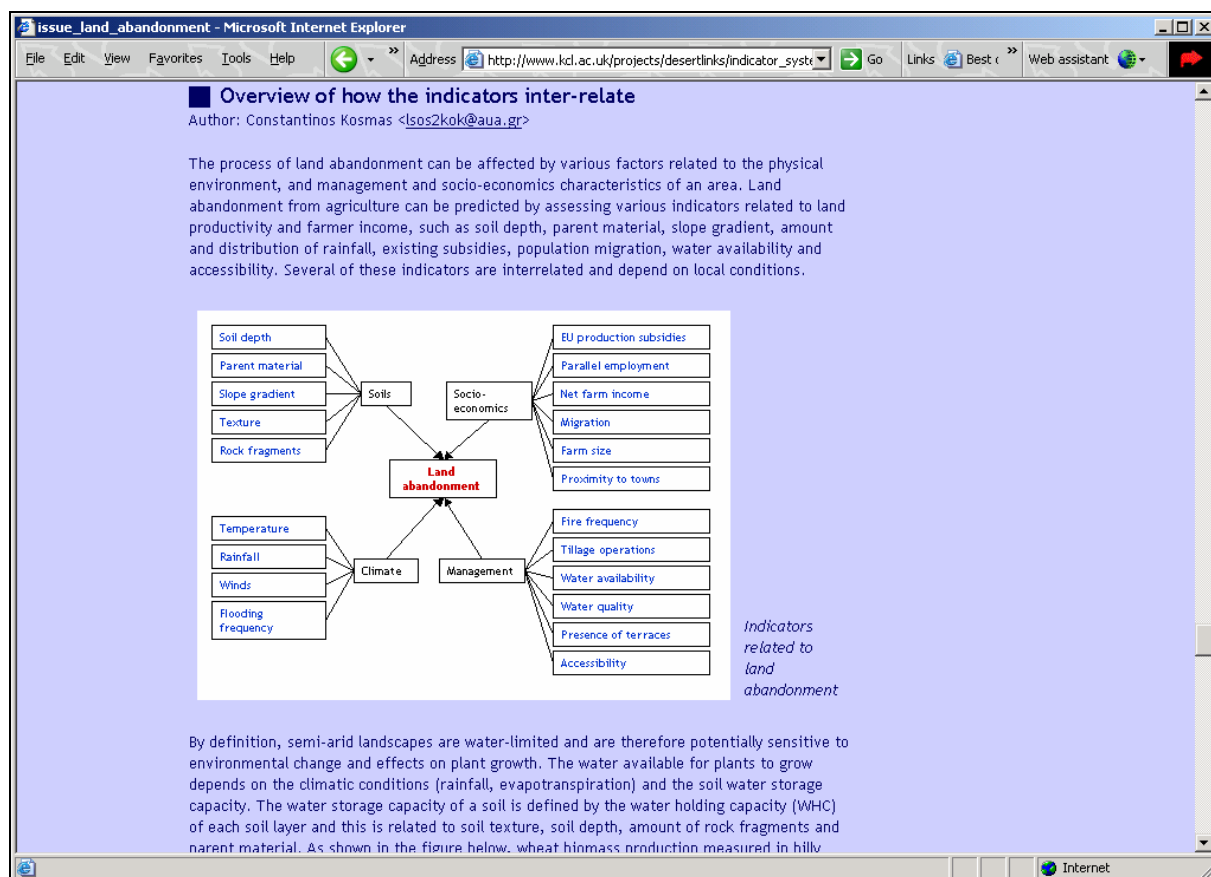


Figure 4: Indicators specifically related to land abandonment

All the other issues have similar pages, bringing together a synthesis of knowledge about desertification processes and how they are known to affect different parts of Mediterranean Europe. In this way an integrated approach is brought to each of the desertification issues.

4. Combining indicators into an index of desertification

It is easy to become over-enthusiastic in the search for a single, desertification indicator or index that is universally applicable. The problem is that, as indicators are aggregated, great care has to be taken with interpreting the resulting single number. Clearly there are indexes, such as the aridity index (the ratio of annual rainfall to potential evapotranspiration) which are in widespread use and easily interpreted, but as the number of indicators combined increases, so interpretation becomes less clear. However, within DIS4ME there are several examples of indexes calculated by combining a number of different indicators. These indexes have been developed using field data collected over 15 years of research, from field sites in each of the study areas. One of these indexes is the expert system for evaluating the environmental sensitivity index (ESI) of a local area. The ESI has been developed from the method for mapping environmentally sensitive areas to desertification developed during the MEDALUS III

project¹¹. It is calculated from 13 different indicators associated with vegetation, climate, soil and management.

- Fire risk, Soil erosion protection, Drought resistance, Vegetation type and Plant cover together determine the **vegetation** quality.
 - Rainfall, Aridity index and Aspect determine the **climate** quality.
 - Drainage, Soil depth, Rock fragments, Soil texture, Parent material and Slope gradient determine the **soil** quality.
 - Policy enforcement and Land use intensity determine the **management** quality.
- Together these four qualities determine the ESI. Full details of the methodology, written by A. Ferrara, are given in DIS4ME.

Complete the table and the System will analyse the Environmental Sensitivity to desertification of your local area

Vegetation		Climate	
Vegetation type	Cereals, annual grasslands	Mean annual rainfall	< 280 mm
Plant cover	high (>40%)	Slope aspect	N, NW, NE, plain (<5%)
		Aridity index	>150
Soil		Management	
Soil Depth	very shallow (<15 cm)	Land use intensity	low (sustainable)
Slope Gradient	very gentle to flat (<6%)	Policy enforcement	complete (>75%)
Texture	loamy (L, SCL, SL, LS, CL)		
Parent Material	shale, schist		
Drainage	well drained		
Rock Fragments	very stony (>60%)		

Evaluate ES Index

	Quality class	Critical factors, %	Quality score
Vegetation quality	Low	64	1.51
Soil quality	Medium	21	1.26
Climate quality	Low	66	2
Management quality	Good	0	1

	Sensitivity class	Sensitivity index	Sensitivity score
ES Index to desertification	Area with high environmental sensitivity (Critical)	35	1.4

Main risk factors of the area are:
 The type of vegetation characterised by a very low erosion protection and resistance to drought. Very shallow soil. The arid climate with a very low annual rainfall.

Figure 5: Appearance of the ESI Tool page in DIS4ME

For any local area, DIS4ME allows the user to calculate the ESI. The user selects values for each of the parameters from the drop down menus and then clicks Evaluate ES Index button. The results table shows the values of each of the vegetation, soil, climate and management qualities separately as well as the index itself. However, it also provides additional feedback on indicators which particularly influence the result. For the combination of indicator values in the example above the expert system reports that "The type of vegetation characterised by a very low erosion protection and resistance to drought. Very shallow soil. The arid climate with a very low annual rainfall."

This expert system is potentially of great interest to any land user, enabling him to analyse the properties of his own land and to understand what its sensitivity to

¹¹ Kosmas C., Ferrara A., Briassoulis H., Imeson A. 1999. Methodology for mapping Environmentally Sensitive Areas (ESAs) to Desertification. In 'The MEDALUS project Mediterranean desertification and land use. Manual on key indicators of desertification and mapping environmentally sensitive areas to desertification. Edited by: C. Kosmas, M. Kirkby, N. Geeson. European Union 18882. pp:31-47 ISBN 92-828-6349-2

desertification is and why, and which of the factors under his control could be altered to improve the situation.

The method has already been used to map desertification sensitivity over areas the size of municipalities or river basins.

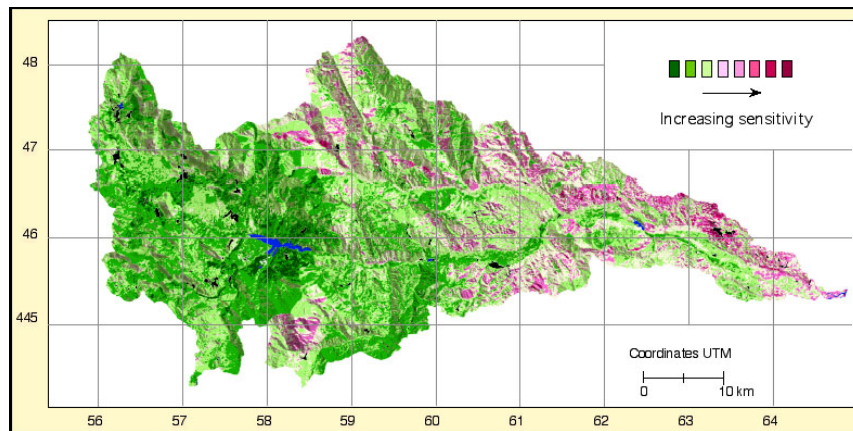


Figure 6: Map of the Agri basin showing desertification sensitivity (map courtesy of A. Ferrara)

The Agri basin in Southern Italy is about 1,700 km². The map shows that areas to the north and east of the basin are particularly susceptible to desertification. The ESI's ability to analyse, investigate, and identify the causes or sources that contribute to each land unit's score is important. It is possible to compare and characterise areas with the same levels of sensitivity but caused by very different combinations of critical factors.

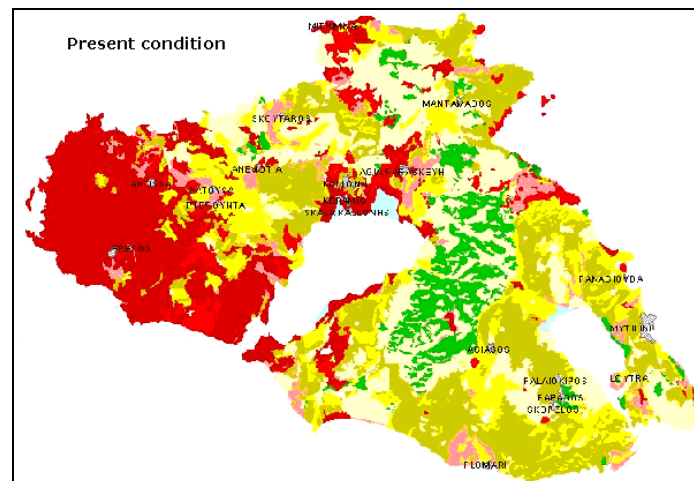


Figure 7: Map of the island of Lesbos showing desertification sensitivity (map courtesy of C. Kosmas)

The Greek island of Lesbos has been mapped under its present conditions, showing that the western part of the island is in a critical situation. However in DIS4ME the map alternates with another map showing an alternative scenario in which (a) animal grazing of pastures is reduced to a sustainable number according to the land productivity; (b) olive groves terraces are protected from collapse; and (c) adequate fire protection is given to pine and oak forests. Hence the methodology can also be used to demonstrate that under existing physical conditions, were such sustainable land uses to be applied, the desertification sensitivity on the island would be greatly improved.

This methodology has already been used to map areas sensitive to desertification in other affected parts of Europe. For example, the EU research project OLIVERO¹² has mapped desertification sensitivity in the olive grove belt of Chania (Crete), an area which has been selected as pilot area by the Local Focal Point of the Greek Committee for Combating Desertification.

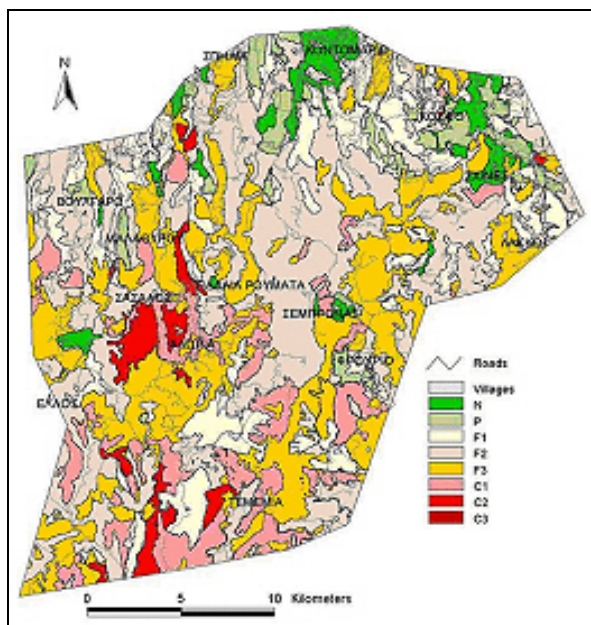


Figure 8: Map of part of Crete showing desertification sensitivity (map courtesy of C. Kosmas, N. Moustakas, J. Metzidakis, G. Papathanasiou, D. Kosma, M. Tsara, and X. Sergedani)

The map shows that most of the area is in a fragile state.

As a result of the National Action Programme in Italy, administrative regions have been requested to identify their sensitive areas and many of them have also applied this same methodology. Environmentally sensitive area maps of Toscana¹³ and Basilicata¹⁴ are already on the web. The methodology has been used and adapted by DISMED¹⁵ to map sensitivity to desertification for the whole Mediterranean basin, at a scale of 1:1,000,000.

¹² OLIVERO: The Future of Olive Plantation Systems on Sloping and Mountainous Land; Scenarios for Production and Natural Resource Conservation. Quality of Life and Management of Living Resources, Project No: QLK5-CT-2002-01841

¹³ <http://www.ibimet.cnr.it/Case/desertnet/>

¹⁴ <http://www.unibas.it/desertnet/>

¹⁵ DISMED is funded by Italian cooperation. The coordinating institutions are the UNCCD Secretariat, the European Environmental Agency (EEA) and the Foundation for Applied Meteorology (FMA). http://dismed.eionet.eu.int/index_html



Figure 9: Map of desertification sensitivity for the Mediterranean basin (map courtesy of EEA)

The expert system and the accompanying method for mapping environmental sensitivity to desertification is an example of unified methodology which has already been applied at municipality, national and Mediterranean-wide scales as part of the national and regional action programmes.

5. Stakeholder participation in the development of DIS4ME

The final part of DIS4ME highlighted in this paper is the section describing how a participatory as well as a scientific approach has been taken to developing the indicator system.



Figure 10: Results of the stakeholder consultation workshops presented in DIS4ME.

Stakeholder groups were formed in each of the study areas (Alentejo, Guadalentín, Agri, Lesvos). These stakeholder groups included:

- representatives from different socio-professional groups and organisations drawn from local communities;
- representatives from different levels of political and governmental decision making, including representatives of the National Committees to Combat Desertification;
- members of the scientific community in the different fields related to desertification, from the natural to the social sciences.

The stakeholders were invited to take part in a series of four workshops which took place over a period of three years in each of the study areas.

- The first workshop examined the impact of desertification as it is perceived by the local stakeholders and the results were used in the identification of the list of desertification issues.
- The second workshop analyzed the effects of different types of land management on land degradation. The results were used in the development of a tool for Agricultural Management Practices Assessment which is also part of DIS4ME, but which is not presented in this paper.
- The third workshop analyzed the factors affecting land use decision-making in order to identify indicators related to driving forces and pressures imposed on the natural resources. The results were used to revise and adjust indicators included in the database.
- In the final workshop the stakeholders were given an opportunity to spend some time looking in detail at DIS4ME and to provide feedback on the contents. In order to facilitate this, the system was translated into Spanish, Italian, Greek and Portuguese.

Although the last workshop in this series has not yet been completed, the feedback received to date from the stakeholders has been very positive and it is believed that, through DIS4ME, great success has been had in promoting sensitisation of the issue of desertification and the use of indicators by different groups such as NGOs and community-based organisations.

6. Conclusion

Although DIS4ME has been specifically developed for use in Mediterranean Europe, many of the indicators included and approaches taken should be useful in other regions too. For example, indicators relating to population health and mortality are not included in the database, but indicators relating to the effects of agricultural subsidies from the European Union do feature. However there are certainly many physical and ecological indicators described, which would be useful in any desertification-affected environment. The individual indicator descriptions are a step towards consensus in the definition of the indicators.

The approach that has been taken to breaking down the overall problem of desertification into separate issues or facets, such as land abandonment or water resources may well be one which is transportable to other areas.

Finally, although the expert system for determining environmental sensitivity to desertification has been parametrised and validated for use in Mediterranean Europe, the methodology is fully described in DIS4ME, and the same approach could be replicated in other areas.

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SESSION II

Integrated approach for the Use of Desertification B&I

INTEGRATED APPROACH FOR THE USE OF DESERTIFICATION B&I: ADDRESSING THE SESSION TOPIC IN THE AID-CCD PERSPECTIVE

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Abstract

Based on the different COP/CCD decisions number of countries undertook the elaboration of B&I for NAP monitoring. Ten years after the adoption of the CCD important results were achieved in terms of setting up M&E systems. However the evaluation of state of CCD implementation in Africa points out the necessity to strengthen activities aiming to combine both socio economic and biophysical indicators. In this spirit there is a strong need for elaboration of appropriate indicators able to tackle both the two main CCD objectives: sustainable natural resource management and poverty eradication.

Key words: benchmarks, desertification, indicators, participatory approach, mainstreaming, process indicators, resource mobilization.

1. Introduction

Although a great deal of work has been done on indicators in the past, Monitoring & Evaluation of drought and desertification still constitute one of the key issues of the Convention to Combat Desertification (CCD). Drawing lessons from the past experiences all the Countries Parties to the Convention agreed on the necessity to achieve an operational monitoring and evaluation system. To this end different CST/CCD studies proposed guidelines for building up an operational national M&E system which should include, inter alia, a permanent network of representative sites based on agro ecological homogeneity, an environmental/desertification information system based on agreed management procedures for database, partnership and scientific cooperation framework, and, last but not least, coordination mechanisms bringing together information users and producers.

Setting up a national M&E system is however a very complex and difficult task. It requires important human, scientific, technical and financial resources, as well as an adapted institutional framework. Although M&E in the countries concerned is lagging well behind the many other undertakings, number of affected countries has undertaken this work by themselves or in cooperation with developed scientific specialised institutions. They did it through specific ways that is interesting to know and analyze since they faced the main same problems or issues, like:

- How M&E is mainstreamed in the NAP process, as a needed tool for decision making at all levels?
- How the M&E system can meet with the needs of the various decision makers in terms of indicators?
- How the M&E system makes it possible to combine biophysical and socio-economic indicators?
- What are the synergies with other environmental conventions?
- How the M&E system can give a global view of both NAP implementation impact and desertification assessment?

- How the implementation of the desertification M&E system contribute to strengthening dialogue between the different key stakeholders, especially between scientists and decision makers at all levels?

- How traditional knowledge is taken into account when designing indicators?

So, 10 years after the adoption of the Convention what is the situation ?

In the context of the preparation of African National reports to the Conference of the Parties of the CCD three workshops on Lessons Learnt and Good Practices in the Context of National Reports on the Implementation of the United Nations Convention To Combat Desertification (UNCCD) were held in February 2005 in Africa (respectively in Ouagadougou, Douala and Addis Ababa). These workshops gave a very good and accurate situation of state of implementation of the CCD in Africa and, inter alia, the level of use of CCD indicators.

The objectives of the workshops were to:

- Exchange information on progress made on the implementation of the National Action Programmes (NAPs), Sub-regional Action Programmes (SRAPs) and Regional Action Programmes (RAPs);
- Present and discuss experiences made in the context of implementing relevant programmes by countries, multilateral and bilateral partners;
- Exchange information on the countries' findings and lessons learnt during the national report writing process.

In accordance with the national report format agreed by the COP/CCD seven topics had to be documented:

1. Participatory processes,
2. Legislative and institutional frameworks,
3. Resource mobilisation and coordination including partnership building,
4. Linkages and synergies with other environmental conventions,
5. Measures for the rehabilitation of degraded land and early warning systems,
6. Drought and desertification monitoring and assessment,
7. Access to appropriate technologies and know how.

It is important to notice at this stage that five out of the seven priority topics call for socio-economic or institutional indicators while two topics call mainly for biophysical indicators. It means that actually the CCD indicators can not be limited to desertification indicators *stricto sensu*. As the CCD objectives cover both natural resource management and poverty alleviation the indicators related to CCD implementation have also to take into account these two main objectives.

2. The general evaluation on use of indicators for CCD monitoring

The different national presentations made during the workshops pointed out the following issues as the most important concerns for CCD implementation in Africa:

- Lack of baselines for NAP implementation;
- No combined use of biophysical and socio-economic indicators;
- Few experiences in terms of setting up national integrated M&E system;
- Number of initiatives exists related to the elaboration of desertification indicators, but they are not undertaken within a pre established framework with the participation of all the actors: producers and users of indicators.

And, at this stage of the Convention's implementation, "many people in Africa are calling for a qualitative assessment of participation to be carried out; this is because the lack of accurate data on the extent of civil society actors' involvement fuels concerns about transparency."

The communications which will be presented during this session will highlight three experiences in direct link with the issue of putting in place a monitoring and evaluation system for NAP implementation:

- The example from Namibia will emphasize, inter alia, on the information needed at local level, and on involvement of local actors in the elaboration and implementation of their local development plans;
- The example from Niger will present an original experience on use of dashboard for M&E of the NAP/CCD;
- FAO will share with us the LADA experience which aims, at the international level, to reach to and harmonized and standard definition of indicators, with a possible common set of indicators.

3. Need for more accurate indicators related to CCD implementation process

As shown above the CCD is not only an environmental convention but, more than that, quite a development programme for arid zones. African national reports reflect indeed the socio economic dimension of the Convention and, in this spirit, from the synthesis of African national reports the following key issues emerged:

- There is a poor involvement of certain target groups such as pastoralists, women, young people, the private sector and academic institutions during NAP preparation, implementation and monitoring;
- The institutional framework seems inadequate, in most of the case, to support the implementation and monitoring of the Convention;
- Important difficulties arise in mobilizing resources and it is noticed a slow progress in the establishment of environmental and national desertification funds through legislation and partnership building;
- There is a need for strategies of making coherence of local, national and global level initiatives on drought mitigation and desertification control;
- Linking NAP and poverty reduction strategies is a critical issue;
- There is a need to promote partnerships with institutions and appropriate centres of the region and developed country parties.

In this respect two key items appear to be very crucial for CCD implementation:

- Mainstreaming of NAP into national strategic development frameworks, and the integrated related indicators, and
- Resource mobilisation and the related indicators.

3.1 Mainstreaming of NAP: the links with the PRSP (Poverty Reduction Strategy Paper)

All agree that integrating NAPs into economic and social development frameworks, such as Poverty Reduction Strategies, is crucial. The advantages to be gained from doing this are that it heightens awareness of the NAP as a planning development tool, it attests to countries' commitment to tackling desertification. Mainstreaming tends to be a key factor for mobilizing new resources and raising the awareness of development partners. Actually the PRSP is the most important funding source for all the development activities, in particular for sub-Saharan countries in Africa, since all the external financial contributions are channelled through the PRSP.

During the elaboration of the PRSP a set of indicators have been established and agreed upon between donors and recipient countries. These indicators will allow monitoring of PRSP implementation and serve to decision makers. Since there are no indicators, in the PRSP, related to NAP implementation, land degradation and/or desertification issues, it is no possible to take into account land degradation related activities in PRSP priorities,

and thus to ensure coherence between poverty eradication and combating desertification. And the remark about lack of indicators related to PRSP can easily be extended to another important issue like synergies between CCD and other Rio Convention: no indicators are documenting the relationships on the field between Rio Conventions.

3.2 Example of indicators related to resource mobilisation

It can be easily conceived that the most affected countries by desertification and drought are also the poorest ones. As such they have a crucial need for external financial support to implement their National Action Programmes to combat desertification. So, all through the evaluation of CCD implementation in Africa, the question raised was related to the evaluation of the external support: what are the indicators available to evaluating this support? The analysis of African national reports showed that, in fact, African countries didn't have at their disposal any objective and agreed set of indicators to tackle this very important Convention commitment.

The following example of the EU contribution to Africa to combating desertification is, in this sense, very instructive. During the subregional workshop in preparation of the CRIC3, held in Ouagadougou in February 2005, a presentation was done related to the financial EU contribution to combat desertification in Africa. An EU compilation of EU members' national reports for CCD have been done with the objectives to:

- Map out contributions by EU, and to
- Make recommendations to improve reporting

As a result of this exercise resources mobilized by EU countries for UNCCD related activities for the period 2002-2004 were evaluated to € 1.29 billion for specific African countries and € 1.32 billion for Africa in general. € 352 million were difficult to target. In total roughly € 900 million/ year have been devoted to related desertification issues.

As pointed out by the EU representative during the Ouagadougou workshop the limits of this work are that:

- The financial evaluation of EU contribution is based only on submitted reports;
- There are differences in reporting period;
- There is a difficulty in targeting CCD-related activities.

The lessons learned from this example are that:

- EU contribution in general terms could be considered substantial, but not objectively documented;
- Reporting format is not always practical and easy to implement;
- There is a necessity for harmonizing reporting methodologies within the EU member countries.

From the African point of view we could also consider that African countries have not at their disposal objective tools, like a set of common agreed indicators on resource mobilisation, to make them able to discuss and negotiate on the basis of objective indicators.

4. Conclusion

The present workshop will give the opportunity to exchange experiences between scientists and decision makers from both developed and affected countries on the different approaches for setting up a M&E system in the context of the CCD, and for providing useful and adequate indicators, paying particular attention to:

- Achieve a better knowledge of the different experiences and main challenges with which the developing countries are confronted in the implementation of a M&E system,

- Relate NAP indicators to the indicators of the PRSP or the National socio-economic development Plan, to allow NAPs to be taken into account by these strategic frameworks.

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- ICCD/CRIC(3)/2/Add.2, Progress in the formulation and implementation of subregional action programmes and the regional action programme in Africa
- ICCD/CRIC(3)/2/Add.3(A), Compilation of summaries of reports submitted by affected African country Parties (*English, French, Spanish only*)
- ICCD/CRIC(3)/2/Add.3(B), Compilation of summaries of reports submitted by affected African country Parties (*English, French only*)
- ICCD/CRIC(3)/2/Add.4, Results of the subregional workshops of affected African country Parties
- ICCD/CRIC(3)/3, Review of the reports by developed country parties on measures taken to assist in the preparation and implementation of action programmes of affected African country parties, including information on financial resources they have provided, or are providing, under the convention
- ICCD/CRIC(3)/3/Add.1, Synthesis and preliminary analysis of reports from developed country Parties
- ICCD/CRIC(3)/3/Add.2, Compilation of summaries of reports submitted by developed country Parties (*English, French only*)
- ICCD/CRIC(3)/3/Add.2(B), Compilation of summaries of reports submitted by developed country Parties (*English only*)
- ICCD/CRIC(3)/4, Review of information provided by relevant organs, funds and programmes of the United Nations system, as well as other intergovernmental and nongovernmental organizations, on their activities in support of the implementation of the convention in affected African country parties

INTEGRATED APPROACH FOR USE OF DESERTIFICATION BENCHMARKS AND INDICATORS: AN EXAMPLE FROM NAMIBIA

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Abstract

This paper addresses the approach used by Namibia to develop and implement benchmarks and indicators within a framework that allows local communities to take the lead in planning and implementing their development goals. This framework is referred to as the Forum for Integrated Resource Management (FIRM) and was developed under the umbrella of Napcod, Namibia's Programme to Combat Desertification. The FIRM approach was initially tested in response to meeting fatigue among local communities. Previously meetings were called in an uncoordinated manner by outsiders with the objective of assisting communities in their development. This resulted in overlap and conflicting goals among different stakeholders. Often this led to disillusioned communities. The FIRM approach allows the community to take the lead in their own planning and development. Annual work plans are prepared by the community members working with their service providers, and based on these plans relevant stakeholders are invited to support the community in reaching these goals. The forum has become a tool to enhance decision making towards better resource management and diversification. One important aspect of improved decision making is access to relevant information. To improve communities' access to relevant information a local level monitoring system was developed by Napcod. The indicators developed were based on information needs identified by local farmers. Four main indicators were developed: livestock condition scoring, veld condition and bush density, fodder availability and rainfall. These indicators have been adjusted to local conditions at each site where the system is being implemented. The monitoring system was first introduced at Napcod pilot sites in northern, north-western and southern Namibia but is presently being introduced by local extension officers throughout the country. The success of the implementation differs from area to area, depending on the community's experience, interest and capacity to collect information and to share the results.

The local level monitoring system also serves as an important validation tool for a national land degradation monitoring system that was also developed under the umbrella of Napcod. This system provides decision makers at national and regional levels with information about where the risks of land degradation are highest. Four primary indicators were developed in close cooperation with relevant stakeholders, i.e. population pressure, livestock pressure, erosion hazard and rainfall variability.

The Namibian experience has shown that it is not enough to define benchmarks and indicators in order to successfully monitor desertification on local and national levels. For monitoring to be successful a proper platform is required, where relevant stakeholders get together to develop benchmarks and indicators and jointly respond to the results of the monitoring. In the case of community-driven local monitoring in Namibia, the FIRM serves as the platform from which the various indicators are developed based on local farmers' information needs. The FIRM is also where the results from the monitoring are discussed. FIRMs contribute to the decision making and planning of activities done by communities, and involve all relevant stakeholders, e.g. local NGOs, government institutions and other experts. In the case of national level monitoring, the Napcod umbrella serves as the appropriate platform.

1. Introduction

Desertification, defined as ‘land degradation in arid, semi-arid and sub-humid conditions, caused by various factors including climatic variations and human activities’ (UN 1994) describes a change in state of the environment and its associated productivity. One approach to measuring a change in state involves using benchmarks against which change can be measured and appropriate indicators that record the change. Benchmarks and indicators, explicitly or implicitly, have long been used to measure changes in state from a variety of perspectives. Agriculture, terrestrial and marine environments and atmospheric conditions come immediately to mind. Farmers and fishermen have used implicit benchmarks and indicators to support their decision making processes for millennia. These indicators of state evolved and were adapted depending on the users and how the indicators were being used by them.

Benchmarks and indicators for desertification have been discussed for the greater part of a century (Mabbutt 1986; McQueen and Noak 1988; Mouat *et al.* 1992; Noss 1990; OECD 1993) and predate the United Nations Convention to Combat Desertification (UNCCD) (1994). They represented an important focus for the first meeting of the Committee on Science and Technology (CST) at the first Conference of Parties (COP) in October 1997, and have remained an issue for implementation of the UNCCD since that time. Most early benchmarks and indicators reflected a change in the state of the environment and its resources. Several indicator-based monitoring frameworks have been developed, e.g. the pressure, state and response framework, PSR (OECD 1993) and the driving forces, pressure, state, impact and response framework, DPSIR (CEROI 2001). These benchmarks and indicator frameworks or systems have been developed and used by scientists, academics and environmental managers with the results being incorporated into reports on the state of the environment and other decision making tools. Initially the benchmarks and indicators were used to measure changes of environmental state taking place through naturally induced change or through the interventions of people. Some of the early observations on the extent of desertification were of this type (Lamprey 1975).

In recent years, and particularly since the advent of the UN Convention to Combat Desertification (UN 1994), additional uses for benchmarks and indicators have been identified. First, a variety of interventions to reverse and prevent land degradation were being taken for several decades and these efforts increased with the convention. These interventions required a framework in which to measure not just uncontrolled changes but the changes representing ‘impact’ on the natural environment of focused interventions through development programmes. Moreover, these interventions addressed not only changes in the natural environment but addressed a broader perspective including, *inter alia*, changes in terms of people’s livelihoods and the overall socio-economic situation surrounding land degradation and desertification.

State of the environment reports advocated by Agenda 21 arising from the UN Conference on Environment and Development (UNCED) provide good examples (Klintenberg 2001, MET 1999a, MET 1999b, Malloy and Reinikainen 2003, Noongo *et al.* 2002). These benchmarks and indicators are designed by and intended for use by the managers and academicians who identified and developed the relevant tools. This type of indicator system has been at the heart of many programmes designed to combat desertification and land degradation.

An entirely new dimension in use of state of environment indicators arose when the people-centred, ‘bottom-up’ approach of the UNCCD was introduced (UN 1994). The relevance of the indicators identified by managers and academicians, intended for use by other people, particularly those affected by desertification, were often not perceived

to be of importance by the intended users. Moreover, concise benchmarks and indicators for a complex phenomenon such as desertification or land degradation, with long time frames and multiple causes and manifestations, were difficult to clearly identify, develop and measure by any potential users.

A second type of indicator system evolved more recently focused on implementation of development programmes including those designed to address desertification. These are known as 'process indicators' and measure the accomplishment of programmes and activities rather than the state of the environment with respect to desertification or land degradation. These benchmarks and indicators are designed to meet the needs of development agents and donors and are intended for use by developers, donors and managers to monitor implementation of development programmes.

The people centred, bottom-up approach of the UN Convention to Combat Desertification was more readily integrated into this system. These types of benchmarks and indicators were adopted by developers involved in desertification and were more easily communicated and transmitted and then adopted by those with whom the developers were working. The comparative success of the application of process indicators rested at least partially on the ready made application 'platform' in the form of donors and the communities, NGOs and governments with which they worked. Process indicators are comparatively easier to identify, develop and use by those involved in combating desertification, are more directly tied to the funding available and therefore tend to have greater immediate application than impact indicators.

2. An example from Namibia

Namibia gained its independence in 1990, in time to prepare for and participate in the UN Conference on Environment and Development (UNCED). In preparation for this event, Namibia's Green Plan was developed (Brown 1992). Although not directly addressing benchmarks and indicators, this document attempted to take stock of the environment and related programmes and activities that were addressing perceived deficiencies. For Namibia, this document serves as a qualitative benchmark against which overall progress can be judged.

Prior to the Green Plan, Namibia had established a variety of environmental monitoring programmes, with attendant baselines (e.g. Huntley 1985). The associated benchmarks and indicators reflect the interests of and application by academics and resource managers. Exceptions in terms of application of indicators, if not their development, were the Wildlife Conservancies established on private game farms (Barnes and de Jager 1995), NGO-led, community implemented monitoring programmes addressing single species, e.g. black rhinoceros, and the emerging Community Based Natural Resource Management programmes (Ashley 1995). These programmes involved local communities who monitored wildlife numbers in their areas. These exceptions tended to be based on monitoring of discrete indicators of environmental condition in the form of wildlife numbers.

Namibia became involved in addressing desertification before the UNCCD was ratified. A formal programme, known as Namibia's Programme to Combat Desertification (Napcod) was established by the Ministry of Environment and Tourism in 1994 with German funding (Wolters 1994). Although not originally specifically so designed, the Steering Committee of the Napcod programme, with members from government, NGOs, the private sector and donor organisations, evolved into an oversight body known as the 'Napcod umbrella' with many partner organisations and projects reporting to it. As sub-structures of Napcod, inter-institutional 'technical working groups' were

established to address various components of desertification. These, in turn, worked with various community groups, service providers and other involved parties.

The Napcod umbrella with its diversity of partner organisations, the Napcod programme itself and the technical working groups including the community organisations and service providers with which they worked provided a platform from which different types of benchmarks and indicators could be supported. Different components of the oversight constellation supported identification, development, measurement, interpretation, dissemination and review of the systems of benchmarks and indicators elaborated to support the Napcod programme.

A national level monitoring system, firmly embedded in the platform provided by the Napcod umbrella, was established to enable an assessment of desertification risk in Namibia using available data and information already being collected (Table 1) (Klintenberg and Seely 2004). Identified, developed, measured, synthesised and disseminated by members of the Napcod umbrella, the indicator system is used by its developers and, most importantly, high level decision makers. The system provides decision makers on national and regional levels with information about where in Namibia the degradation risks are highest. In particular for Namibia's purposes, it provided a tool that represented the state of the environment, reflecting pressures and responses, which did not automatically refer to expanding deserts *per se*. (An ongoing theme in Namibia is that encapsulated in the slogan: proud of our deserts but combating desertification (Wolters 1994)).

Environment B&I	Local Level Monitoring	National Level Monitoring
Identification of B&I	FIRM ¹ including AE ² & Napcod ³	Technical Working Group
Development of B&I	FIRM including AE & Napcod	Technical Working Group
Measuring B&I	Farmers/ FIRM members	Napcod members; MET ⁴
Interpretation of results	Farmers/ FIRM including AE	Napcod members
Dissemination of B&I process	AE & Napcod	Napcod members
Dissemination of B&I results	FIRM, AE & Napcod	Napcod members
Using B&I for decision making	Farmers/ FIRM members	National Planning Commission; Prime Minister's Office
Platform for B&I process	FIRM	Napcod umbrella

¹FIRM- Forum for Integrated Resource Management

²AE- Agricultural Extension

³Napcod- Namibia's Programme to Combat Desertification

⁴MET- Ministry of Environment and Tourism

Table 1 Steps involved in development and use of benchmarks and indicators (B&I) to monitor changes in the state of the biophysical environment and the organisational structures involved at local and national levels

The four primary indicators measuring environmental state for the national level monitoring system were developed in close cooperation with relevant stakeholders under the guidance of the technical working group of the Napcod umbrella (Table 1). These included: population pressure (from the decadal census figures and estimated rates of change) clearly linked to land degradation in Namibia (Lange *et al.* 1997, MET 1999b); livestock pressure (from annual veterinary services records) linked to permanent water points (Quan *et al.* 1994), erosion hazard (from Agro-Ecological Zones Project (Pauw and Coetzee 1996)) and rainfall variability (from annual records of the Namibian weather bureau). This system represents a set of benchmarks and indicators to monitor land degradation the results of which are used by e.g. the Office of the Prime Minister and the National Planning Commission with support from the

Napcod umbrella. The technical working group served as an important think tank during the elaboration of impact indicators. It was fully recognised that many of the usual indicators, e.g. amount of grass cover, can vary greatly year to year because of rainfall variation and other factors and changes need not reflect the impact of a desertification programme or any other. During the technical working groups' discussions, extensive lists of suggested indicators derived internationally were reviewed and analysed. Two concerns were central to the discussion. Would high rainfall variability mask the changes being followed? Are the data readily available at little or no additional cost for their collection? These proved key to shaping the monitoring system derived (Klintonberg and Seely 2004).

The indicators derived concerning the biophysical state of land degradation are considered by the Napcod umbrella to represent a first level of information. Socio-economic information is collected, at great expense, during the national household surveys, poverty assessments and other tools used to assess economic well being. Although not integrated under the Napcod programme *per se*, these diverse indicators are being taken forward under the continuing Napcod umbrella to provide an integrated overview of socio-economic well being of Namibia's population.

Throughout the process of establishing environmental indicators, the Napcod programme did not expect to use these indicators to directly measure the impact of interventions of the Napcod programme. It is recognised that rainfall variability and other natural factors are anticipated to overwhelm any results that might be derived from a short-term programme. Moreover, with a variety of projects and programmes working in a similar direction, the impacts would be cumulative and complementary supporting overall development.

Parallel to the process of developing environmental indicators, and strongly supported by the funders of Napcod, was the development of process indicators for the Napcod programme and for the Napcod umbrella (Steering Committee) itself (Table 2). Based on cooperative planning using a logical framework approach, benchmarks and indicators were established for each component of the programme (e.g. Wolters 1994 and later project documents). More direct and easier to measure, these indicators measured progress within the programme that was intended to enhance the state of the environment. As a consequence, they measured implementation of the UNCCD but not the success of that implementation for people living in the drylands.

Process B&I	Local Level Monitoring	National Level Monitoring
Identification of B&I	FIRM ¹	Napcod ² SC ³ & donors
Development of B&I	FIRM	Napcod SC & donors
Measuring B&I	FIRM	Napcod & donors
Interpretation of results	FIRM	Napcod & donors
Dissemination of B&I process	FIRM, AE ⁴ & Napcod	Napcod SC & donors
Dissemination of B&I results	FIRM, AE & Napcod	Napcod SC & donors
Using B&I for decision making	FIRM	Napcod SC & donors
Platform for B&I process	FIRM	Napcod umbrella

¹FIRM- Forum for Integrated Resource Management

²Napcod- Namibia's Programme to Combat Desertification

³SC- Steering Committee

⁴AE- Agricultural Extension

Table 2 Steps involved in development and use of benchmarks and indicators (B&I) to monitor the process of combating desertification and the organisational structures involved at local and national levels.

At a different level, the ‘technical working group’ contributing to capacity enhancement amongst local communities supported the development of a local level monitoring system (Table 1). The first step of this process involved development of Forums for Integrated Resource Management (FIRM). These forums were designed to close the gap between resource users and the service providers supporting them (Kroll and Kruger 1998, Kruger 1998, Kruger 2001, SDDI 2003). For example, a Farmers’ Association would invite agriculture, education, health, water and other extension persons to become members of the FIRM. At their annual meetings, during the strategic and operational planning processes, milestones and indicators would be derived in a participatory manner involving all members of the FIRM. The FIRM thus serves to identify, develop, measure, interpret, disseminate and use for decision making the indicators derived through extensive participation.

Dryland farmers are the primary developers and users of local level monitoring indicators. As a consequence, aspects of their environment that are of most interest to them are developed to serve as indicators (Kambatuku 2003a) of the state of their environment and socio-economic situation. Four indicators have been developed by different communities in Namibia. These were supported by facilitated inter-community interactions. From one to four are used regularly by many community groups. Currently the local level monitoring system focuses on livestock condition throughout the communal areas of Namibia where it is being used. Livestock condition reflects the immediate condition of the rangeland to a large extent. As an indicator it provides the farmer with an early indication of fodder availability and condition of the veld. The farmer can then use this indicator to support decisions on selling stock or increasing stock numbers or other management actions. A second indicator focuses on rainfall, the most important factor determining fodder availability. Variation in rainfall has a direct impact on the availability of fodder for livestock. A third indicator, focused on changes in grass, bush and tree cover, has a bearing on biodiversity and the productivity of rangeland in the longer term. Although the discussion continues on the ultimate impact of bush encroachment in the Kalahari basin, particularly in Namibia, local farmers felt it was important to monitor these changes. Direct measures of fodder availability represent the fourth indicator identified by farmers as important to measure. Methodologies derived by the farmers and service providers, as facilitated by Napcod, focus on photographic comparison methods backed up by scientific measurements (Kambatuku 2003b). Farmers themselves use the photographs to assess livestock or range condition and then record their observations on monthly, annual and long-term forms. Not all indicators are measured by all farmers or farmer groups with livestock condition being the exception and adopted by all to date. The second step of using the results of monitoring indicators for decision making is less well developed but being applied by many communal farmer groups.

The FIRM, through its strategic and operational planning also establishes a set of process indicators in the form of milestones (Table 2). In this way the drylands farming community, with its service providers, can measure progress toward the agreed-upon goals established by all FIRM members. This serves as a very important monitoring, evaluation and adjustment tool for both communities and services providers.

3. Discussion

The concept of ‘integrated use of benchmarks and indicators’, the title of this paper, can be interpreted in a number of ways. In the history of global concern for desertification, indicators of desertification have been referred to frequently. Terminology such as benchmarks, thresholds, milestones and indicators has been used in different ways for

different purposes (e.g. Klintenberg and Seely 2004). Moreover, less attention has been paid to the actual integrated use of indicators than to the identification and development of these indicators (e.g. OECD 1993). Several factors contribute to this situation.

Desertification, when defined as land degradation, refers to a long-term ongoing loss of productivity with biophysical as well as socio-economic ramifications (Wolters 1994). It is subjected to the vagaries of variable climate as well as human activities. Few long-term environmental observation networks have been established globally (e.g. Henschel *et al.* 2003) and only a few of those are located in drylands (e.g. ROSELT). These long-term measurement series can provide information on environmental and socio-economic change but questions pursued have not necessarily been developed in the format of benchmarks and indicators nor in a format usable by local decision makers.

Benchmarks and indicators, where they have been formally constituted, have been identified and developed and are measured, interpreted and results disseminated by academic scientists or environmental managers. Connecting desertification research directly to the process of combating desertification has been notoriously difficult (e.g. Correll 1999, Seely and Wöhl 2004) with poor communication a major impediment.

Under the UNCCD, the NAP process and the CST are intended to enhance broad-based research competence in combating desertification but this goal has been hardly realised (e.g. Seely and Wöhl 2004). Dryland farmers and others who are daily confronted with desertification and its ramifications have neither the capacity nor the interest in developing and using indicators of environmental state to further elaborate what they already intuitively know.

Since the UNCCD has been implemented, various donor funded programmes and projects have been initiated or at least refocused to address desertification. Benchmarks and indicators are usually developed along with the project design documents to assess the success of the projects but not necessarily the impact of the project on the biophysical or socio-economic environments affected by desertification. These indicators usually address the needs of the donors and not of the people coping with desertification locally, regionally or nationally.

Use of benchmarks and indicators can take on several meanings. It may mean simply identifying lists of indicators for inclusion in project documentation. It may mean development of the indicators, measurement, interpretation and dissemination of the results gained from their use. In this context, we are of the opinion that these components must also be used for decision making, from grass roots to policy levels. This is in keeping with the UNCCD that advocates a grass-roots involvement and contribution to the overall process.

Many of the interventions initiated to combat desertification, including the use of benchmarks and indicators, are directed at the technical level. It has been recognised during the implementation of the UNCCD that technical solutions are insufficient without organisational support amongst local farmers for their implementation.

The above-mentioned impediments to integrating use of benchmarks and indicators into combating desertification have only partially been addressed. The Namibian example emphasises a key component, both for combating desertification and for the use of benchmarks and indicators in this process. This component is the presence of a platform from which to support communication amongst role players at all levels. For integrated use by national level decision makers, benchmarks and indicators must have a recognised platform, such as the Napcod umbrella. Such a platform supports the technical process of developing and disseminating results of indicators. At the same time, the platform must be recognised as an 'honest broker' supplying the high-level policy makers with credible information.

The key component at the local level is also a credible platform from which to support the development, use and community ownership of relevant benchmarks and indicators. In the Namibian example the FIRM provides that role. Without a suitable platform to integrate benchmarks and indicators into decision making at all levels, their use is limited and not supporting the UNCCD as intended.

Acknowledgements

The authors wish to thank the German Government through Gesellschaft für Technische Zusammenarbeit for supporting Namibia's Programme to Combat Desertification under which these Namibian examples were developed. The authors fully acknowledge the contributions from numerous colleagues at all levels without whom the reported experiences would have been less comprehensive.

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ESTABLISHING A COMMON SET OF B&I FOR DESERTIFICATION MONITORING AND EVALUATION: OSS AND CILSS EXPERIENCE IN NIGER

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Abstract

OSS and CILSS developed in 2001 an approach to elaborate criteria and indicators for land degradation/ desertification control. This approach has been used by Niger to develop specific indicators suitable with his NAP and his context. Based on information given by Niger delegation at CRIC.3/CCD, the document gives, without any critical spirit, some of the products developed by Niger.

Key words: Land degradation, desertification, dashboard, indicator

1. Context

Land degradation / desertification is the major environmental problem / issue of Sahelian countries. Those countries, therefore, played and continue to play a key and active role in the UNCCD negotiation and implementation processes.

Drawing lessons from their past and recent experiences in desertification and effect of drought control, mainly from the National Plans to combat desertification in the context of the Nairobi's Action Plan (1997), those countries concluded on the necessity of having monitoring and evaluation tools and mechanisms really connected to NAPs, RAPs and RAP to combat desertification.

In the same time, CILSS and OSS, in the context of their respective mandate, decided to support their member states in defining relevant tools to effectively monitor their NAPs and SRAPs. For those two institutions, the lack of efficiency in previous efforts to combat desertification did not result from the plans and/or programs elaborated, but from the lack of tools and mechanisms to insure that those efforts suit / are relevant with the problem to be solved.

Regarding CILSS member states concerns in one hand, CILSS and OSS concern in the other hand, the two institutions and their partners, namely Club du Sahel and GTZ, decided to establish a think tank to specifically tackle the issue of CCD-NAPs and SRAPs monitoring and evaluation in Northern and Western Africa.

This Think Tank activities lead to the definition of an approach for Monitoring and Evaluation implementation and impact indicators production that is included as an integral part of the NAP implementation cycle.

Each country / sub regional organisation (CILSS and AMU) involved in the activities of the Think Tank was expected to adapt this approach to its own context and to produce indicators that may be used as a minimum information base required for (i) reporting on changes in desertification and effects of drought control; (ii) comparing changes in action programme among the countries and the sub regions.

The results of the Think Tank activities have been reported to COP.5/CCD (see document ICCD/COP(5)/CST/7) and it has been asked to each affected country Party to implement them. This document presents use made by Niger of the approach developed by CILSS and OSS and the results obtained.

2. Valorisation of monitoring and evaluation products by Niger

Niger is a West African sahelian country. More than 95% of its territory is affected by land degradation / desertification. In fact, 2/3 of the country is desert area.

Up to UNCCD process, desertification monitoring & evaluation was done by projects or by international specialised institutions, such as AGRHYMET Regional Centre, ACMAD, ICRISAT, etc. At the national level, M&E activities was more concentrated on seeing if activities planned by the different projects have been realised and what are the impacts in terms of crops yield, land use - land cover, etc. There was no an integrated system allowing decision makers to take decisions addressing several issues in natural resources management, changes in desertification entropic factors (changes in population's way of acting).

After COP.5, the CCD National focal point in Niger decided to implement the approach developed by CILSS and OSS. In this regard, and with the assistance of OSS and Italian cooperation, he started a consultative process between data producers and data users, with the objective to have an efficient and operational monitoring and evaluation mechanism which may be used across the country.

The different actors reached the consensus that the mechanism to be built must be country driven and use the existing means and capacity. Important efforts, therefore, were developed to (i) involve all the ministries, the private and non governmental institutes, international organisations based in Niamey and the different projects having a monitoring and evaluation component, (ii) valorise the results of existing or finishing projects: Keita, Tahoua, etc.; (iii) to share information and data between the different actors: those who are producing data and those who are using them.

One outcome of this process, is the elaboration of a dashboard taking into account the objective of the NAP/CCD and giving a common understanding of the indicators to be used across the country, and the data to be collected to insure the calculation of each indicator. For each indicator the following description has been made:

Descriptive file

Name of indicator (wording of the indicator)
Definition / Calculation formula
Connection with the objectives of the NAP/CCD-NRM
Type of indicator
Measurement unit
Data sources
Geographic coverage (national, regional...)
Reference value
Collection method
Collection periodicity
Required data (data used to calculate the indicator)
Available data (time series, years, coverage)
Costs
Accessibility (mode of management, storage, . . .)
Problems/ Reliability
Users
Connection with other indicators
Additional data
Influence potential

Samples

Sample1. Growth rate of agricultural productions

Name of indicator (wording of the indicator)	Growth rate of agricultural productions
Definition / calculation formula	Volume of agricultural productions. For lack of data, only major crops are considered (millet, sorghum, niebe, groundnuts rice and maize / corn).
Connection with the NAP/CCD and natural resources management	This indicator represents a measurement of the main source of economic growth in rural environment
Type of Indicator	Impact indicator
Measurement Unit	In tons
Data sources	Ministry of agriculture
Geographic coverage	National and regional
Reference value	1999, date of development of the NAP/CCD
Collection method	Compilation of results of the agricultural survey and documentary research at the relevant departments of the Ministry of Agriculture. Breakdown by region and by type of crop.

Sample 2. Evolution of Agricultural GDP

Specific objective : Improving agricultural productivity and increasing fodder potential

Type of indicator : Impact indicator

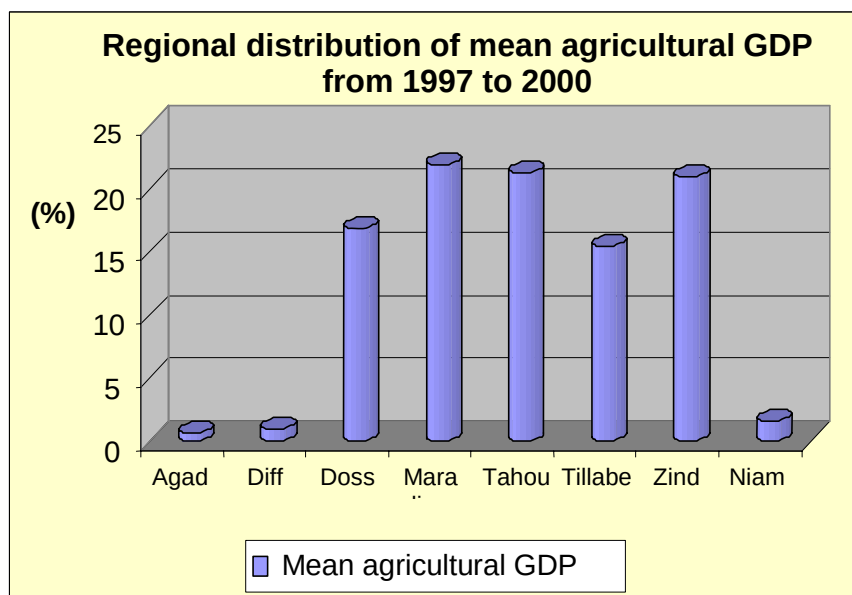
Interpretation

Regarding intra-regional analysis, agriculture is the main sector of activity for the Maradi households; indeed, it accounts for about 77% of the region's primary GDP for the period 1997-2000. It is followed by the regions of Dosso, Tahoua, Zinder, Tillabéri and Agadez, with respectively 73%, 69%, 68%, 50% and 45% (Cf. Graph N° 2).

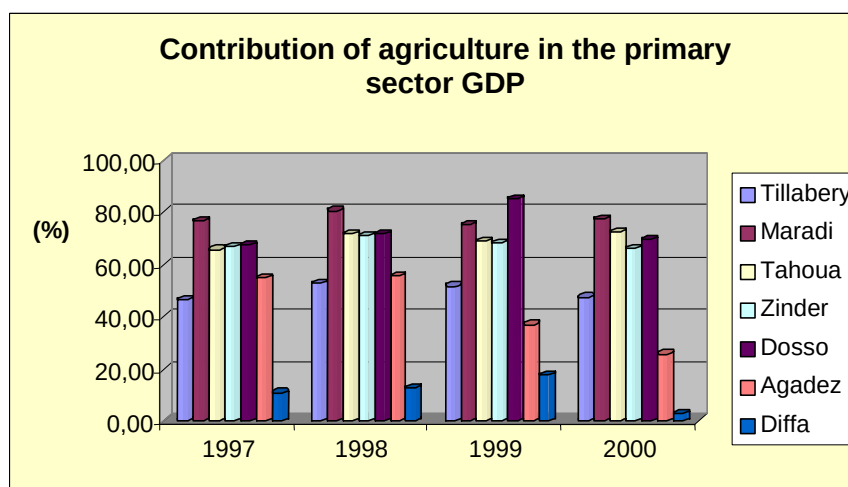
Only the region of Diffa is an exception to this rule. Indeed, in terms of contribution to the primary GDP of Diffa, agriculture—unlike what is commonly held—had hardly exceeded 20% between 1997 and 2000; besides, it reported very low thresholds for certain years (10,9% in 1997 and, worse still, 2,98% in 2000).

In view of the figures given by Graph N° 1, it emerges that, on the national level, the regions of Maradi, Tahoua and Zinder are in the lead as regards their contribution to the national agricultural GDP. They are followed by the regions of Dosso and Tillabéri. As to the other regions (Diffa, Agadez and the CU of Niamey), they constitute the weaker link in the chain. It is worth mentioning that the agricultural activities of the region of Diffa represent a very modest contribution of less than 1% of the total national contribution in this regard.

Recommandations



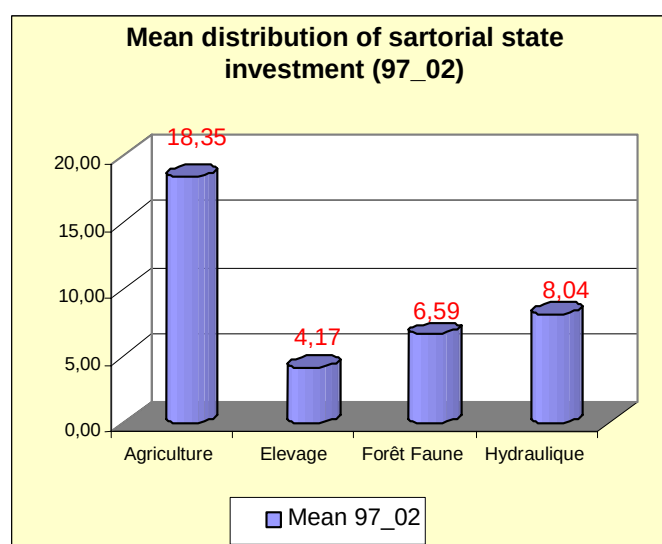
Graphic 1. Regional distribution of mean agricultural GDP from 1997 to 2000



Graphic 2. Contribution of agriculture in the primary sector GDP

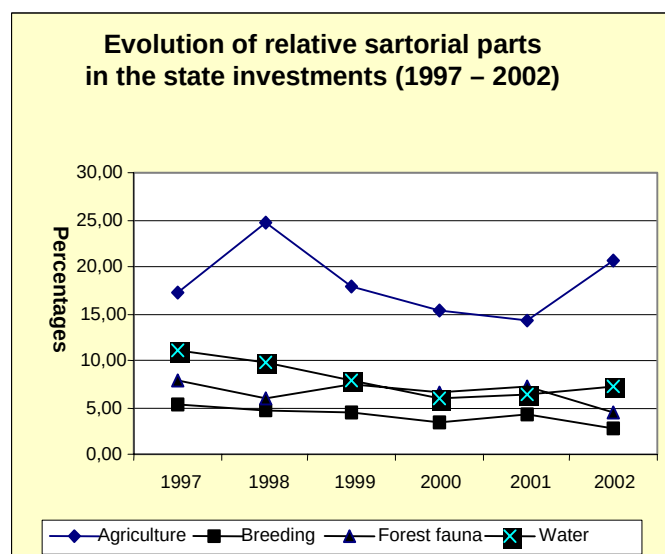
Sample 3. Portion of state investment in the NRM

Specific objective: Mitigate the impacts of drought and desertification by building the capacity of the services concerned
Type of indicator Response indicator
Interpretation Graph N° 3 reveals that, during the period 1997 - 2002, State investments in the various NRM sectors have been substantial in the agricultural sector which claimed 18,35%. The water monitoring, fauna forest, and stock-breeding received much lower investments (Cf. Graph N° 3). In the agricultural sector, investments had, on the whole, decreased continuously from 1999 to 2001. Investment efforts were, however, reported in 1998 and in 2002. The year 1998 was the year in which average investments in the sector were the highest, with about 25% of the national total (Cf. Graph N° 4). In terms of inter-regional comparison, Graph N° 1 reveals that the part of the region of Diffa in the EIB is the lowest and had hardly exceeded 5% between 1997 and 2002, except for the year 1997 only. With regard to intra-regional analyses, it is worth pointing out that there is no clear-cut trend that emerges. Investments have been up and down with no recognisable trend.
Recommendations



Graphic 3 . Mean distribution of sartorial state investment

The important point to be mentioned is the fact that with this method, M&E stopped being a cemetery of data and become a useful toll for decision making at national and local level. It is important to know that the use of this tool allowed technical experts to call public decision makers awareness on food shortage in different regions affected by locust in august and September 2004.



Graphic 4 . Evolution of relative sartorial parts in the state investment(1997-2002)

Sustainability of the mechanism

To insure the sustainability of the mechanism, a monitoring and evaluation unit has been created within the UNCCD national coordinating body (CNEDD). This unit works with relevant institutions and experts from the University, the agronomic research centre, international partners and technical ministries.

The key challenge remains: how to better benefit from the different international partners based in Niamey and from some specific networks: CILSS/AGRHMET Regional Centre, ACMAD, EAMAC, Roselt, and some new projects developed without any references to NAP/UNCCD.

In this regard, it is important for the monitoring and evaluation unit within CNEDD to develop relations and cooperation with all those institutions and networks, instead of trying to do what those institution are already doing. It is important for this unit not to produce or pay for the production of data needed to construct the required indicators.

SESSION III

*Data gathering for the development of the reference B&I
for monitoring and assessing desertification*

BENCHMARKS AND INDICATORS

DATA GATHERING FOR THE DEVELOPMENT OF THE REFERENCE BENCHMARKS AND INDICATORS

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The collection and dissemination of environmental data are of major importance in advancing knowledge on our environment. Being able to access these data quickly is indispensable in developing effective policies for fighting (combating) desertification in particular and protecting environment, in general. Further, the rational exploitation of these data requires the existence of precise documentation on methodologies adopted for data collection. The harmonisation of data collection methodologies is also a significant condition when making diachronic and comparative synchronic studies. The development of indicators and benchmarks needed to evaluate the impact of combating (fighting) desertification is very often held back by the problem of the availability and/or disparity of data and useful information. The majority of the studies on this subject underline the crucial requirements in this field.

Defining indicators to support decision-making is essential to identify, and hence be able to product the necessary data, and to define methodologies for their collection, treatment and storage. There are several technical difficulties related to gathering data needed to identify these indicators: scale, precision, validity... Similarly, one often notes that data from different sources are not always comparable. Harmonisation is needed to avoid problems of data coherence and comparability.

Harmonisation of definitions and nomenclatures, training, and development of databases and metadata are all tools which serve to valorise data-gathering investments and to optimise their use. So, it is important to understand the data-gathering methodologies and then shift to a metalevel of information to characterise and document these data. Updating data is also relevant. The category to which the data belong, determines the frequency of their collection.

Further to the synthesis of the African report prepared by the UNCCD Secretariat, one general observation that could be made is that there is a great lack of indicators and benchmarks. For the first time, most of the countries added statistics and maps to their country profile reports. Information was requested on the biophysical and socio-economic indicators which make it possible to assess the impact of desertification on natural resources and the people living in the affected area. As far as biophysical indicators of desertification and drought are concerned, the data contained in the reports are scanty. Emphasis is mostly placed on describing the various types of land degradation and the factors involved. Careful reading of the country profiles reveals that the data supplied are of uneven value. In General, the countries have relatively good mastery of the socio-economic statistics, but most of the reports contain no quantified indications of the land degradation degrees and processes or of actual achievements.

Some biophysical indicators were not considered. Errors due to problem measurement units and other obvious errors have been noted. In terms of data sources, most country parties relied on data are issued from government ministries and earlier national reports. Several countries based their reports on data gathered from international organisations publications (UNEP, UNDP...). However, many country profiles did not mention sources of data. Considerable discrepancies exist between available data sources in many categories; this could affect the consistency and accuracy of baseline information.

During the plenum of the 3rd CRIC Session, there did not seem to be any significant progress in setting up systems devoted specifically to desertification monitoring and evaluation. Alongside the session, several side-events were organised, and many regional and international initiatives and national projects were presented that were designed to monitor or assess desertification and/or land degradation.

A mass of information, often very substantial, is available but many constraints stand in the way of progress in developing frameworks for environmental assessment, e.g. poor quantification of phenomena. Studies made by the AID-CCD project concerning the state of the use of indicators to assess and/or monitor desertification came to the same conclusion. Globally the reports highlight the following:

Several technical difficulties are related to the gathering of data required for calculating these indicators: scale of data, precision, validity. Similarly, the coherence and compatibility of data are very important; it presupposes due harmonisation of methodologies. Updating data is also relevant. The category to which the data belong determines the frequency with (at) which they are/must be collected. Last, it is important to understand the data-gathering methodology and then shift to a metalevel of information to characterise and document these data.

The question, thus, is to identify measures and strategies to make up for these shortcomings and needed to surmount difficulties that still curtail the operational implementation of decision-support tools derived from reliable indicators.

In the base of the results of various analyses, careful thought, investigations and studies carried out to understand the origin and causes of the mismatch between available information and the real needs for monitoring natural resources, we can summarise the necessary actions as follows:

- establish a 'culture' for data collection, processing and storage in the structures/bodies/organisations/administrations responsible for natural resources management. This should be one of their core responsibilities. Capacity-building and training are the first steps in developing this aimed functioning mode. Support projects for NAP implementation and for the development operators in charge of natural resources management should give special attention to these aspects;
- strive to develop observation mechanisms for use in collecting data and elaborating information that is complementary to those generally obtained from administrations producing national environmental statistics and that is needed/indispensable for monitoring natural resources;
- networks of local observatories for the periodical collection of ecological and socio-economic data needed to monitor the functioning and dynamics of the natural resources/concerned population interfaces;
- systems for monitoring the vegetal covers, the state of the soils and the land use and land cover through observations taken from space data (remote sensing) at different scales and different time intervals.
- establish mechanisms for circulating information generated by various partners producing data with added value in desertification monitoring. The Implementation of information circulation systems, furthermore, will break the isolation (institutional partition?) of institutions. This problem has been identified as the main obstacle to the production of relevant information based on data collected from different sources.
- provide support for the National Coordinating Bodies (NCBs) so that they can play their role as federating framework and in developing synergy in the data collecting and circulating processes and in the production of decision-support tools.

With support from development cooperation projects, certain NCBs in countries in

Annex IV, that are members of OSS, have launched an instructive process for implementing NAP monitoring-evaluation mechanisms.

Tunisian five years Social and Economic Development Plans are drawn up to coincide with sectoral strategies (10-year strategies). These plans are broken down into annual activity programmes. Indicators and analyses of the annual monitoring results are used in preparing dashboards which, in turn, are used to revise/improve the next plan and so on. Yearly monitoring data contribute to the elaboration of the global 5-year assessment that is useful in defining the following economic and social development plan.

For each activity, the monitoring exercise uses parametric indicators that cover all kinds of planning and development actions:

- Physical,
- Biological,
- Socio-economic,
- Institutional,
- Support and accompaniment.

Data are collected by the same technicians in charge of the realisation of combating desertification activities (self-evaluation), and the results are discussed by all the stakeholders in the framework of sub-national workshops. The example of Morocco is quite different. Monitoring-evaluation of the Moroccan NAP is based on the available data, and a list of indicators was defined. It does not include specific indicators of desertification.

An information circulation system was developed to share these indicators and other relevant data at national level, and an approach to aggregate these indicators on seven main thematics was tested and adopted..

At the national level in Niger, the NAP monitoring-evaluation mechanism uses data collected through development projects. A dashboard based on relevant indicators for this level has been produced. Concerning observations at the local level, the ROSELT (Long-term ecological monitoring observatories network) experience is the most significant in the OSS zone. There are two types of achievements:

- methodological: standardised/labelled mechanisms for collecting data concerning ecosystems have been developed. Basic methodology documents have been drawn up and published to serve as guides and references in all phases of establishing the network of observatories;
- institutional: which related to the first phase in establishing nationally accepted/adopted mechanisms for producing data on the evolution of natural resources at the local level.

Besides these accomplishments, ROSELT has been working on capacity building for national institutions which are responsible of the observatories network implementation.. The training sessions and workshops that were organised as part of this effort also attracted the senior and technical staff from national institutions that especially focus on natural resources management and combating desertification. After the regional network establishment and methodology development phase, ROSELT/OSS entered the second phase during which it assists the countries establishing national environmental monitoring mechanisms as essential component of the NAP/CD monitoring-evaluation mechanism. Tunisia, using ROSELT achievements, is now developing a *sustainable development observatory for the arid zones* (OZADD – Observatoire des Zones Arides pour le Développement Durable).

Yet, in general, experiences in developing data collection and useful information formulation mechanisms are still in the demonstration stage. Pronounced support for the concept and mastery of the technical tools have not been followed by the commitments

and the institutional decisions needed for their uptake and operationalisation. Certain success stories whose results are beginning to spread in a few countries confirm the fact that establishing such mechanisms is a long-term undertaking that has to accommodate both the scientific and technical aspects and the institutional and organisational ones.

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- ICCD/CRIC(3)/2/Add.1 : Synthesis and Preliminary Analysis of Information Contained in Reports Submitted by Affected African Country Parties
- Synthesis of AID-CCD reports

THE ROSELT/OSS EXPERIENCE IN DATA GATHERING FROM LOCAL TO REGIONAL LEVEL

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Abstract

In Africa, intense and recurrent droughts that occurred in the mid 1960s have highlighted the ecosystems vulnerability and their serious consequences on human well-being. Scientific community pointed out the need for reliable and precise environmental data to monitor long term changes and to ensure sustainable development. However, environmental monitoring was difficult due to the absence or the lack of necessary data to elaborate and update the information. These data and information, whenever they exist, are often unconnected and either not shared, or insufficiently shared, with other institutions. Thus, in the frame of the international mobilisation towards sustainable development and environmental protection (Earth Summit, Rio de Janeiro, june 1992), the Sahara and Sahel Observatory designed the ROSELT (Long-term Ecological Monitoring Observatories Network) programme during a joint meeting between OSS, IGBP and UNESCO in 1992 (Fontainebleau, France). This programme was concretely launched in 1994 in Rabat (Morocco) and the first phase was focussed on the concept's development (ROSELT/OSS 1995) and the observatories choice through a labellization process. Twenty-five observatories or cluster of observatories, at local scale, distributed in eleven countries of Northern Africa, Western Africa and Eastern Africa, have been identified. Twelve among them have been selected as pilot-observatories to serve as a basis for refining the concept and finalising the harmonised data collection and processing techniques and methodologies. Managed by African team themselves, ROSELT/OSS is the first African network on environmental monitoring which aims:

- to enhance the state of knowledge about the effects, causes, consequences, mechanisms and scope of desertification around the circum-Saharan zone;
- to monitor the state and long term evolution of ecological systems and their resources;
- to understand the ecological systems functioning and the interactive effects between human populations and their environment, particularly with a view to identifying the respective part and/or synergy between climate change and land degradation human causes.

Since 1998, these objectives are achieved thanks to the implementation of coordinate and multidisciplinary work on the field, in a long-term perspective, characterised by integrated environmental approaches through a systematic observations design of the biophysical and socio-economic features. The activities focus on environmental monitoring, analysis, interpretation and synthesis of information, development of products and tools to help decision-making, at local and regional scales. In spite of the difficulties encountered (synergy between national institutions, multi-disciplinary and inter-disciplinary approach...), some important results have been obtained: diachronic studies using previous and actual data, synchronic studies characterizing the variations in the space of a given factor such as plant cover or sand encroachment, development of local and regional metadata bases to disseminate the useful environmental information, setting up of Local Environmental Information System, development of relevant indicators on a local or regional scale, development of prospective simulations... The

work done allowed defining "a minimum data set" to collect at the lowest cost in order to ensure the long-term monitoring. This phase aims also to encourage the insertion of the ROSELT/OSS observatories in the national and regional monitoring-evaluation devices of the National Action Programmes to Combat Desertification. Thus, the ROSELT/OSS observatories must constitute the "core" of the reference sites for the studies and research concerning the implementation, in the circum-Saharan zone, of the post-Rio Convention on environmental issues (combat desertification, biodiversity and climatic changes). Particularly, ROSELT/OSS provides useful information for the UNCCD implementation that called for reliable and detailed data on the condition and evolution of arid zones, particularly in Africa where desertification and land degradation processes are the strongest.

Keywords: observatories, ecological monitoring, desertification.

1. Context and origin of the concept of long term ecological monitoring

Following the intense and recurrent droughts that had prevailed in sub-Saharan Africa in the mid-1960s, political awareness and the mobilisation of the scientific community toward checking the desertification processes and mitigating drought effects have brought about the need to monitor and evaluate the natural resources in order to ensure their sustainable management. Several studies and research works on droughts and aridity, as well as on their ecological implications (soil degradation, desertification) and socio-economic impacts (migration, rural exodus, pauperisation) were conducted. This period was characterised by the adoption of the action plan to combat desertification which was developed during the United Nations Conference on Desertification (Nairobi, Kenya, August/September 1977) and the entry into force in 1994 of the United Nations Convention to Combat Desertification (UNCCD). This convention—a strategy in its own right—strongly emphasises the development of scientific and technical cooperation among the relevant institutions at national, sub-regional, regional and international level.

Despite the international efforts, many challenges had to be solved in order to make possible an efficient environmental monitoring. Available data and products for environmental monitoring are of unequal performance levels and with several shortcomings: numerous sources of data; non availability of data (propriety rights); absence of necessary data and long term data series to elaborate and update the information; disparate data and inadequate basic and thematic maps, lack of certain statistical data and of standardisation (formats, quality) of available information and finally a lack of knowledge of the dynamics of agro-sylvo-pastoral production systems, of the distribution and evolution of the population and economic activities. Finally, local and regional scales miss indicators and benchmarks. These data and informations, whenever they exist, are often unconnected and either not shared, or insufficiently shared, with other institutions. Moreover, the difficulty to adopt a multi-disciplinary and inter-disciplinary must be underlined. Finally, in order to share useful knowledge for decision making, environmental information systems, data and metadata bases must be developed from local to regional scale.

In this context and based on the conclusions and recommendations of a workshop organised jointly with UNESCO and the International Geosphere-Biosphere Programme (IGBP) in July 1992 in Fontainebleau (France) on continuous monitoring of terrestrial ecosystems, OSS proposed the set up of a Long Term Ecological Monitoring Observatories Network (ROSELT/OSS) whose objective would be to better understand the causes and effects of desertification in the circum-Saharan African region.

This initiative constitutes a response to the need expressed by the Southern member countries to access reliable data on the state of the environment, and more particularly in circum-Saharan arid and semi-arid zones that are severely hit and/or endangered by desertification. All institutions working in the framework of UNCCD are involved in this programme, and particularly, the sub-regional organisations (CILSS, UMA, IGAD...), research institutions, universities, development institutions, National Coordination Body of NAP/CD...

2. ROSELT/OSS and its objectives

The key objectives of ROSELT/OSS in the field of environmental monitoring and research relate to:

- improving knowledge of the mechanisms, causes, consequences and scope of desertification;
- monitoring of the state and long term evolution of the ecological systems and of the resources that they contain;
- understanding the functioning of these systems and the interactive effects between the populations and their environment at local level, particularly with a view to identifying the respective and/or synergetic part of the climatic causes (climate change) and human causes of land degradation.

The objectives of ROSELT/OSS in the field of support for development are :

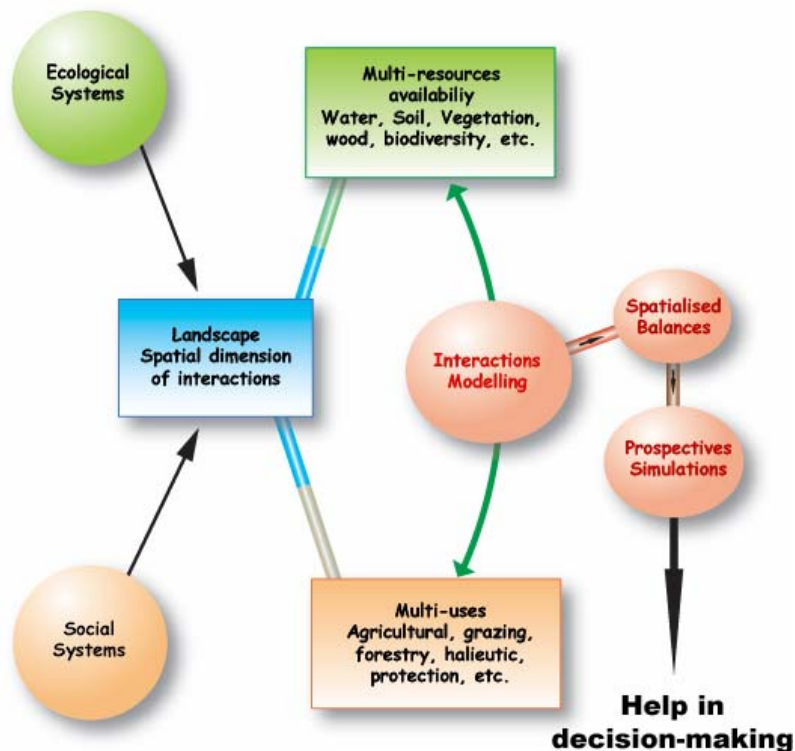
- to provide reliable and useful decision-making products;
- to develop training in the use of environmental data and information in development plans and projects.

3. The network of observatories and its methodology to collect and process environmental data

Between 1992 and 1994, the inventory of Potential Candidate Territories (TCP)—which had been conducted by the African countries—allowed an ad hoc Scientific Committee to select 25 observatories or observatory clusters, distributed over 11 countries. Among these 25 ROSELT/OSS observatories, 12 were further selected as pilot-observatories, intended to serve—within a first phase—as a basis:

- to harmonise the scientific methodologies using an inter-disciplinary approach (ROSELT/OSS, 1995) about environmental themes and issues related to Agenda 21 and the international Conventions on Climate, Biodiversity and particularly Desertification through:
 - the establishment of long term field measurements through harmonised sampling methods and data collection,
 - the development of a minimum data set to be collected at lower cost, and which would allow the spatialisation of data, their possible extrapolation to larger zones and their integration within models of use of both space and resources,
 - the development of relevant and reliable indicators,
 - the common methods of information collection, processing and dissemination,
- to exchange and share information between observatories and countries and to establish links between researchers and decision makers,
- to promote research actions focused on selected themes designed to better understand desertification processes.

A comprehensive conceptual frame (ROSELT/OSS 2001, ROSELT/OSS, 2004a) for the study of environmental changes within the ROSELT/OSS was developed (Figure 2).



Source: ROSELT/OSS 2004b

Figure 2: Conceptual model for understanding the mechanisms, causes and impacts of desertification and for assistance in decision making

Actually, this method is applied in all the observatories to integrate in the analyse both biophysical and socio-economic data and to study the impact of uses on the natural resources in order to develop products that help in decision making, such as reliable data on soil degradation in arid zones, biophysical and socio-economic indicators, state of the environment of the OSS region, spatialised resources/uses balances, prospective scenarios using a Local Environmental Information System LEIS-ROSELT/OSS (Loireau 1998).

The long term functioning of ROSELT/OSS is possible thanks to the integration of ROSELT/OSS in the national policies (NAP/CD), the strengthening of capacity building and training and the development of National Environmental Monitoring Device.

4. Methodological tools and information circulation products

In order to make useful knowledge and information for decision makers, the network elaborates numerous tools and products as follows:

- the previous achievements : development of reference states through thematic maps, such as « land use » maps, and « physical features » maps (pedology, geomorphology...),
- the scientific and technical documents which are gradually issued as part of the « ROSELT/OSS Scientific and Technical Collection », such as the methodological guidebook and its thematic leaflets (including Vegetation, Socio-economic Features, Fauna...), the national scientific and technical reports, the charter on the management and the dissemination of the data and products within ROSELT/OSS...,
- the information processing and circulation systems in order to evaluate the impact of human activities on the environment (Local Environmental Information System

LIES-ROSELT/OSS) and to share information within the network (metadata bases MDweb, web site, etc.),

- decision-making and support products for the implementation of sustainable development strategies and plans (indicators of environmental changes at local and regional levels, diagnosis, spatialised balances between resources availability and resources extraction, prospective scenarios, maps, observatories scientific reports and thematic syntheses, etc.).

To conclude, the experience developed in the network can be duplicated to implement National Environmental Monitoring Device based on the periodic collection of the ROSELT/OSS minimum data set and the periodic development of indicators. All ROSELT/OSS data and products supply the Monitoring – Evaluation National Devices of NAP/CD.

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INDICATOR SYSTEM ON DESERTIFICATION IN CHILE

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Abstract

Chile ratified in 1997 the United Nations Convention to Combat Desertification (UNCCD). The National Action Programme to Combat Desertification and Drought in Chile (PANCCD-Chile) has been implemented since this year.

Development of Indicator Systems on Desertification has been a constituent part of the PANCCD-Chile's activities. The objective of these systems is monitoring land degradation and effectiveness of measures to reverse desertification processes.

Chile is implementing its National System for Monitoring Land Degradation. In this scope, the sub-systems listed below have been developed for management of information concerned with indicators of desertification.

- REDATAM System. The Economic Commission for Latin America and the Caribbean (CEPAL) developed this computational system. Multiple national and sub-regional application on desertification indicators received support from the German Agency for International Cooperation (GTZ), Inter-American Development Bank (IDB), and the Inter-American Institute for Cooperation in Agriculture (IICA);
- MONITOR System. University of Chile developed this computational system with support from The Global Environment Facility (GEF), IDB and the Inter-American Development Bank (IDB), and;
- National Monitoring System on Land Use. The National Forestry Commission of the Ministry of Agriculture of Chile (CONAF) developed this national geographic information system at scale 1:50.000, which is updated every five years. The World Bank supported the implementation of this national system.

The "Preliminary Map of Desertification in Chile" has been a practical application of national and regional indicators of desertification. This national map was published by CONAF in 1999 (<http://www.sinia.cl/mapas/>).

Also, a full set of national and regional indicators on socio-economic impact of desertification has been established for the whole country since 2003 (<http://www.eclac.cl/ddpe/desertificacion/DesertChile1/index.html>).

Local indicators have been developed in rural communities of the IVth Region, the most affected area by desertification in Chile. Local indicators have been developed by using MONITOR system for management of information retrieved by Expert Protocols during field works. In addition, indicator systems contributed to characterise the eight hotspots of desertification and drought in Chile: Norte Chico; Puna; Atacama Desert; Secano Area; Pre-Cordillera; Araucanía; Austral Patagonia and; Oceanic Small Islands, such as Easter Island, Robinson Crusoe Island, Juan Fernandez Archipelago, among others.

Finally, the indicator systems on desertification contributed to the selection of pilot areas of the GEF/World Bank/FAO Project on Desertification in Chile (GEF N°2182: Chile: Sustainable Land Management Project).

The next chapters describe the results obtained on monitoring desertification in Chile.

1. Milestones for Developing Indicators on Desertification in Chile

The PANCCD-Chile defined procedures to develop indicators to assess Desertification in Chile. This has been a participatory process, and also it has been an inter-disciplinary, educative and interactive process. The steps in this process may be summarised as follows:

- Agreement on a common conceptual basis about desertification processes,
- Identification of factors, variables, and parameters describing this phenomena,
- Development of models to analyse interaction among factors,
- Development of computational systems for appropriate management of information on indicators.

A Land Degradation Monitoring National System is the aim to be get through successive steps. Relevant indicators have been calibrated to describe adequately desertification processes. Expert Protocols have been developed supporting fieldwork for characterisation of desertification.

Focus indicators on desertification have been set in an iterative process. Thus, successive steps have been carried out for conceptualisation, selection, developments of Expert Protocols for field recognition, calibration and validation. A similar process has been carried out in many countries of Latin America and the Caribbean.

The implementation of a National System for Monitoring of Land Degradation (NSMLD) is the final aim of this development of indicators. NSMLD will be a solid basis to achieve sustainable development on areas affected by desertification and drought in the country.

A conceptual basis agreed by national organisations defined a common language for a national system of indicators on desertification. The conceptualisation defines 3 main domains for desertification phenomena, and 5 main factors, then a number of variables and parameters for a full description of desertification processes along the country. Domains and factors are listed below.

- Natural Domain of Desertification:
 - Indicators for physical environment
 - Indicators for biological environment
- Social Domain of Desertification:
 - Indicators for biologic needs for human development
 - Indicators for social and cultural needs for human development
- Human Domain of Desertification:
 - Indicators of demography.

This conceptualisation summarises a comprehensive set of constituent elements and its interactions and relationships that fully describe desertification phenomena. Consequently, a set of models have been developed for analysis and interpretation of different phenomena associated with desertification processes. The most successful models developed are listed below.

- Multi-scale models for land use and desertification (GEM; MODAP).
- Models on climatic variability and primary production in arid zones (SIMPROC).
- Model for spatial distribution of vegetal communities in arid ecosystems (COBER).
- Model for load capacity on grasslands in arid zones (CAPAS).
- Hydrological and environmental model, physically-based and spatially distributed (SHETRAN).
- Model of Desertification dynamics (EIMS)
- Monitoring system of Desertification through remote sensing (SIM-SIP-MULTIR).

Sensitivity analysis of parameters and variables was a result from model development on components and processes of Desertification. Thus, since 1994, Chile implemented indicators on Desertification at national level from a perspective of regional scale.

Specialists in Argentina, Bolivia, Brasil, Chile and Perú defined the indicators at a regional scale. A set of indicators were agreed following the Organisation for Economic Co-operation and Development (OECD) approach on State-Pressure-Response model, also known in Latin America as the model Problem-Causes-Solutions. Chile has taken in account this set as primary basis for developments on national indicators on desertification. The components of the model State-Pressure-Response are summarised below.

- State: current state of the environment.
- Pressure: use pressure of human activities on natural environment.
- Response: actions from human society to improve current stat of natural environment.

Regional indicators on desertification adopted by Chile are listed as following.

Physical Indicators	Regional	Component E-P-R (State-Pressure-Response)	Regional agreement (% countries)
Soil losses		State	100
Soil salinization		State	100
Fertility		State	100
Albedo		State	100
Organic matter		State	100
Run-off		State	80
Depth of phreatic surface		State	80
Suspended sediments		State	80
Temperature and rainfall indexes		State	80
Water salinization		State	60
Soil contamination		State	60
Water bodies volume		State	60
Rainfall trend		State	40
Soil compaction		State	40
Glacier melting		State	40
Water contamination		State	40

Biological Indicators	Regional	Component E-P-R (State-Pressure-Response)	Regional agreement (% countries)
Biodiversity		State	100
Vegetation profile		State	100
Bio-mass		State	100
Primary productivity		State	80
Vegetation cover		State-Response	80
Indicator species		State-Response	60
Resilience		State	40
Animal capacity load		Pressure	40
Animal productivity		State-Response	40

Crop production	State-Response	40
Changes in feeding relationships	State-Pressure-Response	40
Seed storage in soils	State	40

Human Domain Regional Indicator	Component E-P-R (State-Pressure-Response)	Regional agreement (% countries)
Poverty	State	100
Income	State	100
Out-Migration	Response	100
Population in awareness on desertification issues	Response	80
Children mortality index	State	80
Masculinity index	State	80
Agriculture income / Total income	Pressure	80
Population / crop area	Pressure	60
Children morbidity	State	60
Age structure	Response	60
Illiteracy	State	60
Access to basic services	State	60
Self-consumption / Total consumption	Response	60
Bad-nutrition	Response	40
Participation in decision processes	Response	40
Policies on desertification control	Response	40
Appropriate technology	Response	40

Local indicators have been focused in the IVth Región of Coquimbo in the northern part of the country. His region is the icon of Desertification in Chile, and it is the current border between the hyper-arid zone and the arid zone.

Thus, variables, parameters, measure units and indicative parameters were defined for appropriate description of desertification at local scale. Indicative parameters were used as listed below.

- Quantity
- Intensity
- Worth
- Presence
- Trend
- Quality

In a first step, it was defined a set of 34 variables with its parameters. Physical and Biological indicators are described in a detailed manner. In contrast, indicator for social and human domains were summarised concisely.

2. Indicator of physic environment.

Soil erosion

Variable: Soil erosion				
Value	Value	Indicative Variable	Códe	Índex
Affected area (%)	Loss of soil (ton ha ⁻¹ year ⁻¹)	Intensity		
> 60%	>30	Very severe	VS	1
50-60	25-30	Severe	S	2
40-50	20-25	Moderately severe	mS	3
30-40	15-20	Moderate	a	4
20-30	10-15	Moderately slight	mL	5
10-20	5-10	Slight	L	6
<10	<5	Very slight	VL	7

Soil compaction

Variable: Soil compaction			
Value	Indicative Variable	Códe	Índex
Áffected area(%)	Intensity		
> 60%	Very severe	VS	1
50-60	Severe	S	2
40-50	Moderately severe	MS	3
30-40	Moderate	A	4
20-30	Moderately slight	ML	5
10-20	Slight	L	6
<10	Very slight	VL	7

Organic matter

Variable: Organic matter				
Value	Value	Indicative Variable	Code	Índex
Content M.O. (%)	Reduction of M.O. (%)	Quality		
< 0.5	<20	Very low	VL	1
0.5-1.0	20-30	Low	L	2
1.0-2.0	30-45	Moderately low	mL	3
2.0-4.0	45-65	Moderate	A	4
4.0-5.0	65-80	Moderately high	MH	5
5.0-6.0	80-90	High	H	6
> 6.0	>90	Very high	VH	7

Water retention capacity in soils

Variable: Water retention capacity in soil			
Value	Indicative Variable	Code	Index
Retention capacity (mm)	Quality		
< 25	Very low	VL	1
25-50	Low	L	2
50-100	Moderately low	mL	3
100-150	Medium	a	4
150-200	Moderately high	MH	5
200-300	High	H	6
>300	Very high	VH	7

Soil salinization

Variable: Soil salinization							
	PSI (%)						
	0-5	5-10	10-15	15-25	25-30	30-40	>40
C.E. (mmohs cm ⁻¹)							
0-4	ML	ML	L	mL	m	mF	F
4-8	ML	L	mL	m	mF	F	MF
8-12	L	ML	m	mF	F	MF	MF

Fertility

Variable: Fertility		
Indicative Variable	Code	Index
Quality		
Very low	VL	1
Low	L	2
Moderately low	mL	3
Medium	A	4
Moderately high	MH	5
High	H	6
Very high	VH	7

Suspended sediments

Variable: suspended sediments			
Value	Indicative Variable	Code	Index
Retention capacity(mm)	Abundance		
< 25	Very abundant	VA	1
25-50	Abundant	A	2
50-100	Moderately abundant	mA	3
100-150	Medium	A	4
150-200	Moderately scarce	MS	5
200-300	Scarce	S	6
>300	Very scarce	VS	7

Water mineralising

Variable: water mineralising							
	RAS (%)						
	0-8	8-14	14-19	19-23	23-26	26-28	>28
C.E. (ummoths cm ⁻¹)							
0-4	ML	ML	L	mL	m	mF	F
4-8	ML	L	mL	m	mF	F	MF
8-12	L	ML	m	mF	F	MF	MF

Water surface depth

Variable: Change in phreatic surface water		
Indicative Variable:	Code	Index
Trend		
Strong depletion	SD	1
Moderately depletion	mD	2
Slight depletion	LD	3
Without change	O	4
Slight increase in depth	LI	5
Moderate increase in depth	mI	6
Strong increase in depth	SI	7

Rainfall changes

Variable: Rainfall changes			
Value	Indicative Variable:	Code	Index
Rainfall changes (%)	Trend		
<- 30	Strong decrease	SD	1
-30 a -20	Moderate decrease	mD	2
-20 a -10	Slight decrease	LD	3
-10 a +10	Without change	O	4
+10 a +20	Slight increase	LI	5
+20 a +30	Moderate increase	mI	6
> +30	Strong increase	SI	7

Land use

Variable: Land use			
Value	Variable indicativa	Code	Index
Retention capacity (mm)	Quality		
< 5	Very low	VL	1
5-10	Low	L	2
10-25	Moderately low	mL	3
25-50	Medium	a	4
50-75	Moderately high	MH	5
75-90	High	H	6
>90	Very high	VH	7

Indicator species

Variable: Desertification indicator species			
Value	Indicative Variable	Code	Index
Indicator species (%)	Abundance		
>60	Very abundant	VA	1
40-60	Abundant	A	2
30-40	Moderately abundant	mA	3
20-30	Medium	A	4

10-20	Moderately scarce	MS	5
5-10	Scarce	S	6
<10	Very scarce	VS	7

Flora diversity

Variable: Flora diversity			
Value	Indicative Variable	Code	Index
N° species / 90% cover	Diversity		
1	Very poor	VP	1
2-3	Poor	P	2
4-6	Moderately poor	mP	3
7-8	Medium	a	4
9-10	Moderately rich	mR	5
11-12	Rich	R	6
>12	Very rich	VR	7

Resilience

Variable: Resilience of arid ecosystems			
Value	Indicative Variable	Code	Index
Restoration time back to the original state (years)	Resilience		
>50	Very poor	VP	1
30-50	Poor	P	2
20-30	Moderately poor	mP	3
15-20	Medium	a	4
10-15	Moderately good	mR	5
5-10	Good	R	6
<5	Very good	VR	7

Seed storage in soils

Variable: Seed storage in soils							
	Seeds cm ⁻²						
	0-0.5	0.5-1.0	1.0-3.0	3.0-8.0	8.0-15.0	15.0-25.0	>25.0
Appropriate species (%)							
0-32	VP	V	P	mP	m	mR	R
33-66	VP	P	mP	m	mR	R	MR
67-100	P	mP	m	mR	R	MR	MR

Volume of wood material in vegetation

Variable: Phyto-volume			
Value	Indicative Variable	Code	Index
Ratio Phyto-volume Maximum Phyto-volume	Quantity		
<0.06	Very low	VL	1
0.06-0.11	Low	L	2
0.11-0.28	Moderately low	mL	3
0.28-0.55	Medium	a	4

0.55-0.83	Moderately high	MH	5
0.83-1.00	High	H	6
>1.00	Very high	VH	7

Primary production

Variable: Primary production			
Value	Indicative Variable	Code	Index
Productivity (kg M.S. ha ⁻¹ año ⁻¹ mm ⁻¹)	Quantity		
<0.06	Very low	VL	1
0.06-0.11	Low	L	2
0.11-0.28	Moderately low	ML	3
0.28-0.55	Medium	A	4
0.55-0.83	Moderately high	MH	5
0.83-1.00	High	H	6
>1.00	Very high	VH	7

Reduction in crop yield

Variable: Crop Yield			
Value	Indicative variable	Code	Index
Change in crop yield wrt. potential crop yield (%)	Quantity		
> 60	Very sharp	VL	1
50-60	Sharp	L	2
40-50	Moderately sharp	ML	3
30-40	Medium	A	4
20-30	Moderately slight	MH	5
10-20	Slight	H	6
<10	Very slight	VH	7

Sustainable animal load capacity

Variable: Sustainable animal load capacity			
Value	Indicative variable	Code	Index
Load capacity (ha U.C.C. ⁻¹ year ⁻¹)	Quantity		
>20	Very low	VL	1
10-20	Low	L	2
5-10	Moderately low	ML	3
2-5	Medium	A	4
0.67-2	Moderately high	MH	5
0.33-0.67	High	H	6
<0.33	Very high	VH	7

A list of regional indicators for human and social domain of desertification is presented as following.

N°	Regional Indicator	Value	Indicative Value
20	Rate for children mortality	Mortality (%/00)	Quantity
21	Nutrition	Indicative descriptor (class)	Quality
22	Quality of life	Indicative descriptor	Quality

		(class)	
23	Activity index (unemployment)	Employment index (0-100%)	Quantity
24	Education	Education (years)	Quantity
25	Illiteracy	Illiteracy (%)	Quantity
26	Poverty	Population (%)	Quantity
27	Un-equity	Un-equity index (ratio)	Intensity
28	Awareness of desertification	Population (%)	Degree
29	Modernity	Indicative descriptor (class)	Quality
30	Participation	Indicative descriptor (class)	Quality
31	Human pressure on ecosystems	Indicative descriptor (class)	Quality
32	Dependence index	Coefficient (0-100)	Quantity
33	Masculinity	Masculinity index (ratio)	Quantity
34	Rate of population growth	Relative rate	Trend

Identification process for indicators on desertification in Chile is considered as concluded. Thus, Chile faces a new step to fulfil all required information at national and local level. There are a significant success in calibration and validation of the adopted indicators. Specially, it is considered a main success all different developments on operative systems for direct use of indicators by communities, institutions and authorities concerned with desertification and drought in Chile.

Information systems for desertification analysis and monitoring are other results based on previous development of models for desertification processes. There are a number of computational tools for management of information on the critical areas affected by desertification in the country.

MONITOR is the most advanced system of this type. AGRIMED, the Agriculture and Environment Centre of the University of Chile developed MONITOR since 1996, with support from IBM, GEF, PNUD and other organisations associated with the National Action Programme to Combat Desertification in Chile (PANCCD-Chile).

A significant number of workshops have been carried out on training for MONITOR concerning communities, institutions and authorities. International workshops held in different countries of Latin America have been carried out. MONITOR can supply demand from all countries in the region of Latin America and the Caribbean for management of information on indicators of desertification.

REDATAM is another special system used in Chile for handling social and economic data. Based on REDATAM, a full set of indicators has been determined "on line" for social and economic impacts of desertification in Chile.

Also, a National System for Monitoring of Land Use (Ex-Native Forest National Survey) has been developed since 1994 at the National Forestry Commission (CONAF), the UNCCD's National Coordinating Body in Chile. The national coverage of this information scale 1:50.000 is free access through Internet. Most of the physical and biological indicators on desertification in Chile are determined by using the information provided by this national system.

As a proposal, a National Monitoring System for Land Degradation has been proposed in the framework of a GEF project to combat desertification and drought in Chile. This national system will nest all information systems developed for managing data on status, dynamic and impacts of desertification and drought, as well all actions to combat these processes. National capabilities allow the UNCCD's National Focal Point to participate in most of the regional projects on indicators on desertification for Latin America and the Caribbean. GTZ, CEPAL, BID, IICA, UNCCD's Executive Secretariat

and Global Mechanism have been the most prominent organisations supporting indicators development in the region. Brazil, Chile and Mexico, then Argentina, Brazil and Chile, and recently Argentina, Brazil, Bolivia, Chile, Ecuador and Peru have been the group of countries in the region involved in technical cooperation with international funding involved in projects concerned with indicators on desertification. MONITOR and REDATAM were tools used on these projects for training and capacity building. In a next step, seven countries of Central America will be supported on these capabilities with the support of the Executive Secretariat of the UNCCD. As an expected result of this process, the countries of Annex III will give full accomplishment on the request of the IUNCCD to raise indicators on desertification to assess status and dynamic of desertification and evaluation of the impacts of the actions to combat desertification. Finally, it is presented as annexes the Preliminary map of Desertification in Chile, and other information on indicators used to identify critical areas within the hotspots of desertification.

Acknowledgements

This report is based on information available at the PANCCD-Chile's National Coordinating Office. It has been highly valuable collaboration from Mr. Juan Claudio Rodriguez, Mr. Fernando Bascuñan, Ms. Veronica Oyarzun, Ms. Marie Berthier, Ms. Lorena Pavez, Ms. Paola Oyarce and Mr. Ariel Villarroel.

Also, Dr. Fernando Santibañez, Director of AGRIMED Centre and representative of Chile in the Group of Experts of the UNCCD's Science and Technology Committee-, provided most of the basic information. In addition, the group of professionals from the Economic Commission for Latin America and the Caribbean (ECLAC), Mrs. Martine Dirven, Mrs. Soledad Parada, Mr. Cesar Morales and Mr. Juan Eduardo Faundez, contributed with fundamental background.

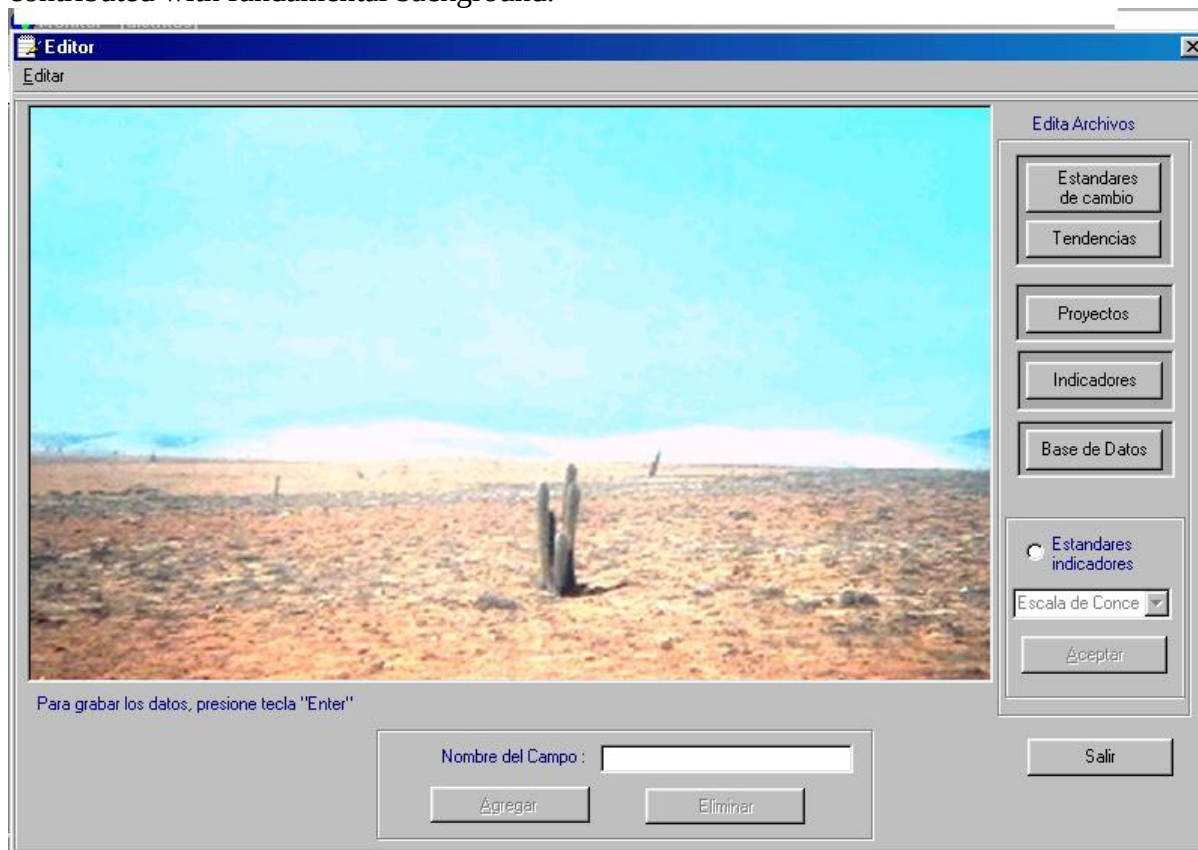


Fig. 1. Edit menu of MONITOR system.

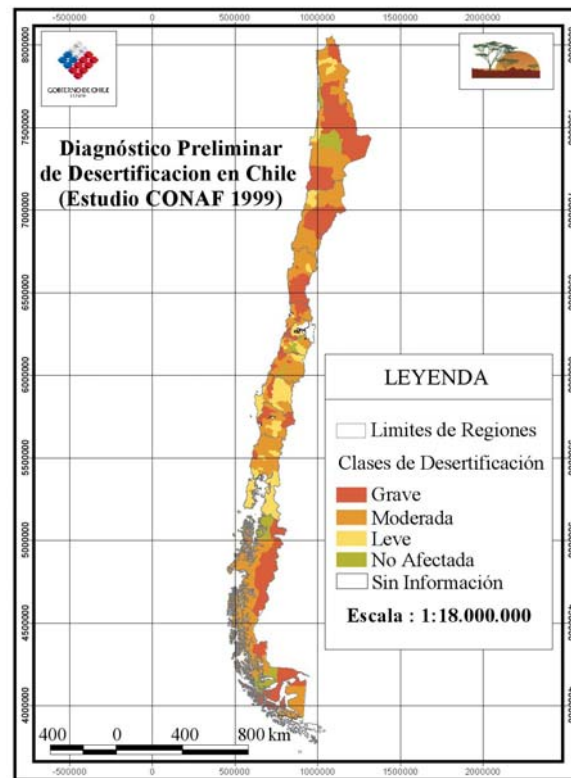


Fig. 2. Preliminary Map of Desertification in Chile.

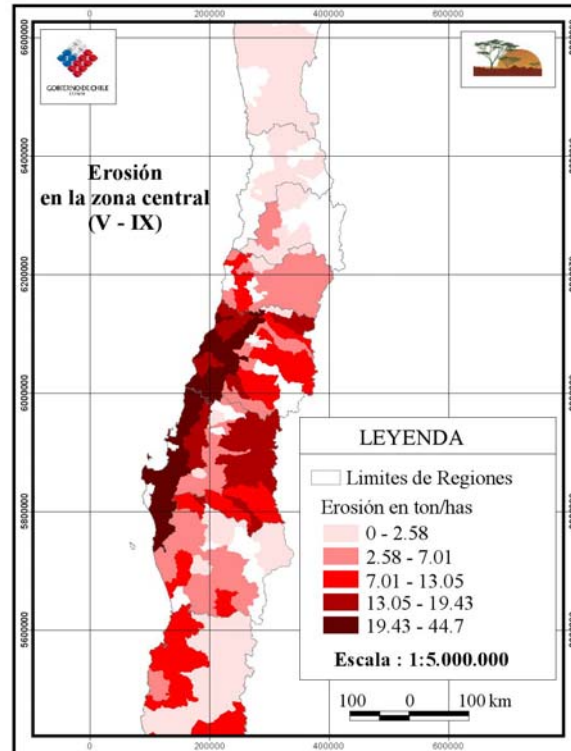


Fig. 3. Example of a national indicator for soil erosion.

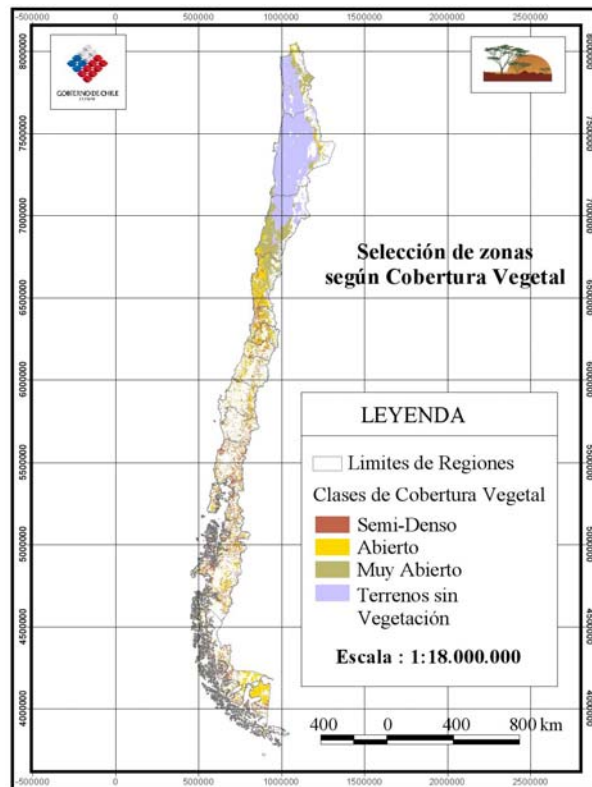


Fig. 4. Example of a national indicator in vegetation cover.

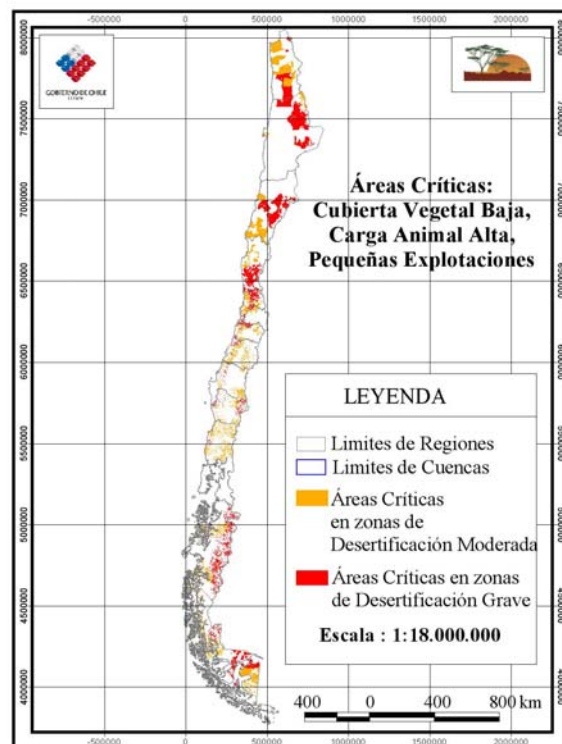


Fig. 5. Critical areas at national level determined by using indicators on desertification.

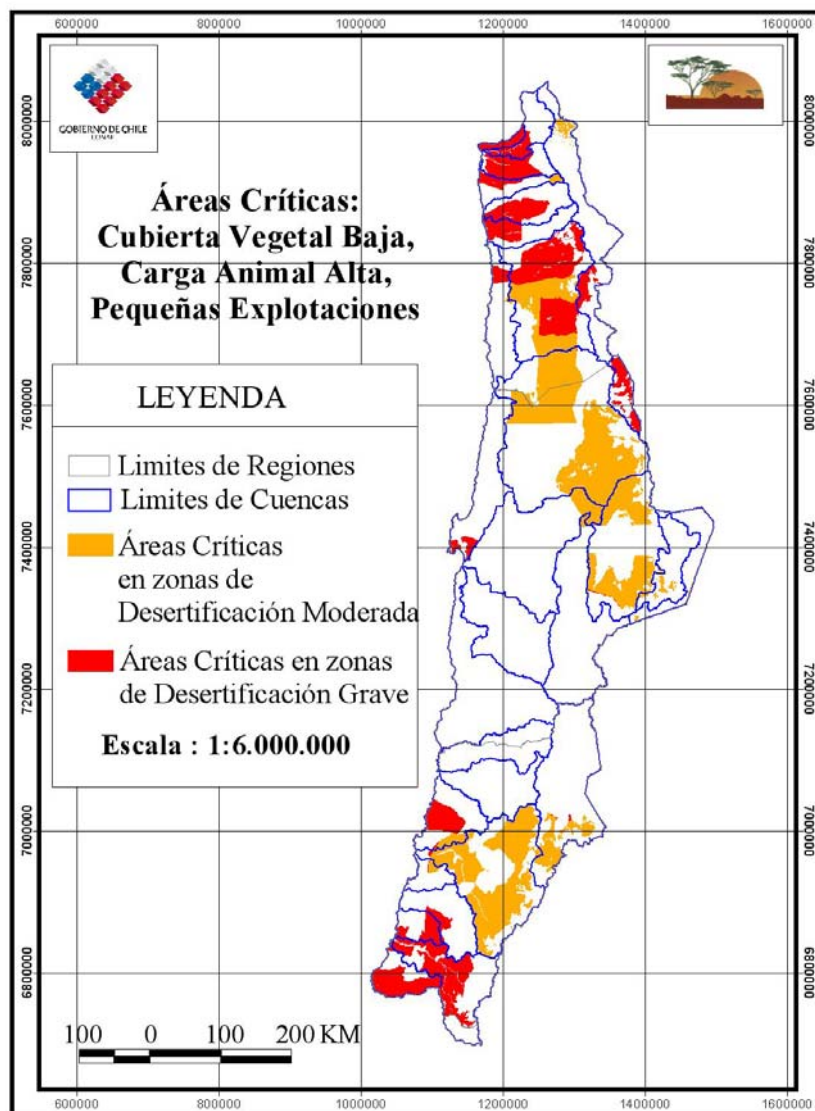


Fig. 6. Details of critical areas in the Hotspot of desertification in the American Puna of Chile.

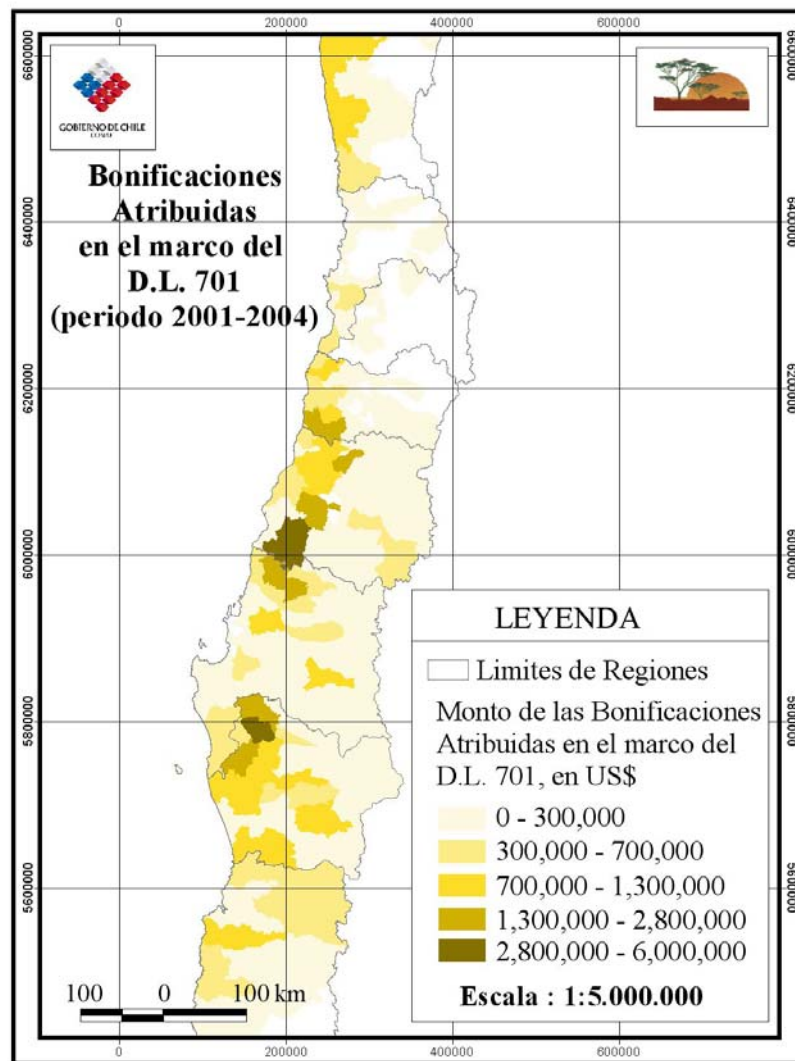


Fig. 7. Example of an economic indicator concerning with amount of funding from Chilean government to combat desertification through forestation.

DATA GATHERING FOR DEVELOPMENT OF THE REFERENCE B& I FOR MONITORING AND ASSESSING DESERTIFICATION REMOTE SENSING (RS) APPLICATIONS A USEFUL TOOL

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Abstract

This paper discussed the main issues of Remote Sensing (RS) Application in the point of view from AID-CCD. These are remote sensing (RS) as an advanced technology of desertification data collection, technical and application development of RS, aspects of RS application for desertification monitoring and assessment (M&A), and Some problems should be aware in RS application.

Key words: remote sensing (RS) application, desertification monitoring & assessment (M&A), data collection, benchmark & indicator (B&I) of desertification

Desertification has resulted in deteriorating environment and poor economy. It has been listed as the first of first in the ten environment and development problems of concern to man. Desertification has not only imposed threat to the surviving environment of the overall mankind, but also become an important factor in hindering global economy development and has adverse impact on social security.

1. Objectives of Desertification Monitoring and the Role of Remote Sensing

1.1 Objectives of Desertification Monitoring

Great efforts should be made in order to obtain monitoring data to provide evidence for executives and planning sectors; to assist them in making macro-decisions of combating desertification, comprehensive monitoring in arid, semi-arid and dry sub-humid areas. Among these areas, land desertification in dry sub-humid arid climatic zones where agriculture and husbandry are overlapping should be selected as the key areas for monitoring. The evidence specifically refers to existing desertification affected land area, dynamic change and future development prediction data in the whole country as well as concerned provinces/municipalities /counties.

To carry out evaluation on areas affected by desertification for sustainable development of resource and environment.

To provide monitoring data in areas specified by the definition of UNCCD and promote exchange of domestic and international data; to share cooperation channel;

1.2 The Role of Remote Sensing in Desertification Monitoring

Remote sensing is the high space technology of observation, data collecting and information processing. Featured by its capacity in the fields of wide range, short cycle and large quantity of data, remote sensing is a must condition for desertification monitoring. It plays a very important role in desertification monitoring which is conducted in a vast region at periodical intervals. Remote sensing image data not only record various information from terrain in digital form and can be produced easily by computer, but also has space position and continuous distribution which shows terrain situation in a form of map, so as to help to understand natural world objectively and exactly, analyze and solve a variety of problems of natural resources and environment

that man is facing with.

The primitive data from remote sensing can produce images for the use of different purposes through a series of image processing. These images are classified by means of visual interpretation and computer automatic recognition and then compiled into thematic maps of suitable scale so as to help researchers in analysis and estimation of desertification status and damage in time of image data acquisition. Information of change can be abstracted and dynamic analysis undertaken through the resolution and adding up of remote sensing images of different time concept so as to realize the dynamic monitoring for the occurrence and development process of desertification.

RS usually applied with GIS and GPS technologies. They are together so called modern “3S” technologies of spatial application. RS is for data collection. GIS is for building a spatial information system and data analysis. GPS is for positioning the location in field survey and checking. Along with the development of remote sensing and GIS technology and its widening scope in application, remote sensing and GPS have been more and more closely related. The former can acquire new data consistently for the use of regenerating GIS overlay of map. It will be an important data source of GIS in the future. GIS has no vitality without accepting remote sensing data. In the same way, the geometric precise rectification of remote sensing image and compiling of image map depend on the support of GIS. The classification of remote sensing image also needs the auxiliary data from GIS to improve the degree of precision. Remote sensing and GIS can together provide data for the models of dynamic monitoring, estimation and prediction of desertification.

Remote sensing and GIS have been offered with new vitality with GPS coming into being. The “3S” technology has become the integrated spatial application in desertification monitoring. The application of 3S technology has made the collection and analysis of spatial data much easier. With the support of 3S technology, more accurate and reliable data will be obtained for monitoring desertification so as to realize the sharing and effective use of monitoring data and finally assist the decision making in evaluation, development of resource and environment and desertification control.

2. Problems Statement in the point of view from AID-CCD

Compared with common nature resource monitoring which focuses purely on land, forest and prairie, desertification monitoring combines resources and ecological environment. It contains complex elements and is undertaken in a vast area and featured by continuity in time and comparability in evaluation index. It is impossible to accomplish such work which has a high-level and sophisticated starting point with traditional methods. Modern high-tech support is of extremely necessity. Remote sensing (RS), GIS and GPS are three indispensable tools to accomplish desertification monitoring.

Although RS technology has been proved as a very useful tool of desertification and data are widely used in monitoring and assessing the present and dynamic situations of desertification and drought at local, regional and global scales for decades. Many countries and institutions have achieved very good results in this area. Some of the results have helped the elaboration of relevant NAPs, RAPs.

But to promote the RS application in M&A Of desertification still have a lot of work should be done since:

1. Up to now many other countries and institutions still haven't really or operationally use RS as a technical tool for the mentioned above purpose.
2. Data collection and processing methodologies and tools are often very different from one project to another. Data from the various stakeholders are often difficult to

combine and possibilities for information and data exchange are weak, both at the national and the regional level.

3. This is why the global or regional figures of desertification used by UNCCD or other international as well as regional organizations are rough estimations and couldn't be broken down to a lower scale, such as each specific country etc..
4. This is not an ideal situation and does not favor making and adjusting NAPs and RAPs.
5. That is why it is necessary to exchange experiences on the topic of Remote Sensing to monitor and assess desertification.

So to serve the requirement for global desertification, desertification monitoring in a specific country should be based on the international criteria. It requires our hard efforts to promote international cooperation and integrated research in multiple discipline. Remote sensing technology has enormous application potential in this field.

3. Development of RS technology of satellites

Space remote sensing data includes information sources of many kinds. For desertification monitoring sensors are carried mainly by resource satellites and meteorological satellites such as AVHRR, TM, ERS and SPOT images data which are widely used. Different data have different resolution, cover area and repeat period which are decided by orbit altitude of observation system. The higher platform for observation is, the wider the monitoring range is; the shorter the repeat period, the lower the ground resolution. Different data source suits various monitoring at different levels. The resolution of AVHRR image is 1 km with better continuity in time and a wider monitoring range and higher repeat rate. AVHRR data suits national monitoring or monitoring at a wider range. TM, ERS and SPOT images data are with much smaller monitoring range, a longer repeat period and much bigger ground resolution ranging from 10-100 meters. These data sources suit regional monitoring and ground inventory at provincial level or typical localities.

In recent years many of new resource RS satellites had launched, such as SPOT5, ERS-2 and Envisat of ESA, Canadian Radarsat1, Indian IRS-1C and 1D, Landsat7 of USA as well as the joint venture CBERS etc.. And will be more in the near future.

Resolution of those RS sensors at this stage among the commercial satellites: the pan channel of TM7 is 15m, multiple channels are 30m; the CCD channels of CBERS-1 are 20m; the pan channel of SPOT5 is 5m, multiple channels are 10m (5m). Even some high resolution data source have been allowed for public use such as American IKONOS, 1m for pan channel and 4m for multiple channels; and QUICKBIRD, its resolution of pan channel reaches to 61cm and 2.44m for multiple channels.

So remote sensing technology is an advanced data collection tool for not only macro observation but rather detailed observation in now a days.

3.1 Deferent elements data (indicators) collected or derived from RS data

Bio-physical characters (some of them considered as monitoring indicators) related to desertification like land cover, land use, wind erosion and water erosion etc. could be easier monitored by RS technology. It could also derive other elements related to desertification from RS data such as rainfall, vegetation index, drought, climatic moisture index, soil moisture index etc..

The following are some RS application cases of desertification monitoring and assessment (M&A):

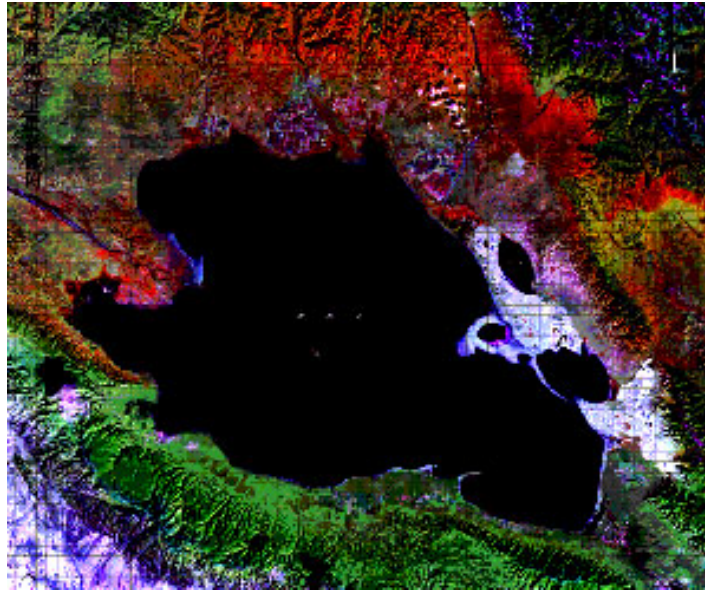


Figure 1: TM image of QingHai Lake at western China in 2000 (show some sandy land areas became larger in recent years)

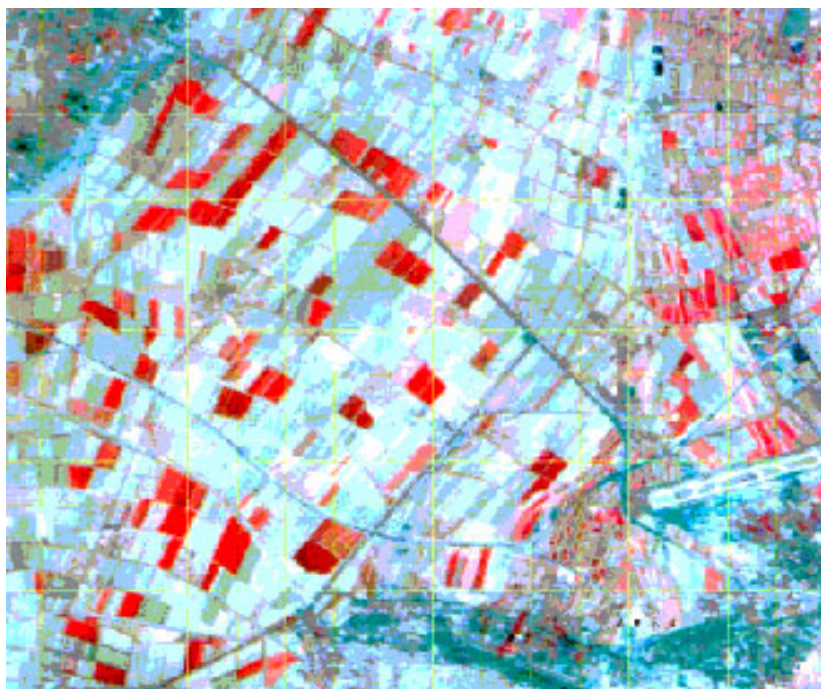


Figure 2: CBERS-1 Image of Farmland and wind brick in Oasis, Xinjiang

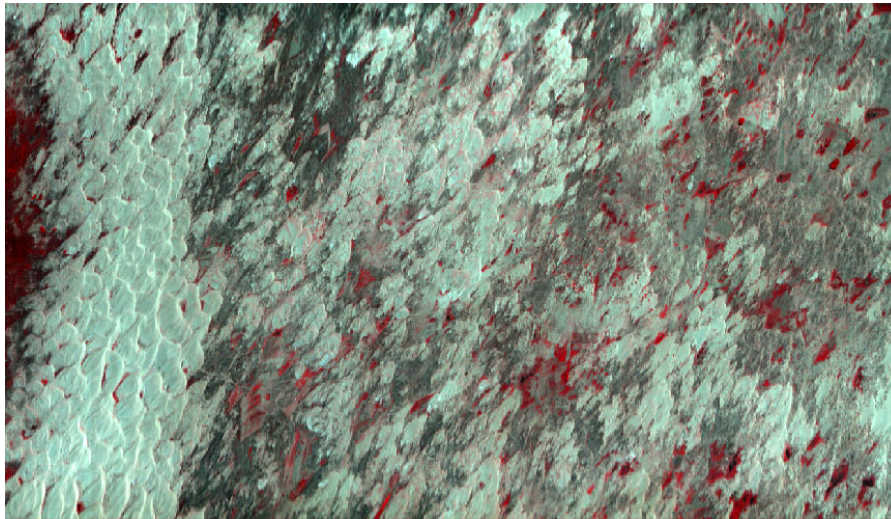


Figure 3: Color composite of Hyperspectral remote sensing OMIS I image (128 bands, resolution 5m) in Naiman, Inner Mongolia Autonomous Region.

Technical methodology assisted by Remote Sensing technology for monitoring and assessing climate change also could be done. For example climatic moisture index (CMI) that as an indicator determined by UNCCD to define the desertification affected climatic zones. Scientists of Netherlands and China have developed a water and energy balance monitoring system-CEWBMS using geo-stationary satellite data. There is a sub-system DMS in the system especially designed to produce CMI maps and soil moisture index (SMI) maps which cover the whole country of China. After collect these data and maps year by year we could find the changes of desertification affected areas. It much fast and less cost than the normal meteorological may.

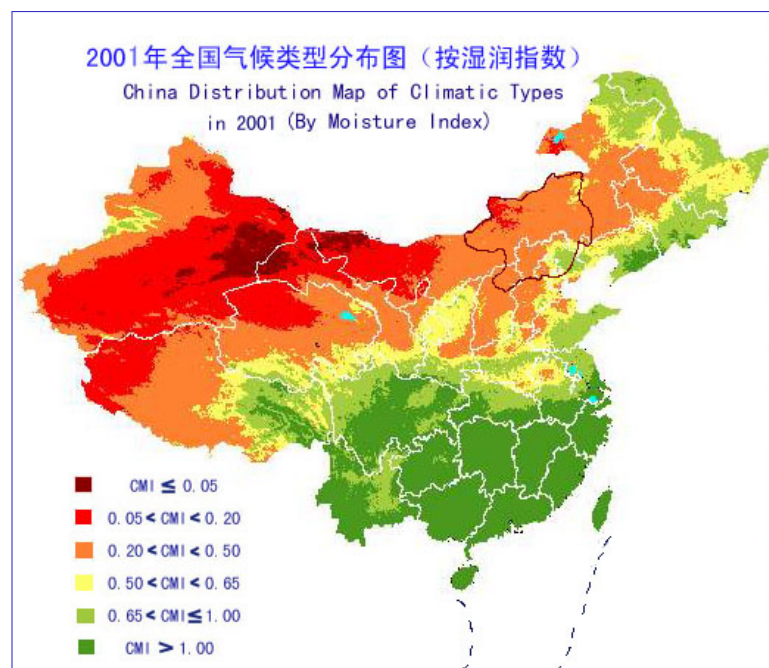


Figure 4. China Map of climatic moisture index (CMI) in 2001

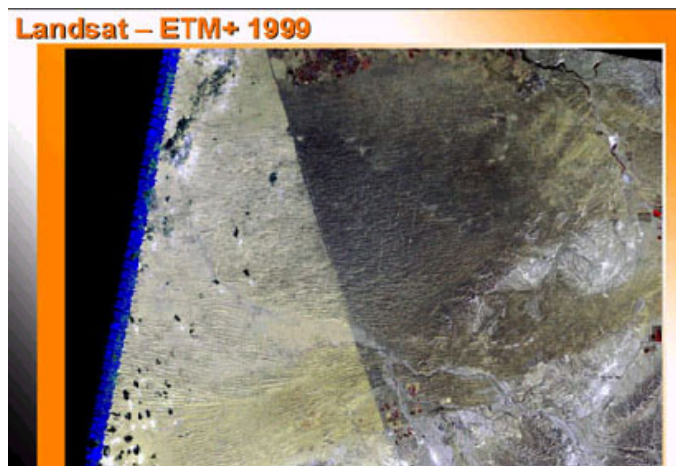


Figure 5. Border line between Negev Israel and Sinai Egypt (not manmade but by deferent land management ways). Note: This image is provided forr this paper by Dr. Arnon Karniel, The Remote Sensing Laboratory Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev

4. Points must be aware in RS application

As the difficulties that the institutions in charge of the data-gathering meet to satisfy the needs of the decision makers at various levels, and the difficulties encountered by the users to have access to the relevant data, the following point must be aware in RS application. The modern Remote Sensing technology is a very useful tool and has great potential capacity for serving and contributing to the local and global fight against desertification. It will thus be a priority for them to use it for monitoring-evaluation in their national action program. So for those countries who not survey the desertification by adopting RS technology;

Hopefully RS technology will be widely accepted by all countries and UNCCD for desertification M&A. This implies an effort in standardizing information content and exchange procedures (interoperability). So it is necessary to focus on drawing setting up consensus on a limited set of operational indicator for monitoring and assessing desertification by using Remote Sensing technology. Desertification monitoring should be based on a international criteria. Specific and proper indicator sets must be developed according to different mapping scales and RS data sources; Which specific and limited sets of indicators with each specified mapping scales could be selected by using Remote Sensing technology (alone or in conjunction with in normal data)? In fact RS survey by image interpretation must be checked with field truth and analyzed with social and nature factors.

For desertification monitoring between time interval the comparable scale, resolution and season of spatial data collection of RS image is very important; In most situation countries have a low level of collecting regular information. Existing data and maps in most situations are not compatible with each other. This is not an ideal situation and does not favor making and adjusting NAPs and RAPs.

Finally data from the various stakeholders are often difficult to combine and possibilities for information and data exchange are weak, both at the national and the regional level. This is why the global or regional figures of desertification used by UNCCD or other international as well as regional organizations are rough estimations and couldn't be broken down to a lower scale, such as each specific country, etc.. Some

desertification data, world maps did exist, but they are too general since the mapping scale are too small unfortunately. So for international organizations and projects like Asia TPN1 and LADA, the scale of RS image is the limitation for producing the useful result; If the results wished to be accepted by national focal points and NAP for M&A purpose the image scale derived by RS data should be at least large than 1/100000 or 1/50000. If the work arranged for all countries it will be or say need a huge funding; Above points explained why it is very much necessary to promote the application of Remote Sensing technology in monitoring and assessing desertification at local, regional and global levels. The remaining question is scientist group, country users and UNCCD must discuss and make agreement about: which kind of (such as indicator of driving factor, state, pressure, impact, response; Geo-physics and socio-economic factors etc.)? which specific indicators could be detected by Remote Sensing technology and which specific earth observation satellite data have been used for the purpose? which indicators are the most relevant? How can they be collected in an operational way? how can they be used in operational systems?

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REMOTE SENSING AND GEOMATICS CONCEPTS FOR DESERTIFICATION AND LAND DEGRADATION MONITORING AND ASSESSMENT

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1. Introduction

Desertification, as a specific expression of land degradation processes, is a concept applied by scientists and policy makers after droughts threatened the Sahel in the last quarter of the 20th century, defined by the United Nations Convention to Combat Desertification (UNCCD) as “the degradation of the land in arid, semi-arid and dry-sub-humid areas, as a result of several factors, including climatic change and human activities”. The dominant symptomatic character of this definition does not account for the underlying processes of the phenomenon. The consequence is that the popular meaning of desertification is often associated with a catalogue of environmental calamities rather than specific distress in the human population-renewable resources system. In such conditions both prospects and mitigation become extremely uncertain. Purely climate climatic factors were rarely responsible for desertification processes in the Mediterranean region. This is primarily because dry spells are and have been relatively short-lived, and natural ecosystems and agricultural systems have the potential to recover easily. Present land degradation in Northern Mediterranean countries is primarily due to dramatic land use changes that occurred during the second half of this century and which in many cases lead to an unstable state of ecosystems (Brandt & Thornes, 1996). It is widely agreed that socio-economic disturbances, particularly when they occur combined with climatic fluctuations, become the main drivers of desertification (i.e., Reynolds & Stafford-Smith, 2002). They affect water balances and land degradation through changes in land-use patterns. In particular, large areas of Mediterranean rangelands are affected from transitional processes that cause conflicts between past and present land uses or economic and ecological priorities, i.e. between optimised productivity and ecosystem conservation. Substantial research efforts have been launched and carried out to investigate various aspects of the desertification problem, but it is quite recent that projects have adopted a more holistic concept. Among these we find the LADAMER project that has been launched under the umbrella of the GMES initiative, as well as the Integrated Project DeSurvey to be started in 2005 (both supported by the European Union, DG Research). Both projects are to a considerable extent focussed on remote sensing and geomatics applications in the desertification context (e.g., Hill & Peter, 1996; Hill, 2000), an approach which quite recently has also been adopted by the European Space Agency (ESA) in launching their DesertWatch project.

2. The Conceptual Framework

A major difficulty of assessing land degradation is inherently related to the very concept, as ‘the loss of the land’s capacity to produce goods and services’. This is a rather unspecific symptom which may involve a large array of processes, each with its own boundary conditions for its detection or monitoring. Land degradation assessment methods have evolved from classic field survey methods for soil and vegetation mapping and land suitability evaluations to the more recent ecological approaches (e.g., Ludwig & Tongway, 1992; Mouat et al., 1992). These ground-based methods score low for most of the practical requirements, but when based on broad field experience, they may yield very accurate results in relatively small areas.

Initially, although it was already recognized in principle that land degradation involved complex interactions between physical and socio-economic process domains (e.g., Perez-Trejo, 1994), a large part of research activities focussed on soil erosion assessments as a core indicator for degradation processes. The European Commission, for example, launched a first attempt to produce exhaustive maps on natural resources and soil erosion risks in Mediterranean Europe (CORINE, 1992). These initial mapping experiments on one hand suffered from methodological shortcomings but also revealed major deficits due to the limited availability of base data layers on European scale. The data availability has meanwhile largely improved (i.e. European Soil Map at 1:1 million scale, CORINE Land Cover, etc.) such that recent research activities like the “Pan-European Soil Erosion Risk Assessment”-Project (PESERA) can build on more solid grounds and are achieving substantially improved results (e.g., Grimm et al., 2001).

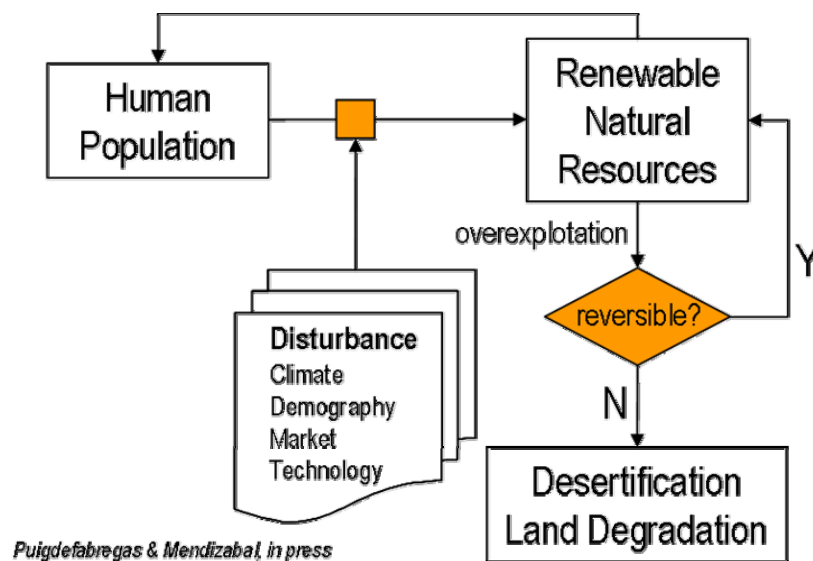


Figure 1. A conceptual view on desertification (from Puigdefabregas & Mendizabal, in press)

Besides, the insight that land degradation assessments must go far beyond the soil erosion issue has grown considerably. Human population and natural renewable resources may be considered two linked elements in a single system, which is affected by climatic or socio-economic disturbances. The former include droughts, rain spells, etc. The latter involve demographic, political, market and technological changes that enable or disable access to those resources. Under steady-state conditions, intensity and duration of disturbances remain within the range of those that have appeared throughout the history of the system. They have been incorporated in its own evolution, in such a way that it recovers quickly after they have ceased. However, a new or very

extreme disturbance or combination of disturbances may happen that takes the system beyond its threshold of sustainability (Puigdefabregas & Mendizabal, in press). This may occur as an increased availability of resources (i.e. a humid period, the introduction of a new technology) an increased demand for products (i.e., higher prices, local increase in agricultural population) or the contrary, as a reduction of available resources (i.e., extreme drought).

In both cases, resources become over-exploited. If the system is endowed with feedback mechanisms to reverse this condition, it can recover and return to the steady state. Otherwise it falls into an over-exploitation loop that leads to its own extinction. This process, when it happens in drylands, may be considered the core of desertification. Such disturbances or desertification drivers may continue working to date or not. In the first case we are dealing with ‘current’ desertification. In the second, the forces that drove desertification in the past are no longer at work today. If resilience thresholds of natural resources have not been exceeded, natural recovery is possible, if they have (i.e., extreme soil erosion), we are dealing with ‘relict’ desertification. In the latter case, the imprints of past desertification are observable today, even after disappearance of the underlying factors. Distinguishing between current and relict desertification is crucial for designing treatment programs. The former require either relieving driving forces or providing the affected systems with capacity for adaptation. The latter need only ecological and economically sound restoration.

3. The LADAMER and DeSurvey Approaches

During the past 10 years, the European Commission has funded numerous dedicated research projects in the field of land degradation and desertification which focussed on data collection in specific field sites, detailed methodological studies, assessment and monitoring experiments, and the development of specific modelling concepts. Although substantial scientific progress has been achieved and some projects succeeded to link a considerable number of field sites and case studies across the Mediterranean basin, the scientific community has, apart from few initiatives not been able to provide unifying concepts for assessing land degradation processes on Mediterranean scale as required by political decision makers. Two new projects, LADAMER and DeSurvey, have been launched to address these ultimate objectives.

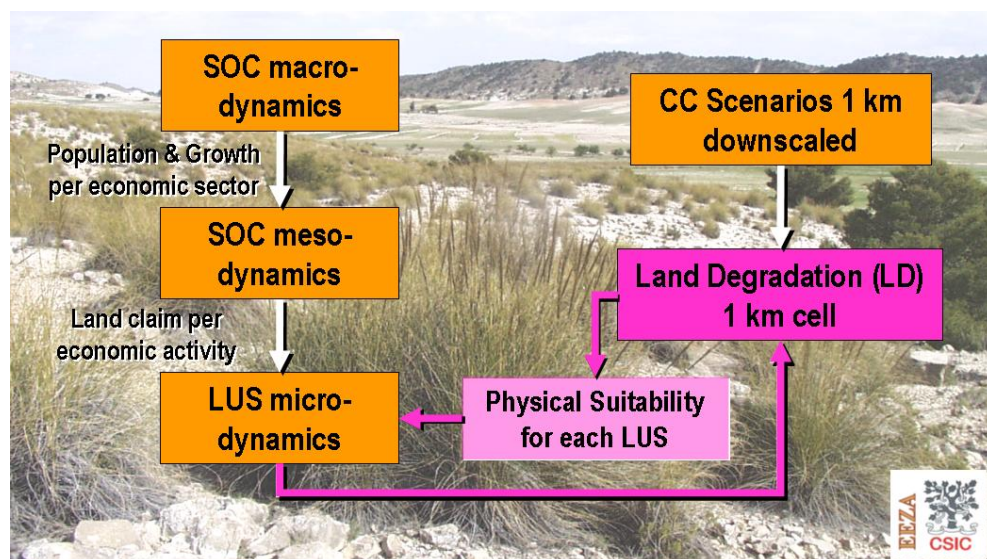


Figure 2. Design of a Dynamic Systems Approach for Land Degradation Assessment followed under LADAMER and DeSurvey

LADAMER (EVK2-2002-0599, see also www.ladamer.org) builds on an integrated approach which combines specific fields of expertise in landscape ecology and soil science, remote sensing, spatial analysis and knowledge system management. The major concern of the project is to identify hot spot areas subject to a high desertification/degradation risk, and to provide an assessment of the present degradation status of Mediterranean lands on small scales. With regard to the substantial progress in data availability and methodological concepts achieved during the past decade it is a major objective of this proposal to provide such an exhaustive assessment. Following this rationale, it is believed that the LADAMER approach might supply products relevant to institutional end-users on national and international level, by integrating different models and techniques that have already proven their validity on local to regional scale. The major challenge for this integration is that the resulting methodological packages, in order to ensuring their applicability, are required to be objective, reproducible and transferable; include error estimates of the category assignation; be applicable at the regional scale over large areas; and have low data requirements, be cost-effective and easy to apply. Although complemented by additional important topics such as the analysis of climate change impacts, ground-based land condition assessments (model-based approaches), agricultural risk assessments, socio-economic issues, the Integrated Project DeSurvey (see also www.desurvey.net) is a new project platform to further develop and expand the remote sensing and geomatics approaches initiated within LADAMER. This work basically involves three major components - remote sensing based time series analyses, land degradation modelling and land use / land cover change modelling - that will allow for adequate monitoring, assessment and modelling of land degradation at a European Mediterranean scale.

4. The Land Degradation Assessment Component

A major difficulty of assessing land degradation is inherently related to the very concept, as ‘the loss of the land’s capacity to produce goods and services’. This is a rather unspecific symptom which may involve a large array of processes, each with its own boundary conditions for detection or monitoring. Land degradation assessment methods have evolved from classic field survey methods for soil and vegetation mapping and land suitability evaluation to the more recent ecological approaches. These ground-based methods score low for most of the practical requirements, but when based on broad field experience, they may yield very accurate results in relatively small areas. Current knowledge of land degradation processes, particularly concerning runoff and soil erosion, has already been incorporated in a range of distributed physically-based models, such as ANSWERS, SHE, KINEROS, LISEM and MEDRUSH. These models can provide theoretical insight in complex cause and effect relationships and may be suitable to catchment scale case-studies on land degradation. Besides the fact that they are only addressing a facet of the land degradation problem they are also too demanding, in terms of input data, model implementation and calibration, to be an option for national and trans-national assessment studies. The characterisation of terrain form and topographic position has been an almost intrinsic part of land surveys for a long time. More recently, the use of digital elevation data and derived terrain attributes for the modelling and prediction of runoff and sediment transport patterns has been advocated. These approaches score better on many of the practical requirements and are especially suitable for the identification of potential hazard zones, but cannot be used for the monitoring of change.

The vegetation cover interferes more or less directly with all water loss processes at a site in order to optimise to a certain extent the local water availability for their own benefit, an optimisation process which involves several sub-processes and feedback mechanisms. Recently, in the frame of the MEDALUS project, a theoretical framework for land degradation assessments has been developed (Boer, 1999) which relies on these vegetation functions to estimate the local water balance, in terms of rainfall to evapotranspiration ratios. Experience with the application and qualitative evaluation of this method was obtained in a medium sized area (1000 km²). The approach is innovative in the sense that it provides a process-oriented, rather than descriptive, procedure for assessing land degradation on the basis of an established ecological theory while meeting most of the mentioned requirements for small scale applications. Its adaptation to LADAMER/DeSurvey, requires the method to be upgraded in a number of aspects. The conceptual basis will be adapted to a wider range of climates, vegetation types, and land use settings. The temporal resolution will be increased from mean annual to annual and, possibly, seasonal to better capture the cover changes of deciduous and annual vegetation types or crops. Moreover, the conceptual basis and cartographic modelling procedures will be modified to allow application at a range of spatial resolutions (e.g. 30 m – 1 km). Multivariate regionalisation of the target area, in terms of soil-lithology, terrain and land cover types, is used to reduce uncertainty of the assessment.

5. The Remote Sensing Component

It is widely accepted that satellite remote sensing offers considerable advantages for land degradation assessments. With a comprehensive spatial coverage it is intrinsically synoptic, and provides objective, repetitive data which contribute to resource assessments and monitoring concepts of environmental conditions in drylands (e.g., Hill et al., 1995; Lacaze et al., 1996). However, only if these observations can be coupled with GIS-based ecological modelling concepts, they may develop their full capacity to be used for modifying and adapting environmental management principles and mitigation strategies.

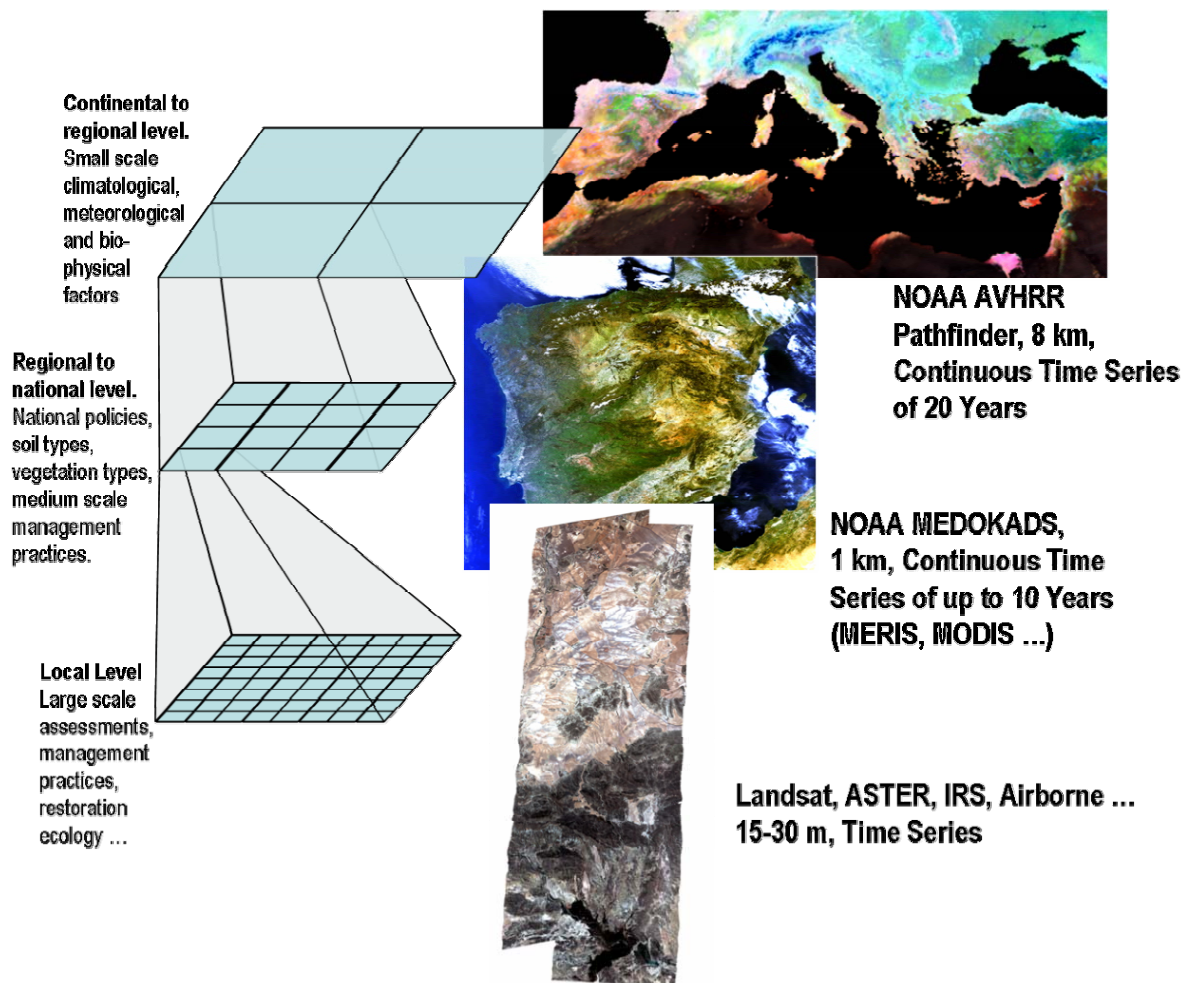


Figure 3. Remote sensing data products covering the range of scales addressed in the LADAMER and DeSurvey projects developed with financial support of the European Commission (DG Research)

It has long been known that surface properties (i.e., vegetation cover and composition, specific properties of parent material and soils) control water availability or the spontaneous emergence and development of new plants in arid and semi-arid regions. Consequently, one of the objectives of remote sensing approaches is to focus on this particular interface. Particularly the application of the ecological assessment framework sketched before requires spatially distributed estimates of the actual vegetation density (i.e. proportional cover), and preferably a set of geo-referenced sample sites where the deviation between actual and potential vegetation density can be assumed to be minimal. So far, the primary remote sensing input into the model has been limited to spatially distributed estimates of actual vegetation density (either as fractional cover or Leaf Area Index derived in relation to a satellite-based vegetation estimate) which can be derived with reasonable accuracy (e.g. Hostert, 2001). In order to meet the prerequisites of LADAMER, this interface, which so far has been based on limited data series obtained from earth observation satellites (e.g. Landsat TM/ETM, ASTER) must now be extended to accommodate small scale multi-year observations from global monitoring satellites, such as SPOT VEGETATION, NOAA-AVHRR, MODIS, MERIS (figure 3). Therefore, the objective is not only to classify each pixel into land cover based on predefined classification schemes but rather to derive continuous fields

of vegetation characteristics at a resolution of 1 km where also sub-pixel heterogeneities of land cover can be considered (e.g., DeFries et al., 1995; Moody & Johnson, 2001; Shababov et al., 2002). A number of techniques have been proposed which also appear suited for a dedicated analysis of multi-year time series of SPOT VEGETATION data that cover the Mediterranean member states of the European Communities. Among these, the most interesting approaches include linear mixture modelling to deconvolve proportional land cover based on spectral or spectro-temporal endmembers, and artificial neural networks which make no assumptions about the linearity of the spectral response to mixtures (e.g., Atkinson et al., 1997). In several Mediterranean ecosystem studies, spectral unmixing techniques have already been successfully used at local scales using high resolution Landsat time series which may facilitate a local validation of the continuous vegetation assessment derived global monitoring satellites (Hostert et al., 2004; Röder et al., 2005).

Changes of the vegetation density over time also bear important information on land degradation dynamics which are induced by natural or man-made processes. In this respect, the production of suitable small-scale map representations of existing degradation trends requires the decoupling of long-term trends and cyclic components of vegetation dynamics (e.g., Moody & Johnson, 2001). Due to the complexity of such approaches, mostly automatic classification or principal-component-related techniques have been employed to global coverage and high temporal resolution imagery for mapping either phenology types or seasonality effects. While these approaches allow identifying pixel clusters with similar temporal and radiometric behaviour, they fail to unveil long-term degradation trends as expressed by associated vegetation changes. In comparison, it has been shown for regions similar to Mediterranean Europe that the first and second harmonics of the discrete Fourier transform concisely summarised the amplitude and phase of annual and biannual signals embedded in time-series of AVHRR-NDVI-data. While this is not yet providing a trend analysis in the classical way, it does constitute information that is of high significance for detecting hot spots of land use changes. The description of regional degradation trends will be further based on a classical trend analysis (parametric and non-parametric) of 20 years of pre-processed 8-km AVHRR Pathfinder data. Major emphasis will be given to novel approaches such as wavelet transforms, singular spectrum analysis, or temporal mixture analysis. Applied to a regional Mediterranean scale the remote sensing component should additionally provide a regional map on which areas of gradual (i.e. long-term) changes can be identified as well as so-called 'hot spots' of abrupt land use change. By coupling trend analysis of vegetation density with the local water balance approach described in the previous objective, we expect to be able to introduce the time dimension in the land degradation assessment. It is important to state that the methodology will be applied at the regional Mediterranean scale, and its performance for monitoring and early warning purposes will be evaluated.

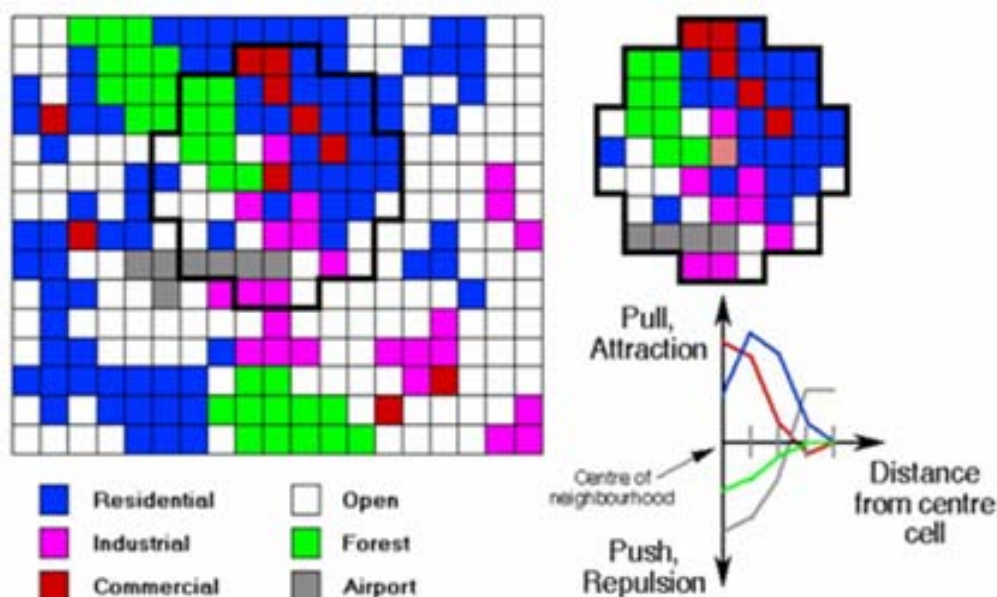
6. The Land Use / Land Cover Change Modelling Component

The development of integrated assessment models is currently a rapidly expanding activity. This trend is propelled by the growing understanding that policy-making should be based on integrated approaches. System theory clearly has shown that systems and problems do not exist in isolation, rather that they have dimensions that extent into other domains, other disciplines, other levels of detail, and other temporal and spatial scales. Complexity and Computation Theory has shown that even seemingly weak linkages may have major repercussions on the behaviour of the system as a whole. Policy makers, responsible for the management of regions, watersheds, or coastal zones

are confronted with this reality on a daily basis. They are to manage fragile systems that exhibit an extremely rich behaviour not in the least because of the many intelligent actors, the human inhabitants or users that steer the development in a direction of their own interest. Confronted with this complexity on the one hand and with better informed, agile recipients of the policies on the other, policy makers have to be able to rely on adequate instruments enabling them to better understand and anticipate the effects of their interventions in the system as fully as possible (e.g., Engelen et al., 1993; 1996). As a result, today's research and development agendas strongly promote the development of tools enabling an integrated approach, which is propelled by the revolution in the computing hardware and software since the beginning of the eighties. Most relevant in the field of spatial planning and policy making has been the rapid growth of high resolution remote sensing and Geographical Information Systems in the past two decades. As a result new dynamic modelling techniques have been added to the toolbox of the spatial scientists. Agent based approaches, and in particular Cellular Automata, are rapidly gaining interest (e.g., Couclelis, 1997).

Cellular Automata (CA) models can be thought of as simple dynamic systems in which the state of each cell in an n-dimensional array depends on its previous state and on the state of the cells within its neighbourhood, according to a set of stated transition rules. While the early applications of CA models in the spatial sciences remained rather conceptual and theoretical, most recent applications are developed with an aim to realistically represent geographical systems, both in terms of the processes modelled and the geographical detail represented. This trend has come with an increase in the complication of the models developed. One of the very essential relaxations to the standard CA definition is the introduction of the finite non-homogeneous cell space: a bounded cell space consisting of cells having different attribute values representing physical, environmental, social, economic, infrastructural or institutional characteristics of the cell. This has allowed to conceptually and practically link Cellular Automata models with GIS. As a result, most recently, a number of authors have suggested ways to build Cellular Automata functionality into GIS and/or GIS functionality into CA. In this context, remote sensing plays a more than viable role in repeatedly injecting land use information into CA-based land cover change models on various scale levels (e.g. Liverman et al, 1998).

Figure 4. Conceptual aspects of cellular automata (RIKS, Masstricht)



Just as important in the context of integrated modelling are the possibilities for linking CA models to other cellular models representing changes in the cellular space -in which the CA dynamics unfold- or to dynamic models operating at a more macroscopic scale. In the latter case, the macro-models will constrain the overall dynamics of the CA. The models developed, or under development, as part of EU-projects like MODULUS, Medaction, MURBANDY, and MOLAND have taken full advantage of the possibilities to link CA and other dynamic models. In MODULUS this has resulted in an integrated model representing the non-homogeneous character of the cellular space by means of models calculating among other: the soil quality and water balance, the quality and quantity of the aquifer, the characteristics of the natural vegetation. On top of these physical layers (partially also to be derived from remote sensing data), the human dynamics unfold changing the land use and land cover. These dynamics are governed by CA decision rules, representing human (spatial) behaviour, socio-economic preferences and decision-making, crop choices, etc. This is the basis from which LADAMER will start in its effort to integrate physical, ecological and land use models and apply them to the full Western Mediterranean in an effort to define the 'hot spots' areas prone to desertification. The Integrated Project DeSurvey will follow this line of research and further develop these approaches.

7. Validation and Methodological Refinements

LADAMER is intended to provide a framework for generating at regional scale information on land degradation status and trends, which allows international and national planners and decision makers to identify those areas where efforts and eventually resources should be concentrated to prevent or mitigate desertification and related land degradation processes. To fulfil this function the information must be reliable and unambiguous, respectively the limitations and uncertainty levels of the methodology must be known. Consequently elements of product validation and uncertainty analyses of the various model parameters and remotely sensed variables are needed. An at least partial validation for the western Mediterranean appears feasible with regard to existing case studies produced in former EU-funded projects. Among these we find the southern Alentejo (DesertLinks, MedAction), the Guadalentin region in SE-Spain (MEDALUS, ERMES, DeMon), Languedoc in S-France (DeMon), Sardinia (GeoRange) and Crete (DeMon); some of these sites will be further investigated within the DeSurvey Project.

8. GMES and Data User Element of the Earth Observation Envelope Programme

While the integration of remote sensing derived information into ecological process models has triggered widespread applications using medium and high resolution imagery, increasing emphasis is attributed to the synoptic, integrated assessment of larger spatial units, and the provision of dedicated information products for administrations and policy-makers. In the frame of the the European Commission's initiative on Global Monitoring of Environment and Security (GMES), the Ladamer project aims at the small-scale assessment of the degradation status of large areas, and the identification of degradation 'hot spots'. In order to meet these prerequisites, the remote sensing interface, which so far has been based on limited data series obtained from earth observation satellites must now be extended to accommodate small scale multi-year observations from global monitoring satellites; this approach also forms the backbone of the remote sensing component of the recently launched Integrated European Project DeSurvey.

An alternative approach is followed by the DesertWatch project which has recently been launched within the context of the Data User Element of the European Space Agency (ESA) (see also <http://dup.esrin.esa.it/desertwatch/>). This project is primarily triggered to derive land use changes in desertification-affected European countries based on the analysis of Earth observation satellite data from three distinct time steps (1984-1994-2004). Countries affected by desertification are implementing the Convention by developing and carrying out national, sub-regional, and regional action programmes. Criteria for 'preparing these programmes are detailed in the treaty's - five "regional implementation annexes": Africa, Asia, Latin America and the Caribbean, the Central and Eastern Europe and the Northern Mediterranean area (i.e., the Annex IV countries). The DesertWatch project focuses on the latter. In this context, the DesertWatch project addresses the information needs of the national and local authorities of the Annex IV countries of the UNCCD. In particular, the project has been prepared in close collaboration with the national authorities of Italy, Greece, Portugal and Turkey. Its complementarity to the Ladamer Project suggest that both projects should establish linkages to optimise their impact.

9. Summary

Considering remote sensing and geomatics-oriented approaches, the combined output of the LADAMER and DeSurvey projects should be a comprehensive as well as spatially explicit image of land degradation effects and associated processes for the relevant European Mediterranean countries, in particular for the prototype region of the Iberian Peninsula. It will hence serve as a kind of integrating project between former research approaches and ongoing monitoring and assessment efforts. Consequently, the innovative aspect of LADAMER and DeSurvey lies in the novel combination of optical remote sensing methods with advanced physical, ecological and socio-economic modelling components. Combining these in a surveillance system is expected to substantially improve the quality of land degradation assessment and monitoring at the regional Mediterranean scale. The compiled data base is expected to build a basis for further GMES developments in the domain of land degradation research and other closely connected issues. These aspects will also be further pursued in the Integrated Project DeSurvey which also includes application sites in Northern Africa, Senegal, China and Chile.

Acknowledgements

The LADAMER project is funded by the European Commission, DG Research, as a contribution to the GMES action, the Integrated Project DeSurvey under the 6th Framework Programme. This support is gratefully acknowledged. The project consortium involves partners from four additional institutes who contributed to this paper. I'm particularly grateful to Maria Roxo (Universidade Nova de Lisboa, Portugal), Juan Puigdefabregas (Estacion Experimental de Zonas Aridas, CSIC, Almeria, Spain), Stefan Sommer (European Commission, Joint Research Centre, Ispra, Italy), and Guy Engelen (Research Institute for Knowledge Systems, Maastricht, The Netherlands). DesertWatch is supported by the European Space Agency as part of the Data User Element of the Earth Observation Envelope Programme. We appreciate this support and are grateful for the assistance of Advanced Computer Systems (ACS, Italy), ENEA-Casaccia (Italy), and the Desertification Research Group (NRD) from the University of Sassari, Italy.

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DESERTIFICATION INDICATORS AND STATUS MAPPING IN THE CONTEXT OF SATELLITE REMOTE SENSING: INDIAN EXPERIENCE

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Abstract

The phenomena of desertification is like a human disease which is diagnosed by the symptoms called *Indicators*, in various agro-ecological regions, perpetuated by numerous triggering factors and having different severity levels of land degradation. The remote sensing provides a platform to gather brisk, accurate, true and real-time information of land cover. Besides, it is also cost effective and less laborious. This helps in 'diagnosing' those indicators on satellite image which suggest land degradation in any dry-land area, both in hot and cold desertic conditions. However, the selection of dependable and interpretable indicators of desertification is the most critical and challenging task. Thus, the desertification indicators, amenable to remote sensing needs to be identified for local, regional and global assessment and monitoring of desertification.

In India, under the UNCCD programme, an attempt has been made to finalise the indicators of desertification and subsequently evolve a comprehensive methodology, classification system for Desertification Status Mapping. This is a step wise compliance to the UNCCD TPN-1 programme on Desertification assessment and monitoring. A pilot project on Desertification Status Mapping, at 1:50,000 scale has been carried out in India, covering about 16 study areas, in arid, semi-arid and dry-sub humid areas of both hot and cold deserts. This is a maiden attempt in the country and involves about 16 different agencies collaborating together towards achieving the objectives of the project. Having established the methodology, the same exercise is being carried out for the entire country at 1:1 million scale. The mapping work is over and is being integrated to get a full and final map of India showing the Desertification Status.

The present report discusses the desertification indicators finalized (especially those amenable to remote sensing), the methodology evolved, and the results obtained so far from Desertification Status Mapping projects on different scales i.e. 1:50,000 and 1:1 million scale.

Key words: Remote sensing, IRS, land degradation, indicators.

1. Introduction

Desertification is defined as the process of land degradation in Arid, Semi-arid and Dry-Subhumid areas resulting from various factors, including climatic variations and human activities (UNCED, 1992). This definition is used as the basis of the UNCCD. The focus of this programme is to assess, monitor and combat the desertification world wide. However, to achieve this mammoth objective, a hierarchical approach has been adopted to reach the goal step-by-step as there are certain basic issues like indicators of desertification (regional, local, global), legend / classification system, methodology etc. To start with, the indicators are the basic element of any desertification related studies. There are several indicators of desertification viz. climatic, physical, hydrological, biological, socio-economic etc. These are some times grouped into Pressure indicators, state indicator, impact indicators etc. Some of them are amenable to remote

sensing, especially the physical indicators are directly obtained from interpretation of satellite data. Past workers have tried to identify and ascertain the main indicators of desertification Aubreville was the pioneer researcher of desertification and carried out remarkable work in 1949. According to him cultivation, deforestation, and erosion were main cause of vegetal degradation in the forested regions of tropical Africa.. Deflation and wind erosion induces maximum soil erosion in arid regions and hot, windy climates, at the end of the dry season, or when vegetation is removed for cultivation or as a result of overgrazing (Dregne, 1985; Mainguet, 1994; Sabadell, et al., 1982). It shows that both natural and human induced factors are responsible for the desertification.

In the present study, the authors have tried to address the issue by taking the local and regional indicators/factors into account from within the country.

India has a total geographical area of 328 m ha, (2.4 % of world's geographical area.) , of which 228 m ha (69%) area is dryland , comprising of 15.8 % Arid, 37.6 % Semi-Arid and 16.5 % Dry-Subhumid. This indicates that more than two third area of India is dryland. In this regard, in India, the following sequence of efforts have been made in last five years, under the auspices of UNCCD-TPN 1, to formulate the following :

1. To identify the indicators of desertification, including those , amenable to remote sensing.
2. Bench marking (BM) of each of the indicators.
3. To evolve and standardise a Methodology including a comprehensive 'Classification System' for 'Desertification Status Mapping' (DSM) based on the above benchmarks and indicators.
4. To validate the above said, through pilot projects in various agro-ecological zones of dryland,. for both hot and cold regions, in India, carried out on 1:50,000 scale.
5. To compare and critically assess the applicability of these indicators and BM's while attempting DSM for entire dryland region of India on smaller scale of 1:1 million .

The indicators of desertification can be broadly classified into four categories:

- a) **Pressure Indicators:** Climatic indicators like temprature, droughts etc.
- b) **State Indicators** : Hydrological, Physical, Biological etc.
- c) **Impact Indicators** : Socio-economic, migration, unemployment etc.
- d) **Implementation Indicators** : The changes in the land cover conditions owing to mitigation measures aimed at combating desertification.

Some of these are very conspicuously amenable to remote sensing and are discussed in this paper.

The present report discusses the indicators, especially those amenable to remote sensing vis.a. vis the conventional ones. Besides , it also describes the efforts to evolve and standardize the methodology for Desertification Status Mapping (DSM) at 1:50,000 and 1:1 million scales, as a part of assessment of the present day condition of the land.

2. Objective

The over-all objective is Desertification Assessment, monitoring and combating. However, this is achieved step by step. In the current context , the following sub-objectives have been determined to achieve the goals of UNCCD.

- a) To finalise indicators of desertification and
- b) To evolve and standardize methodology for Desertification Status Mapping

3. Study area

There are two different projects and thus there are two different study areas. The flagship project, called as pilot project, has about 16 test sites in arid, semi-arid and dry-

sub humid conditions of both hot and cold regions of India. This is carried out at 1:50,000 scale. The other project is at smaller scale encompassing the entire dry-land regions of the country at 1:1 million scale.

4. Data Used

Indian Remote Sensing Satellite (IRS) false colour composites (FCC) of LISS III and AWiFS sensors have been used in the form of geocoded paper prints and transparencies.

5. Methodology

Satellite based remote sensing is the basis of the desertification studies carried out by the authors. Visual interpretation techniques have been used to identify indicators on the image and to prepare DSM maps using Indian Remote Sensing Satellite (IRS) data. Major elements of interpretation such as tone , texture, shape, size, association etc. have been used to interpret the data visually.

A comprehensive interpretation key for DSM – land use mapping has been used and shown in the following table no. 1

S.No .	Land use / land cover	Tone	Size	Shape	Texture	Pattern	Location	Association	Season	Remarks
1.	Agriculture Unirrigated	Bright red to red	Variable	Regular to irregular	Medium to smooth	Contiguous to Non-contiguous	Plains, hill slopes, valleys, cultivable wastelands etc.	Amidst rainfed arable lands	Mainly May/June to September	It consists of crop grown in kharif season under different farming and land tenure systems. Mixed and multiple cropping patterns generate mixed spectral response on the images.
2.	Agriculture – irrigated	Pink	Variable	Regular to irregular	Smooth	Contiguous to Non-contiguous	Plains, valleys, etc.	Amidst irrigated (canal, tank, well etc.) arable lands, proximity to rivers/streams etc.	Mainly October to April (Hot desert) And April to September (Cold Desert)	It consists of crops grown in different season under different farming and land tenure systems in Hot and Cold Deserts. Mixed and multiple cropping patterns generate mixed spectral response of crops on images.
3.	Forest	Dark red to Dark brown (Subject to Canopy cover)	Variable	Irregular discontinuous	Smooth to mottled	Contiguous to Non-contiguous	Mountain slopes, isolated hills and foot slopes and within notified forest areas	Hill slopes having skeletal soils, different forest types/ sub-types and where abiotic interference	Jan to April (Except evergreen) (Hot desert) April to October (cold desert)	It accounts for total tree cover within notified forest area. The degradation is due to biotic and abiotic disturbances caused to dense forest cover. It contributes to land degradation found on uplands and on foot slopes with thin soil cover.
4.	Grassland/ Grazing land	Light red to Light brown	Variable	Irregular	Coarse to Mottled subject to the vegetation	Contiguous to Non-contiguous	Plains, uplands, hill slopes/foot slopes, close to river	Amidst agricultural lands, dry land and lands, fenced from	Dec-March	It includes lands where grasses occur naturally providing food to cattle. It includes natural pasture and meadows, excessive grazing contributes to loss of vegetation cover and

							/stream	cultivation		accelerated erosion.
5.	Land with scrub	Light red	Variable	Irregular	Coarse to Mottled	Contiguous, Dispersed in patches	Terrain with varying lithology and landforms	Gentle relief with moderate slopes in plains and foot hills and surrounded by agricultural lands	Octo-March	Thin veneer of soil cover on the top supports, scrub grass devoid of vegetation where surface erosion is dominant, such lands occur in dry lands, foot hill areas, undulating uplands and also along fallows.
6.	Barren/Rocky area	Greenish blue to yellow (Subject to varying rock type)	Variable	Irregular	Very coarse to coarse and medium	Linear to contiguous and dispersed	Steep isolated hillocks, hill slopes/crest, plateau and eroded plains	Barren and exposed rock/stony wastes, lateritic outcrops, mined areas and quarried sites, boulders.	Jan. to March	These are rock exposures of different rock types which occur as massive rocks, boulders, talus material, stony wastes etc. in hill forests, plateau and plains. These are barren and are devoid of soil cover and vegetation.
7.	Dune/Sandy area	White to light yellow (subject to moisture content and red for vegetation)	Variable	Regular to irregular	Smooth to mottled (subject to vegetation)	Contiguous to linear	Deserts, river beds and coastal onshore plains	River sand, shifting desert sands, sand dunes, coastal beach/dune sands and river bed/natural levees.	Oct. to March	Areas which have an accumulation of sands which are in situ or transported. These occur as sandy (desert) plains, in the form of sand dunes, beach sands and dune (wind blown) sands etc. They support vegetation wherever moisture is available.
8.	River/Stream	Light blue to Dark blue	Long narrow to wide	Irregular, Sinuous	Smooth to medium	Contiguous, Non-linear to dendritic/sub-	Natural rivers/streams (perennial and non	Drainage pattern on Hill slopes, flood plains	Jan. to Dec.	These are water courses in the channels of different dimensions and lengths. It may be perennial or non-perennial river or stream.

						dendritic etc.	perennial)	uplands etc. Also with vegetation along the banks and in river bed.		These exhibit different drainage pattern depending on surface lithology, landform, climate etc. Excess run-off of water results in over-flow of river/stream banks causing floods.
9.	Water body	Light blue to dark blue (subject to weeds/vegetation)	Small/medium to large	Regular to irregular	Smooth to mottled subject to vegetation	Non-contiguous dispersed, linear for canals	Tanks and lakes in low lands/plain s, reservoirs surrounded by hills and across rivers, canals in plains	Amidst cultivated lands, low lands, reservoirs with hilly terrain and rivers, canals with irrigated arable lands	Jan. to Dec.	These are impounded water bodies in low lands, plain across rivers/streams, un-irrigated lands etc. surface water spread of reservoir/tanks/lakes vary from season to season. These act as the source of irrigation, power generation and flood control.
10.	Others (urban)	Dark Bluish green in the corse and bluish on the periphery	Small to big	Irregular and dis-continuous	Coarse and mottled	Clustered to scattered and non-contiguous	Plain plateaus, on hill slopes, deserts, water front, road, rail canal, etc.	Surrounde d by agricultura l land, forest cover, wastelands , network of river, road and rail etc.	Oct. to March	Built-up land can be big or small size, settlement, industrial structures, buildings or any other artifact, physical spread or sprawl along with density of transport network are useful surrogates to classify it as urban or rural. Perceptible land transformation can be noticed around built up land.

Table 1. Interpretation Key for Desertification Status Mapping

Similarly, various parameters of DSM amenable to remote sensing and conventional survey have also been enumerated and listed in table no. 2 , as follows.

Amenable to Remote Sensing				Amenable to Conventional Survey			
Sr.No.	Process of degradation	Degree of severity	Percentage of crown Cover	Plant community	Percentage of climax species	Decrease of total plant cover, %	Loss of forage(grasses), %
1	Vegetal degradation	Slight	40-20	Climax	>75	<25	<25
2		Moderate	20-10	Long lasting secondary	75-25	25-75	25-75
3		Severe	<10	Ephemeral secondary	<25	>75	>75

Amenable to Remote Sensing				Amenable to Conventional Survey			
Sr.No.	Process of degradation	Degree of severity	Type of erosion	Dimension of channel in metres	Density of channel in km	Loss of yield of main crop, %	Removal of top soil horizon,%
1	Water erosion	Slight	Rill	D=0.5/ w=0.4-0.9	<0.5	<25	<25
2		Moderate	Gully	D=0.6-3 w=1-3.5	0.5-1.5	25-50	25-50
3		Severe	Ravine	D=3-10 w=3.5-20	1.5-3.0	>50	>50

Amenable to Remote Sensing				Amenable to Conventional Survey			
Sr.No.	Process of degradation	Degree of severity	Type of erosion (% area covered by fresh sand)	Sand sheet in cms./ hummock	Loss of yield of main crop	Percentage of area covered with sod forming plants	Loss of yield of main crop

1	Wind erosion	Slight	<30	<5	<30	<25	<50-30
2		Moderate	30-70	5-10	50-150	25-50	30-10
3		Severe	>70	>10	1-4m	>50	<10

Amenable to Remote Sensing				Amenable to Conventional Survey					
Sr.No.	Process of degradation	Degree of severity	Crops Supported	pH	Soil salinity ECein ds/m	Salinity of ground water g/litre	Loss of yield of main crop	Soil residue, %	Salinity of irrigation water, g/litre
	Salinity	Slight	Two Crops	<8.5	4-8	3-6	<25	0.20-0.40	0.5-1.0
		Moderate	One Crop (Kharif)	8.5	8-30	6-10	25-50	0.40-0.60	1.0-1.5
		Severe	No crops	>8.5	>30	10-30	<50	>0.60	> 1.5
Amenable to Remote Sensing				Amenable to Conventional Survey					
Sr.No	Process of degradation	Degree of severity	Crops Supported	PH	ESP		Loss of yield of main crop		
1	Alkalinity	Slight	Two Crops	8.5-9.0	<15		<25		
2		Moderate	One Crop (Kharif)	9.0-9.8	15-40		25-50		
3		Severe	No Crops	>9.8	>40		>50		

Amenable to Remote Sensing					Amenable to Conventional Survey			
Sr.No	Process of degradation	Degree of severity	Submergence	Crops Affected	Depth of Groundwater (in mts.)	Change of Dominant Plants	Plant Cover %	
1	Water Logging	Slight	Seasonal	One	10-5	Tamarix, ramosissima, Alhagipersarum	< 30	

2		Moderate	Permanent	Two		5-2	Tamarix, ramosissima, Alhagipersarum, Karelinia caspia	30-70	
3		Severe	Inland Marshes			< 2	Fragmatis australis	> 70	

Table 2: Various natural indicators, indicating processes, especially those amenable to Remote Sensing and Conventional Survey

The indicators which are amenable to remote sensing have been enlisted and discussed with the experts nationwide. A comprehensive classification system and methodology has also been discussed through brain storming sessions, and circulated nationwide to seek comments from various experts on the topic. The classification system has been finally evolved and listed in table 3 , below.

LEVEL 1 : Land use / Land cover –

Agriculture – Unirrigated	(D)	
Agriculture – Irrigated	(I)	
Forest	(F)*	
Grassland/Grazing land	(G)	
Land with scrub	(S) **	
Barren / Rocky area	(B/R)#	B(Sc) indicating scree areas in cold deserts
Dune / Sandy area	(E)	
Waterbody / Drainage	(W)	
Glacial / Peri-glacial (In cold region)	C/L	
Others (Urban, Man-made etc.)	(T)	

(*Rocky areas within forest can be annotated as only FV3-R in the map)

(**Vegetal degradation in Land with Scrub around periphery of notified forests can be delineated as SV)

(Encroachment in forest area especially agricultural practices, is FV3)

(#Barren and rocky areas to be delineated separately as B or R and shown in other categories of the legend)

(All settlements should be hatched)

LEVEL 2 : Processes of Degradation

Vegetation Degradation	(v)
Water Erosion	(w)*
Wind Erosion	(e)
Waterlogging	(l)
Salinization / Alkalinization	(s/a)**
Mass Movement (in cold areas)	(g)
Frost heaving (in cold areas)	(h)
Frost shattering (in cold areas)	(f)
Man made (Mining/Quarrying, Brick Kiln, Industrial Effluents, City Waste, Urban Agg etc.)	(m)

(*Gully/ravines should be shown as Xw3, where X is the Land use / cover class of surrounding area).

(**Salinization or Alkalinization should be shown as ‘s or ‘a’ separately. Where both occur, they should be shown together i.e. s_xa_y, where x and y are respective degree of severities)

LEVEL 3 : Severity of Degradation

Slight	1
Moderate	2
Severe	3

Table 3 : The Classification System

The methodology used to prepare the DSM maps has been given in the figure 1. , as below.

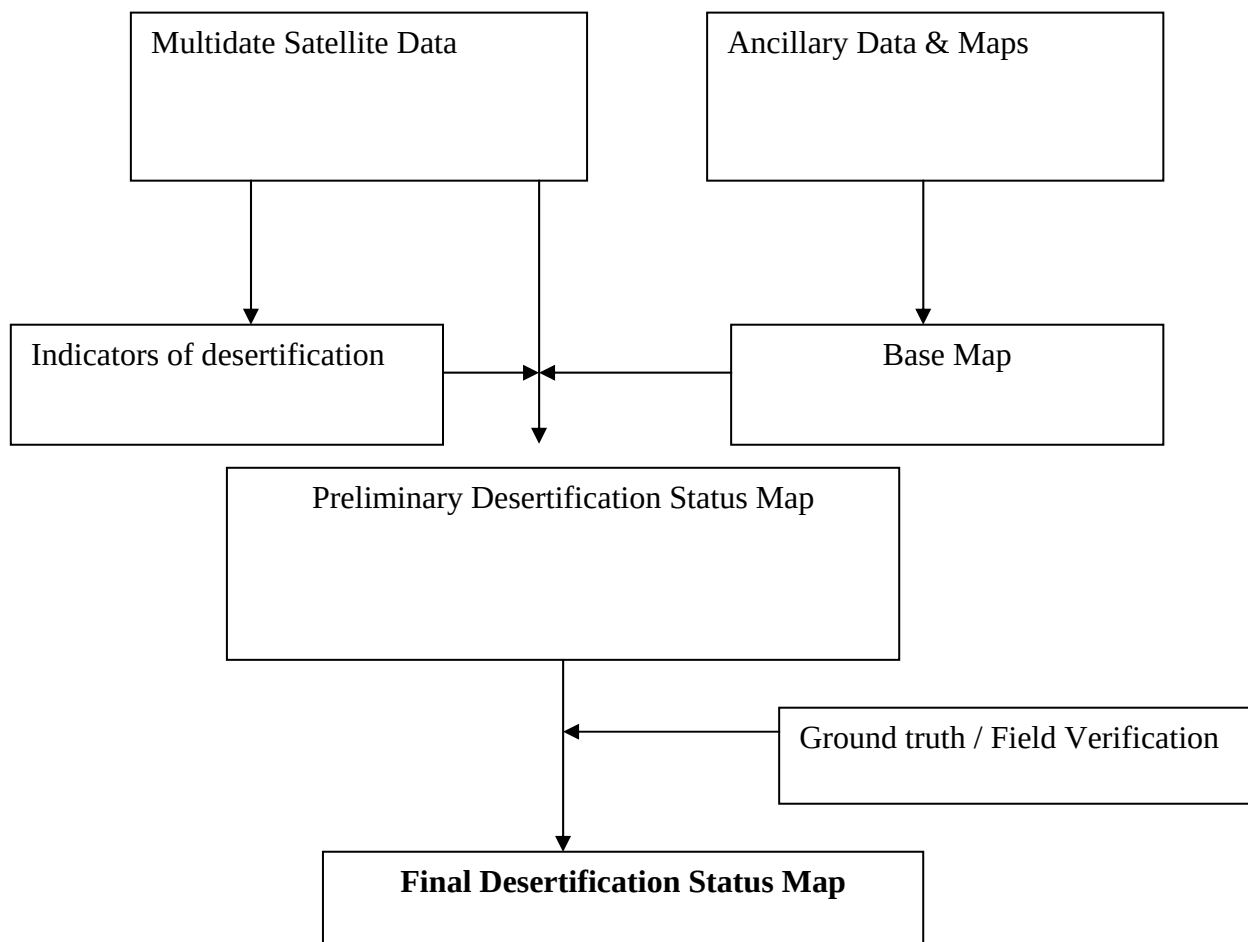


Figure 1. Schematic showing the methodology for desertification Status Mapping(DSM)

6. Discussion and Results :

Based on the image characteristics some significant indicators were chosen and finalized for desertification studies, especially those amenable to remote sensing. These have been shown as below :

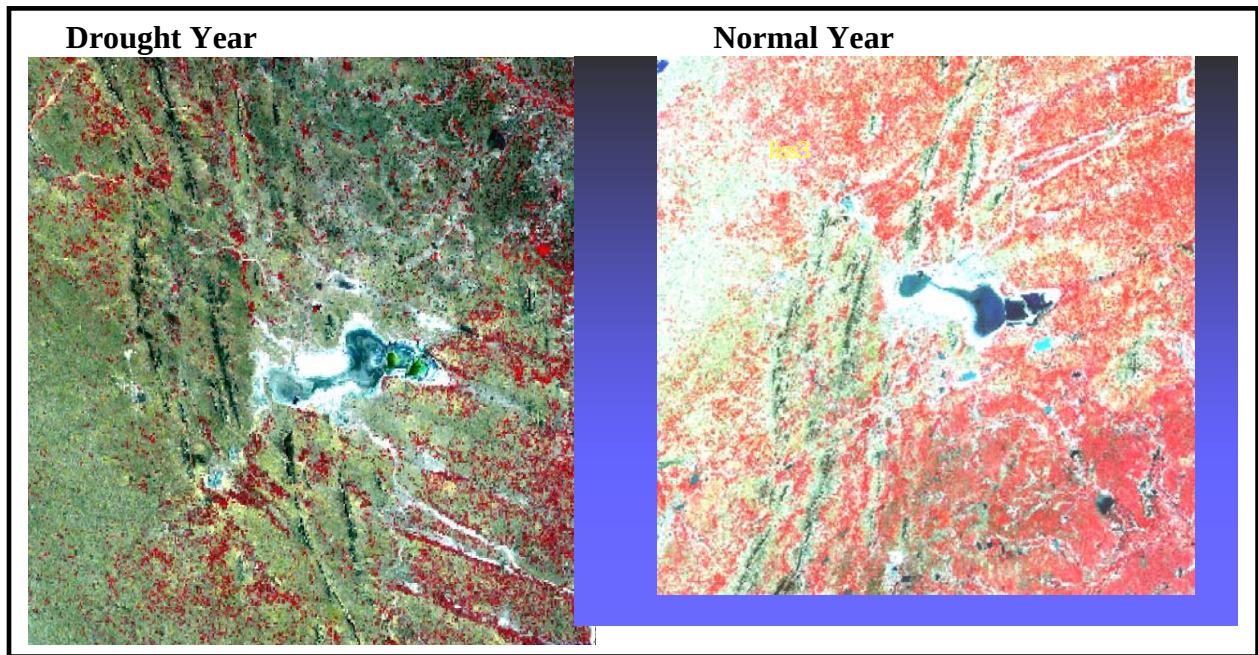


Figure 2 : Climatic conditions and vegetal cover as Indicators:

The perpetually occurring droughts do inflict land degradation as in the above case, where the dwindled vegetal cover (during droughts) in Sambhar area of Rajasthan , India, permits the inflow of sand blown from the western margins, thus converting the productive agricultural area into dune fields.

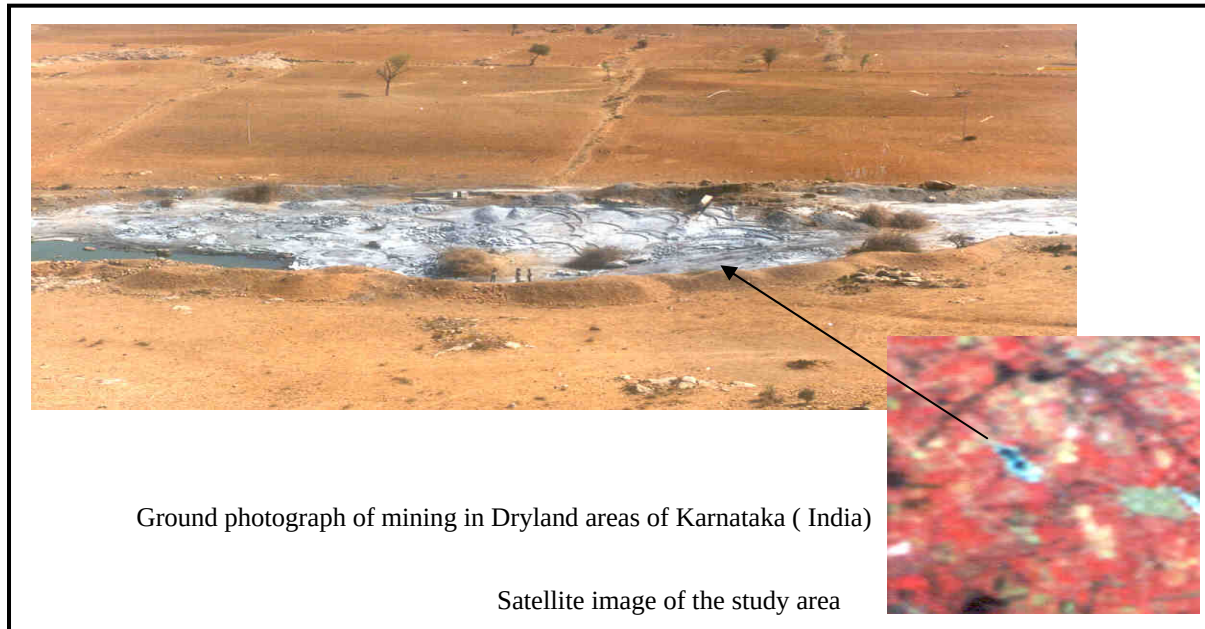


Figure 3. Indicators of human intervention.(Mining)

This figure shows the mining of land in a land which supports crop during Kharif season.. Such activities lead to irreparable loss to the productive marginal lands.

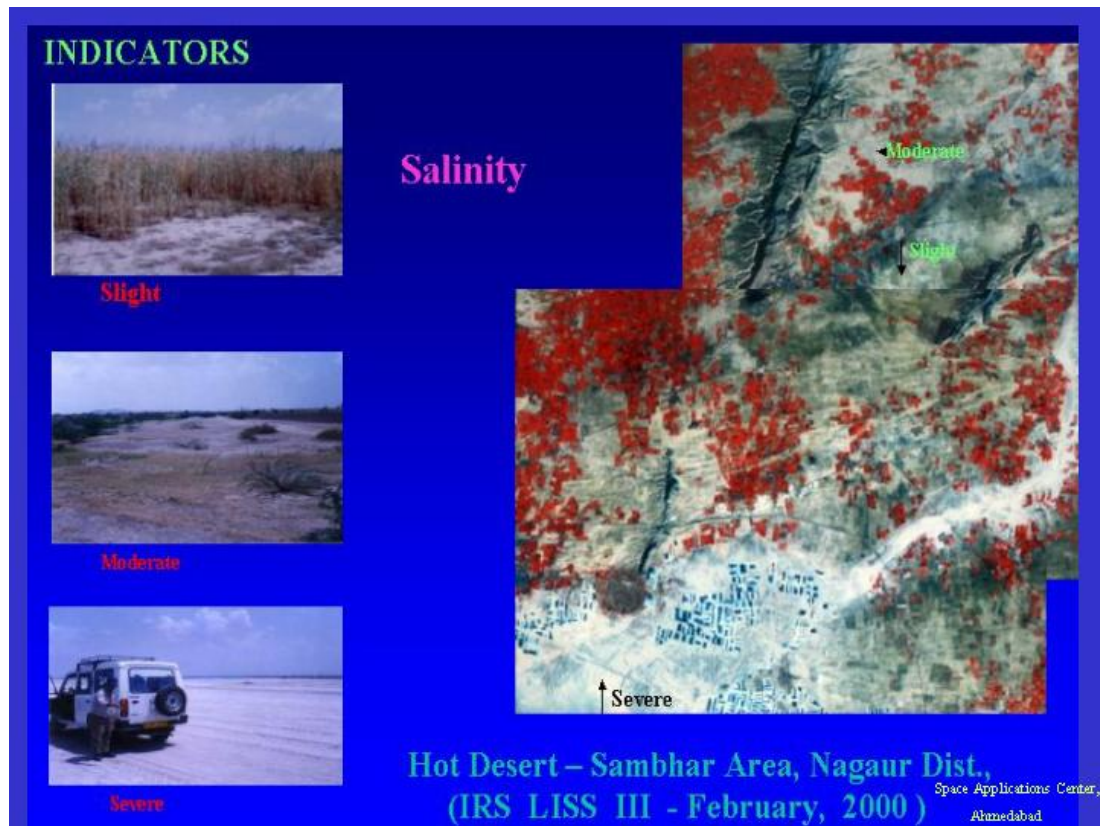


Figure 4. Salinity as an Indicators of desertification

In the above figure area shows salinity of varying severity levels. The land with slight severity supports some crop. Land with moderate severity does not support crop but does allow some xerophytic vegetation to grow. While the severe category of saline land does not permit any kind of flora.

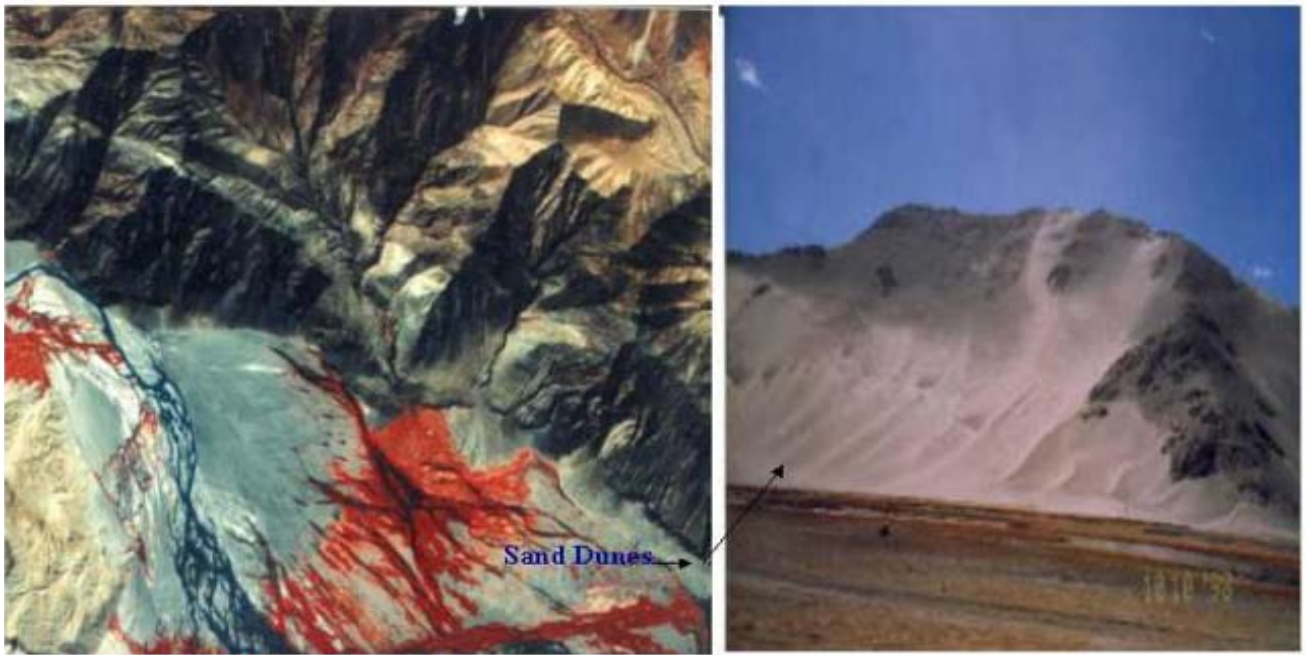


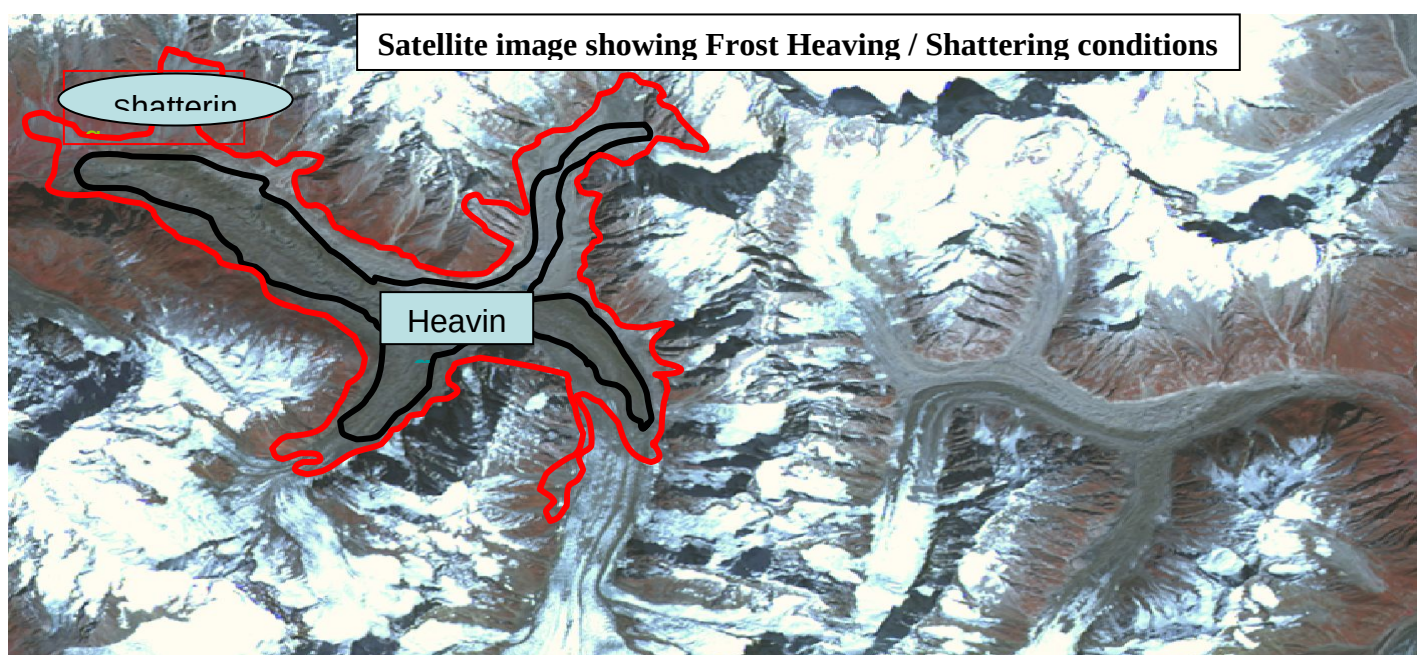
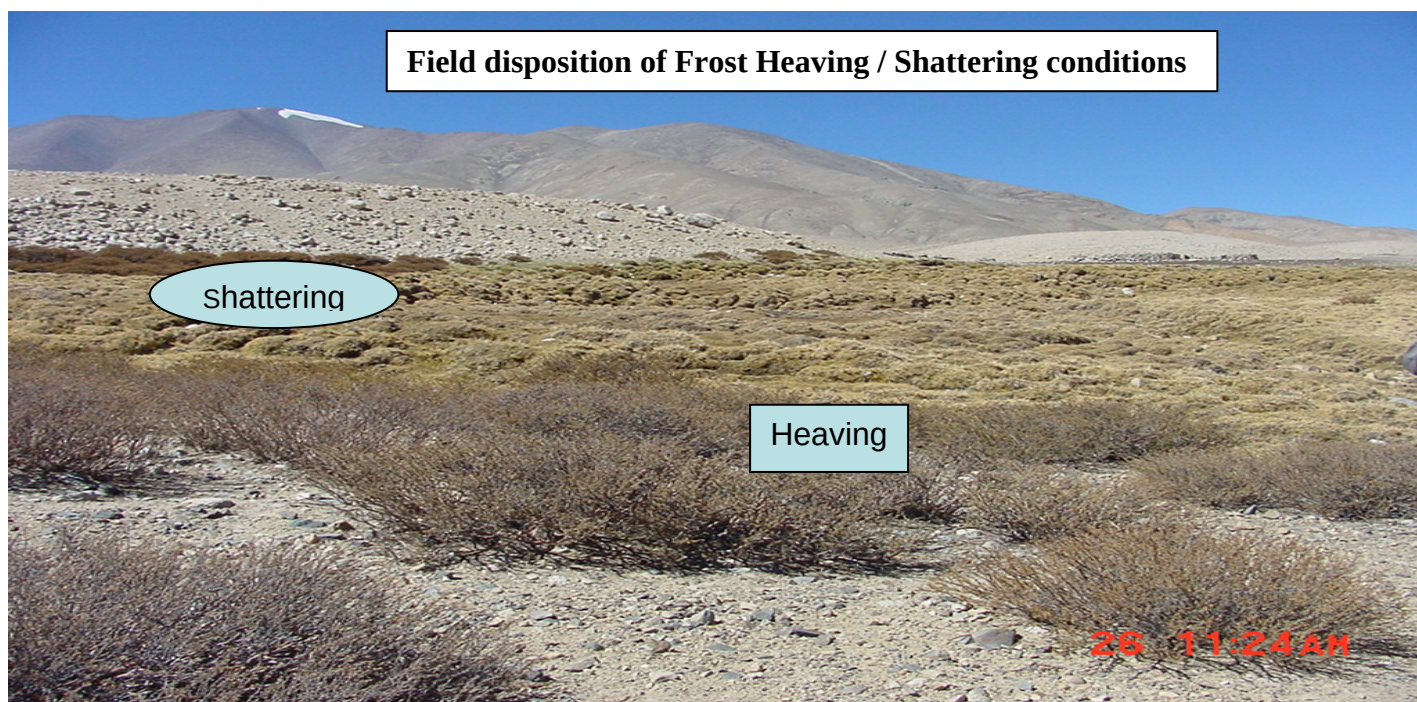
Figure 5. Sand spread as an Indicators of desertification (cold desert)

Above figure shows the effect of the blown sand spread over lofty hill, right upto the peaks. This is a picture from the cold desert of Ladakh, Himalayas, India. The left picture shows the satellite image of the study area and the picture on the right shows the ground reality. Very few people realize that such severe dune conditions exist at a height of about 15,000 to 17,000 feet above mean sea level.



Figure 6 : Wind Erosion is another strong and significant indicator. The picture shows a granite block with a hole carved in the middle due to Wind-blasting. (Leh, India)

Figure 7 : This picture shows very unique but significant indicators of dilapidation of land in higher altitude regions of cold desert in India, represented by Frost Heaving and Frost shattering.



Even the peri-glacial shattering, which is an important indicator of land diminution in cold deserts is also seen on satellite images.

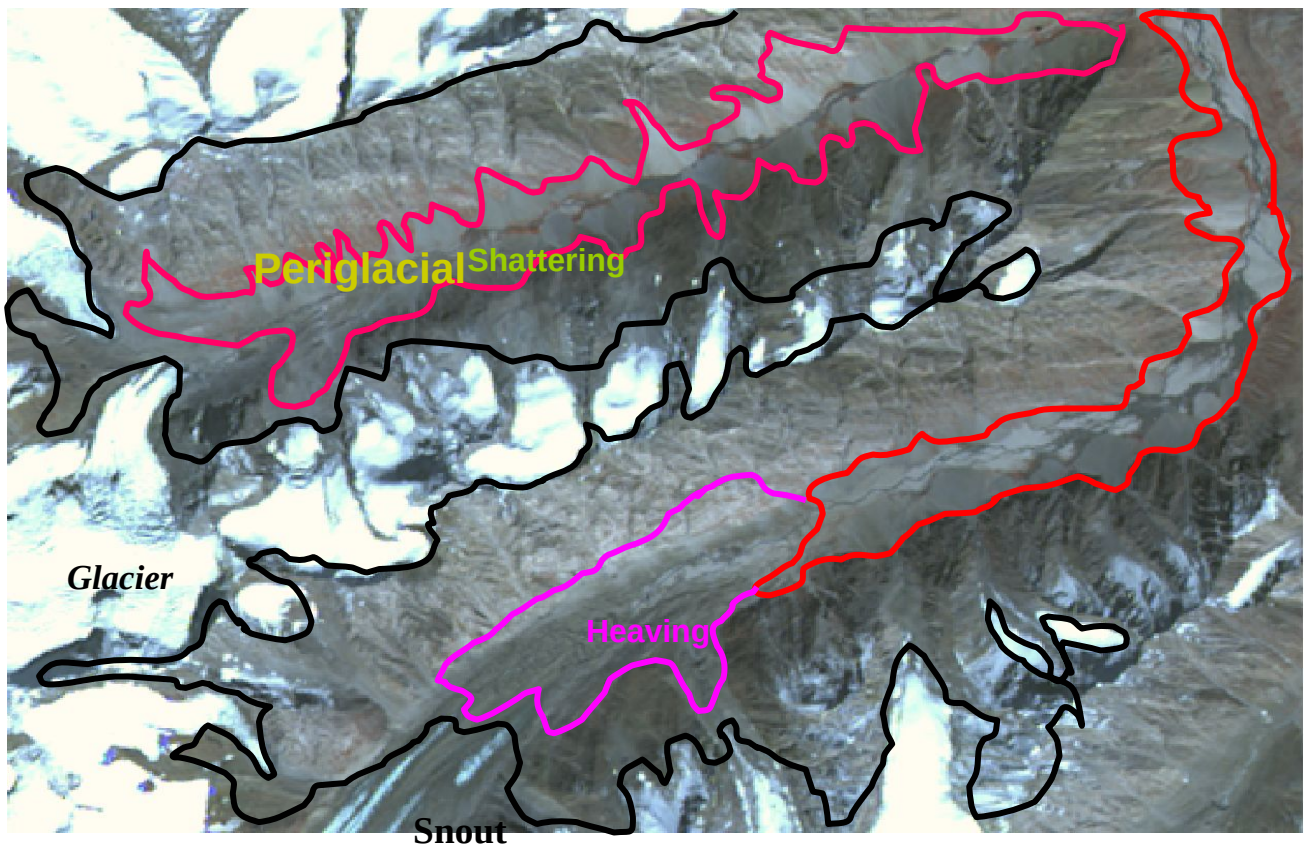


Figure 8 shows the pictures from greater Himalayas, Nobra valley. Deep cut trenches in the mountainous regions is actually carved by the snow melt run off induced severe water erosion in this other wise dry area.

Figure 8. Water erosion is the most important indicator in both hot and cold deserts:



These are the pictures from greater Himalayas, Nobra valley. Deep cut trenches in the mountainous regions is actually carved by the snow melt run off induced severe water erosion in this other wise dry area.

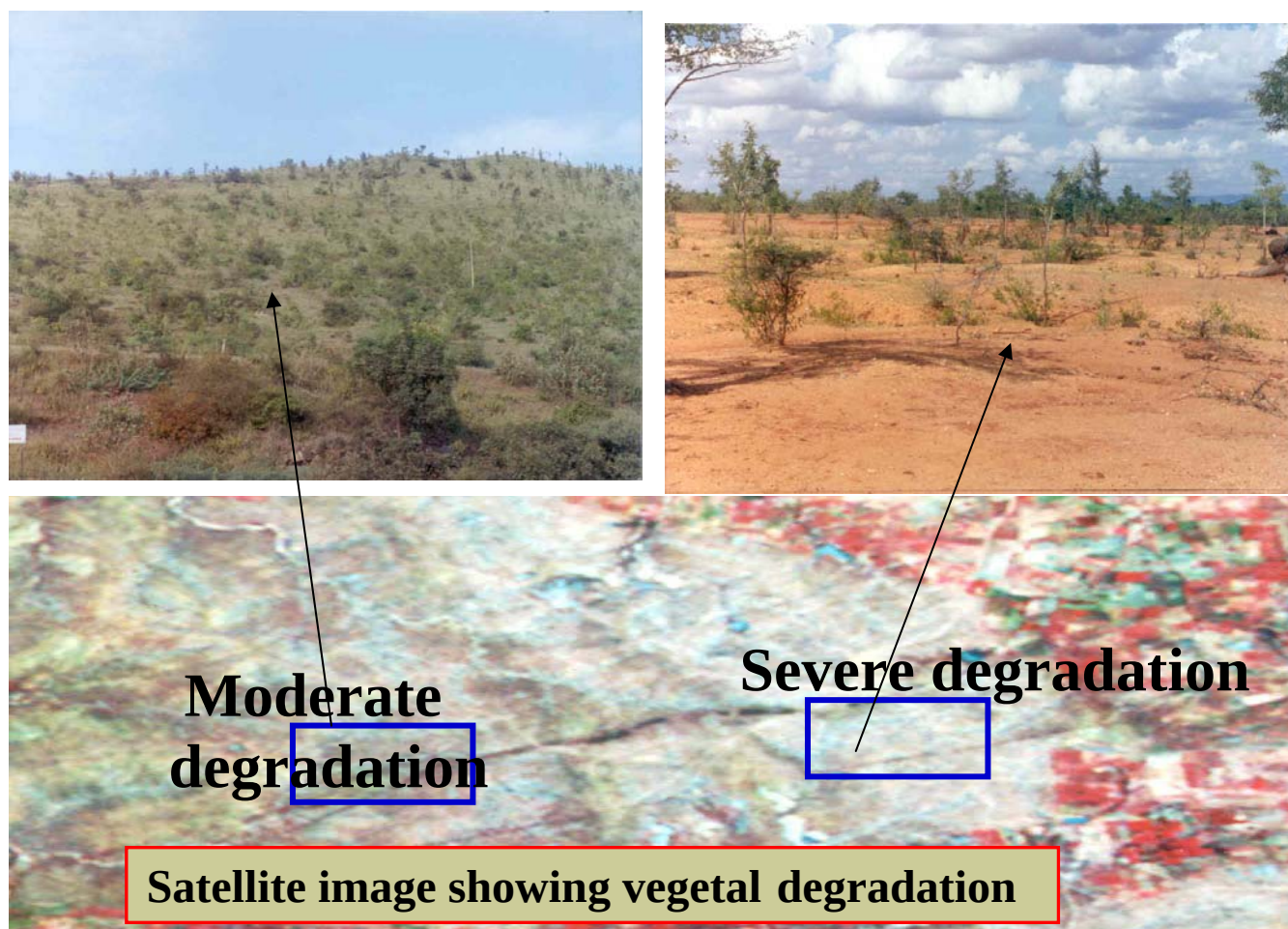


Figure 9 : Vegetal Degradation is one of the most comfortably delineable indicator of desertification on satellite image.

Based on the above indicators , an attempt has been made to carry out Desertification Status Mapping (DSM) on 1:50, 000 scale using remote sensing data.. This study has been carried out as a pilot project in about 16 different test sites spread all over the country in Drylands of both Hot and cold desertic areas. A comprehensive classification system has been evolved based on the experience and expertise available within the country, involving about 14 different organistaions/institutions/universities. The classification system is given in given in table 3. DSM maps have been made for the areas under study and one such sample of the map is given in the following figure.

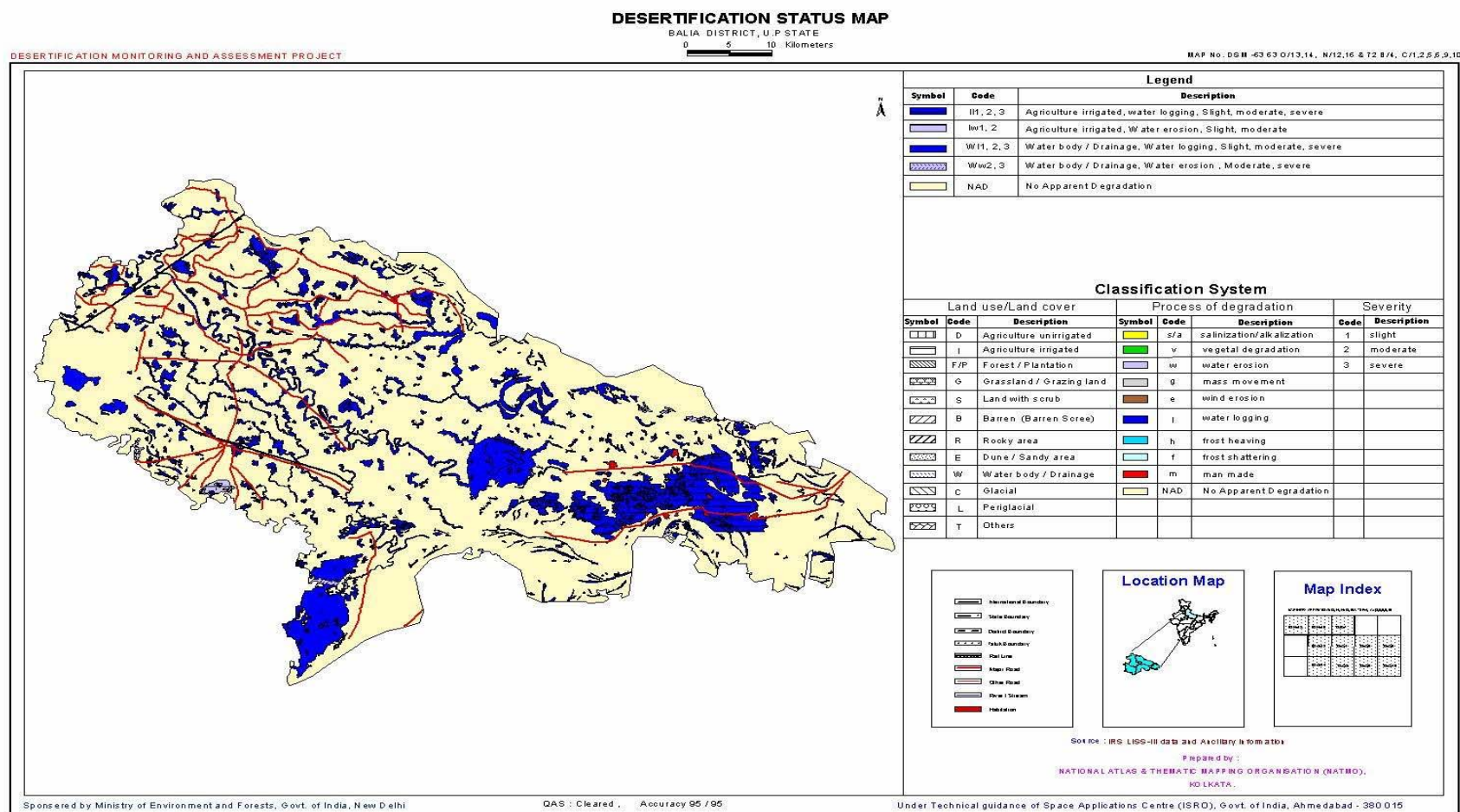


Figure 10: Desertification Map of Balia District, U.P (India)

Having successfully carried out the pilot project on 1:50,000 scale for selected test sites, the authors were encouraged to attempt Desertification Status Mapping of entire country (India) at 1:1 million scale. The IRS-AWiFS data was chosen to execute this task, as this data has a reasonably good spatial resolution (approx. 50 m) and has a large swath of its quadrants. (340 kms). This enabled the authors to complete the preliminary DSM task to be completed in record time of about 6 months. There are about 54 frames of AWiFS quadrants those were used to interpret these scenes for preparing DSM. All these are being integrated to get a full DSM view of the country and this shall be ready in about a months time.. The DSM map shows the land use cover affected by the processes of desertification (water erosion, vegetal degradation, wind erosion etc.) along with their severity levels (low and high).It may be noted that after some discussions and evaluation studies, the same classification system and legend were used for this project, that was used for the pilot project on 1:50,000 scale. However, it was observed that while most of the land-use classes and processes defined in the legend used for pilot project at 1:50,000 scale are clearly delineable on 1:1 million scale mapping. The delineation of severity levels, especially in cold deserts , is a challenging task. Most of the time, they are not so distinguishly identifiable . Also, in the hot desert areas, the severity levels of 'slight' category, either do not show up on image or get merged with the 'moderate' class. For this reason, the severity levels 'slight' and moderate' mapped on 1:50,000 scale were merged together for mapping purpoer. So ultimately , there are only two severity levels in the 1 million scale DSM maps viz. 'low' and 'high'. One such sample DSM map of state of Tamil Nadu, prepared at 1:1 million scale is given in the following figure

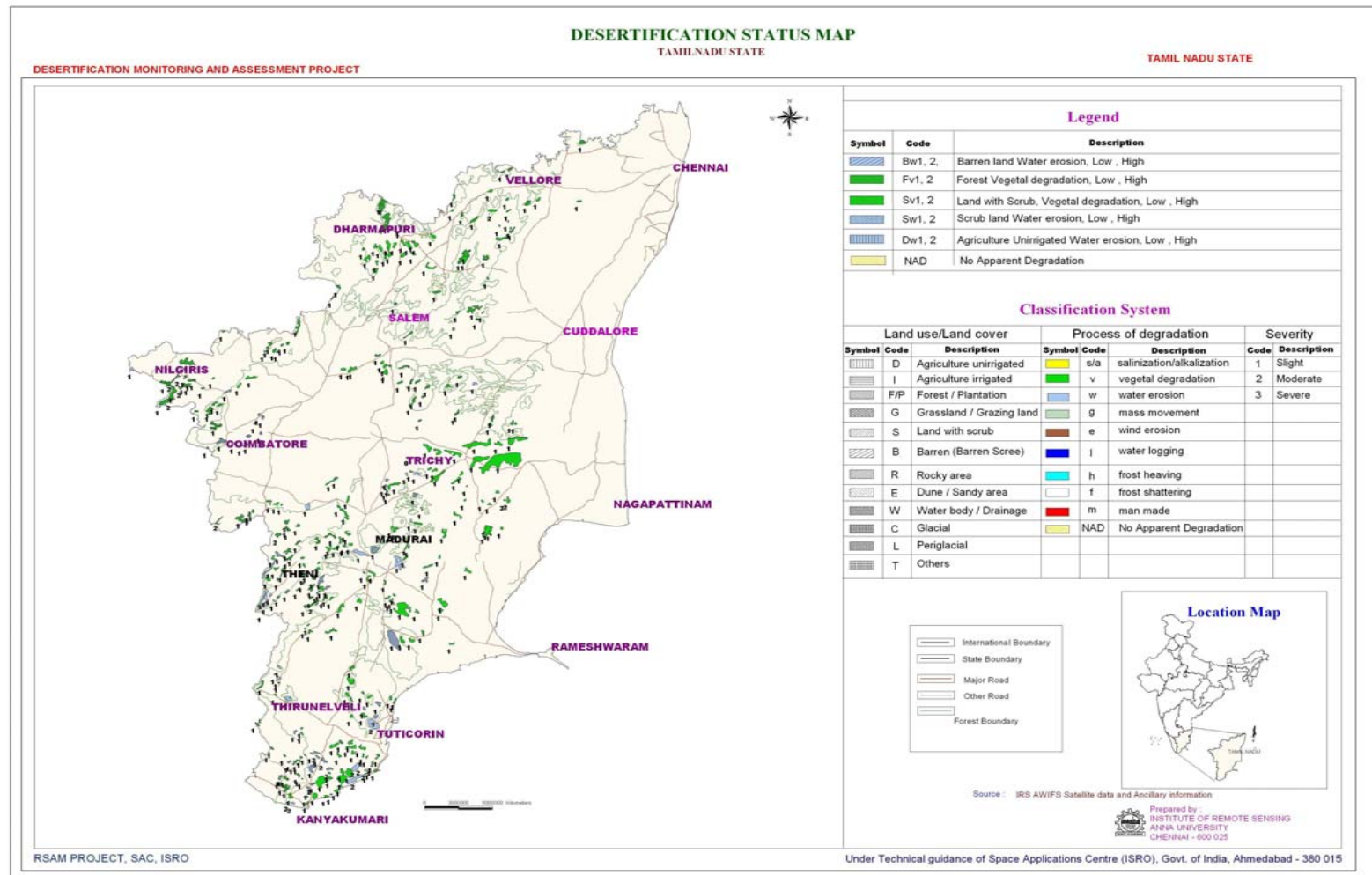


Figure 11: Desertification Status Map of State of Tamil Nadu (India) at 1:1 million scale prepared using AWiFS data

The above results show that remote sensing data has been very useful to carry out assessment of the status of desertification in various dryland regions of both hot and cold climatic conditions. Also, this exercise provides a baseline information for monitoring the desertification conditions in the future, by carrying out DSM mapping of the same areas at a suggested interval of every five years. Such an effort would show how land degradation much area has been actually added every five years. Besides, it will also help in monitoring the degraded areas which has been put to mitigation measures for combating desertification in future. The areas with high severity can be taken up on priority for implementing combating plans and rest of the areas could be closely monitored for their desertification status, rate of degradation and impact of existing mitigation measures.

7. Conclusions ;

1. The Indian Remote Sensing Satellite data has been found extremely useful for identifying, delineating and mapping of the desertification indicators. Besides, it is most useful for carrying out desertification status mapping at large and small scales of 1:50,000 and 1:1 million.
2. This study provides a baseline information on the present status of the desertification in arid, semi-arid and dry-subhumid regions of India, in both hot and cold climatic conditions.
3. This baseline information generated has been used to compare the land degradation conditions in the past for some selected areas and the intensification of the desertic conditions have been spectacularly observed.
4. Besides, the present state of desertification is useful for monitoring the desertification conditions in the future, by repeating this exercise every five years to monitor the growth of desertification and its severity in the study areas.
5. Such information is hitherto unavailable to planners in the country. In view of this, the planners can have the complete comprehensive picture of progressive desertification conditions in the country and will help them to plan the mitigation measures on priority basis, to take up desertification combating task on priority for the areas with severe intensity and rate of desertification.
6. In all, the objective of UNCCD to use remote sensing data for identifying desertification indicators and carrying out assessment and monitoring of degraded lands in dryland regions have been successfully achieved by the above study and efforts.

Acknowledgements:

The authors sincerely thank the Director, Space Applications Centre for his constant support to carry out this work. Thanks are due for Dr. S.K Pathan, head-LPPD, for his valuable suggestions time to time. Very special thanks to all the collaborating agencies, for their untiring efforts to complete the project in time.

All the colleagues who have supported this study needs to be thanked, for it was not possible to refine the approach without their critical suggestions.

Special thanks to Ministry of Environment and Forest (MoEF), New Delhi, India for funding the pilot project.

The UNCCD is to be thanked for their constant guidance, appreciation and support.

We sincerely thank the European Union for funding the AID-CCD seminar. The patient efforts of Prof. Giuseppe Enne, Prof. Sun Siheng to organize this seminar is worth praising. Special thanks to Dr. Chiara Zanolla for the prompt actions and

communications with participants. We do thank the efforts of all the staff at Università degli Studi di Sassari who must have put all their sincere efforts to make this seminar a big success. We also thank the staff at CNDMS, who helped Prof. Sun Siheng for their , technical, logistic and clerical support locally.

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THE LAND DEGRADATION ASSESSMENT IN DRYLANDS (LADA) PROJECT: ESTABLISHMENT OF A BASELINE AND MONITORING SYSTEM THROUGH THE USE OF REMOTE SENSING AND TRADITIONAL DATA GATHERING.

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Abstract

The Land Degradation Assessment in Drylands (LADA) project aims to develop assessment tools to collect up-to-date information on the status of land at local, national and global levels. For this it has developed a flexible methodological framework which relies in traditional and digital or computed assisted methods of data collection.

The LADA project will produce an overview of the global status of land, indicating hot spots and bright spots and producing higher resolution studies on six pilot countries. Both the global assessment and the country assessments will serve as a baseline to design and monitor actions for combating land degradation and rehabilitating degraded land. This paper gives an overview of the LADA project to establish a baseline and monitoring system through the use remote sensing and traditional data gathering.

1. The Land Degradation Assessment in Drylands (LADA) project

1.1 Need for a baseline and previous degradation assessments

Land degradation is a complex process that involves several natural, technical, institutional and policy factors at different levels. To design and monitor sound and cost-effective strategies for combating land degradation and rehabilitating degraded land, it is necessary to know the current status of land degradation, to understand the factors that have contributed to degradation and those that could lead to improvement or further losses of ecosystem functions.

Although several efforts have been carried both at national and international levels to assess land degradation, there are still gaps and space for improvement. Many assessments deal with land degradation risks rather than with degradation status and its socio-economic direct causes or its socio-economic indirect causes (drivers). Most estimates of soil erosion for instance, have been of erosion hazard (e.g. the Universal Soil Loss Equation or a variant), not actual, observed, erosion. There are large differences between estimates of areas at risk and areas actually affected by soil degradation.

Both at national an international levels the available databases on land resources are in general incomplete on the biophysical and socio-economic aspects of land degradation. These data are usually not comparable in terms of scale and often not compatible, they cannot be integrated and inter-linked enough to facilitate decision and policy-making. These gaps also limit the possibilities of countries for joining and implementing international conventions such as the United Nations Convention to Combat Desertification (UNCCD), the United Nations Convention on Biological Diversity (UNCBD) and the United Nations Framework Convention on Climate Change (UNFCCC) or in seeking foreign assistance and investment for land rehabilitation.

The only available global assessment of soil degradation to date is the UNEP/ISRIC GLASOD study carried out during the 80's decade at a 1:5 Million scale (published at a 1: 10 Million scale). The study highlighted areas where specific types and intensity of effects of soil degradation occur, but has been criticized because of its reliance on

expert judgement only. Since then more specific and objective studies have been undertaken, notably the SOVEUR study for Central and Eastern Europe (FAO/ISRIC, 2000) and the ASSOD study for south East Asia (UNEP/ISRIC/FAO, 1995).

1.2 Need for harmonised definitions

In order to carry out assessments which are compatible and comparable at different scales, it is of primary importance to use standardised and harmonised definitions. For the purpose of LADA, land degradation is the set of processes-natural, human induced or both- which lead to the land no longer being able to sustain properly and economic function and/or the original ecological function (FAO 1998; ISO, 1996).

Land degradation encompasses damages or changes to one or more of its components:

- Soil: including changes to physical, chemical or biological properties
- Water resources: including changes to both surface and groundwater
- Biota: including changes to vegetation cover and other micro and macroorganisms

1.3 LADA objectives

The Land Degradation Assessment in Drylands (LADA) responds to the need of developing harmonised methodologies to carry out a land degradation assessment at different scales and establish a baseline. The main objective of the LADA project is to develop tools and methods to assess and quantify the nature, extent, severity and impacts of land degradation on ecosystems at a range of spatial and temporal scales. The project aims also to build national, regional and global assessment capacities to enable the design and planning of interventions to mitigate land degradation and establish sustainable land use and management practices.

1.4 LADA achievements (2002-2004) and approach (2005-2009)

The initial phase of the LADA project (2002-2004) worked towards the development of a methodological approach for land degradation at local, national and global scales. For this purpose a variety of information was analysed and several information products were developed (<http://lada.virtualcentre.org/pagedisplay/display.asp>). At the same time, three pilot countries (Argentina, China and Senegal) worked through an initial methodological approach at different degrees and provided useful insights on the feasibility of this approach. Several case studies related to LADA were carried out in several countries (Mexico, South Africa, Uzbekistan, Kenya, Egypt and Malaysia) (Nachtergaele, 2005). Currently the indicators toolbox is being finalised.

For the second phase of the project (2005-2009) LADA will test the assessment tools at three levels: subnational, national and global. For this FAO will work with different international partners and six pilot countries to collect information on land degradation, analyse it and integrate it into a land degradation information system. The information collected will be used to identify hot spots¹ and bright spots to be later used for designing policy options for combating land degradation.

LADA will build capacity at national and regional levels through training centres which will disseminate knowledge on land degradation topics.

¹ Hot spots in the LADA context are areas where swift rehabilitation action is required as land degradation is particularly severe or fast, with actual or expected particularly harmful or extensive impacts on-site or off-site. A hot spot may also be an area where the land is vulnerable and threatened by degradation. A bright spot may be an area without significant land degradation that is stable, naturally or under the present conditions of sustainable management. A bright spot can also be a formerly degraded or vulnerable area where land protection or land rehabilitation has been successful or is in progress.

The major products from LADA can be classified in general as:

- Improved approach to land degradation assessment (strategies, methods and tools)
- Baseline (from global assessments of land degradation in drylands)
- Detailed local assessments and analysis of land degradation in hot and bright spots with linkages to policy formulation
- Promotion of action and decision making for the control of land degradation
- LADA will therefore catalyse widespread adoption of validated techniques of land degradation assessment and trained people to deliver improvements.

2. The LADA indicators toolbox

2.1 Development and characteristics of the indicators toolbox

To identify the status of the land the LADA project will rely on the use of indicators. For the purpose of LADA, indicators are statistics or measures that relate to a condition or attribute of ecosystems, through which the change of quality or state can be recorded. Both qualitative and quantitative indicators can be used for natural resources management, including policy review.

The LADA project is developing an indicator toolbox containing a minimum set of indicators that can be measured at local and global scale and which allow for extrapolation at these different scales. The indicators in the toolbox are relatively easy to measure or obtain and in general data collection methods are of low cost. The LADA indicators are related to several conditions of the land, in such a way that they can describe the system in a cost-effective way. For illustration purposes, an extract from the indicators toolbox under development is included in Table 1.

State indicators		
Indicators	Degradation Type	Measurement
CLIMATE RESOURCES		
Aridity index	Drought/Desertification	Analysis climatic stations (LOCLIM)
Soil Moisture change	Drought/Desertification	Remote Sensing
SOIL RESOURCES (local/national to be extrapolated globally for most at a later stage)		
Soil type	For extrapolation nationally	National soil map/SOTER
Organic Matter	Nutrient Decline/Soil Biodiversity decline	VSA
TERRAIN RESOURCES (Local, National and Global)		
Surface Aspects	Landslides & Gullies & Wind Erosion	Remote Sensing
WATER RESOURCES		
Irrigated Areas	Salinization	database
VEGETATION RESOURCES (Local, Nationally and Global)		
Changes in land cover	Loss of Biodiversity & loss of nutrients	Remote Sensing UNCBD
changes in key species	Loss of biodiversity	UNCBD
Direct pressure on the resources (pressure indicators)		
Indicators	Pressure Type	Measurement
BIOPHYSICAL		
Climate Extreme Events	Salinization (Tsunami) Landslides (Heavy Rains) Loss of land cover & Biodiv. (Long Drought)	Model/Remote sensing Model/Remote sensing Model/Remote sensing
Slope/Land Use	Water Erosion	USLE Model
SOCIO-ECONOMIC		

Frequency of forest fires	Deforestation/Nutrient loss	database
Urbanization	Sealing (abs.loss of land)	database/Remote sensing
Livestock pressure over CC	Compaction/ Loss of land cover	databases
Driving forces		
Indicators	Type of indirect cause	Measurement
SOCIO-ECONOMIC		
Incidence of poverty/ Headcount poverty index	Low budget for agricultural inputs leading to extensive farming. Relates to soil fertility decline and deforestation	Population censuses
Population density	May lead to agricultural intensification as the land labour ratio fall, or deforestation as new land must be cleared for agriculture. Soil erosion.	Population censuses

Table. 1 Extract of indicators toolbox under development (not all indicators included for each category, not all categories included, only for illustration purposes)

To study the status of land and the possible linkages between biophysical and socio-economic factors, the LADA project uses the Driving Force – Pressure – State – Impact – Response (DPISR) Framework” (Dumanski, 1994). In its general form the DPSIR framework states that driving forces exert pressures on the environment and that these pressures can induce changes in its state or condition. The subsequent impacts on socio-economic and biophysical attributes cause society to respond by developing or modifying environmental and economic policies and programmes aimed to prevent, minimise or mitigate pressures.

Since the first stage of the land degradation assessment is “scanning” the attributes of land and determining its status, the point of entrance of the LADA methodology to the DPSIR framework is at the state indicators window (Figure 1).

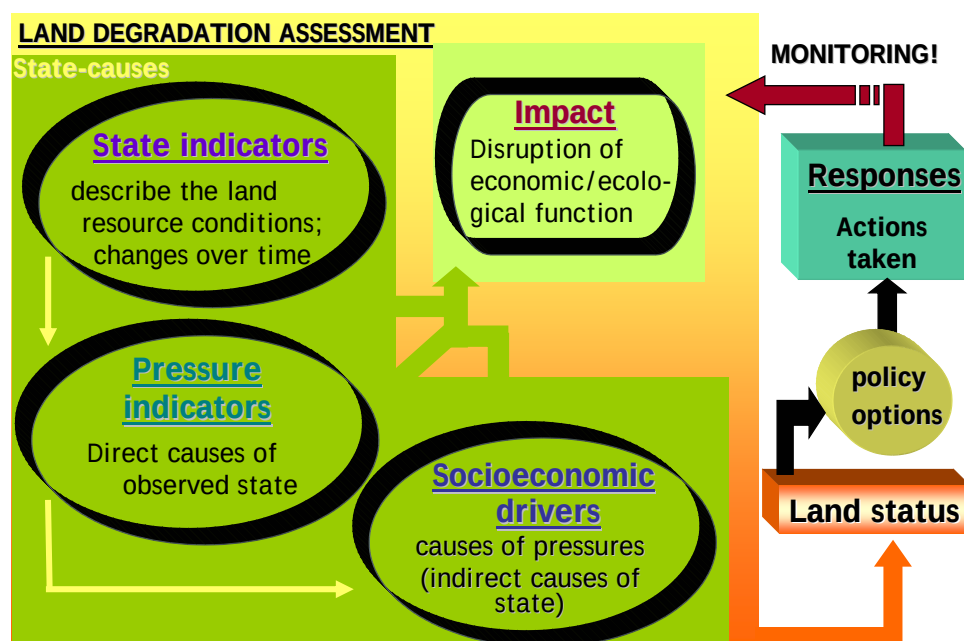


Figure 1. Sequence of indicator investigation using the DPSIR framework.

Once the status of land is determined, the direct and indirect causes of the land status can be investigated through the analysis of pressure indicators and possible

socioeconomic drivers, respectively. The state indicators, pressures indicators and socio-economic drivers all contribute to the impact observed (for example, decrease in productivity, loss of cropland, loss of biodiversity, etc.) and to which society responds. LADA will therefore generate a fair overview of land degradation at a global scale, which can be considered as a baseline and from which countries can decide if a more thorough assessment is needed or if that level is enough to design and monitor preventive or rehabilitation policies. The cycle re-starts when monitoring the changes in the resource base as a result of responses to land degradation.

3. Data collection methods

LADA uses traditional data collection methods and digital or computer assisted methods. The traditional methods include: agricultural and other national censuses; resource surveys (soil and natural resources maps, previous field investigations); participatory surveys and the Visual Soil Assessment tool (VSA) developed for LADA. The digital or computer assisted data collection methods include models, remote sensing and geographic information systems (GIS).

3.1 Data collection at local level using the Visual Soil Assessment tool

The collection of information at local level is an important part of the LADA project. Through exercises in the six participating pilot countries, LADA will test and collect information using a method developed for LADA which is based on a participatory approach. The principle of the Visual Soil Assessment Tool (VSA) is to use simple techniques which can be learned by farmers and that they need for improving land conditions. The VSA has three main types of investigations: site details (e.g. previous management, “walk-in” clues), soil morphology (e.g. soil structure, root development, colour, and biota) and soil measurements (e.g. soil texture, pH, organic carbon, soil slaking and dispersion, water infiltration). All VSA indicators are related to laboratory-based soil characteristics. For example, there is a strong correlation of the VSA soil structure assessment with the dry aggregate-size distribution, saturated hydraulic conductivity (Ksat) and air permeability. The VSA soil porosity assessment is strongly correlated to dry aggregate-size distribution and macroporosity, and weakly related to dry bulk density. The colour assessment is strongly correlated to total carbon and moderately correlated to anaerobic mineralisable nitrogen of conventionally cultivated mineral soils. The soil colour relationship holds only for those conventionally cultivated soils that do not have strongly bound and/or high amounts of organic matter, and do not show visual evidence of anaerobic conditions.

The methods used in the VSA allow for the transfer of information between sites, soil types, land uses, etc., while providing a “cross check” and physical reality to structure descriptors.

3.2. Data collection using remote sensing

The LADA project will rely on the use of remote sensing imagery and its analysis as an important component of the land degradation assessment. Lantieri (2003) reviewed the possible uses of remote sensing for land degradation assessment; he considered the following to be useful for LADA:

1. land cover and land cover changes;
2. land form and landscape;
3. vegetation activity and growth;
4. soil conditions (moisture);
5. Remote sensing derived models

3.2.3 Land cover and land cover changes

Land Cover

Land cover is usually defined as the observed biophysical cover on the earth's surface. Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. The link between land cover and land use focuses on the human interventions on the land. Various projects and initiatives have developed remote sensing based-legend or even classification systems to map land cover. Recent examples include large programmes such as the European Union project Corine and the FAO project Africover. Africover for example, uses a hierarchical standardized *a priori* classification method, called *Land Cover Classification System (LCCS)*. This classification is designed to meet specified user requirements, but independent of the scale or means used. It can be used as a reference classification system because it allows for correlation with existing classifications/legends. Land cover mapping requires ground truthing, the level of which increases with the complexity of the legend.

Time and cost for land cover mapping depends on the scale and the complexity of the legend, for example the Africover project reports that an average size country can be mapped at 1: 200 000 scale with 100 classes within 3 to 6 months, with only three photointerpreters.

Mapping directly land degradation features from remote sensing images

It is possible use high resolution imagery to map several land degradation features such as:

- Wind erosion patterns in particular over large areas (particularly well described in several exercises in China, Egypt, Mali)
- salinization patterns in field crops of large irrigated schemes (salt appears as white patches);
- overgrazing features, shown by low cover grasslands around animal paths for example;
- sedimentation of lakes or rivers (water colour being light blue or green instead of black on colour composites) which are consequent to soil erosion upstream;
- soil water erosion pattern only when of great size and over large areas (gullies);
- burnt areas or areas subject to bush fires.

These land degradation features are better seen in very high resolution satellite data or on aerial photography but most of them can not be seen on low to medium resolution imagery (1 km) where ground resolution is too coarse. Again, field checking is of prime importance to better characterize these land degradation types. It is important to note that only some land degradation features can be seen on remote sensing imagery, examples of land degradation features that cannot be seen on remote sensing include: sheet erosion, rills, fuel wood depletion on trees, loss of soil fertility, changes in tree and shrub species.

Land cover changes

In practice, high resolution remote sensing data taken at two distant periods can be used to prepare land cover changes maps or databases. Among the features that can be shown on remote sensing data and that are of prime interest to LADA are: agricultural areas under intensification; reduction of woody cover; reduction of grass cover; forest clearance; reduction of size of water bodies.

3.2.4 Landforms and landscapes

Remote sensing imagery allows having an overview of the landscape over large areas (countries, regions) through colour composite “real colour” images (vegetation is green). Through “landscape analysis” interpreters with a good background in physical geography are able to read from this imagery important information on the land. This interpretation process is even more efficiently carried out on 3D space imagery which incorporates a digital elevation model (DEM).

In practice, the visual interpretation of HR data retrieves information on watersheds; drainage patterns; geomorphologic features with a high level of detail; morpholineaments; and topography, slopes.

This information in association with land cover and Agroecological zones maps, lead to a very complete analysis of the landscape. This landscape analysis can also be combined with other ancillary data coming from e.g. socio-economic database and surveys (e.g. agriculture census) and/or from administrative datasets to prepare a comprehensive “ecosystem stratification” of the territory.

3.2.5 Vegetation activity indexes.

There are many possible types of remote sensing derived vegetation indices of which the Normalized Difference Vegetation Index (NDVI) is the most commonly used. The NDVI is a practical way to represent the level or intensity of vegetation activity. In the context of LADA, GIMMS 22 years rectified NDVI data (8 km) will be used to analyse the spatial and temporal changes in biomass. The images will be superimposed with soil/ terrain and land use databases to determine deviations from local norm (hot spots and bright spots). Higher resolution data from Landsat multispectral (30 m resolution) will be used to determine the type of land degradation in the hot spots/ bright spots in combination with field validation and traditional assessment methods.

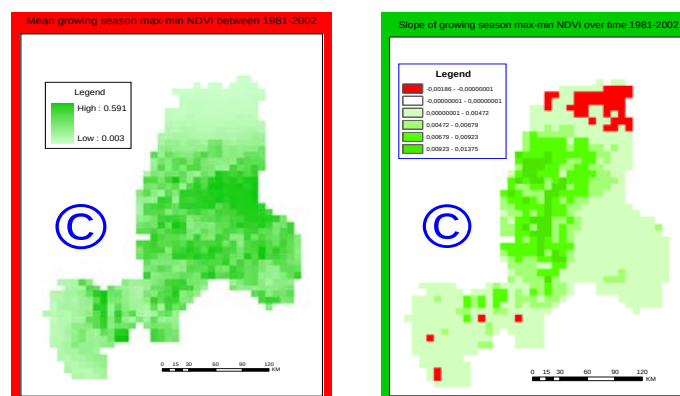


Figure 2. Spatial analysis of biomass changes (ISRIC)

Remote sensing derived vegetation indexes have a high potential for assessing the vegetation activity as a result of both rainfall availability and land conditions. A continuously decreasing vegetation index along the years can be interpreted as a sign of desertification. However, NDVI should not be analysed by itself. In combination with land cover/land form/rainfall/land use information, and calibrated on the ground with biomass measurements, it could provide significant indications, even quantitative, on the different types of vegetation degradation (or rehabilitation).

3.2.6 Soil conditions

Soil erosion and salinization

As mentioned previously some erosion and salinization patterns can be seen directly on high or very high resolution imagery. However, most of this kind of soil deterioration cannot be seen with remote sensing data and still relies on ground measurements. It should also be noted that the sampling design of full surveys can be largely assisted by the use of remote sensing derived products.



Figure 3: Soil erosion mapping in Tunisia

Soil moisture

Soil moisture can be “sensed” using low to medium resolution imagery. Several soil moisture indexes (SMI) have been proposed using a wide range of methods and sensors e.g. using NOAA imagery (School of Forestry, University of Montana, USA; using Meteosat imagery (EARS laboratory, the Netherlands); using ERS Scatterometer (Vienna University of Technology). Further research is still needed to assess which of these SMI can be the most useful for LADA. Also, ground resolution of these indexes remain rather low (in the range of km), which make them more useful for overall drought assessments rather than detailed land degradation assessments.

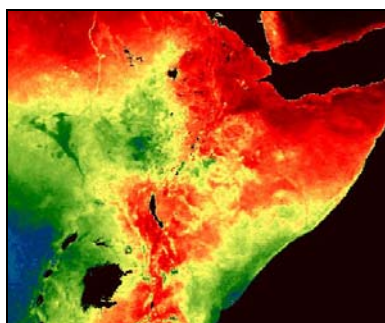


Figure 4: Example of a soil moisture map over East Africa (EARS product, Year 2000)

3.2.7 Remote sensing derived models

Remote sensing includes a component of complex research, especially when it intends to model physical parameters related to energy or atmospheric cycles. Although it is still difficult to assess how useful this research can be for an operational and decision making driven project such as LADA. Examples of the available models are those based on MODIS.

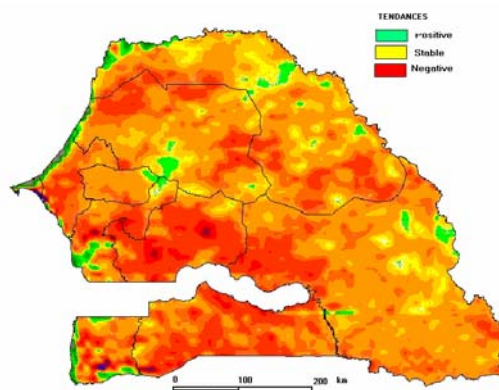


Figure 5. Evolution of net primary production in Senegal (1986-1999)

4 Conclusions

In order to design and monitor policies to combat land degradation and rehabilitate degraded land, it is important to establish a baseline that takes into account the complexity of land degradation. The LADA project is aiming to produce an overview of the status of land degradation and a monitoring system that includes biophysical and socio-economic indicators.

Remote sensing offers three main categories of information useful for LADA:

- It can assist in identifying areas where changes (positive or negative) in trends of the dynamics of land have occurred and which are directly related to the degradation process.
- It can be used to stratify the territory and to optimise field sampling design for in-depth land degradation studies
- It can assist in mapping directly many areas under degradation. It was shown that in certain cases, land cover analysis allows to identify specific features of degradation.

Remote sensing is useful and cost-effective for land degradation studies and LADA; nevertheless, it needs to be used in combination with traditional data collection techniques (field surveys and censuses) in order to better understand the direct and indirect causes of land degradation.

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SESSION IV

Climate change impact on Desertification – what B&I should be used

INTEGRATING CLIMATE CHANGE INTO DESERTIFICATION BENCHMARKS AND INDICATORS

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1. Introduction

The main features of climate change comprise variations in average temperatures and rainfall and the occurrence of extreme events, including their temporal and spatial variability. Even without any anthropogenic intrusion, the response of ecosystems to climate change proves to be complex and highly non-linear; it shows bifurcation or choke points and memory effects. Both slow trends and extreme events may lead to severe changes likely to be irreversible, among which desertification. This is for example evidenced by the evolution of Sahara over the past millenniums. Besides, due to the dramatic increase in human population and activities, interferences between anthropogenic and climatic impacts become more and more acute and may be quite difficult to single out in spite of their theoretically different temporal and spatial scales. It might happen for instance that major human-induced interferences occur when an ecosystem is in an unstable state or at a bifurcation point, or that intricate couplings between extreme events and human pressure arise on similar time scales (see for instance Lambin, 2004). On the other hand, desertification might entail feedbacks on climate change (changes in albedo and hence in the energy balance, in the water cycle, etc...). Climate change has a global signature, but also exhibits strong regional and sub-regional heterogeneities. Downscaling from the global scale to regional and sub-regional scales is an active domain of research. Addressing these scales is mandatory when attending to desertification issues.

Policy makers are increasingly aware of the possible adverse impacts of climate change and the urgent need to define mitigation measures. They are also conscious of the need to combat desertification, which can be one of these negative impacts. Attempting to link both approaches raises the more precise following questions:

- How does climate change affect arid and semi-arid ecosystems?
- How do impacts of anthropic activities associate with climate change to alter such ecosystems?
- What are the main features and results of IPCC-endorsed scenarios (including accuracy)?
- What are the state-of-the-art and results in downscaling climate change scenarios to the proper temporal and spatial scales in arid and semi-arid regions?
- What is the leading scheme to deal with desertification as an impact of global change? (this should be related to human activities).

The following points should be attended to in order to focus on benchmarks and indicators:

- What are the main indicators used to characterise global change and its impacts?
- How could these indicators be coupled to other ones in order to improve the relevance and accuracy of the desertification indicators discussed?
- Is it possible to set up a coherent set of indicators intended for policy makers who have to simultaneously handle climate change, loss of biodiversity and desertification impact in arid and semi-arid regions?

2. How can this issue be addressed?

There are various questions to be sorted out. It is essential to understand how climate change affects desertification, and therefore to get to know which indicators are the most sensitive to climate change. Then, it should be undertaken to define qualitatively - and if possible quantitatively - how these indicators are impacted by climate change, and more precisely by which parameters related to climate change. In fact, no additional indicators are sought after; the aim is to provide mechanisms that integrate climate change into AID-CCD selected indicators. This introduces “horizontal” questions and requires “horizontal” analyses. It is also necessary to ascertain the impacts of climate change on benchmarks, and to determine whether they can be isolated from others.

The basic issue is to lead a study regarding the “responsivity” (a word to be further explained) of benchmarks and indicators to climate change features. Each “thematic” topic addressed must regard this issue as a “horizontal” one and raise the above mentioned questions, keeping in mind that the main characteristics of climate change to be considered in a first approach are:

- change in temperature trends,
- change in rainfall patterns,
- change in the occurrence of extreme events,
- change in natural variability.

The current need is to identify these “responsive” indicators and explain how climate change features as determined by scenarios and regional climate models impact them. Similar questions should be put forward regarding benchmarks.

The precise meaning of “responsivity” can be developed as follows:

- *Sensitivity* characterises the degree to which a system is directly or indirectly affected by climate-related stimuli: mean climate characteristics, climate variability, frequency and magnitude of extremes.
- *Adaptive capacity* characterises the capacity of a system to adjust to climate change (including variability and extremes) with a view to moderating potential damages, taking advantage opportunities or coping with consequences.
- *Vulnerability* characterises the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change (including variability and extremes). Vulnerability is a function of the character, magnitude, and rate of climate change, and of the sensitivity and adaptive capacity of this system.

Consequently, the basic issue brought up above can be expanded by assessing if mechanisms connecting sensitivity and climate change are properly understood and whether sensitivity can be quantified. The aim would be to attempt to find which indicators:

- exhibit a high degree of sensitivity to the main climate change features;
- can characterise and/or measure the capacity of a system to adjust to the main climate change characteristics, to moderate potential damages, and to cope with consequences (and how);
- can characterise and/or measure the degree to which arid lands are susceptible to, or unable to cope with, the adverse effects of climate change (and how).

Indicators are crucial in allowing managers to make decisions. The conclusions drawn from these analyses should lead them to anticipate decision making processes in relation to the predicted perturbations induced by climate change according to these indicator values, thus enabling them to make decisions in a sustainable development perspective.

3. Desertification and climate change: natural coupled effects

As stated by M. Leighton (1998) and M.A.J. Williams (2001), both climate and desertification interact at a variety of scales through a complex and still only partially understood series of feedback loops. In arid and semi-arid regions, phenomena of desertification, climate change, biodiversity loss, and loss of wetland habitat are linked by a number of mutually reinforcing physical dynamics and can become the simultaneous causes and consequences of one another.

Indeed, the Convention to Combat Desertification (UNCCD) has to consider climate change since this agreement cannot be viewed in isolation from other efforts to promote sustainable development. UNCCD frequently refers to sustainable development, climate change, biological diversity, water resources, energy sources, food security, and socio-economic factors. Even though the interactions between these issues and desertification might not be fully understood, they are clearly important. UNCCD emphasises the need to coordinate desertification-related activities with research efforts and response strategies inspired by these other concerns, including climate change. Some data are worth recalling here. Desertification is the degradation of drylands; it is mainly due to climate variability and unsustainable human activities. Drought is a natural phenomenon that occurs when rainfall is significantly below normal recorded levels for a long time. Drylands are known to respond quickly to natural climatic fluctuations. Satellite imagery has shown that the vegetation boundary south of the Sahara can move by up to 200 km when a wet year is followed by a dry one, and vice versa (Tucker et al., 1991). People have to adjust to these natural fluctuations. When land managers cannot or do not respond flexibly to climate variations, desertification is the result.

Climate change might actually worsen the effects of desertification. Climate has an important but often subtle influence on desertification processes through its impact on dryland soils and vegetation, on the hydrological cycle of drylands, and, ultimately, on human land use in drylands. The relative role of climate and mankind remains equivocal, especially in rangelands and the most arid regions of the world. Countries with arid and semi-arid regions or areas liable to floods, drought and desertification are particularly vulnerable to the adverse effects of climate change. Natural climate variations can strongly affect drought patterns. Efforts to strengthen predictions are an important part of national action programmes to combat desertification and aim at improving dryland farmers and herders' preparedness for drought. According to the third IPCC report (2001), the globally averaged temperature of the air above the Earth's surface would rise by 1.4 to 5.8° over the next 100 years. This report describes how this global warming could impact civilisation and the natural environment. Projecting trends likely to continue through the present century, the report states that desertification is expected to worsen in response to a reduced rainfall in parts of Africa, that declines in agricultural productivity will diminish food security in many Asian countries, and that floods and droughts are to become more frequent in Latin America. The anthropogenic origins of climate change appear to be increasingly obvious. The same report asserts that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities". During this period, natural factors are estimated to have induced "negative" (i.e. cooling) radiative forcing, while anthropic activities have resulted in "positive" (i.e. warming) radiative forcing: higher concentrations of various greenhouse gases (largely due to fossil fuel burning) warm the Earth surface, and land use change (especially deforestation) raises CO₂ concentration in the atmosphere. The net balance of natural and anthropogenic factors is the significant warming recorded over the period (+0.1°C per decade in the Earth surface and the lowest 8 km of the atmosphere), thus showing the major human influence.

Human-induced climate change is predicted to persist for many centuries, but anthropic factors may considerably vary in the future, following the evolution of human society: hence the need for simulations considering different future worlds. “Scenarios” commonly agreed and endorsed by IPCC have been designed with this aim.

For instance, the world according to B2 storyline is characterised by:

- an ever-increasing global population,
- intermediate levels of economic development,
- less rapid and more diverse technological change than in other storylines.

This scenario is based upon :

- an orientation towards environmental protection and social equity,
- a focus on local and regional levels,
- a clear emphasis on local solutions to economic, social and environmental sustainability.

This scenario leads to temperature trends as shown in figure 1:

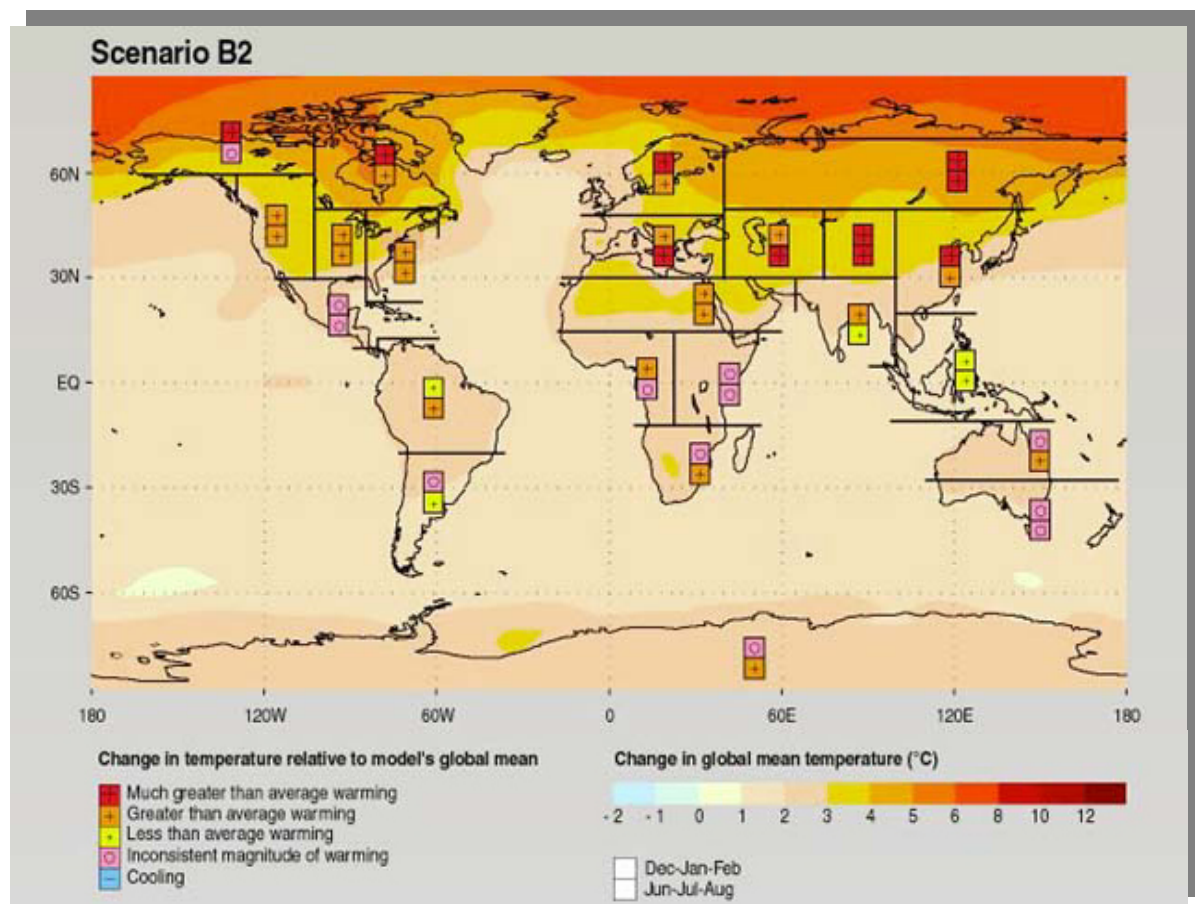


Figure 1. Temperature trends at the end of the century, according to the 2001 IPCC report, B2 scenario.

After IPCC experts, natural systems may be especially vulnerable to climate change because of their limited adaptive capacity. Some of these systems may undergo significant and irreversible damage. The geographical extent of the detriment or loss, and the number of systems affected, grow with the magnitude and rate of climate change. For instance, higher maximum temperatures (hot waves) imply a greater risk of damage to a number of crops, while increasingly dry summers and their associated risks of drought entail decreased crop yields. If we take special consideration of Africa,

desertification would be exacerbated by a reduced average annual rainfall, runoff and soil moisture, especially in the southern, northern and western parts of this continent. In this part of the world, the adaptive capacity of human systems has been acknowledged to be low due to the lack of resources and technology, whereas vulnerability is high as a result of poverty, frequent droughts and floods, and heavy reliance on rain-fed agriculture.

Desertification can in turn affect climate change. As stated by Kelly and Hulme (1993), dryland degradation modifies surface characteristics (e.g. vegetation disappearance, lower soil quality). Consequently, soil moisture decreases, which may adversely affect precipitation. Land cover change then accelerates as rainfall is reduced, which in turn lowers soil moisture levels and further decreases rainfall amounts, thus closing the feedback loop. Desertification also contributes to modifying sources and sinks of carbon, since it disturbs ecosystems which cannot store as much carbon; warming is likely to follow. Climate modelling experiments have clearly shown that large-scale conversion of land surface characteristics can generate climate change from the local to regional spatial scale.

4. Climate change impact over drylands: facts, findings and predictions

Regarding temperatures, it has been evidenced that a significant warming has dominated dryland areas. However, this century, a region of cooling is centred in the Asian deserts. As to rainfall, most drylands show no statistically significant changes in precipitation levels. Nevertheless, the Sahelian region displays by far the most pronounced change in precipitation levels in any of the dryland areas. There, rainfall levels have dropped sharply since the mid-50s and the decrease in precipitation has contributed to enormous human and economic losses in the region.

The global warming that will affect dryland climates in the future is difficult to assess with confidence. Predictions based on a number of general circulation model experiments suggest that temperatures will rise in all dryland regions, in all seasons. There is some evidence that the warming will be more rapid in the middle to higher latitudes (see fig. 1). Predictions of future changes in precipitation, including impacts on rainfall variability, vary widely from model to model and region to region, and consequently, the confidence limits on the predictions of precipitation changes in dryland areas are lower than those regarding temperatures. The forecasted rise in temperatures would most probably entail increasing evapotranspiration rates in drylands, and in the absence of any large increase in precipitation, many of them are accordingly predicted to become more arid during the 21st century.

5. Conclusions: the way ahead

In order to integrate climate change into desertification benchmarks and indicators, the main tasks to be undertaken would include:

- choosing among global desertification benchmarks and indicators which:
 - exhibit a high degree of sensitivity to the main climate change features,
 - can characterise/measure the capacity to adjust to these features,
 - can characterise/measure the degree to which arid lands are susceptible to, or unable to cope with, the adverse effects of climate change;
- defining qualitatively - and if possible quantitatively - how these indicators vary with climate change indicators;
- determining impacts on benchmarks;
- building up a “static” and “dynamic” (climate change dependent) table of benchmarks and indicators;

- conveying the message to relevant policy makers. This would allow them to take into account scenarios about climate change impacts on desertification and help them to better define sustainable development policies. Important side recommendations must be specified to scientists, their donors and other decision makers;
- the highly complex issues at stake exhibit a strong interdisciplinary dimension. Research to federate available results should be a priority for scientists and their donors;
- feedback from scientists to decision-makers has to be reinforced through relevant channels;
- indicators defining the feedback of desertification on climate have to be consolidated. This is a key issue in modelling the global process.

According to Martin A. J. Williams (2001), there is a particular and increasingly urgent need for uniform and objective methods of data collection related to the characteristics and status of dryland ecosystems, and for the evaluation and dissemination of such data on an integrated basis. There is also a very real need to strengthen existing centres and to establish a more extensive international monitoring network. This infrastructure would support regional analyses and the consequent detection of any long-term trends and their causes.

Climate change-related benchmarks and indicators are expected to provide valuable information, all the more that they allow long-term repeated measurements and consequently usefully help to monitor changes. These benchmarks and indicators should be envisaged as components of the holistic approach to understand the factors and features of desertification, thus contributing to predicting trends and to raising awareness about possible actions for counter-measures.

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CLIMATE CHANGE IMPACT ON DESERTIFICATION – EXPERIENCES OF DEVELOPMENT OF BENCHMARKS AND INDICATORS IN EAST AFRICA

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Abstract

Climate change impact on desertification in arid and semi-arid ecosystems is a complex issue that involves interactions among natural environmental variables and human activities. Climate change, one of the environmental variables, may arise internally within the climate system and also from natural external forcing and anthropogenic activities. Benchmarks and indicators relevant to these interactive relationships are discussed with special reference to the IPCC endorsed climate change scenarios. The relevant experiences in East Africa in developing indicators on land use change, land degradation, biodiversity loss and socio economic indicators on sustainable livelihoods in the arid and semi- arid ecosystems are described. The attribution of climate change impact on these indicators, which also relate with desertification, is uncertain. Further, the confounding effects between climate change and climate variability and especially the extreme climatic events such as drought and global warming are still uncertain. It is recommended that well designed long term observatory sub-regional regional schemes such as OSS/ROSELT observatories be strengthened to provide climate change and desertification indicators which are relevant for local and global benefits on sustainable management of dryland ecosystems. More research within the framework of long term observatories will also shed some light on the role of climate change on land degradation, biodiversity loss, and land use change and land cover changes.

Key words: Livelihood, land degradation, land use, biodiversity indicators

1. Introduction

Climate change is linked to any factors that affect the climate system. These factors may generate within the various factors that internal to functioning of the climate system or they arise from what is referred to as external forcing. External climate forcing is from natural factors such as volcanicity or the change in the quality of solar radiation. Anthropogenic activity is also considered and external forcing for climate change. Climate change interacts with desertification phenomenon and actually shares more or less the same driving variables. Desertification can occur in response to climate change or climate natural variability, or due to non-sustainable human activities.

The paper attempts to respond to the questions posed for the workshop on the subject of climate change and desertification. It touches on some of the climate change impacts on the arid and semi arid ecosystems and some of the root causes of desertification. In reference to the interaction between the anthropogenic factors and their impacts on the dry ecosystems, the paper gives a few findings of the United Nations Environment Programme – Land Use change Impact Dynamics (UNEP-LUCID) study on analytical approach to link land use change to land degradation and biodiversity loss in four study sites in East Africa.

The relevance of the Inter-governmental Panel for Climate Change (IPCC) endorsed scenarios and the possible contribution to the impacts of climate change on desertification is also briefly described. Some thoughts on the downscaling of climate change scenarios and possible approach to address desertification in global change context are also briefly mentioned. The second part of the paper reviews the issues on benchmarks and indicators drawing examples from several initiatives including Long Term Ecological Observatory/Observatory Sahara Sahel (ROSELT/OSS) programme.

2. Climate Change and Desertification

2.1 Climate change impacts on arid and semi arid ecosystems

Climate, defined as average weather conditions over a certain time-span for a certain area (Baede *et al.* 2001), varies from place to place due to factors such as latitude, distance from sea, and elevation among others. It is variable in time: season-to-season, year-to-year, decade-to-decade and or on much longer time scales. Its system is interactive consisting of five major components namely the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere.

In general terms, climate change refers to changes on all the five components and emanates from external forcing due to human activities like combustion of fossil fuels for industrial or domestic use, biomass burning, produce of greenhouse gases and aerosols which affects composition of atmosphere. On the other hand, land use change such as urbanisation, livestock grazing and agricultural based livelihoods affect the physical and biological properties of the earth's surface. Natural activities such as volcanic events, changes in hydrosphere, cryosphere or biosphere also initiate considerable variations in the climate system. Predictability of the impacts of these forcing to climate change is limited by our little understanding and predictability of human activities such as changes in human population, economic trends, technological trends and other characteristics. For instance the enhanced greenhouse effect affects water vapour, and temperature, while the effects of aerosols may have a negative radiative forcing. Driving forces from land use change can be changes in agriculture and irrigation, deforestation, re-afforestation, afforestation, overgrazing and urbanisation. Land use change results in changing physical and biological properties of the land surface hence change on the climate system.

Changes on land surface at the margins of deserts including arid and semi arid lands accentuate processes such as desertification. Desertification, as defined by the UN Convention to Combat Desertification (UNCCD) is, the *"land degradation in arid, semi-arid or sub-humid areas resulting from various factors, including climatic variations and human activities."* By itself, desertification is a complex phenomenon, as it reduces the land's resilience to natural climate variability, results in less productive soils, damage vegetation, undermines food production, contributes to famine, contributes to enormous social costs and causes huge drain on economic resources (UNCCD, 1994). Root causes of desertification include the following:

1. Degradation of drylands resulting from unsustainable land use such as over-cultivation; overgrazing, deforestation and poor irrigation practices among others. This leads to loss of biological or economic productivity and complexity in croplands, pastures, woodlands, loss of seasonal migratory routes for both domestic and wild animals.
2. Climatic fluctuation and adaptation of drylands ecosystems due to limited fresh water supplies, and erratic rainfall leading to seasonal variability, annual and decadal fluctuations that may cause droughts and flooding events.

3. Sedentarisation trend of nomadic population weakens traditional strategies of adapting to fluctuating climate. The socio-economic driving forces- such as politics, economics, population growth and conflicts over scarce resources.
4. Low priority given by national and local governance institutions on the formulation and implementation of environmental protection policies. The outcome of such policy laxity is reflected in desertification and increasing vulnerability to disasters like droughts and floods.
5. International economic forces that encourage people to overexploit their land for export horticultural and commodity crops, and livestock products. International trade patterns and their impacts on local resources do not support community level management or land restoration as a result of negative environmental impacts from intensification of agriculture for export markets outside the arid and semi arid ecosystems.
6. Application of inappropriate policies or technologies that lead to land degradation due to ignorance, errors, natural and man-made disasters.
7. The negative impacts of increasing populations and population densities. Such impacts accentuate land degradation and desertification.
8. Expanding human population as an ultimate driving force in land degradation- direct and indirect (demands by urbanization trend)

Focus on impact of climate change is important because of the potential negative effects on unique, fragile and threatened systems such as arid and semi arid, tropical glaciers and on the water distribution down hill, biodiversity hotspots and wetlands, and on potential relationship between climate change impacts and on changes in extreme events such as drought and flooding events (Smith *et al.* 2001). The linkages between climate change and desertification are therefore complex due to their interactive and synergistic effects.

2.2 Interaction of anthropogenic activities and climate change impacts on arid and semi arid ecosystems

Livelihood activities based on agriculture, livestock husbandry, urban settlement, natural resources extraction (charcoal, mining, sand harvesting, community conservation; gums and resins) have caused conflicts over dwindling natural resources (water, pasture, natural resource tenure). Frequent droughts have accelerated the displacement of pastoralists from livestock- based livelihoods to environmental refugee settlements around local trading centres. These activities have caused significant environmental problems on the land surface especially in the deforested areas, water catchments, and rangelands leading to forage reduction due to soil fertility loss and increased erosion. Recent findings of UNEP- GEF funded project (UNEP-GEF LUCID, 2004) from four pilot sites in East Africa confirm the strong relationship between anthropogenic activities that lead to land use change, land degradation, biodiversity loss as well as the overall environmental degradation of ecosystems. Key findings are listed below.

LUCID key findings

The impacts of land use change on land degradation and biodiversity loss in four pilot sites in East Africa are listed below (UNEP- LUCID Project 2004)

- Expansion of intensified farming systems and increased settlements lead to less freshwater available for people, livestock, and wildlife. In particular increased use of water for horticultural production for export has increased pollution of water bodies through high inputs of agrochemicals.

- Farmers who practice mixed cropping system conserve more native crops compared to those practicing monoculture. Single cash crops require high external resource input that seems incompatible with conservation of high plant diversity. Mixed cropping under subsistence agriculture is less destructive to biodiversity than single cash crop farming systems.
- High potential land in the highlands is highly fragmented into small parcels, while the process of fragmentation is rapidly spreading to arid and semi arid ecosystems. The root cause of this fragmentation trend is intensification of land use and change of land tenure system.
- Increasing crop biodiversity by some farmers is a coping mechanism and response to land degradation problems. Increased crop biodiversity encourages regeneration of indigenous plant species.
- Moderate farming system in less forested areas is found to increase tree cover thus increasing the diversity of bird species. Expansion of moderate farming in grassland, woodlands and bushland ecosystems with fewer trees, increases the diversity of habitats due to the introduction of agro-ecosystems that attract new species of birds. However intensified farming system and reduced diversity of habitats reduce the diversity of birds.
- Higher productivity of agro-ecosystems is maintained by a mixed farming system where livestock manure is used to replenish soil nutrients.

These findings should now be translated into land use policy guidelines to reduce land degradation and other related negative environmental trends.

2.3 IPCC endorsed scenarios: main features and relevance to dryland ecosystems

Climate change scenarios are classified into three categories (IPCC Report, 2001).

In the first category are those that lead to simple extreme events such as individual local weather variables exceeding critical levels on a continuous scale. Examples of such events include heavy rainfall, high/low temperatures, and high wind speeds.

The second category includes those complex extreme events such as droughts and El Nino Southern Oscillations (ENSO) related events. These are severe weather events associated with a particular climatic phenomenon, often requiring a critical combination of variables. The characteristics of these events are frequent/return period, magnitude, duration of variable(s) exceeding a critical level and severity of impacts.

The third category is the unique or singular phenomenon that is only plausible to think about in future climatic state with potentially extreme large scale and global outcome. Examples include possibility of the collapse of major ice sheets or major circulation changes. These type of scenarios are speculative and not of immediate concern. But the first two categories demand immediate attention because of the possibility that they are already being expressed in the present climate change events and trends.

Evidence that climate change is taking place comes from a body of observations that is available from existing data. Statistically significant associations between trends in regional climate and impacts have fairly been well documented (IPCC Report 2001, Chapter 19: 915, 916). The gradual global warming is likely to threaten unique and vulnerable systems such as tropical glaciers, biodiversity hotspots etc. The glaciers on Mt Kenya and Kilimanjaro have decreased by 80% over the last 50 years or so and it is speculated that if this rate of melting of the glaciers continue, the glaciers will disappear by 2015. This trend has serious implication on the biodiversity hotspots like Serengeti-Mara Ecosystem and the Amboseli. The rivers flowing through the arid and semi arid ecosystems in Kenya are already affected. The report also speculates on the distribution of impacts of changes in temperature and precipitation regimes. Eastern Africa seems to

be experiencing greater incidences of drought and other climate related disasters such as floods and unusual disease patterns (Rift Valley Fever and Malaria vector habitats).

According to IPCC report (Cubasch *et al.* 2001 in Climate Change 2001 pages 527 to 528) the very likely to happen- scenarios or virtually certain to happen in the arid to semi arid ecosystems include:

1. The increase of global average mean water vapour, evaporation and precipitation;
2. Most tropical areas have increased mean precipitation, most of sub tropical areas have decreased mean precipitation and, in high latitude the mean precipitation increases;
3. Intensity of rainfall events increases scenario: Some regions are observing high incidences of rainfall intensity causing floods; (i.e. Nyando and Budalangi areas of Kenya)
4. There is a general drying of the mid continental areas during summer (decreases in soil moisture). This is ascribed to a combination of increased temperature and potential evaporation that is not balanced by increases in precipitation. This is causing considerable unpredictability of seasonal rainfall in the greater horn of Africa with increased incidences of drought hence need for early warning systems. Until fairly recently droughts caused few problems. Out of 14 disasters recorded in Kenya alone in the last 30 years, 11 were drought related (IIRR *et al.* 2004). Refer to the figure below.

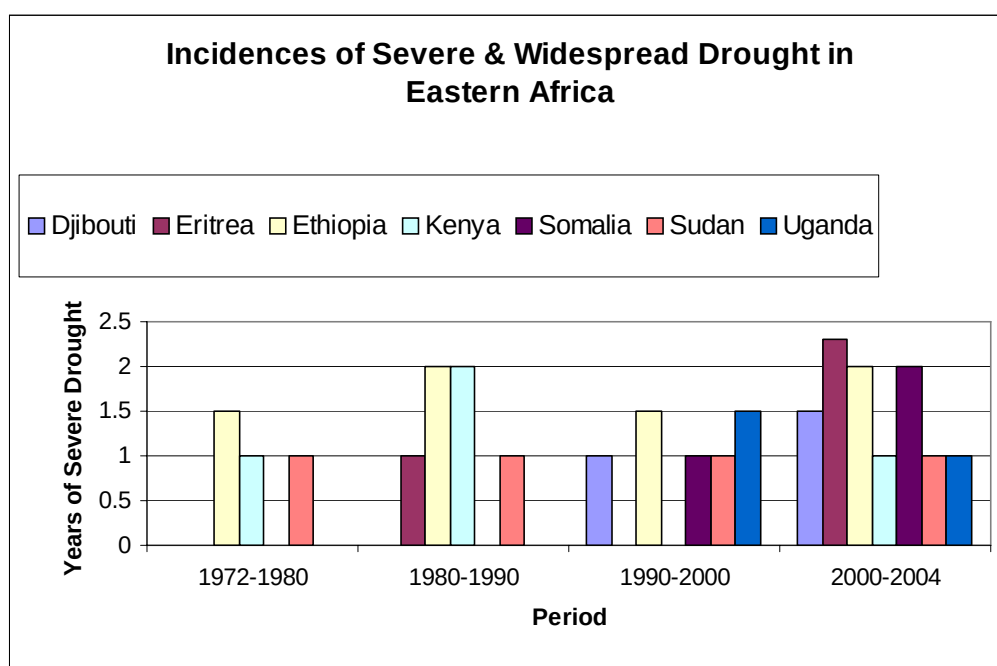


Figure: Source: Modified from IIRR *et al.* (2004) page 3

5. Available studies indicate enhanced inter-annual precipitation variability of northern summer monsoon climate. Predication of the beginning and end of monsoon rains in Eastern Africa has become less reliable due to unusual seasonal variability of rainfall. This is probably due to climate change impacts on Inter-Tropical Convergence Zone (ITCZ) is the confluence of the NE and SE monsoon trade winds in the tropical latitudes. Increase in the mean surface air temperature, there are more frequent extreme high maximum temperatures and less frequent extreme low

minimum temperatures. There is a decrease in the diurnal temperature range in many areas, with night time lows increasing more than day time highs.

2.4 State of the art and results in downscaling climate change scenarios in dryland ecosystems

Downscaling Climate Change Scenarios in the Eastern Africa has been undertaken by individual projects in the context of afforestation, early warning systems, development initiatives in arid and semi arid lands, water development, agricultural research initiatives to produce drought tolerant crops and animals, soil conservation measures, community wildlife conservancies, land management programmes (land use planning, grazing schemes, tenure definitions, conflict management, natural resource inventory and monitoring). The central theme of all these initiatives revolves around alleviating the effects of land degradation, biodiversity loss, global climate change and improving the quality of the environment. These actions are closely linked to efforts in combating desertification process. UNEP-GEF programme has identified land degradation as priority issue in Africa. According to the report, land degradation is closely linked to climate change and biodiversity loss. Africa is losing 5 to 6 million hectares of productive land to degradation every year (UNEP-GEF Land Degradation 2001). Root causes of land degradation are highly complex and are site specific but driving forces involve adverse climatic conditions in combination with social, political, economic and cultural factors that strain the marginal lands beyond ecologically sustainable limits. The following are examples of (UNEP-GEF) programmes/projects scaling down climate scenarios with focus on dry ecosystem.

1. Land Degradation Assessment in Drylands (LADA)-(UNEP-GEF). The objective is to provide policy tool for the implementation of the National Action Programmes (NAPs) and Sub regional action Programmes (SRAPs) in support of UNCCD implementation. Priority interventions are those that address land degradation and their inter-linkages between land degradation and other focal areas of GEF including climate change.
2. Development of tools and methodologies for sustainable land management: Management of indigenous vegetation for rehabilitation of degraded rangelands in the Arid zone of Africa
 - a. *Desert Margin Programme (DMP)-ongoing*: the programme is implemented in Kenya, Botswana, Burkina Faso, Mali, Namibia, Senegal, South Africa and Zimbabwe and is aimed at building on existing National Action Programme (NAP). DMP is a strategy emphasising development and action oriented research to identify the root causes of biodiversity loss through land degradation in arid and semi arid areas and then formulate appropriate mitigation measures at pilot scale.
 - b. *Land Use Change Impacts Dynamics (LUCID) 2001- 2004* was a designed framework for Investigating Land Use Change, Biodiversity Loss and Land Degradation. This project has taken advantage of the foundation of long term detailed landscape scale studies of environmental change and resource management in East Africa. Four sites representative of highlands to lowlands ecological gradients in east Africa and the semi arid plains in the lowlands contain biodiversity and land degradation characteristics and problems representative of those ecosystems within the wider region. LUCID objective is to contribute to the conservation of biodiversity and prevention of land degradation by providing useful instruments to identify and monitor change in landscape associated with

biodiversity losses, land degradation, and identify the root causes of those changes.

3. New Partnership for Africa's Development (NEPAD) - This is an Africa Union (AU) Environment Initiative of the New Partnership for Africa's Development adopted in July 2002. NEPAD implementation focus is on the linkage between poverty and environment in Africa. AU is responsible for coordinating the implementation of UNCCD under six Thematic Programme Networks as listed below:
 - a. Ecological monitoring, Natural Resources Mapping Remote sensing and early warning systems: African Organization on Cartography and Remote Sensing (OACT), based in Algiers (Algeria);
 - b. Promotion of Agroforestry and Soil Conservation in Africa. Institute du Sahel, CILSS, based in Bamako, Mali;
 - c. Rational Use of Rangelands and Development of Fodder Crops in Africa Institutional Focal Point- AU/IBAR based in Nairobi, Kenya.
 - d. Integrated management of international river, lake and Hydro-geological basins in Africa: SADC Water Sector Coordination Unit based in Maseru, Lesotho;
 - e. Network Programme for the promotion of renewable energy sources and Eco-technologies: the National Agency for Renewable Energy Sources based in Tunis jointly with ENDA, based in Dakar, Senegal;
 - f. The promotion of Sustainable Farming systems: the OAU Coordination Bureau of the Semi-Arid Food Grain Research and Development Project (SAFGRAD) based in Ouagadougou (Burkina Faso).

NEPAD will therefore catalyse the process through the regional and sub-regional institutions to ensure that the elaboration of the UNCCD Thematic Programme Networks (TPNs) will be owned and addressed by NAP process and that these themes add value to the downscaling of climate change scenarios and mitigation of desertification and drought conditions. For example the overall objective of TPN3 on the rational use of rangelands and development of fodder crops is "To support rational management and improvement of rangeland resources for sustaining human livelihoods and the environment in socially equitable way and in conformity with the provisions of UNCCD framework." The purpose of TPN3 therefore is to add synergy to complementary activities at national and sub-regional level.

4. National Action Programmes (NAP) and National Environmental Management Authority (NEMA). At national level national action programmes on the three conventions are established and some are already operational in the Eastern Africa sub regional as in other sub-regions and regions. Kenya is taken as an example of ongoing initiatives at national level. Kenya has formulated her NAP document in line with the guidelines of UNCCD. Similar national strategies on climate change and biodiversity conventions are formulated and progress reports done regularly at Conference of the Party meetings. However, the downscaling of Climate Change scenarios at national level is not based on comprehensive integrative strategy or approach. Progress towards integrated reporting of downscaling initiatives on climate change scenarios is not well coordinated. One of the reasons behind this uncoordinated action is the lack of coordinating structure with the political and technical clout to coordinate other key players.

Early Warning System (EWS) activities for example are scattered in various institutions with loose collaboration. There is no policy or legal framework governing the operation of various EWS institutions dealing with food security, drought surveillance and other related issues of conflict management. This is however not withstanding progress in

EWS technology development over the last 30 years. Consequently there has little impact on food security or in halting desertification process. In the new NAP process for the implementation of the UNCCD, the following constraints are to be addressed for effective downscaling of climate change impacts in conjunction with other priority environmental issues.

2.4.1 Constraints to be being addressed under Kenya NAP and NEMA

1. Unclear conceptual frameworks and objectives of EWS
2. Inadequate data collection and analysis procedures
3. Inadequate human, technological and institutional capacities for information management, networking and coordination.
4. Weak institutional framework for information management, networking and coordination;
5. Lack of trust /credibility among stakeholders
6. Untimely release of early warning results
7. Use of information for selfish ends

2.4.2 Proposed Mitigation Measures

The Kenya NAP strategy paper proposes the following mitigating measures of climate change and desertification scenarios:

1. Link meteorological knowledge to local experience related to drought occurrence, frequency and duration.
2. Evaluate, appraise and document the current capabilities of drought monitoring and early warning system
3. Strengthen environment monitoring systems through expansion of national meteorological and hydrological networks and improve range of resource monitoring systems
4. Build human, technological and institutional capacities for monitoring environment degradation and indicators of desertification in dryland;
5. Develop benchmarks and indicators to monitor, assess and mitigate effects of desertification on proper time scale probably short term (0- 5 years); medium term (5 to 15 years) and long term measures (15 years plus)
6. Develop decision making tools and mechanisms for early warning
7. Strengthen partnerships in order to establish an enabling institutional environment.

2.5 Strategy addressing desertification in context of global change

2.5.1 NAP: National Action Programmes for combating desertification

The convention to combat desertification will be implemented through national action programmes. Full participation of the local communities is required in the design of the overall programme

- Programmes to start with long term strategies and priorities- to provide continuity for long term programming, programmes to address the underlying causes of desertification and pay particular attention to preventive measures. The problem is complex and should address – loss of agricultural productivity, reduced vegetation cover, soil erosion, and socio-economic costs among others.
- Local communities to play a key role in formulating programmes
- National governments will commit themselves to providing an enabling environment- strengthening existing legislation and when necessary enacting new ones; land tenure security, mechanisms of conflict resolution, decentralization of

power, sustainable woodland management, economic reforms that promote investment and reduce poverty.

- Action programmes will also specify the practical steps and measures to be taken to improve economic environment- creating financial instruments, introducing drought resistant crops, conservation of natural resources, control of fuelwood gathering, drought contingency plans and early warning systems
- Efforts to combat desertification will be fully integrated with other development programmes- reversing land degradation and alleviating poverty go hand in hand – i.e. improving food security, educating and training people, strengthening the capacity of local communities and mobilizing Non Governmental Organisations (NGOs). Desertification also affects biological diversity and climate change, NAP need to be integrated with the programmes dealing with these issues.
- Subregional and regional action programmes can help to harmonize and strengthen national programmes

2.6 Desertification, global change, and sustainable development

- The United Nation Convention to Combat Desertification (UNCCD) cannot be viewed in isolation from other efforts to promote sustainable development, climate change, biological diversity, water resources, energy sources, food security and socio economic factors. The convention needs to coordinate desertification related activities with the research efforts and response strategies inspired by other concerns.
- Efforts to combat desertification need to complement efforts to protect biological diversity. Dryland ecosystems are rich with biota given that they are critical habitats for wildlife. They are particularly vulnerable to land degradation.
- Land degradation affects the quantity and quality of freshwater supplies
- Natural climate variations can strongly affect drought patterns. – the best understood link between global climate variability and drought involves sea- surface temperature patterns.
- Climate change could worsen the effects of desertification- arid and semi arid areas are liable to floods, drought and desertification and are also particularly vulnerable to adverse effects of climate change.
- Desertification may temporarily affect climate change.
- Desertification exacerbates poverty and political instability.

3. Issues of Benchmarks and indicators

3.1 The main indicators used to characterize global change and its impacts

The UNEP global land data show agricultural production index that shows the stagnation of the production systems or decline in production. The global, sub-regional and national agricultural production indices from 1975 to 2000 show interesting trend. Global Environment Outlook GEO – Data compendium has several variables that can be used to come up with climate change and desertification indicators. The data set has information on carbon dioxide emissions, water consumption, and forest cover change, and population growth, land use change among others. It also contains socio economic data.

Indicator	1975	1990	2000
Agricultural production index using 1989/90 as baseline			
Global	71	101	125
Eastern Africa Region	74.6	100	107
Kenya	56.4	100.5	101
Uganda	98.8	100.1	131.0
Cereal production, hectograms per Hectare.			
Global	19122	27574	30348
Eastern Africa Region	10257	12801	11750
Kenya	13489	14879	13295
Africa	10761	11687	12236

Source: UNEP Global Environment Outlook -Geo 3 data Compendium report of 2002

Table: A Sample of Global Environment Outlook 3 Agricultural global data records relevant in characterization of global change and its impacts

There are existing body of indicators at global, regional, subregional and national levels that are relevant in the characterisation of global change and its impacts. At biophysical level, the Global environmental Outlook data and scenarios will support interactive impact indicators of climate change and desertification.

The link of poverty reduction indicators to desertification process is now possible because of the poverty baseline measurement in several developing countries. FAO has also developed indicators on land degradation approach with a good analytical framework (Pressure, State, and Response indicator Model). On the driving variable UNDP also collects valuable data on Human Development Index. Other variable information comes from FAO, Earth Watch Institute among many others.

The application of Sustainable Livelihood Framework is useful in the analysis of the root causes of desertification process from the anthropogenic perspective. There is plenty of information generated from Early warning Systems such as drought monitoring. The satellite information can be adapted to come up with cost effective timely and area specific desertification indicators based on climate monitoring organisations. The Drought monitoring centre in Nairobi generates a lot of useful information that can be adapted to climate change impact monitoring on desertification. The main challenge however is how to re-synthesise data and information from all these datasets to come up with a policy decision- making tools for the mitigation of climate change and desertification process.

3.2 Biophysical indicators

The biophysical indicators are generated through monitoring the environmental changes in the arid and semi arid ecosystems. Monitoring the integrity of ecosystems and their services provides future benchmark of changes in the environmental trends in the climate system, water, soil, vegetation, animals and human population growth. The FAO Pressure-State-Response Model is used to categorise the driving variables in three categories: namely, pressure variables referring to those driving variables like population growth, desertification, climate change which are responsible for the current state of the environment. The response variables refer to those variables that indicate adjustment to the state of the environment indicated by change of livelihood strategies or adoption of non-sustainable resource exploitation strategies. Some key variable for monitoring are listed below.

Physical environment possible indicators

1. Climatic variability- Key climatic elements include temperature, rainfall, wind, humidity, sunshine, evapo-transpiration
2. Droughts, floods and climatic irregularities
3. Water indicators-drying up of water sources, drying up of swamps; monitoring springs and rivers, water table; ground water resources; quality, amount siltation,
4. Soil Indicators: soil erosion; soil fertility; soil water, soil surface cover, soil temperature, albedo indices, soil organic carbon, soil surface characteristics, organic matter, texture
5. Changes in organic matter components in the soil and carbon sequestration.

Flora and Fauna indicators

6. Changes in vegetation canopy cover;
7. Loss of forest cover;
8. Changes in standing phytomass
9. Changes from perennial to annual
10. Quantity and quality of fodder
11. Extinction of certain wildlife species
12. Disappearance of medicinal plants,

Ecosystem level Indicators

13. Changes in species richness
14. Loss of biological diversity.
15. Variability of the Resource base.
16. Desertification - vulnerability
17. The technological impacts on the environment.

Land use change indicators

18. Uses and maintenance of ecosystems, overgrazing, cultivation etc.
19. Increased cultivation of rangelands
20. Increased artificialisation of rangelands
21. Ecosystem integration in sustainable development strategy.
22. Encroachment of cropping areas into pasturelands
23. Changes in proportions of land cover time
24. Changes in crop yield
25. Emergence of banana weevils and other crop pests and diseases;

3.3 Socio-Economic Indicators

A more comprehensive identification of these socio economic indicators based on livelihood Framework approach is briefly summarised below.

The application of the integrating Sustainable Livelihood Framework is useful in selecting key indicators from a wide choice of indicators relevant to sustainable development objectives.

Vulnerability Indicators: Vulnerability context of the arid and semi- arid ecosystems have been discussed above. However, in the context of sustainable development, the policy makers are interested to know the patterns of change in shocks and trends that are driven by worsening interaction of extreme climate events (drought, floods, heat waves etc) and desertification process. The link between the losses of coping capacity of human populations exposed to climate extremes in dryland is likely to be based in the degree of desertification of the arid and semi arid ecosystem. Corrective measures must

therefore include interventions aimed at restoring the natural resilience of dry ecosystems.

Conflict trend over declining natural resources is another factor that enhances the vulnerability of the local people to climate extremes and desertification. Monitoring and mapping the occurrence of conflicts in the dryland ecosystems will assist the policy makers in linking climate change and desertification interactive indicators to the increasing levels of poverty and non sustainable exploitation of natural resources.

The slow changes that go unnoticed until threshold levels are realised can be monitored and identified as negative trends in dry ecosystems. Long term integrated monitoring frameworks such as OSS/ROSELT approach among others should establish benchmarks for various livelihood assets in the arid and semi arid ecosystems. Monitoring of natural resource base, human development indices, particularly in terms of health and education status, the strength of social supporting networks, and effectiveness of lack of public and private investment policies in dryland ecosystems will be useful in formulation of strategies to minimize the suffering of the vulnerable communities living in Drylands.

The establishment of an enabling policy framework that provides for equitable access to livelihoods assets and that promotes sustainable livelihood strategies in the dryland is a benchmark development of key indicators on drought and desertification challenges. The policy makers will make informed decision in arresting negative trends in human population growth, economic, cultural and social political changes, as well as in promoting appropriate technology transfer to mitigate adverse impacts of climate change and desertification. A summary of suggested list of socio economic indicators is as follows:

a Vulnerability Indicators

1. Trends:

- Human population trends- migration into Drylands, change of migratory routes
- Natural resource trends- quality and quantity- well covered in biophysical section
- National/internal economic trends
- Trends in governance
- Technological trends

2. Extreme events (shocks)

- Human health extreme events- Malaria, HIV/AIDs
- Droughts, floods, fires, earthquake etc
- Economic shocks- inflation etc
- Conflicts
- Crop and livestock shocks (diseases)

3. Seasonality indicators

- Prices
- Production
- Health
- Employment

b Livelihood Assets

1. Human capital

- Health: causes of morbidity and mortality
- Education including indigenous knowledge system

2. Social capital

- Network and connectedness

- Social organisations into groups such as cooperatives
- Relationships of trust and reciprocity
- Political factors and issues of access outside the community

3. *Natural Capital Asset*

- Intangible capital include public goods (e.g. the environment) while tangible assets include vegetation, animals, land and water
- The information needed in this area is dealt with in Section 3 C below.

4. *Physical capital*

- Infrastructure: changes to the physical environment that support the livelihoods of the people
- Technology equipment: such as tools and equipment used for productive purpose

5. *Financial Capital*

- These are the financial resources that people use to achieve their livelihood objective – roads, transport, health services, education facilities shelter, water supply, communication and energy.

c Policy environment Indicators

- Assessment of the existing policies and institutions relating to the current way the people meet their livelihood objectives.
- Examine policies on access to resources, - land; terms of exchange or trade; returns to any livelihood strategy, the issue of “exclusion” and “inclusion” factors
- Examine the structures – public sector, private sector, and civil society
- Assess the processes – policy, legislation and institutions and culture

d Livelihood strategies indicators

- Opportunities available to improve diversified livelihoods;
- Monitor improvement on the access to assets;
- Review structures and processes to facilitate access to wider options for livelihood strategies

e Livelihood outcome indicators

- These are indicators of the achievement of livelihood strategies and with reference to sustainability criteria (sustainable development goals)
- Indicators may include: more income, increased well being, reduced vulnerability, improved food security and more sustainable use of the natural resources, improved security and sustained agro-biodiversity.

3.4 ROSELT/OSS Framework- Experiences and challenges in Generating Benchmarks and Indicators.

3.4.1 Challenges of development of Benchmarks and Indicators

ROSELT has faced the challenge of assisting OSS member countries to adopt a sustainable monitoring- evaluation system that is owned at national level and as a part of the UNCCD NAP process. If such a system is established and operational at national level the development of benchmarks and indicators that will inform the decision makers on the steps needed to combat against desertification and drought will be realised. OSS Workshop in 1997 identified three types of benchmarks and indicators. One category contains those benchmarks and indicators, which focus on the tracking the progress towards the implementation of UNCCD. The second category is for those that respond to the need to understand the desertification process and the third category are

those for monitoring the effects of the CCD through impact indicators. ROSELT programme is well placed to undertake an integrated monitoring- evaluation approach at least at initially at pilot level in each country. This approach by ROSELT will contribute significantly to the overall objective of UNCCD contributing to the sustainable development goal.

Given the multidisciplinary challenges of implementing an integrated monitoring and evaluation strategy in the context of UNCCD objectives, ROSELT organisation has the potential to bring key players together to define and establish benchmarks and indicators as part of national monitoring and evaluation approach. Close collaboration of scientists and policy makers at local and national level will facilitate consensus on suitable indicators for the realisation of the NAP objectives. The key players will also define the information needed and how to collect at minimum cost. The conceptual framework of ROSELT/OSS was guided by needs identified above. Desertification is a complex issue and accurate scientific information is required to understand the process and at the same time there is the need to monitor and evaluate UNCCD implementation and its impacts on sustainable development goals.

3.4.2 Status of ROSELT Network in Eastern Africa

The organisation framework of the ROSELT /OSS is described in various OSS documents. The programme aims at promoting scientific and technical cooperation in OSS region to address the following problems (ROSELT Representativity at sub-regional scale 1997):

- Production of reliable and precise information on the state of the environment for end- users (policy makers)
- Dissemination of results of research and knowledge on the functioning of the ecosystems prone to desertification
- Promotion of harmonisation of scientific approaches, exchange of information and synergy of teams and partners.

In 1993, Eastern Africa Countries proposed candidate Territories for labelling. Out of the several territory countries identified in East Africa, the Rabat ROSELT workshop labelled only two sites in Eastern Africa, namely, Kiboko –Kibwezi in Kenya and the Awash Valley in Ethiopia. The two observatories were certified by OSS based on the criteria of ecological representativeness, and capacity to generate high quality scientific information for monitoring the desertification. A sub regional workshop was held in Nairobi in May 2003, which was attended, by Ethiopia, Uganda, Djibouti and Kenya. Uganda and Djibouti expressed strong desire to join the ROSELT network. Kenya launched Kiboko- Kibwezi observatory during this workshop and it was expected that Awash Valley observatory in Ethiopia would follow soon after.

The Kiboko- Kibwezi Observatory has brought together eight government institutions that are now working together to resolve issues that have slowed down the pace of implementation. The institutions have leveraged additional funds to supplement ROSELT/OSS funding under a complementary one-year project on the use of MSG satellite data to monitor land degradation and flooding. It is expected that after the short project ends in September 2005, the team will make ROSELT observatory fully operational. It is also expected that MTAP project outputs and impacts will strengthen the technical and institutional capacity to implement ROSELT objectives.

Ethiopia ROSELT observatory is not operational as a framework of ROSELT/OSS but a lot of scientific work has been done and continues to be done by the various national institutions with little collaboration among them.

3.4.3 ROSELT Programme- Lessons learnt

1. Although there are national institutions collecting regular data on the biophysical and socio- economic data, there are no plans to bring the data together and to establish a long term integrated monitoring system similar to ROSELT. The ROSELT conceptual framework is still relevant and strategic in the development of benchmarks and indicators to respond to the climate change and desertification concerns.
2. At national level, the participating institutions are expressing the type of data required for various end-user needs. For example, the NAP national focal point requires information and indicators on land use change and land cover change, while the Ministry of Water and Irrigation is interested monitoring data on spring and river flows to rationalise water allocation policy to avoid increasing water related conflicts in the country. The department of Meteorology is keen to partner with end-user institutions to define Meteorological Satellite Second Generation (MSG) weather products relevant to other sectors – i.e. the monitoring of seasonal disease patterns in crops, human and livestock
3. The impact of joint efforts to leverage funds from international partners has cemented the national team to work together for similar initiatives in future. Those institutions with similar grants and are collaborating are willing to share information among themselves. For example, several team members participating in UNEP-GEF Desert Margin Programme are sharing the research findings with the other ROSELT team members. Further, the team members are influencing the allocation of resources to the observatory.
4. Although it has taken a long time for the members to understand the thrust of ROSELT programme, there is appreciation from the team members that implementation of UNCCD and other conventions will need joint participation to implement, monitor and evaluate. This awareness is likely to result in end-user driven development of benchmarks and indicators. It will also be possible to agree on suitable impact benchmarks and indicators for climate change and desertification.

3.5 Linking global change indicators to desertification indicators

3.5.1 Strategic role of UNCCD NAP framework

Global change indicators are linked to issues at regional and national level. UNCCD framework of dealing with desertification issues is strategic for incorporating global change indicators under other environment concerns such as climate change, biodiversity loss and land degradation. The NAP process provides a flexible policy and institution framework for taking on other environmental issues of global significance.

The NAP process is to focus on long-term strategies and priorities on approaches to integrate development and environmental concerns to achieve sustainable development goals. The NAP process is supported by the political will of national governments and therefore any global change issues that are potential drivers of the desertification process is supposed to be addressed as priority issues. The goal of the NAP process in combating desertification is to reverse land degradation and to improve the livelihood of the people. The NAP should finally become the entry point of all Sub Regional Action programmes (SRAP), Regional Action programmes (RAP) and International interventions in ensuring synergy of efforts to achieve sustainable development objectives. Hence all initiatives touching on climate change impacts on desertification, biological diversity, food security and other issues of social development such as poverty alleviation should be well accommodated in this NAP national framework.

However, the strengthening of NAP institutional framework and human capacity building remain daunting problems in responding to global change issues.

3.5.2 International initiatives to link global change indicators to desertification indicators

International initiatives for the surveillance of global changes driven by changes in the environment and anthropogenic activities are more or less well developed. Indicators of global environmental change are monitored by remote sensing technology. The Global Trade Organization (WTO) is also taking place. With the improvement of information technology, it is not surprising that data are captured and analyzed with minimum delay. However, the human capacity to link this data to desertification indicators is still lagging behind. Examples of a few initiatives providing environmental data on global scale described in the MWO website include:

1. Global Climate Observatory System: (GCOS) Relevant key objective of GCOS is climate system monitoring, climate change detection and monitoring the impacts of and the response to climate change, especially in terrestrial ecosystems. Purpose: Established in 1992 to ensure that observations and information needed to address climate related issues are obtained and made available to all potential users. It is intended as a long term, service-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, for supporting research towards improving understanding, modelling and prediction of climate system
2. Global Atmospheric Watch (GAW) GAW was established in 1989 to enhance our understanding the complex mechanisms with respect to natural and anthropogenic atmospheric change among others. It is also intended to provide reliable scientific information and data for national and international policy makers.
3. Global Terrestrial Observing System (GTOS): GTOS collaborates with several institutions and organizations. Global Terrestrial Observing Network (GT-NET) has thematic networks as well as regional networks. The Ecology network is relevant to Desertification monitoring. Global observation for Forest and land cover dynamics (GOFC-GOLD) focuses on forest cover. GTOS – South Africa Programme focus on environmental issues in the southern Africa region. Other collaborating programmes include, ROSELT/OSS, Net Primary Productivity Demonstration project (NPP), and International Long Term Ecological Research (ILTER) network.

3.5.3 Indicators for policy makers

Climate change and desertification reinforce each other in undermining the coping strategies of arid and semi arid livelihoods. Since non-sustainable exploitation of natural resources is the major driving force in enhancing vulnerability of livelihoods to climate extremes, indicators on extreme climate events such as drought need to be monitored. The slow trends that gradually weaken the coping mechanisms (population trend; national and international economic trends, governance and technological trends are important to monitor. Seasonality trends in prices, unemployment, hunger, diseases are also relevant. Regular baseline information on the social changes needs documentation to form benchmarks for detecting vulnerability trends. Human livelihood strategies in the dry ecosystems largely depend on the available natural resources as well as on the socio economic factors influencing access to these resources. The application of the above sustainable livelihood indicators will respond to the key policy questions posed

by policy makers. The elaboration of the natural resource based indicators of interest to policy makers are listed as follows:

- Indicators of *Long Term trends in quality and use of resources*- range condition and trend analysis, strategic environmental impact assessment
- Indicators of *natural resource tenure* – access rights- this will influence the quality of stewardship of natural resource management and hotspots of resource based conflicts.
- The *natural resource productivity* indicators of the resources to establish land use impacts and carrying capacity assessment
- *Adoption of Technological options* in reversing desertification
- The *impact of the natural resources to external forces* especially to climatic change and desertification
- Spatial and temporal *distribution* of the resource
- *Multiple use* of the resource to make room for sustenance of human needs as well as sustainable ecosystems functioning and services- compatible land use option.

Regular statistical information on the socio economic status of people living in ASAL area-Income levels, indicators of improved well being , reduced vulnerability; improved food security indicators, good natural resource management practices; improved security and conservation of agro-biodiversity as well as wild biodiversity.

4. Conclusion and Recommendations

While it is true that the natural causes of climate change contribute to desertification process in arid and semi arid ecosystems, the human activities and especially those to do with land use change are more significant and relevant to the adverse impacts on climate and biodiversity losses. Studies in East Africa and elsewhere in the world indicate that human activities are responsible for decline of vital ecosystem services, extinction of species and increase of desert conditions in fragile ecosystems.

Since the interactions between climate change and desertification process are so closely interlinked with each other and also with other environmental changes like biodiversity loss, only a well designed long term monitoring and evaluation network organisation will be well placed to detect local, regional and global impacts of climate change and desertification. The process of establishing such a scheme is tedious and challenging especially at national level where scientific, technical and logistic administration continue to weaken the NAP process and ultimately, the monitoring of impacts of UNCCD implementation. The definition and development of benchmarks and indicators will have to be developed by national teams in charge of the NAP process with the sustained accompanying technical and small catalytic financial support by development partners at sub regional, regional and international level. Use of existing information and databases with various organisations (FAO, ILRI, and Government Departments will shorten the process of identifying benchmarks and indicators for assessing climate change impacts on desertification. The results of the Kenyan case study on the driving forces in land use change in section 2 A iii illustrate the point.

In the mean time documentation of ongoing development and research activities that relevant monitoring and assessment of climate change, desertification and implications on the environmental conventions should continue and be put in the context of UNCCD and Climate change framework.

5. Acronyms

AU/IBAR	African Union – Inter Bureau of Animal Resources
DMP	Desert Margin Programme
ENDA	
ENSO	El Nino Southern Oscillations
EWS	Early Warning System
FAO	Food and Agriculture Organization
GAW	Global Atmosphere Watch
GCOS	Global Climate Observatory System
GOFC-GOLD	Global observation for Forest and land cover dynamics
GT-NET	Global Terrestrial Ecology Network
GTOS	Global Terrestrial Observatory System
IIRR	International Institute of Rural Reconstruction
ILTER	International Long Term Ecological Research network
IPCC	Inter- governmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
LADA	Land Degradation Assessment in Drylands
MWO	Meteorological World Organization
NAP	National Action Programme
NEMA	National Environment Management Authority
NEPAD	New Partnership for Africa's Development
NGOs	Non Governmental Organisations
OACT	African Organization on Cartography and Remote Sensing,
RAP	Regional Action programmes
ROSELT/OSS	Long Term Ecological Observatory/Observatory Sahara Sahel Programme
SADC	Southern Africa Development Cooperation
SAFGRAD	Semi-Arid Food Grain Research and Development Project
SRAP	Sub Regional Action programmes
TPN	Thematic Network Programme
UNCCD	UN Convention to Combat Desertification
UNEP-LUCID	United Nations Environment Programme- Land Use change Impact Dynamics
WTO	World Trade Organization

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SESSION V

Case studies of B&I operational monitoring initiatives at various scales

CASE STUDIES OF BENCHMARK & INDICATOR OPERATIONAL MONITORING INITIATIVES AT VARIOUS SCALES

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Abstract

Many countries have identified potential indicators to monitor the extent of desertification and/or the progress of the implementation of the NAP for the UNCCD. However, very few initiatives have led to fully functional benchmarks and indicators being developed.

On the international level the European initiatives MedalusIII and DesertLinks serve as good examples. Both projects have developed long lists of indicators, all considered to be important for desertification monitoring. The outputs, so far, are maps showing the extent and severity of degradation. The owners of the projects are mainly academic institutions. The benefit is that it might give indicators developed some scientific credibility. However, if decision makers are the intended users of the monitoring systems developed, they must be part of the process; otherwise the chances of success are small. Other examples of international initiatives are given but most of them are still in the initial stages of establishing a common base for development and streamlining benchmarks and indicators.

All reports from the different Annexes, prepared for the Beijing seminar give examples of implementation at national level, e.g. the desertification risk map of Greece, the hierarchical Chinese land classification system and the Namibian desertification risk index. Most of the initiatives intend to support decision makers. However, few of the initiatives make any reference to how the information generated has contributed to decision making. Argentina has come up with an innovative approach, "Indicators at the request of decision-makers", designing a benchmark and indicator system directed to the decision makers. However, no references are given to actual outcomes of this project.

Few examples were given of local level implementation. One is the monitoring system developed in Namibia. This initiative is centred around the local farmers, who are the decision makers on the ground. By putting the local community in the centre of the identification of information needs and definition of relevant indicators, the chances are better of making the users of the collected information the owners of the process. The importance of local knowledge and involvement of local communities has also been realized in Argentina, exemplified by an initiative in the desert of Mendoza, where local communities also have been involved in the development of benchmarks and indicators. So why have so few initiatives led to implementation? One obvious reason is that many countries still are in the process of developing their NAP. If the action plan is not in place it is difficult to carry out any activities under the UNCCD umbrella. Secondly, most indicators defined are country-specific, implying that there are different causes and effects of desertification in different parts of the world. This lack of a blueprint of indicators is one of the contributing factors to the few examples of actual implementation. Finally, there is no common understanding of what benchmarks and indicators are. This is manifested with the large number of indicators being proposed, but very few of these being measurable. Even fewer of these indicators have any meaningful benchmarks against which the results can be evaluated.

1. Introduction

This paper is mainly based on information provided in the state of the art reports on use of benchmarks and indicators for monitoring of desertification prepared by each Annex in preparation for this Beijing seminar. The objective of this paper is to present selected case studies of operational monitoring initiatives on various scales. However, after reviewing the state of the art reports submitted by the different Annexes it is clear that the use of benchmarks and indicators have been mainly focused on the international and national levels. Further, even though a large number of monitoring initiatives are presented in the reports, it seems like just a few of these initiatives have actually contributed to improved knowledge about the rate or extent of desertification. Even fewer initiatives have been documented as contributing to policy making and decision making. Nevertheless, a few examples of operational monitoring initiatives on international, national and local levels have been selected. By examining these selected cases the author is trying to answer the question: why have so few monitoring initiatives led to actual implementation, i.e. contributed to improved decision making and policy development towards halting desertification?

2. International monitoring initiatives

MEDALUS III and DESERTLINKS are two prominent European projects that have contributed to the development of benchmarks and indicators on a wide scale in Europe. The methods developed and lessons learnt by these two projects have also been implemented by and guided initiatives outside Europe.

The MEDALUS III project was a research project run from 1996 to 1998. The project involved Portugal, Spain, Italy and Greece, implemented by over 10 European Universities. The objectives of the project were to:

- Identify and map environmentally sensitive areas (ESAs) including techniques such as geographical information systems, overlays of digital elevation models, land use and soil information in conjunction with climatic data.
- Definition of ESAs to desertification based on sets of measured attributes such as climate variability, ecosystems, land use changes, land abandonment, and landscape characteristics.
- Development of a set of regional indicators that provide a planning tool for application to desertification at regional, national and European scales.

The MEDALUS III project developed desertification indicators at two scales, Mediterranean wide and sub-national (AIDCCD, 2005). The Mediterranean wide indicators form a composite index referred to as the Regional Degradation Index, RDI, which estimates soil erosion by water. This index is based on a one dimensional hydrological model, which is used to estimate potential vegetation cover and storm run-off based on climatic and vegetation data. The index delivers a climatic erosion potential, which is combined with information about topography and soil erodibility to estimate expected rates of soil erosion at a resolution of 1 km. Areas vulnerable to desertification are identified as those with unacceptably high current rates of erosion. The project produced maps showing erosion potential under current climatic conditions and under a rise of 2°C in average temperature for the Mediterranean basin.

The development of the monitoring system initiated by MEDALUS III was continued by the project DESERTLINKS. This is also a European Mediterranean-wide research project, involving Portugal, Spain, Italy and Greece, implemented by a wide range of European universities (AIDCCD, 2005). The project was run from 2001 to 2004. The main objectives of the project were:

- To work closely with stakeholders to identify and develop indicators relating to desertification and measures taken to combat desertification and to provide a conceptual framework for the indicators of different types and scales.
- To develop composite indicators, combining indicators identified by stakeholders with state indicators already developed for Mediterranean Europe (e.g. indicators developed by MEDALUS III) at Mediterranean scale.
- Finally, to combine indicators of different scale and type into a desertification indicator system for Mediterranean Europe, which can be used to explore different management options.

Central in the DESERTLINK project is the close cooperation with stakeholders throughout the project. The project resulted in a data base of indicators relevant to Mediterranean desertification. The database also contains explanatory information about how various subsets of indicators from the data base can be used to understand and evaluate the effects of desertification according to local conditions. The project generated over hundred indicators, of which more than 80 were fully described, meaning that the indicator fulfils the criteria for implementation. One important aspect of this project was to involve stakeholders on all levels throughout the project. One of the outputs based on this stakeholder participation was the development of ways to enhance the use of indicator information to understand and evaluate the effects of desertification according to local conditions. A way identified through this process was to look at specific aspects of issues of desertification.

The indicator system initiated by MEDALUS III was used to develop an expert system based on the methodology of identifying potential Environmentally Sensitive Areas (ESAs), but using a slightly adjusted method for calculation of the ESAs. These ESAs are used together with other indicators to assess desertification risk under different land uses.

3. National level monitoring

The number of national initiatives presented in the reports from the different annexes is high. However, most initiatives have just resulted in lists of indicators with no further information about how they are defined, if they have any defined benchmark or if they are used for monitoring at all. Most of the European initiatives have been supported by one or several international initiatives as MEDALUS III and DESERTLINKS mentioned above.

One common approach for national level monitoring is to define a very small set of indicators, often referred to as primary indicators, which are measures of key processes or conditions of desertification. For instance the national monitoring systems developed in Greece and Namibia respectively are based on few primary indicators that are combined to form a measure of desertification risk. A similar approach was taken in Italy where four primary indicators were defined and then later combined in order to identify areas that are sensitive to desertification. In Italy an aridity index, soil characteristics index, land use index and demographic variation index were combined to get a desertification sensitivity index. In Portugal a climate index, soil loss index and drought index were combined to form an index for desertification susceptibility. Here the monitoring systems developed and implemented in Greece, China and Namibia are presented as basis for discussion.

In Greece the National Committee for Combating Desertification and the Agricultural University of Athens have developed systems for small and large scale mapping of desertification sensitive areas. The systems developed are empirical and have been

incorporated into the Greek National Action Plan (NAP) against desertification (AIDCCD, 2005).

Indicators used for the definition of the sensitivity of the mapping units were:

Soil mapping units of the soil map of Europe. The Greek mapping units of the European soil map are characteristic of erosion sequences of each soil in each geologic formation, climatic zone and vegetation cover. Therefore soil units are indicative of the extent of the erosion that has taken place, the erosion risk, the soil depth and the soil drought risk.

Slope gradient. The slope gradient was used to assess potential erosion risk of each soil mapping unit.

Bioclimatic zone. The bioclimatic zone classified according to the Bagnous-Gausson bioclimatic index for each soil mapping unit was derived from the bioclimatic map of Greece. The aridity of each unit was derived from this map and it was used to estimate soil drought, soil salinity and potential resilience of damaged vegetation cover.

Irrigation intensity and seawater intrusion. Irrational irrigation and intrusion of salt seawater into coastal aquifers were derived from information on irrigation works and a seawater intrusion map produced by the Greek Ministry of Agriculture.

These indicators were used to produce a potential desertification risk map for Greece in a scale of 1:1000 000.

Another monitoring system, developed as part of the MEDALUS III project was used to prepare a desertification sensitivity map of the island Lesvos at a scale of 1:50 000. For this map the method of identifying environmentally sensitive areas (ESAs), developed by MEDALUS III, was applied. According to the Greek experience of implementing this approach, the full-scale application of the methodology requires databases for the parameters used, especially soil maps. Availability of dependable databases and the shortage of experts capable of applying the medium scale systems in the field were the most serious problems encountered. However, the results of applying the method to identify desertification sensitive areas on the island of Lesvos were satisfactory.

The Greek team concluded that much more work is required in order to improve the degree of perception regarding the threat and consequences of desertification among stakeholders and their ability to early recognize these signs. To cope with this problem the team of Agricultural University of Athens has contacted and is presently working with some two hundred individual stakeholders and is planning to increase this number.

In China a national desertification monitoring system has been developed by the China National Desertification Monitoring Centre of the State Forestry Administration (Siheng and Feng, 2005). In this system a highly hierarchical classification system for desertification assessment has been developed. The system defines desertified land types into three components: the type of desertification, type of land use, and the degree of desertification. This resulted in four major categories, 15 sub-categories and 52 types of desertified land to be monitored in China. For the assessment of desertification, six types of desertification were defined, i.e. wind erosion of crop lands, water erosion in forestland and grasslands, water erosion in croplands, and salt affected crop land. For each type of desertification a number of indicators were defined (table 1).

Type of desertification	Assessment indicators
1. wind erosion of forest land and grassland	Vegetation cover Vegetation biomass Water content of soil Soil texture Condition of ground surface crust Form of sand dunes
2. wind erosion of cropland	Crop performance

	Soil nutrient grade
	Soil texture
3. water erosion of forestland and grasslands	Vegetation cover
	Vegetation biomass
	Slope
	Erosion patterns
	% area gully eroded
4. water erosion of cropland	Crop performance
	Slope
	Soil nutrient grade
	Engineering measure
5. salt affected forestland and grassland	Vegetation cover
	Vegetation biomass
	Salt content of soil
6. salt affected cropland	Crop performance
	Salt content of soil

Table 1. Indicators used for desertification assessment in China.

On top of all these variables and possible combinations of variables in the Chinese desertification classification system, additional weights are applied to each indicator. After applying weights to indicators, each indicator is divided into grade criteria on a five grade scale, and endowed with a grade value, also on a five grade scale.

It seems like this system is intended to be used for a remote sensing based assessment of extent and severity of desertification in China. The spatial levels of the Chinese national desertification monitoring system are divided into national, provincial levels and key and typical localities. The provincial and national monitoring, which is based on the results from the provincial monitoring, are undertaken every fifth year. Key and typical areas are monitored annually. The National Desertification Monitoring Centre is in charge of the establishment and operation of the national desertification monitoring system, formulation of the relevant technical methods and organisation of the implementation of the system, management of the collected information in combating desertification, information analysis and forecasting of the desertification trend, provision of guidelines and assistance to the establishment of local level desertification monitoring, study on the basic technologies and their dissemination in regard to desertification, developing operational plans for national and regional desertification projects, monitoring and evaluation of the process. The centre has so far conducted a nationwide inventory of desertified land, developed a general plan for desertification monitoring in China, and main technical regulations for national desertification monitoring. A desertification map in scale 1:2.500 000 has been compiled for the country. In Namibia a national level monitoring system was established under the umbrella of the National Action Plan, NAPCOD (Bethune and Pallett, 2002). This system is based on four primary indicators, i.e. population pressure, livestock pressure, rainfall and soil erosion hazard. These four indicators are combined into a desertification risk index. These indicators were defined by Namibian local and national stakeholders through numerous workshops and expert meetings. During this process a large number of potential indicators were identified, however, a set of criteria were defined in order to assess these indicators, e.g. scientific relevance, data accessibility and known benchmarks/thresholds, which reduced the number to the four primary indicators. The Namibian initiative resulted in annual maps of desertification risk being calculated for the period 1971 to 2002 (Figure 1).

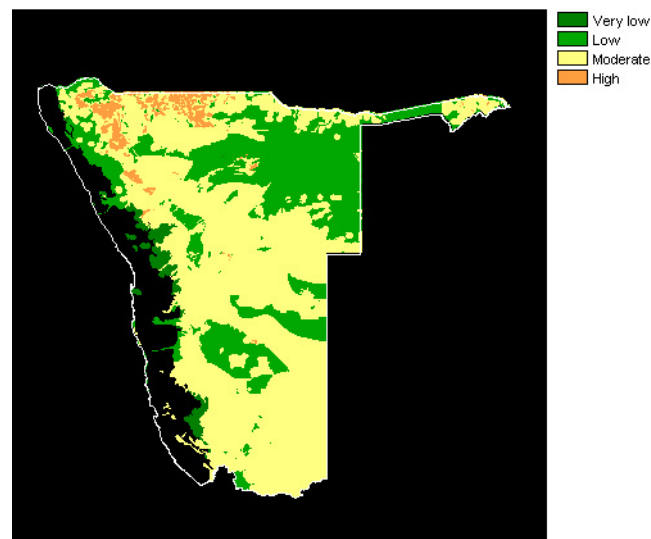


Figure 1. Land degradation risk map for 1997 based on four indicators

These maps were used to identify the most critical areas, where the risks of desertification are highest in the country and to determine if there are any trends over time (Klintenberg, 2005). The lessons learnt from the Namibian process underlines the importance of participation from all relevant stakeholders in the process of identifying and developing indicators and in the actual implementation of a monitoring system. The participatory approach gave stakeholders ownership of the process and the resulting indicators, and led to an increased understanding of the concept of environmental monitoring. Thirdly, a common platform was established for stakeholders from various sectors, leading to an increased interaction between sectors, an important aspect in most developing countries where sectoral approaches predominate (Klintenberg and Seely, 2004). Finally, Argentina has come up with an innovative approach, “Indicators at the request of decision-makers”, designing a benchmark and indicator system directed to the decision makers. However, no references are given to actual outcomes of this project.

4. Local level monitoring

In the Annex reports few references were given to local level monitoring initiatives. Two initiatives will be exemplified here, the first is the Italian project ‘Integrated Research for Applying new technologies and processes for combating desertification (RIADE)’ and the second one is the local level desertification monitoring system developed by NAPCOD in Namibia.

RIADE is a research and training project involving the Italian regions of Basilicata, Puglia, Sardinia and Sicily (AIDCCD, 2005). All activities in this project are carried out with extensive collaboration with local stakeholders in areas in southern Italy affected by desertification. The objectives of the project are to identify impact indicators relating to perceptions of land function, driving force and pressure indicators relating to decision making, and finally, response indicators relating to land management measures taken to combat desertification. The interesting part of this project is the close collaboration between the scientific community, local stakeholders, and the Italian National Committees to test the applicability of developed indicator systems and to validate locally identified high risk areas. The expected output of the project is a monitoring system tested and evaluated by both local stakeholders and the scientific community. The system should be able to explore alternative management scenarios on local level

and support the development of national and regional management and monitoring strategies. In Namibia local level indicators for desertification monitoring were developed based on local stakeholders information needs (Kambatuku, 2003b). The system was developed under the umbrella of Namibia's national programme to combat desertification, and forms part of a system referred to as the Forum for Integrated Resource Management, FIRM, which aims at putting the local community in the centre of their own development (Kambatuku, 2003a). The Namibian local level monitoring system is aimed at supporting the local farmers with relevant information, to enable the farmers to make informed decisions on the local level. Secondly the system also provides information that can be used to validate results from National level monitoring initiatives. Based on the information needs given by local farmers in different parts of Namibia, four primary indicators were developed; Livestock condition scoring, veld condition and bush density, carrying capacity and rainfall. The unique aspect of the Namibian initiative is that it resulted in a set of indicators, developed based on the local farmers information needs, measured by the same local farmers. The FIRM is then used as the platform where farmers get together and compare results and discuss what management strategies would be the best, given the information collected. A key factor of the system is that each observation is noted down in a records book which over time makes it possible for the farmer to compare the present with past conditions and with results obtained by other farmers in the area.

In Argentina the importance of involving local stakeholders in the process of identifying indicators for desertification monitoring has also been realised (Abrahams, 2004). Two groups are leading the development of local level indicators in Argentina: one working in the desert of Mendoza, and one working in the Catamarca, Tucuman and Salta Valleys. For both regions integral desertification assessment systems are being developed. These systems are being supported by the use of indicators and benchmarks, determined through case studies involving local communities. Unfortunately no details about what indicators the local communities identified and how they are used to monitor desertification were given in the report.

5. Discussion

This paper presents selected case studies of indicator based monitoring on various scales. In the introduction it was stated that, based on a review of the reports submitted from the different Annexes in preparation for the AID-CCD Beijing seminar, very few of the initiatives presented have been implemented and even fewer seems to have contributed to improved decision making or knowledge about the extent and/or rate desertification. So why have so few initiatives been implemented?

Originally the information presented in the State of the Art reports was intended to be based on responses to a questionnaire sent to all focal points in the different Annexes. However, the response rate was too low, which resulted in most of the information presented being compiled from country reports submitted to the UNCCD. The review of these country reports shows that many countries are still in the process of developing their National Action Programmes. If the action programme is not in place it seems to be difficult to carry out any activities under the UNCCD umbrella.

Secondly, as was concluded in the southern African report, most indicators defined are country-specific, implying that there are different causes and effects of desertification in different parts of the world. This lack of a blueprint of indicators is one of the contributing factors to the few examples of actual implementation. Based on the conclusion of the southern African report it seems to be rather meaningless to spend efforts on trying to identify a set of indicators that are globally applicable. However, this

is one signal that has been transmitted from the UNCCD secretariat, seemingly resulting in some countries not trying to identify what indicators that would be best for the specific situations in their country, but instead passively waiting for a universal solution that might not exist. It was shown that many countries have developed long and sometimes detailed lists of national indicators that are believed to be of importance for desertification monitoring. However, just a list of indicators does not make a monitoring system. The limited usefulness of identified indicators seems to be an effect of the lack of a common understanding of what benchmarks and indicators are. This is manifested with the large number of indicators being proposed, but very few of these being measurable. Even fewer of these indicators have any meaningful benchmarks against which the results can be evaluated. In Namibia it was concluded that it is important that those involved in identification of indicators have an overall understanding of key elements of land degradation impacts, both socio-economic and biophysical. Secondly, a set of well-defined criteria is required to ensure relevance and usefulness of indicators being developed. Further it was recommended that the same criteria should be used globally to ensure that all developed indicators fulfil these quality requirements (Klintenberg and Seely, 2004). Based on the Namibian experience of developing both national and local level monitoring systems it is clear that the entire process of identifying and developing indicators as well as developing and implementing monitoring systems has to be a fully participatory and transparent process, involving all relevant stakeholders. This involvement gives stakeholders ownership of the process, not least the intended end users. One key aspect that is often overseen is to ensure that the developed indicators and monitoring systems actually provide information of relevance to the decision makers. This can only be done by involving the intended end users from the beginning of the process. This is not least of importance when an academic institution is responsible for the development and a governmental or communal institution will do the actual implementation. As has been shown elsewhere, scientists and decision makers on local, national or international levels seldom speak the same language (Seely and Moser, 2004; Seely and Wöhl, 2004).

Some academic institutions have realised the importance of involving stakeholders in the process. This was exemplified by the transformation from MEDALUS III with a total research focus to the approach of involving stakeholders on all levels in DESERTLINKS and the approach taken in one of the latest European initiatives, the RIADE project, where monitoring systems are developed in close cooperation with the end users to support decision making on local to national levels, based on the decision makers information needs.

Acknowledgements

This paper was made possible by funding to the supporting measures project “Active exchange of Experience on Indicators and Development of Perspectives in the Context of the UNCCD”, Commission of the European Communities- AID-CCD-EVK2-2002-00609. The author would like to express his gratitude to Dr. Mary Seely for her comments on this manuscript.

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CASE STUDIES OF DESERTIFICATION MONITORING A DISCUSSION OF EU INITIATIVES

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Abstract

The word “desertification” was introduced in 1949 by the French scientist Aubreville in his report “Climats, forêts et désertification de l’Afrique tropicale”. The concept, however, was discussed earlier by European and American scientists in terms of increased sand movements, desiccation, desert and Sahara encroachment and man made deserts.

Desertification, at the beginning of last century, meant the spreading (expansion) of deserts or desert-like (non productive or very low productive) conditions from existing deserts into non-desert areas close to the desert margins. The symptoms of the phenomena were often related to sand movement and encroachment into oasis and desert margins. Aubreville also stated in 1949 that there are real deserts being born, under our very eyes, in the 700-1500 mm annual rainfall areas.

At that time, one school favored the idea of a postglacial long term climate change (desiccation) as a major driving force causing desertification. Others stressed the importance of human impact. The human impact was expressed in terms of bad management of the natural resources including over cutting, overgrazing, over cultivation and misuse of water.

Since then, different concepts of desertification have developed and been discussed over and over again by scientists, politicians and the international aid and development society. Important international events were UNCOD in Nairobi 1977, UNCED in Rio de Janeiro 1992 followed up by the UNCCD adopted in 1994 and entering into force in 1996.

The choice of land degradation mitigation strategies and the degree of resulting control success varies with the prevailing concepts of causes and consequences. These concepts are dependent on the monitoring approach used. This is exemplified through a discussion of a few desertification monitoring case studies followed by a presentation of a recent EU integrated assessment, monitoring and modelling initiative, DeSurvey (2005-2010). The initiative is targeting desertification affected areas in Europe, Africa, China and South America. It probably constitutes the largest ever international research project to exclusively focus on desertification surveillance, assessment and modelling.

Key words: EU, desertification, monitoring, modelling

1. Historic background

1.1 Early 1900

The word “desertification” was introduced by the French scientist Aubreville (1949) in his report “Climats, forêts et désertification de l’Afrique tropicale”. The concept was discussed earlier by European and American scientists in terms of increased sand movements, desiccation, desert and Sahara encroachment and man made deserts (Hubert 1920, Boville 1921, Coching 1926, Renner 1926, Stebbing 1935, 1938, Lowdermilk 1935, Jones 1938).

At this time, desertification meant the spreading of deserts or desert-like conditions. The symptoms of the phenomena were often related to sand movement and encroachment into oasis and desert margins. Aubreville (1949) also stated that there are real deserts being born today, under our very eyes, in the 700-1500 mm annual rainfall areas.

One school favored the idea of a postglacial climate change (desiccation, gradually increasing aridity) as a major driving force causing desertification. Others stressed the importance of human impact. The human impact was expressed in terms of bad land management including over cutting, overgrazing, over cultivation and misuse of water leading to salinization.

The American “Desert Bowl” forced millions of people to leave their farms in the American Great Plains in the 1930’s. The drought and land degradation catastrophe had an important impact on the western scientific thinking for a long time initiating research and development efforts in soil erosion and soil conservation techniques (Thomas and Middleton 1994).

Since then, different concepts of desertification have developed and been discussed over and over again by scientists, politicians and the international aid and development society. Renewed international concern can usually be related to the outbreak of major periods of drought and famine in the Sahelian part of Africa.

1.2 Late 1900

Very important international events were the UN Conference on Desertification (UNCOD) in Nairobi 1977, the UN Conference on Environment and Development (UNCED) in Rio de Janeiro 1992 followed up by the UN Convention to Combat Desertification (UNCCD) adopted in 1994 and entering into force in 1996. In 2003 UNCCD designated the Global Environment Facility (GEF) as a financial mechanism to assist developing countries in implementing the Convention (GEF 2003). GEF expects to commit more than US\$500 million to help reduce land degradation in developing countries during the 2003-2006 period.

UNCOD in 1977 was called upon as a result of the severe drought and repeated crop failures that struck the Sahelian zone in Africa during the 1965-1973 period (the Sahelian Drought). It was concluded that desertification was not only an African problem but also a problem of global significance as stressed by Thomas and Middleton (1994). Several definitions were presented in the UNCOD documentation summarized by Mainguet (1991), Helldén (1991) and Thomas and Middleton (1994). It was implicitly understood that desertification leads to “long lasting” and possibly “irreversible” desert-like conditions. “Decreasing productivity” is a key process included implicitly or explicitly in most definitions. Desertification was commonly considered to affect arid, semi-arid and sub-humid ecosystems by the combined impact of droughts and human activities. The relative role of climate, droughts and human impact was discussed. The key problem was identified as a chronic process of land degradation in which man’s occupation and use of the drylands was playing the major role. Drought was rather seen as a catalyst which exposed the effects of the long-term degradation caused by people (Thomas and Middleton 1994). The most important causes of desertification were the same as reported during the first decades of the century i.e. over cutting, overgrazing, over cultivation and misuse of water.

UNCOD formulated and adopted the Plan of Action to Combat Desertification (PACD), endorsed by the UN General Assembly in 1977. The responsibility for following up and coordinating the plan was given to the UN Environment Programme (UNEP). The desertification prone countries were urged to develop National Plans of Action to Combat Desertification. This was seen as a fundamental instrument for the

implementation of the PACD recommendations. Many national plans have been written but few, if any, have ever been financed and implemented. The rhetoric, and sometimes unrealistic, content of many of the national plans was pointed out by Thomas and Middleton (1994).

UNEP's concept of desertification was seriously challenged by groups of scientists during the 1980's and at the beginning of the 1990's (Helldén 1984, 1988, 1991, Mainguet 1991, Thomas and Middleton 1994). The mere existence of desertification, as the UN described it, was questioned. The word "myth" circulated in scientific publications and mass media. The criticism probably contributed to a UNEP initiative to modify the prevailing concept of desertification in 1990.

The new definition introduces the idea that desertification does not need to lead to the development of deserts or desert-like conditions. It simply refers to all types of land degradation in the drylands of the world. Human adverse impact on the environment is considered to be the only cause of desertification (Rozanov 1990, UNEP 1991):

Desertification/land degradation, in the context of assessment, is land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse human impact.

"Land" in this concept includes soil and local water resources, land surface and vegetation or crops. "Degradation" implies reduction of the resource potential by one or a combination of processes acting on the land, including water and wind erosion, sedimentation and siltation, long-term reduction in the level of diversity in natural vegetation, crop yields, soil salinization and sodication.

In mid-1991 UNEP changed the concept again (Helldén 1991):

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting *mainly* (author's italics) from adverse human impact.

The UN at UNCED redefined the definition once more in 1992. The new definition is confirming that desertification is the same thing as land degradation. New is the recognition that not only human impact but also various factors including climatic variations are important causes of land degradation in the drylands. The definition and concept reminds of the old discussions that took place during the first decades of the 20th century.

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNCED 1992). The Earth Summit in Rio de Janeiro resulted in the action plan and recommendations documented in Agenda 21 (UNCED 1992). Beside general and global recommendations of conventional soil conservation and land rehabilitation measures many of the most important recommendations cover the sphere of socio-economy and are as valid for poverty fighting and general development measures as they are for desertification control. Socio-economic issues, mainly as indicators of desertification, were discussed already at UNCOD in 1977. However, socio-economic and political factors are now recognized as important driving forces behind bad land use contributing to land degradation and desertification.

UNCED was followed up by the UNCCD in 1994. National Action Programmes (NAP) is one of the key instruments in the implementation of the Convention similar to UNCOD's previous approach in the Plan of Action to Combat Desertification. More than 40 countries have provided copies of their NAP to the UNCCD Secretariat, most of them during the present millennium. China did so already in 1996.

According to a recent GEF news release, land degradation, which includes desertification, can be described in terms of loss of biodiversity, reduced subterranean carbon sequestration, and pollution of international waters (GEF 2003).

Desertification mitigation approaches and control success or failure varies with concepts of causes and consequences. Nowadays, there is a rich flora of handbooks on all kinds of biophysical theories and practical techniques on how to fight land degradation and desertification assuming it is caused by human impact on the environment (e.g. Wenner 1977, Hurni 1985, Hudson 1985, Mainguet 1991, Lal 1994, Morgan 1995). The handbooks cover most aspects of soil conservation (wind & water erosion control e.g. shelterbelts, fencing, bunding, sand fixation, terracing, water harvesting, gully control, species recommendations, plowing techniques, nursery establishment), irrigation, rangeland management and grazing strategies, forestry, agro-forestry and agriculture. The degradation control difficulties increase when it comes to considering the importance of climate variability in the desertification process. The difficulties grow when the social and economic causes and consequences of human and climate-induced desertification have to be addressed and controlled. The control problem grows even more when alternative survival strategies, i.e. abandoning the land or stop using it for agriculture, is considered the only available solution to save the affected people and land.

Abandoning the land might very well be the best response to climate change. It implies that biological-physical control measures must be replaced by or combined with, social, economic and political measures to avoid poverty and famine in the future.

The causes and consequences of desertification cannot be generalized on a global, continental, regional or even national level. They are site specific (Helldén 2003). Every site and case needs its own diagnosis, based on an integrated and systemic research approach, before the right cure, often complex and integrated in nature, can be identified and implemented. A successful cure is likely to include action of both social, economic, political, biophysical and local participatory character. It also includes an integrated monitoring and evaluation program to measure indicators of desertification, carry out cost-benefit analysis, recognize success, avoid repeated mistakes and initiate positive feed back mechanisms.

2. European desertification research.

European scientists have contributed to the international desertification research and monitoring ever since the beginning of the 20th century as indicated above. Although a lot of efforts have been directed towards African and Asian conditions most of the research and the control activities are focusing on the Mediterranean part of the European union so far. The UNCED (1992) and UNCCD definition of desertification has been fully adopted in Europe. There are also large areas outside the arid, semi-arid and dry sub-humid parts of Europe where land degradation has led to the creation of large true deserts and desert-like environments. Such areas in e.g. Iceland and Scandinavia may exemplify recent and relict severe degradation caused both by climate change and/or human impact (Helldén 2003).

A new European research initiative and one of the very largest on desertification, DeSurvey, is described below. It is an integrated project (IP) building on more than a decade of European Union and European Commission (EC) supported desertification research and environmental modelling projects. MEDALUS, MODULUS, DESERTLINKS, CAMELEO, MEDACTION, DEMON, ASMODE, LADAMER, ARCHAEOMEDES, RESMEDES, PESERA, MEDRAP and AIDCCD are examples on such programs carried out within the EU Research Framework Programs since 1991.

The description below is condensed from the DeSurvey Executive Summary (www.DeSurvey.net).

2.1. DeSurvey-A Surveillance System for Assessing and Monitoring Desertification

Commissioned by the EC in March 2005 with funding of 7.8 million euros over 5 years, the DeSurvey project will deliver a compact set of integrated procedures for the surveillance and assessment of desertification status and land-use system vulnerability from regional to international scales. These procedures will be delivered through a suite of computer-based tools, the DeSurvey system, tailored to the information needs of organisations involved in desertification policy and management. Each tool will address a different aspect of desertification (climatic drivers, socio-economic drivers, land-use and land condition change, water resources and hydrology) and be linked through a common DeSurvey database, metadata catalogue, and information system.

The system will be developed and applied within the EU, accompanied by tutorial material and an end-user workshop. To evaluate the applicability of the DeSurvey system in desertification threatened areas globally, partners from Maghrebian and Sahelian countries as well as from Chile and China are involved in the project.

To fulfil these ambitions a core of leading edge European basic and applied desertification research have been assembled and integrated with international expertise in user-support technology development, data provision, education and capacity building, and stakeholder engagement to form the DeSurvey Consortium. The consortium is composed of 39 Organisations including universities, government research agencies and SMEs from 10 EU Member States and 6 Third Country States. As such DeSurvey constitutes the largest ever international research project to exclusively focus on regional desertification surveillance and assessment.

The project is coordinated by Prof. Juan Puigdefabregas, Estacion Experimental de Zonas Aridas (EEZA-CSIC), General Segura 1, 04001 Almeria, Spain (puigdefa@eeza.csic.es)

2.1.1. Mission and objectives

Desertification surveillance is required for making one-off and periodic assessments of desertification status, for forecasting possible trajectories (early warning), and for evaluating the performance of management programmes. However, assessment procedures have so far been largely empirical and focused on the symptoms of desertification (land degradation) rather than on the underlying human-environment interactions and processes. As a consequence most of the available approaches are impractical to use at regional or global scales for reasons of cost; cannot address critical human-environment driver and process synergies and dynamics, and; only provide limited possibilities for quantifying uncertainty.

DeSurvey will fill these gaps by developing a prototype of a low cost and flexible surveillance system (the DeSurvey system) to facilitate:

- Understanding of desertification in a systemic and dynamic manner;
- Monitoring and assessment of desertification and land degradation status over large areas using objective and reproducible methods, including diagnosis of driving forces;
- Discriminating between *current* and *inherited* desertification, and the identifying of desertification *hot spots*;
- Forecasting of desertification under selected climatic and socio-economic scenarios;
- Bridging the gap between scientific knowledge generated by the project on the processes underlying desertification and the practice of formulating policy and management action to detect, prevent and resolve desertification risks.

To resolve these issues DeSurvey will utilise an integrated perspective of the desertification process (Fig.1). Two complementary approaches will be adopted:

- Spatially explicit cellular modelling of climate and socio-economic forcing impacts on land condition and land claims in land use systems. A feedback loop between land condition and land use spatial allocation will enable dynamic time projections.
- Predator-prey based systems modelling of Land Use Systems Vulnerability.

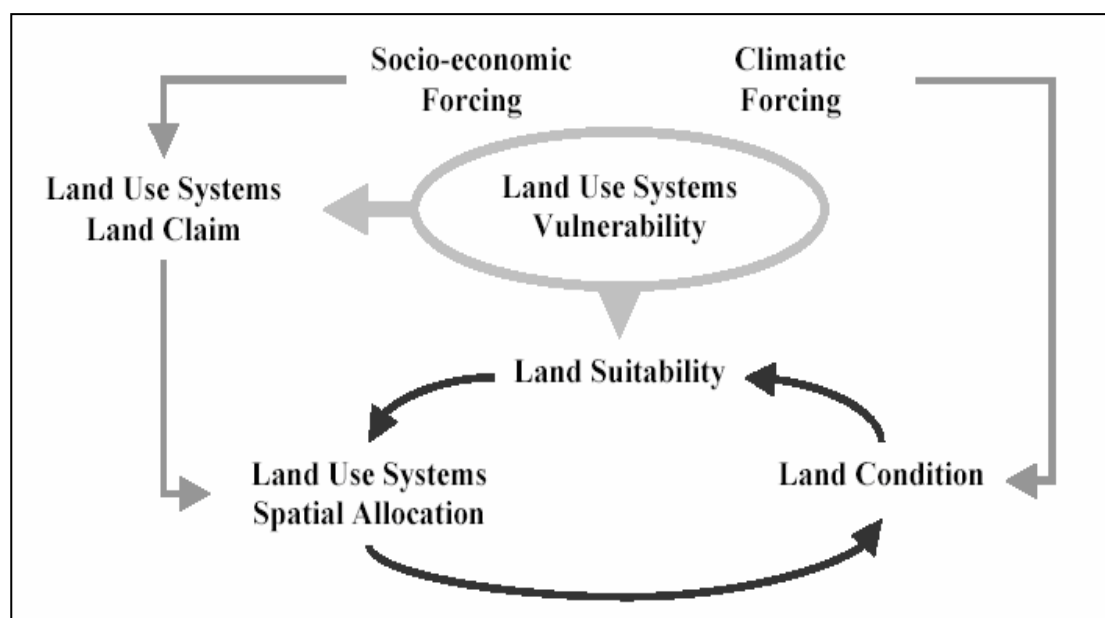


Fig. 1. Core relations in the DeSurvey Surveillance System for desertification assessment, monitoring and modelling.

Modelling work will be supported by independent databases provided by coupled remote sensing and ground information, together with socio-economic data.

The DeSurvey System will be designed to run at three spatial resolution levels:

- Coarse resolutions (~ 8 km or province-NUT equivalents) for preliminary surveys at the regional scale;
- standard resolutions (~ 1 km) for regional applications, and;
- fine resolutions (~ 30 m) for local applications. Further, the system will be designed to meet the information needs of international, national and regional environmental and agricultural authorities, such as the European Union (EU), UN Food and Agriculture Organisation (FAO), the United Nations Convention to Combat Desertification (UNCCD) and local consortia of stakeholders in risk-affected districts.

Target areas of moderate size (~ 1000 – 5000 km²) will be selected and used for three purposes:

- development and parameterisation of models that evaluate land use and land degradation changes as well as vulnerability of land use systems to desertification;
- validation of the DeSurvey surveillance and assessment procedures, and;
- demonstration of the DeSurvey System's performance.

2.1.2. Activities

The DeSurvey project is composed of 10 Modules each containing a number of Workpackages:

- Climate forcing.
 - Socio-economic forcing.
 - Land-use systems vulnerability.
 - Ground-based land condition assessment and forecasting.
 - Integrated remote sensing and geomatics approaches for the assessment and monitoring of land surface conditions.
 - Water resources condition assessment.
 - Data and information systems.
 - Integration and validation.
 - Innovation related activities.
 - Project monitoring, evaluation, contingency planning and management.
- In addition DeSurvey will provide a range of training and demonstration activities.

2.1.3. Outputs

The main outputs of the project will be:

- DeSurvey Desertification Surveillance system tailored to end-user information needs.
- Application examples of desertification assessment and its performance at national scales in Portugal, Spain, Italy and Greece.
- Application examples of desertification assessment and its performance at the sub-national scales in 5 European areas and in Morocco, Algeria, Tunisia, Senegal, China and Chile.
- Algorithms for deriving system-based indicators of discontinuities and breakpoints in the expected trajectories of threatened areas.
- Databases and information systems to run DeSurvey in the afore-mentioned areas.
- Two courses for increasing capacity of postgraduate specialists in desertification surveillance and training them in DeSurvey implementation and use.

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- ASMODE: Assessment of remote sensing techniques for monitoring the extent and progression of desertification in the Mediterranean area. http://directory.eoportal.org/res_p1_Researchproject.html

CAMELEO: Changes in Arid Mediterranean Ecosystems on the Long term and Earth Observation. <http://www.medaqua.org/forum/CAMELEO.html>

DEMON: Integrated approaches to desertification mapping and monitoring in the Mediterranean basin. <http://www.frw.ruu.nl/fg/demon.html>

DESERTLINKS: Combating Desertification in Mediterranean Europe: Linking Science with Stakeholders. <http://www.kcl.ac.uk/projects/desertlinks/>

DESURVEY: A Surveillance System for Assessing and Monitoring Desertification. <http://www.desurvey.net>

LADAMER: Land Degradation Assessment in Mediterranean Europe. <http://www.ladamer.org/>

MEDACTION: Integration of multi-scale dynamic spatial models of socio-economic and physical processes for river basin management. <http://www.icis.unimaas.nl/medaction>

MEDALUS: Mediterranean Desertification and Land Use. <http://www.medalus.demon.co.uk/>

MEDRAP: Concerted Action to support the Northern Mediterranean Action Programme to Combat Desertification. <http://nrd.uniss.it/medrap/index.htm>

MODULUS: A spatial modelling tool for integrated environmental decision-making. <http://www.riks.nl/services/Tool>

PESERA: Pan-European Soil Erosion Risk Assessment. <http://pesera.jrc.it>

RESMEDES: Remote Sensing of Mediterranean Desertification and Environmental Changes. <http://pages.unibas.ch/geo/mcr/Projects/RESMEDES/index.en.htm>

THE PROGRAM TO COMBAT DESERTIFICATION AND MITIGATE THE EFFECTS OF DROUGHTS IN SOUTH AMERICA

G. B. BEEKMAN

Inter-American Institute for Cooperation on Agriculture-IICA - Program to Combat Desertification and Mitigate the Effects of Drought in south America- Agreement ATN/JF – 7905-RG, IICA/IDB, Brasilia-Brazil

Abstract

The *Program* to Combat Desertification and Mitigate the Effects of Droughts in South America is being implemented at a regional scale. The general objective is to provide a sound basis for addressing dry land degradation and drought in, Argentina, Brazil, Bolivia, Chile, Ecuador and Peru, in accordance with the UNCCD principles.

This initiative is being carried out by a joint effort, represented by the Inter-American Development Bank-IDB, responsible for the administration of the financial resources of a non-reimbursable fund from the Government of Japan and the Inter-American Institute for Cooperation on Agriculture-IICA, as the executing Agency, of the *Program*.

The specific objectives are: (i) to improve the institutional capacity in the participating countries to combat the socio-economic and environmental problems caused by dry land degradation and drought; (ii) to develop and apply the use of standard indicators for desertification; and (iii) to contribute to the reduction or address the causes for dry land degradation and drought. These objectives will be pursued with due consideration of gender and indigenous community participation

Among the specific objectives the harmonization and application of the agreed upon set of indicators, constituted by a 'base-line' of indicators can be highlighted. A computer based 'Desertification Indicator Management System', (Sistema de Gestion de Indicadores de Desertificacion-SIGINDES which will represent the interfacing Geographic Information System-GIS, between the databases of indicators and models to be utilized in the simulation of scenarios), currently being developed by the *Program* in cooperation with the University of Chile, is the scope of this paper.

In order to establish a common 'base-line', seminars were held in all countries, where specialized agencies and specialists convened to devise an approach and a methodology for the selection of Desertification Indicators (physical, biological/agricultural, and socio-economic and institutional) from a pool of sources already available, based on clear criteria for their selection (usefulness for specific purposes, cost effectiveness of collection or analysis).

Once the methodology and the indicators are defined, they will be tested in various affected dry land areas (Pilot Sites). These tests will be used to improve the usefulness of the Indicators and the generation of comparable data. This testing will be performed by applying a sound monitoring and evaluation system, using the SIGINDES at selected Pilot Sites.

1. Introduction

Harmonization of Indicators at Regional Level in South America.

The *Program* to Combat Desertification and Mitigate the Effects of Droughts in South America is being implemented at a regional scale. The general objective is to provide a sound basis for addressing dry land degradation and drought in, Argentina, Brazil, Bolivia, Chile, Ecuador and Peru, in accordance with the UNCCD principles.

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Objectives

Within the context of the general objectives there are a number of specific objectives that will be briefly mentioned, keeping the focus mainly on two aspects. How a base line of indicators was derived as a result of several national workshops, as well as, the Desertification Indicator Management System-SIGINDES, to be utilized as a planning and decision making tool.

The specific objectives are: (i) to improve the institutional capacity in the participating countries to combat the socio-economic and environmental problems caused by dry land degradation and drought; (ii) to develop and apply the use of standard indicators of desertification; and (iii) to contribute to the reduction or address the causes for dry land degradation and drought. These objectives will be pursued with due consideration of gender and indigenous community participation.

All six participating countries have ratified the United Nations Convention to Combat Desertification. Since 1996, the six selected countries have been working on a methodology for the selection of Desertification Indicators (physical, biological/agricultural, and socio-economic and institutional). Ultimately, this effort has proven fruitful through the support of the Program and a common base line of indicators was established and to utilized as a common standard for the *Program's* objectives. More recently, the identification of indicators of participation was also included in the list of indicators to be considered by the *Program*. (Abraham, Elena., 2004).

2. Program description

The project comprises the following activities: (i) harmonization and application of existing indicators / data at the pilot level with baseline information; (ii) design of policy proposals to address desertification issues; (iii) institutional strengthening / training, and public awareness / information dissemination. These activities are consistent with priority areas set out in the Conference of the Parties of the Convention and in the National Action Program of the participating countries.

Special attention is to be given to traditional expertise and practices, and their improvement, as well as the collection, analysis and exchange of information on relevant matters to address desertification and drought. The selection of socio-cultural Desertification Indicators will take into consideration traditional practices in dry-lands of the region, compiled in 1999 as mandated by the Conference of the Parties of the UNCCD. Traditional practices will be monitored considering the geographic location of indigenous population in the Pilot Sites in order to assess which management practices are more conducive with prevention or mitigation of desertification, so that good practices could be extracted and disseminated. Likewise, gender issues will be addressed where appropriate. This approach is already being put into practice in the implementation of the first Pilot Projects in Argentina and Brazil. (Plan of Operations, - IDB, Agreement ATN/JF- 7905-RG)

3. Frame of Reference

3.1 Background

Desertification is the degradation of the productive capacity of land in arid, semiarid and dry-sub-humid areas. In the region, at the beginning of the 1990's the total population affected by dry land degradation, without considering Central America and the Caribbean, was around 100 million. The majority of the population was poor (25% of the total regional population), in about 5 million km² of vulnerable dry lands (25% of the total regional area).

Most dry land degradation is caused by inappropriate land-use practices that convert usable land to marginal land to barren land. Examples include excessive grazing; cutting vegetation for fuel; soil-depleting cropping; soil salinization and water logging; and poorly planned public works. Periodic droughts make dry lands increasingly un-usable.

Aimed at halting the process of dry land degradation, the United Nations called for specific actions at the Convention to Combat Desertification, that entered into effect on December 26, 1996. Since then, 172 countries have ratified the Convention.

The main objective of the Convention is to secure the long-term commitment of its Parties to combat desertification and mitigate the effects of drought through effective action at all levels, with a view to contributing to the achievement of sustainable development in affected areas. The Convention calls on the affected countries to develop National Action Programs to Combat Desertification and Drought (NAPCD), within the framework of national development plans. These include strategies and priorities, paying special attention to the related socioeconomic factors, addressing the underlying causes of dry land degradation, promoting the participation of local populations particularly women and youth, and providing an enabling environment by issuing as necessary new laws and policies.

The countries participating in this project (Brazil, Argentina, Bolivia, Chile, Ecuador and Peru) all have extensive dry lands prone to desertification and have asked the Bank to provide them with technical assistance. As a result, the IDB contributed to the financing of the National Action Plans to Combat Desertification and Drought (NAPCDs) in these – as well as other – countries in the region. These NAPCDs identify key dry land areas within the countries, set priorities for public and private interventions to prevent and fight desertification and mitigate the effects of drought. Emphasis is given to the bottom-up approach with local communities, NGOs, private sector, institutions of civil society, and local governments, working together in the decision-making to formulate and execute the programs.

Summaries on desertification indicators by nation in participating countries

In **Brazil**, around 15% (1 million Km²) of the land is semiarid and subject in large areas to degradation processes, often combined and aggravated by recurrent drought, impacting around 16 million poor population. The economic losses directly derived from both phenomena are not yet properly assessed. As for desertification, rough estimates indicated in the country's National Action Program (1997) suggest annual losses close to US\$300 million, disrupting social and productive structures. The observed losses in Northeast Brazil for 1993 were equivalent to 30% of agricultural output of food products. A more comprehensive NAP was elaborated and formally launched on June 17th, 2004 during the CCD+10 meeting held in Fortaleza –Ceará.

Moreover, Brazilian States and Federal agencies incur expenditures that cost usually US\$1 to \$1.5 billion during extreme years (2 out of 5 years) or close to \$600 million yearly adjusted. All together combined annual losses equate to 1% to 2% of Northeast

GDP, and significant investment is used just to rebuild social and productive structures disrupted by the phenomena of drought and land degradation.

- Up to 60% of the landmass of **Argentina** (around 1.6 million Km²) is subject to desertification. This includes the northern highland provinces of Salta and Jujuy, the down slopes and valleys at the base of the Andes including the important agricultural area of Mendoza, and most of Patagonia, affecting a population of 9,0 million inhabitants.

- In *Bolivia*, about 41% (450,000 km²) of the land is affected, involving a similar percentage of the national population (around 5 million people) in three key areas: the highland plateaus, the Yungas valleys leading down from the mountains and the Chaco region to the southeast.

- Much of *Chile's* agricultural production derives from areas subject to the effects of desertification: the irrigated valleys in the northern arid and semiarid areas of the country down to Region IV, and south of Santiago down to Region VII. The areas considered vulnerable amount to about 45% (340,000 km²) of the national land surface, affecting 1.5 million inhabitants.

In *Ecuador*, the affected geographic areas are relatively small but significant in terms of population affected. These include most of the coastal province of Manabi and adjacent areas of Guayas; mountainous areas in the southern province of Loja; and the southern coastal area abutting Peru.

In *Peru*, about 22% of the landmass (283,000 km²) with 20 million people of the country is vulnerable to desertification. Of particular importance are the irrigated valleys of the coastal plain, where most people live. In those areas, soil salinization is a significant problem. Also, much of the Andean highlands are affected by over-cultivation and overgrazing.

The project's strategy

The project's strategy follows the IDBank's strategy, by providing technical training to local stakeholders of the participating countries in the identification of physical, biological/agricultural, socio-economic and institutional indicators of dry land degradation, to address its control. In that context, the Program also contributes to public awareness, information dissemination and institutional strengthening within the framework of the Bank's Institutional Strategy of environmentally sustainable growth and poverty and inequality reduction.

The reduction or loss of the biological or economic productivity and complexity of dry lands (e.g. rained or irrigated cropland, or range, pasture, forest and woodlands) has its roots in land uses or from a process or combination of processes, including those arising from unsound human activities and habitation patterns that affect the livelihood of local populations. With this *Program*, Desertification Indicators (meaning very sensitive characteristics of the dry land environment to degradation processes) will be used, monitored and evaluated in Pilot Project Sites of the participating countries, to standardize their use for dry land degradation prevention and control, aimed to desired results towards policy formulation and application. This in fact will represent a step forward, regarding public policies formulation envisaging structural changes. The primary purpose is to promote scenario changes by physical intervention to control and to reverse the situation of environmental degradation and the overall process of desertification.

Efforts to prevent or control dry land degradation processes within the region, have given raise to an early warning information methodology to cope with them timely and effectively.

Harmonization and compilation existing indicators / data

This component was aimed at revising a methodology for the selection of Desertification Indicators (physical, biological/agricultural, and socio-economic and institutional) from a pool of sources already available, based on clear criteria for their selection (usefulness for specific purposes, cost effectiveness of collection or analysis). The revision and implementation of a methodology to identify test and adjust key indicators that can be used throughout the region for the identification and evaluation of desertification processes in order to recommend appropriate control measures was deemed necessary.

As a next step the definition of the base-line of indicators as adopted will be tested in various affected dry land areas (Pilot Projects). These tests will be used to improve the usefulness of the Indicators and the generation of comparable data. Applying a sound monitoring and evaluation system, such as the SIGINDES, to be utilized at the Pilot Project sites, will perform this testing. This component was extensively discussed during the workshops organized by the respective National Focal Points of the participating countries. The vast majority of the stakeholders had the opportunity to attend these events enabling an in depth debate on the selection of feasible indicators to be adopted nationally and henceforth regionally.

The specific activities of this component are as follows:

Indicators. The methodology to be used will take elements from indicator models designed in the participating countries. The methodology is based on levels of interpretation, analysis and aggregation of information, going from basic information to analyzed information to Indicators. If, for example, the information relates to human exploitation of the soil, possible indicators are the degree of erosion, salinization, contamination, compaction, or organic matter content. Once the indicators can be measured, they can be more effectively addressed with the use of appropriate technology. Indicators can also be integrated to summarize the state of desertification in a given area.

The lines of thought regarding the discussion on indicators as conducted by the Program by means of a series of specific workshops organized in the participating countries has been outlined in more detail henceforth.

Indicators in Focus

Indicators help to reflect and communicate a complex idea. They are everywhere and are part of our everyday lives. They are used to observe, describe, and evaluate actual states, to formulate desired states or to compare an actual with a desired state. These simple numbers, descriptive or normative statements can condense the enormous complexity of the world around into a manageable amount of meaningful information.

To support a monitoring network as envisaged by the *Program* a set of indicators should be evaluated in order to monitor progress towards meeting the targets and goals set out together with the institutional and the community stakeholders. (Beekman, Gertjan B., 2005). Indicators, as mentioned, are used to simplify, quantify, communicate and create order within complex data. They provide information in such a way that both policy-makers and the public can understand and relate to them. They help to monitor progress and trends in the use and management of natural resources, and associated aspects to the control and reverse the process of environmental degradation and its consequent social impacts, over time and space.

Possibly, the most widely used and known approach to indicator development is the cause-effect approach. The pressure-state-response (PSR) conceptual framework was first introduced by the Organization for Economic Cooperation and Development

(OECD) in 1994. Several cause-effect classifications have been developed such as the Driving Force-Pressure-State-Impact-Response (DPSIR). The Driving Force-state-Response (DSR) framework of the United Nations Commission on Sustainable Development was used for the indicators of Agenda 21. The Driving Force-Pressure-State-Exposure-Effects-Action (DPSEEA) framework is used in the burden of disease studies of the WHO. (The United Nations, World Water Development Report, 2003). Although this is the most applied approach and offers a very promising guideline for indicator development. It all too often fails to take the entire system into consideration because of the subjectively involved in understanding the pressure, state and responses. Similarly, indicators can help in the comparison of results in many areas or countries and examine potential links between changing conditions, human behavior and policy choices. Because 'good indicators are easy to understand, they offer a tool for raising awareness about desertification water issues that cut across every social and political group.

The development of indicators is not an easy task, for it involves a great amount of work in collection, storage, retrieval, analyses and systematization of data. The need for clarity and ease of understanding means that indicators often condense large volumes of data into brief overviews and reduce the complexities of the world into simple and unambiguous messages.

The need for scientific validity, on the other hand, requires that indicators must simplify without distorting the underlying patterns or losing the vital connections and interdependencies that govern the real world. They must therefore also be transparent, testable and scientifically sound. Because the same indicator has to satisfy often conflicting but equal important social, political, financial and scientific objectives, deriving indicators becomes an objective maximization exercise constrained by available time, resources and partnership arrangements.

The solution lays in identifying or developing denominators common as many cases as possible, so that comparisons may be made. If data can be gathered according to commonly agreed or standardized norms, then lessons can be drawn that may be transposable from one case to another.

Indicators can tell a different story or message according to specific contexts, for particular purposes and for specified target groups, and therefore resist universal application. Both the design and the use of indicators involve many personal and negotiated decisions, explicit and implicit assumptions, normative and subjective judgment, and disciplinary and method-specific rules. They are based on beliefs, internalized values and norms and on one's perception of "reality".

In establishing indicators, the criteria must be absolutely clear. Yasuda and Murase propose the following six criteria, 2002.

- Relevance: The numerical values of an indicator should represent the degree of 'what should be measured' directly;
- Clarity: Ambiguity and arbitrariness should be excluded from measuring with an indicator;
- Cost: The cost of the evaluation by an indicator should be affordable low;
- Continuity: Availability of coherent data both in historical and regional scope should be respected;
- Comprehensibility: Definition/expression of an indicator should be intuitively/easily comprehensible to users;
- Social benefit: Net social benefit that an indicator yields, as it is applied, should be maximized.

The main functions of indicators are thus simplification, quantification, communication and ordering. Indicators can relate and integrate information and allow comparison of different regions and different aspects.

Purpose and Use of Indicators: Clearly, the growing interest in the use of indicators and indices is closely connected to the increasing complexity of policy problems and the large amount of available data. In the water sector, beyond their face value, indicators can provide various types of information such as:

Descriptive: Describing the state of the resource, or social target group, is the most common use of indicators. In terms of water resources an example of the descriptive use of indicators could be by presenting the values of available water resources, water demand, internal renewable water resources and water supply on a regional scale.

This could be presented on maps clearly showing differences in resources, demand and supply of water. Similarly, maps with social indicators could be produced showing number of landowners holding land titles, family average annual income, number of associations or cooperatives as an indicator of social organization among others. Such maps could eventually indicate a human development stage (HDI) to be utilized as guidelines for development policies.

Showing Trends: Regular measurement of indicators provides time series, which can show trends that may provide information on the system's functioning or response to management. The increase of productivity and yield of agricultural systems run by resettled groups through associations or cooperatives may be an indicator of economic success and sustainability. Benchmarking is important to show scenarios over time.

Communication: Indicators can be instrumental to communicate policy objectives and results to the public. Such indicators help promote action and could reflect the degree of participation of a community.

Translation of an Information need into Policy-Oriented Information using Variables, Indicators and Indices

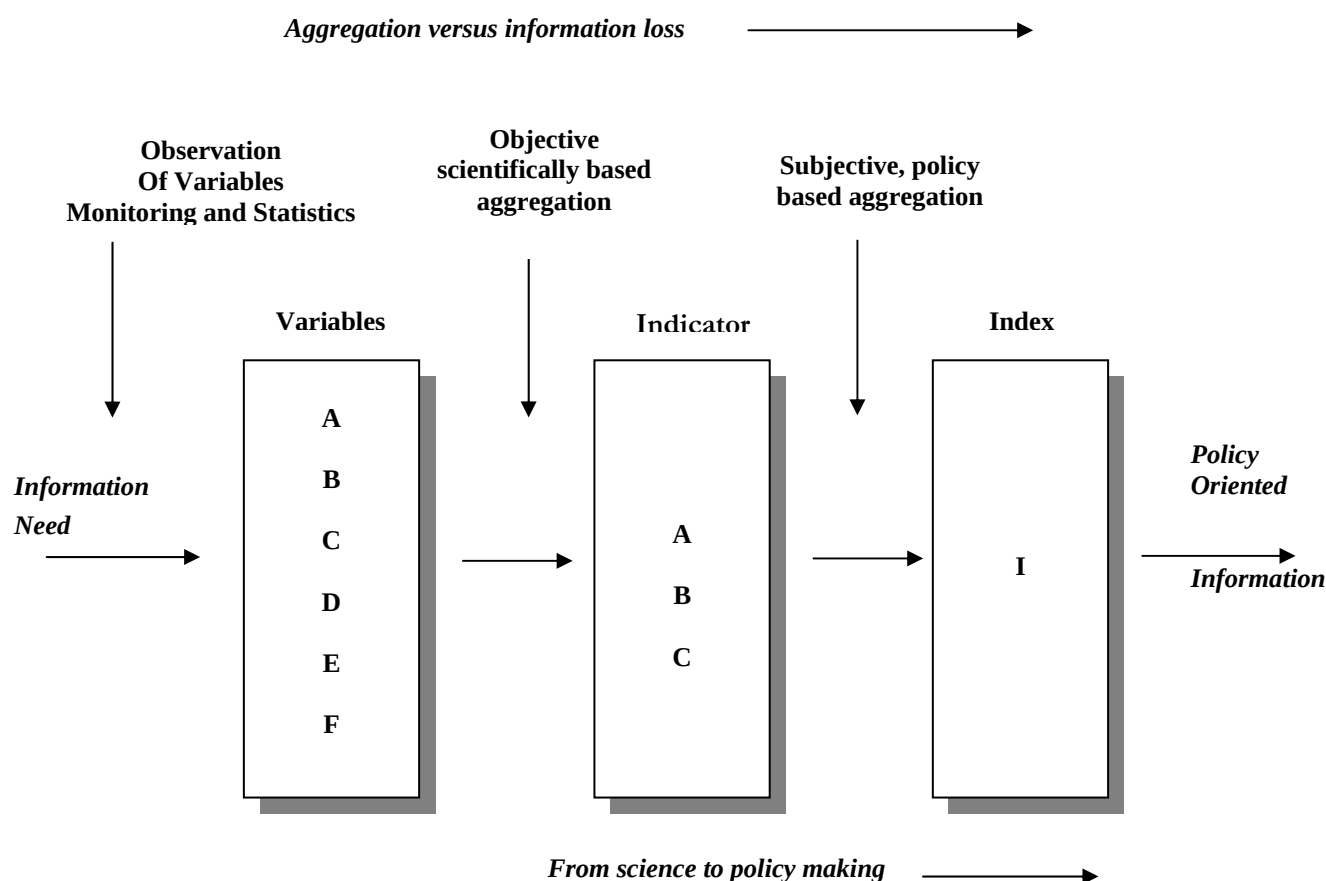


Figure 1: 'This figure shows the difference between variables, indicators and indices, which all represent different stages of information collation, indicators take variables and condense them into manageable information sets, which then are further condensed by indices. These can be translated into policy-oriented information'. (Lorentz-1999).

Monitoring System.

The selected set of Desertification Indicators will be applied in the Pilot Projects Sites (preferably two per country) in dry lands selected by the NFI, preferably within a municipality. The Pilot Sites will be well-defined micro or sub-watersheds, supporting agricultural (i.e. crops, livestock, agro forestry, forestry) and other economic activities. The Pilot Sites will have good secondary information on their natural resource base. The desertification monitoring system will be designed and implemented based on a geographic information system (GIS), satellite products and conventional information in order to follow up the Desertification Indicators. Some of these elements are already being gathered from the Pilot Projects that are carried out in Argentina.

The monitoring process will start with known baseline information. Periodic evaluations will be done to build up the information needed to prevent and halt desertification

processes. To design the monitoring system specific expertise will be brought in by the Program and in close collaboration with local experts from the participating countries will define said system for its application in the Pilot Sites. In this context, the operational guidelines, software and other applications for the effective implementation of the system will also be identified and be made available for each country.

Desertification Indicator Management System-SIGINDES. This system is currently being developed with the support of the *Program* relying on the inputs provided by the University of Chile, IADIZA-Argentina in addition to the data bases on socio-economic indicators as developed by a previous project conducted by ECLAC when the REDATAM-data base/system was constructed with data collected from Argentina, Brazil and Chile. Currently this database is being updated with the insertion of the socio-economic indicators from Ecuador, Peru and Bolivia. Another database input will be provided by RIOD (International NGO's to Combat Desertification) who is in the process of construction a database on Indicators of Participation. Other software components of interest of the system that could make it more useful and comprehensive can be aggregated as additional contributions and arranged in a user-friendly manner.

The SIGINDES upon completion will have as a core element the Monitor (Santibáñez, Fernando, et al.,1997) developed years ago by the Center of Agriculture and Environment at the University of Chile. The aim of this software is to act a management system to interface databases associated to a map-producing tool capable to generate any display based on the variable or set of variables stored in the database. Basically it can be considered a Geographic Information System that interacts as an interface between data bases and models utilized to simulate scenarios that represent a diagnosis of a given situation of desertification or future scenarios based on assumed changes that represent a prognosis due to possible changes of the variables either due to natural causes or anthropogenic activities. Therefore, the Monitor within the SIGINDES context is able to simulate scenarios reflecting the change of state of variables considering a varying time scale as defined by the user of the system. One of the objective of the *Program* is to make the SIGINDES available to institutions representing the participating countries, as well as, those interested in the exchange of experiences in combating desertification as an international cooperation effort.

Institutional strengthening / training

In order to ensure the wide application and human resources sensibilization, awareness and capacity to analyze the data to be collected, appropriate training material will be produced for different target groups (land users and community leaders; local government officials, private institutions, press, NGOs; and decision makers). They will be guidelines on desertification processes, their prevention and control, and guidelines on Desertification Indicators, prepared by local universities inserted in dry land areas.

Depending on the target group, short courses will be delivered by specialized professionals. Courses for public officials should enable them to interpret and analyze the data to be generated by the monitoring system and as a consequence prepare adequate response programs or policies addressing the causes of desertification. Courses for land users and community leaders should provide them with the necessary understanding of the effects of desertification as well as provide them with options that will mitigate, reduce or adapt to said effects.

Furthermore, a post-graduate / or specialty track university program (curricula, teacher profile, costs per student) will be developed for interested universities in the participating countries and in the region. The participating universities will be selected

on the basis of certain criteria, such as geographical location and proven interest in desertification programs. The universities will design this program in collaboration with national institutions involved in the gathering and interpretation of Desertification Indicators, as to ensure an adequate human resources needs profile / demand for technical expertise.

Design of policy proposals to address desertification / public awareness

Based upon the results of the above-mentioned testing period for the application of the monitoring system and based on the selected Desertification Indicators, draft policy and / or program proposals will be prepared. This activity will also be accompanied by actions to raise public awareness on desertification issues. These actions will be performed with the support of community councils or other local NGOs or groups, and made public through different communication media.

Expected outcome / results

It is expected that the principal outcome of this operation will be the formulation of congruent indicators to measure desertification, and as such the production of readily comparable data for various countries in South America. Furthermore, for this information to be translated into concrete actions addressing desertification occurrences, it will be complemented by training activities for specific target groups, and other actions leading to an improved institutional capacity of agencies responsible for measuring and interpreting environmental data as well as for policy making. Furthermore, the design of sound local and specific policy proposals will be an important output of this operation, which will also be supported by the production of awareness material, and the design of academic postgraduate programs or specialty tracks. It is expected that these products lead to the long-term sustainability of the efforts initiated with this *Program*.

Environmental and social aspects

The *Program* has been designed for environmental protection and sound use of the natural resource base of dry lands in the region. Its inputs are basically technical assistance; training and policy design on environmental issues related to degradation control and sound management of dry lands for stakeholders and the well being of local communities. It also includes dissemination of information and the preparation of graduate training programs on dry land management at the national and regional levels.

Beneficiaries / benefits

The *Program* will contribute to raising community awareness of and sensitivity to significant environmental problems associated with desertification. Tools will be developed on a regional scope to assist experts and local communities address the causes of desertification. The consolidation of socioeconomic and environmental indicators on a regional level, as well as their application and analysis at pilot sites, will provide key information conducive to the formulation policies and programs addressing the causes of desertification.

Complementary to the above, it is expected that the training sessions tailored to specific target groups will contribute to the improvement in the planning and management of natural resource use. Additional activities envisioned for institutional strengthening will further support that aspect. Also, the training sessions will promote the conservation and protection of dry land's natural resource base, as well as promote the adoption of environmental friendly agricultural practices and other environmentally appropriate uses

of dry lands. Furthermore, this Program will strengthen existing cooperation on dry land management and conservation activities, among governmental and non-governmental institutions on a national and regional level. This cooperation will ensure continued exchange of technical expertise on desertification/dry land management issues, and as such enrich the formulation of policies or programs in this field.

Benefits and Beneficiaries: The project will contribute to raising community awareness of and sensitivity to significant environmental problems associated with desertification. Tools will be developed on a regional scope to assist experts and local communities address the causes of desertification. The consolidation of socioeconomic and environmental indicators on a regional level, as well as, their application and analysis at pilot sites, will provide key information conducive to the formulation of policies/programs addressing the causes of desertification.

This approach is aimed to foster and promote the conservation and protection of dry land's natural resource base, as well as promote the adoption of environmental friendly agricultural practices and other environmentally appropriate uses of dry lands.

Conclusions

Besides having the overall objective and the specific objectives of *the Program* in implementation and having achieved one of its main targets the harmonization of indicators of desertification at regional level, seconded by the Desertification Indicators Management System-SIGINDES about to be implemented in the Region, as described throughout this text, other aspects could be highlighted as well.

The *Program* has represented an invaluable instrument in the Region in terms of institutional building and in the process of generating knowledge on how to approach the issues of desertification in a comprehensive manner, as well as, providing important means to foster the exchange of experiences among the institutions of the participating countries.

The very means for the implementation of the *Program*, as provided by the financial resources from the Government of Japan in close cooperation with the Inter-American Development Bank-IDB are essential in the pursue of concepts to design policies and strategies backed by methodological approaches and techniques on how to tackle, control and reverse socio-environmental degradation processes that eventually may lead to desertification.

By abiding to the premises of Agenda 21, Chapter 12 and more recently to the Millennium Development Goals, the international cooperation as provided by the executing agency Inter-American Institute for Cooperation on Agriculture-IICA has also proven essential in this overall effort to construct partnerships in the context of international cooperation to combat desertification.

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RESEARCH ON DESERTIFICATION FOR HAINAN ISLAND BASED ON GEOSTATISTICAL TEXTURE

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Abstract

During the research on desertification for Wencang, hainan Island, we found that there are two difficulties in monitoring desertification of this area comparing to the research about desertification of West-North in china. One is the beach sandlot shows the same spectral features with the inland desert, using traditional spectral classification to discriminate them is impossible, accordingly we can't get the real desertification area, the other is the desertification of different degrees in this area is also difficult to differ directly from origin radiometric bands, and because current desertification area is mainly formed by excessive destroy, those experiences for West-North desertification monitoring are not fit, we must find other measures to grade the inland desertification. Based on different sandlot types takes on different spatial construction, the author initially put forward using geostatistical texture to monitor desertification, using the variogram texture to increase the discrimination degree of different samples, the result suggested that the maximum likelihood classification based on the combination of variogram texture and spectral bands can perfectly partition the beach sandlot and the different grades of inland desertification land, which prove that geostatistical texture is validate in the application of desertification monitor.

Keyword: Geostatistical; Texture; Variogram; Desertification; Sandlot

1. Introduction

Desertification is one of severest ecological environment problem, which produces severe environment deterioration and immense economic loss. China is a one of the country which is the most severely affected by desertification, but research about desertification all along focus on North-west in china, because that is the main area which affected by desertification, in fact, the HAINAN island which lies in south of china, because of the land resource development from 1950s, add to the mining and uncontrolled clearance of forest, have already lead to severe destroy and out of balance of ecological system, and generally takes on desertification, for example, the study area for this paper, WENCHANG city, is mainly result from mining titanium excessively. According to the latest land census, the desertification have spread to 443 villages and involved in 1.05 million peoples, the overall area of desertification added up to 1,375 km², account for 4 percent of the island area. The monitor and management of desertification are very pressing.

Currently, there are mainly two methods for desertification evaluation, one is using remote sensing software directly divide land types and desertification degrees through supervised classification or unsupervised classification, the other is that firstly some indicators for desertification are selected, and then different weights are set for them, the final result is get based on synthetically considering these indicators. HAINAN island is the only region in south-east of china which is affected by desertification, research on the region is very scarce, there are few field survey documents and Indicators fitting for the region, what's more, as mentioned in the next sections, research will

encounter problem which is not exist in others relate research, so we must find a new approach to realize the desertification monitor fitting for this region.

2 Description of the study area and data

The area selected in which to apply the methodology is located in the North-East of HAIHAN Island (Island), close to ocean at the east, the longitude is 110.717E, and the latitude is 19.617N, its location corresponding to the whole island is showed as Figure 1. The selected data includes a Landsat-5 TM subscene in which a test area of around 740 km² was taken (1036×795 pixels), the image date is July, 1989, and a Landsat-7 ETM+ subscene representing the same range, the image date is August, 2003, besides a land use map dated 2001 is gotten for this research.

Through Primary analysis to the two images we can get, different from others desertification monitor, the region is close to sea, beach sandlot and inland desertification take on the same spectral features in image, so it is impossible to discriminate the beach sandlot and inland desertification directly based on TM radiometric bands, accordingly we will be unable to calculate the real area of the desertification, in addition, it is also difficult to grade desertification directly based on image, because severe desertification, strong desertification, light desertification and potential desertification take on the same color across different bands combination. A traditional method is calculating desertification indicators (i.e. MSAVI, NDVI), then divide different threshold to different desertification grades, but it is regretful that we find if according to the threshold that fit for other regions to grade current region, the grades result is awfully not coincident with the actual conditions, so these experience that succeed in other regions can not be introduced here, we must find other feasible methods.

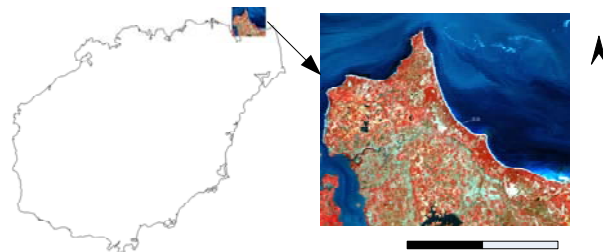


Fig.1. The region for research

In terms of the characters of the two images, this paper arrange for different research emphases, the image dated 1989 show the desertification area is small and the beach sandlot range is large, so we emphasize the discrimination of beach sandlot and inland desertification for this image. For the image dated 2003, although the desertification area increase much comparing to 1989, the beach sandlot have already become unclear because of the planting of beach shelter-forest for fourteen years, so towards the image we focus on how to perfectly realize the grading of different desertification degrees. Finally, we can analyze precisely the desertification trend by means of the result of former, and we can also help to guide the desertification management by means of the result of latter.

3. Methodology

3.1 Variogram and texture

Texture, feature that has received great attention in image processing, represents tonal variations in the spatial domains and determines the overall visual smoothness or coarseness of image features(Lillesand and Kiefer,1994). It reveals important information about the structural arrangement of the objects in the image and their relationship to the environment; consequently, texture analysis provides important discriminating characteristics related to variability patterns of landcover classes in photointerpretation and digital classification.

In practice, some of the most usual terms used by interpreters to describe texture, such as smoothness or coarseness, have a strong element of subjectivity and do not always have a precise physical meaning. Analysts are capable of visually extracting textural information from images, but it is not easy for them to establish an objective model to describe this intuitive concept. For this reason, it has been necessary to develop quantitative approaches to obtain texture descriptors. Thus, in a statistical context, texture can be described in terms of the two main conceptual components associated with the DNs: Local/global variability and spatial correlation. The first component is frequently analyzed at the local level by calculating the variance (σ^2), which is a statistical measure of the DN dispersion with respect to the mean value within a moving window (Woodcock and Harward, 1992). The second characteristic, spatial correlation, assumes DNs are not completely randomly distributed within an image and, consequently, there exists a spatial variability (or dependence) structure associated with each landcover class. As was pointed out by Lark (1996) the amount of variability seen, on average, in a contrast between a pair of pixels depends on their spatial relations, which can be used as texture descriptor of each landcover class. The advantage of the geostatistical approach is that both aspects can be jointly modeled as discussed below.

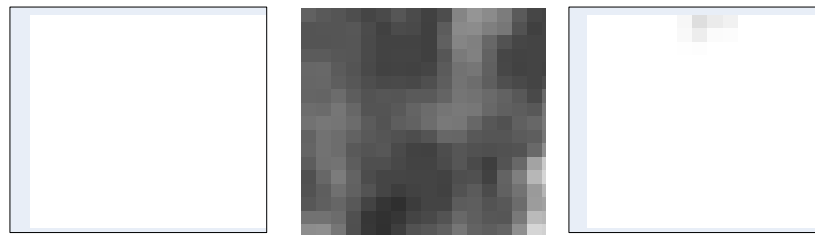
The DN of a remotely-sensed image is geostatistically considered as a regionalized variable, characterized by both random and spatial correlation aspects, associated with the above mentioned texture components. Under the intrinsic hypothesis, both aspects can be jointly studied through the semivariogram function concept, in practice also called variogram, expressed by the classical equation (Matheron, 1971):

$$\gamma(h) = \frac{1}{2} E \{ DN(x+h) - DN(x) \}^2 \quad 1$$

where $\gamma(h)$ represents half of the mathematical expectation of the quadratic increments of pixel pair values at a distance h , i.e., semivariance; $\gamma(h)$ is a vectorial function depending on the modules and the angle of the distance vector h between the pixels $x+h$ and x .

As noted above, texture is closely related to the spatial variability of grey values and consequently to the variogram. This relationship has been studied by other authors (Carr, 1996; Lacaze et al., 1994), who consider the variogram as a potentially useful descriptor of image texture and demonstrate its possibilities to identify multiscale spatial patterns. Miranda et al. (1998) showed that each landcover class in an image presents a different spatial variability pattern, i.e., a different variogram. From our point of view, this spatial pattern could be considered a "texture signature" of landcover class. To illustrate the relation between image texture and variogram we selected three subimages of 17×17 pixels from the second band of image dated 1989, corresponding to beach sandlot, strong desertification land, and potential desertification land. Calculation was performed using a simple computing program which allowed control of parameters such as direction, lag spacing and maximum distance. The variogram what get is

showed as Fig.4. When comparing the difference of variograms, we usually focus on three parameters (Fig.3.): Nugget, Range and Sill, Nugget is defined as the vertical jump from the origin to the value of the variogram at extremely small separation distance (a discontinuity), caused by sampling error and short variability; Range refers to the distance at which the variogram reaches a plateau; and sill refers to the plateau the variogram reaches at the range. We can see from Fig.4, every unique variogram behavior was associated with each corresponding vegetation type. Variogram of beach sandlot was essentially flat, exhibiting little or no spatial correlation for lag distances further than 1 pixel



(a) Inland Desertification (b) Potential Desertification (c) Beach Sandlot

Fig.2. Three landsat TM 2 subscene

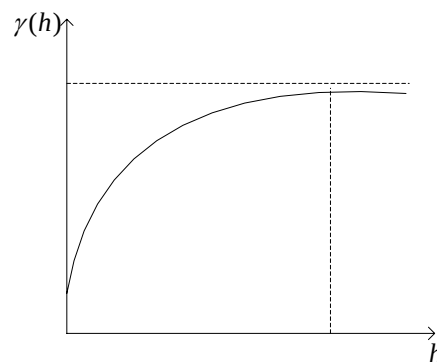


Fig.3. The parameter meaning of variogram

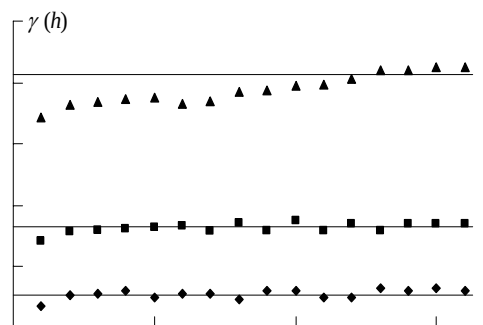


Fig.4. Variograms of different classes

Variogram of strong desertification land rose up to a lag distance of 2 pixels and then curved flat, its sill was larger than that of beach sandlot, which indicated that its DN values displayed a greater variance than open vegetation. Variogram of potential

desertification land showed the greatest variance and rose steadily toward the sill at lag distances further than 13 pixels.

3.2 Texture measures of spatial variability(TMSV)

To introduce geostatistical texture information into the image classification process we propose to calculate a set of texture measures of spatial variability (TMSV) based on estimators of the variogram functions. According to the number of bands involved into the function, the variogram what we used can be divided into two groups, univariate variogram and multivariate variogram. The former includes direct variogram and madogram, the latter includes cross variogram and pseudo-cross variogram^[7]

3.2.1 Direct variogram

The statistical inference of the direct variogram is obtained from the estimator of Eq.(1):

$$\gamma_k(h) = \frac{1}{2P(h)} \sum_{\alpha=1}^{P(h)} [DN_k(x_\alpha) - DN_k(x_\alpha + h)]^2 \quad 2$$

Where $P(h)$ is the number of distant pairs h , $DN(.)$ are the digital values of pixels x_i and $x_i + h$, k is a sensor band.

3.2.2 Madogram

The madogram is similar to the direct variogram but instead of squaring differences the absolute difference is taken(Deutsch and Journel, 1992).

$$\gamma_k(h) = \frac{1}{2P(h)} \sum_{\alpha=1}^{P(h)} |DN_k(x_\alpha) - DN_k(x_\alpha + h)| \quad 3$$

3.2.3 Cross variogram

The cross variogram quantifies the joint spatial variability(cross correlation) between two bands. It is defined as half of the average product of the h -increments relative to the radiometric bands j, k .

$$\gamma_{jk}(h) = \frac{1}{2P(h)} \sum_{\alpha=1}^{P(h)} [DN_j(x_\alpha) - DN_j(x_\alpha + h)][DN_k(x_\alpha) - DN_k(x_\alpha + h)] \quad (4)$$

3.2.4 pseudo-cross variogram

The pseudo-cross variogram represents the semivariance of the cross increments instead of covariance of the direct increments as above:

$$\gamma_{jk}(h) = \frac{1}{2P(h)} \sum_{\alpha=1}^{P(h)} [DN_j(x_\alpha) - DN_k(x_\alpha + h)]^2 \quad (5)$$

3.3 Parameters of variogram

A geostatistical image texture was obtained by computing the TMSV within a neighborhood using moving windows, as showed in Fig.2. During the course of the calculation, we need to consider four factors: window size, lag, calculation direction, bands combination. Window size represents the range that the semivariance of a pixel is calculated, it is usually got by empirical criteria and some experiments. We attempted to find a window that was not too large in order to limit computation time and to avoid the influence of the texture features of adjacent landcover classes; on the other hand, the window should not be too small, as otherwise a robust variogram estimator would not be obtained. The lag changes as the window size changes, which represents the relation

between two pixels, In Fig.2, the window size is three, so the lag may be one or two, a common method is calculating the average semivariances of all lags. Calculation direction is taken into account when the spatial distribution of DN_s reveals anisotropy, we usually consider four main direction: N-S, E-W, N45E, N45W. Bands combination is a parameter directed to cross variogram and pseudo-cross variogram, selection of different bands combination have a great effect on discrimination of landcover.

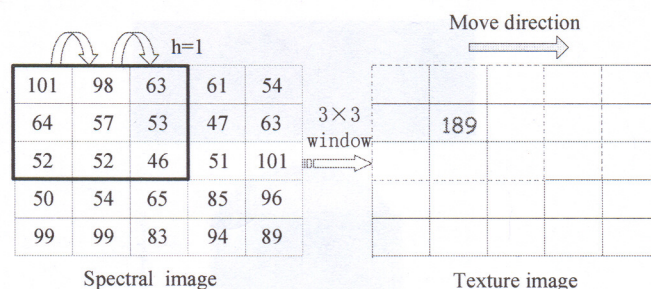


Fig.5. Calculation of Geostatistical Texture

4. Results and analysis

In order to focus on research of sandlot (included beach sandlot and inland desertification land), a mask needed to be performed firstly. For the land types that did not belong to the sandlot, only abandoned infield and mine had similar spectral reflectance features with sandlot in visible bands, but we can use the absorption value of Thermal-Infrared band(the seventh band) and vegetation index to differentiate them, this disposal was composed of three inquire operators and a logic operator, that was:

Not Sandlot (1) = $C_s < \text{spectral reflectance value of visible bands combination} < C_1$

Not sandlot (2) = $R_s < \text{spectral absorption value of infrared band} < R_1$

Not sandlot(3) = $N_s < \text{Modified Soil-Adjusted Vegetation Index(MSAVI)} < N_1$

Not sandlot = Not Sandlot(1) and not Sandlot(2) and not sandlot(3)

Where C_s 、 C_1 、 R_s 、 R_1 、 N_s 、 N_1 respectively represents minimum value and maximum value of spectral reflectance feature for not sandlot in different image, “and” is a logic operator. All these operators are performed in software ENVI4.0. The final result was an image that only included beach and inland desertification.

4.1 Selection of the study variables

In order to enhance the spectral and morphological features of the geological features of the geological material and reduce the number of variables to be analyzed from the textural point of view, we got the geostatistical image texture from principle component analysis(PCA) on the radiometric TM bands.

Because the selection of principle components have a important effect on the precision of variogram texture classification, the method of PCA is important. We compared the efficiency of two method, one is traditional method, that is directly getting principle components from 6 TM bands, the other is called as Feature Principle Component Selection Method, the six bands were divided into two groups, the first one corresponding to visible bands (TM1, TM2, and TM3) and the second to the infrared bands (TM4, TM5, TM7); subsequently, the most representative principal component of each group of bands was chosen. As the above method, we selected three subimages of 17×17 pixels from the two result images of PCA, then calculated the cross variogram of their PC1 and PC2, the result is showed as Fig.5. From this figure we can see the cross

variogram based on Feature Principle Component Selection can discriminate the three sandlot types more perfectly.

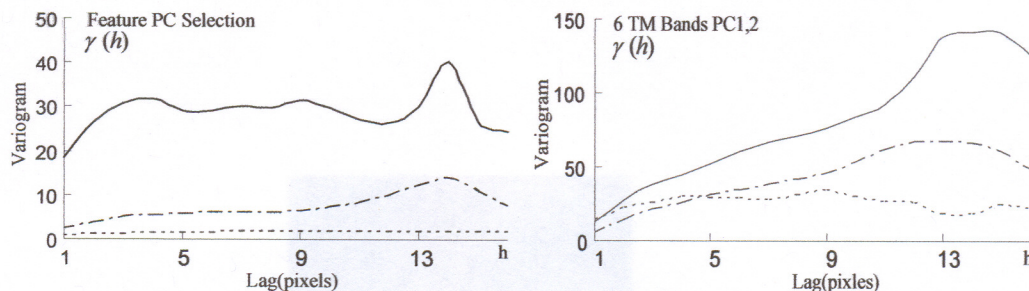


Fig.6. The Comparison of two Principle Component Analysis: inland severe desertification land(solid line), beach sandlot(dashed line),potential desertification land(dotted line)

4.2 Computing the geostatistical image texture

As mentioned above, we used the Feature Principle Component Selection Method to get PC1 and PC2, Based on each of the two PCs, with four types of variogram and three different lags(3×3 , 5×5 , 7×7), average of four main directions (N-S, E-W, N45E and N45W), a set of 12 TMSV would be obtained. In the four images of Fig.6, (a) and (c) are the false color composite images, (b) and (d) are the three “texture bands” composite images, we can see in 6(a) there are the same light white in inland region and inshore region, so it is difficult to discriminate using the traditional spectral classification, but in the corresponding (b), the light white region is divided into blue, cyan and yellow, beach sandlot and inland desertification took on different color; in 6(c) different desertification grades are also difficult to discriminate from those similar light white region, but in (d) the light region is discriminated into cyan, yellow, blue and red region, which corresponded to different grades desertification.

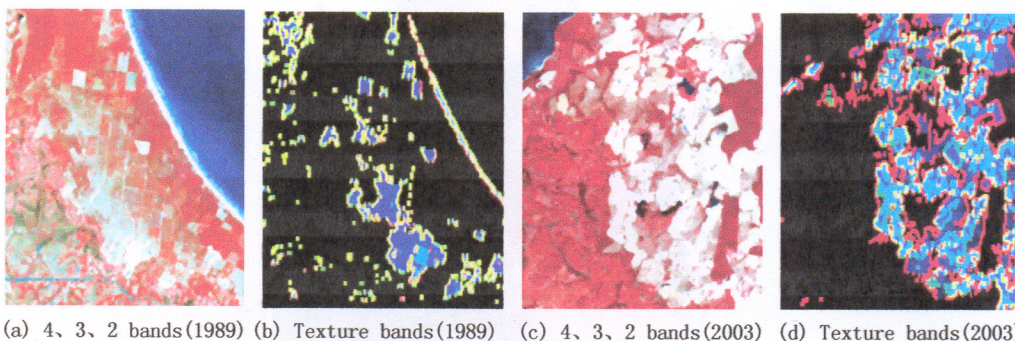


Fig.7. The comparison between combination of spectral bands and combination of Texture bands

4.3 Assessment of the classification accuracy

We used maximum likelihood classification to perform classify, the image dated 1989 will be divided into three classes: severe desertification, strong desertification and others(include beach sandlot), but the image dated 2003 will be divided into five classes: severe desertification, strong desertification, light desertification, potential desertification and others(include beach sandlot). Taking the land use map as reference, we selected 398 samples in 1989 image, including 279 training samples and 119 checking samples, and selected 521 samples in 2003 image, including 364 training

samples and 157 checking samples. The sample divergence degree was checked by Transformed Divergence(TD), after testing TD of different window size, we got the TD is perfect when the window size was 5×5 for 1989 image and 7×7 for 2003 image, their TD are all bigger than 1500(which is excellent), the TD result is showed in table 1. The classification precision matrix is showed in table 2, (a) is for 1989 image, we can see though the classification precision of severe desertification and strong desertification based on 7×7 window is higher than based on 5×5 window, the class "other" is lower, and as mentioned above, for 1989 image we emphasized the discrimination of beach sandlot and inland desertification, so we selected the classification result based on 5×5 window. Table 2(b) is for 2003 image, it is obvious the classification precision based on 7×7 window is higher than based on other windows. Fig.7 shows the classification result for the two images. Finally, according to the classification result, we got the overall desertification area was 1418.49km^2 in 1989, in which the severe desertification area was 475.2 km^2 , strong desertification was 1370.97km^2 , the overall desertification area was 2990.34km^2 in 2003, in which severe desertification area was 934.38km^2 , strong desertification area was 1232.91km^2 , light desertification area was 823.05km^2 , in addition, there existed 2276.52km^2 potential desertification land. Comparing with the statistical data gotten by land census of the two date, the error was respectively 7.6% and 5.3%.

Table.1. The matrix of Transformed Divergence for training sample

class	Severe	Strong	other
Severe	0	1880	2000
Strong	1880	0	2000
other	2000	2000	0

(a)

class	Severe	Strong	Light	Potential	other
Severe	0	1770	1980	2000	2000
Strong	1770	0	1830	1800	2000
Light	1980	1830	0	1887	2000
Potential	2000	1800	1887	0	0
other	2000	2000	2000	2000	0

(b)

Table.2. The matrix for classification accuracy

window	Sever	strong	other
3×3	88.17	87.32	91.75
5×5	88.86	88.24	94.73
7×7	89.73	90.86	92.69

(a)

window	severe	strong	light	potential	other
3×3	85.48	85.06	87.19	88.20	85.31
5×5	87.33	88.40	89.15	91.94	94.48
7×7	89.75	88.73	90.23	92.51	87.62

(b)

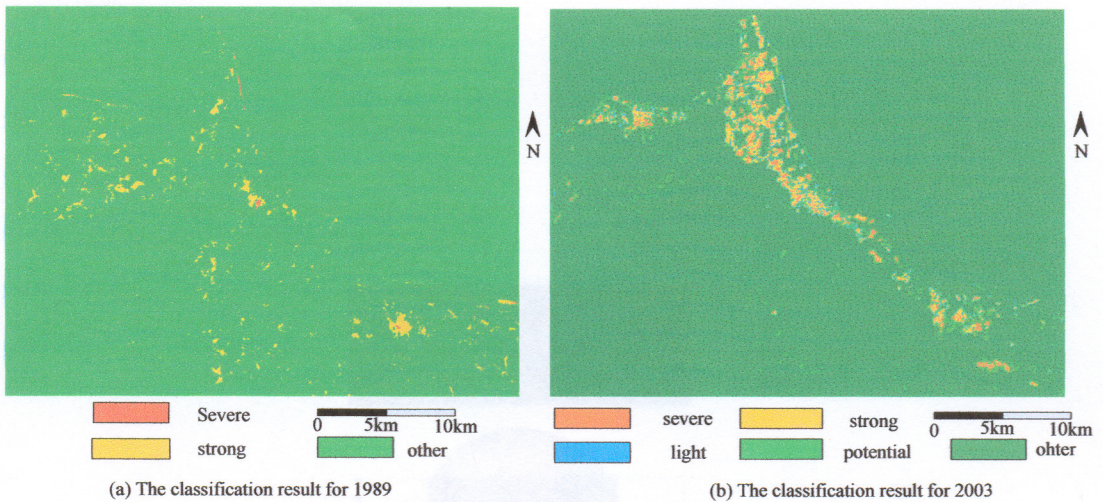


Fig.8. The Result of Classification

5. General discussion

This desertification monitoring method based on geostatistical texture this paper presented had two outstanding merits, one was it got rid of the disturbance of beach sandlot when calculating the desertification area, the second was it provided a feasible method used to grade the desertification, which provided a scientific reference for desertification management of the region. However, the precision has a room to improve, we imaged combination of desertification indicators and geostatistical texture could improve precision, which will be researched in the future, certainly, more research focuses are indispensable, the accumulation of research is a valid approach to improve desertification management of this region.

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INDICATORS USED FOR DESERTIFICATION MONITORING IN MONGOLIA

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Abstract

Desertification is becoming more serious issue in Mongolia due to global climate change and human induced factors. Many kinds of parameters have been used for desertification monitoring in Mongolia.

The specific objectives of this study were: a) to clarify which parameters are more suitable for desertification monitoring b) to develop an operational desertification monitoring method using these indicators c) to monitor changes of desertification indicators and their relationships d) to define areas which can be intensively affected by desertification

The study results show drought index, vegetation coverage and bare soil area, derived by AVHRR/NDVI data, can be successfully used as desertification indicators. Remote Sensing based parameters were independently examined with ground data. Monitoring of indicators shows drought is a leading factor of desertification in Mongolia and desertification has been significantly increased since 1993. Pasture carrying capacity was monitored as one of the indicators related to human induced factors. Carrying capacity assessment was done in both time and space scale.

Key words: Desertification, drought index, carrying capacity, desertification monitoring

1. Introduction

In recent years the intensity, area affected and frequency of droughts has increased significantly due to global climate change. Mongolia, a country located in the arid zone, is sensitive to climate changes. Drought is one of the natural leading factors of desertification. The inadequate use of land such as open-cast mining, overgrazing, logging adversely impact desertification. In Mongolia overgrazing is the main human induced factor. Since 1990 the number of livestock have been increased in relation to market demand for cashmere and wool.

Many indicators of meteorology, soil, vegetation and socio-economy have been used for desertification monitoring. In the of Mongolia meteorological and vegetation related indicators are more important and sensitive and therefore play important roles for desertification monitoring.

2. Data used and methodology

2.1 Source data

- NOAA/NDVI data for 1982-2003
- Monthly sum of precipitation and mean monthly temperature at 60 stations, for 1982-2003
- Yearly statistics of livestock for 1982-2002

2.2. Methodology

For this study were used the following drought indexes based on precipitation and temperature anomaly.

a. *Pedi Index (Pedi, 1978) - S_{it}*

$$S_{it} = \frac{\Delta T_{it}}{\sigma T_{it}} - \frac{\Delta R_{it}}{\sigma R_{it}}$$

where:

i - meteorological station index

τ - month

ΔT_{it} , ΔR_{it} , - monthly anomalies of temperature and precipitation

σT_{it} , σR_{it} - monthly standard deviation of temperature and precipitation

b. *Palmer Drought Severity Index-PDSI*

$$PDSI = \sum_{i=1}^t \frac{(P - \hat{P}) \cdot K}{(0.309t + 2.69)}$$

For a country, such as Mongolia, with large territory and sparse ground observation network remote sensing data are more suitable due to high temporal and space resolution to monitor drought which is more persistent affecting large continuous area. Therefore is used Remote Sensing based Drought Index-RSDI expressed as follow.

$$RSDI = \frac{NDVI_{\max} - NDVI_k}{NDVI_{\max} - NDVI_{\min}}$$

where, $NDVI_k$ – current NDVI value, $NDVI_{\max}$, $NDVI_{\min}$ - long term maximum and minimum value of NDVI.

For overgrazing assessment is used carrying capacity calculated by following expression.

$$CC = RSDI \cdot W \cdot \frac{\sum F_i \cdot S_i}{G \cdot D}$$

where:

CC – carrying capacity

RSDI - remote sensing based drought index

F_i – pasture yield, kg/hect

S_i – area with same yield

G – grass amount consumed by 1 sheep per 1 day, 1.7 kg at summer, 1.2 kg at winter

D – grazed days, in days

W - ratio of edible species to total species

The pasture yield was defined from pasture map by updating the long term average value of biomass measured at agrometeorological stations. Days grazed excluded days with unfavorable meteorological conditions such as heavy rainy, very hot, storm. Remote sensing data show total green mass, therefore W is used to exclude non-edible grasses from total fodder. The value of W varies between 0.27 - 0.41 increasing from north to south. Carrying capacity was calculated at Soum level depending on livestock statistic scale. Soum scale is acceptable to nomadic livestock and recent livestock management. Kinds of livestock were converted to sheep units using the following

criteria. Camel = 5.7 sheeps, cow= 6.0 sheeps, horse = 6.6 sheeps, goat = 1 sheep

3. Monitoring results

Drought monitoring

Drought monitoring was done using RSDI based on NDVI closely related to vegetation as indicator of vegetation stress. Mean value of RSDI and percentage of drought area affected to total area for 1982-2003 are shown in Fig.1. Drought affected area percentage in average 36%, decreases to 3% in 1993 and increases to 63% in 2002. In recent years, especially since 1998, the drought index value and affected area have increased significantly. Since 1999 the value of RSDI exceeded long term average value and more than half the area was affected by drought.

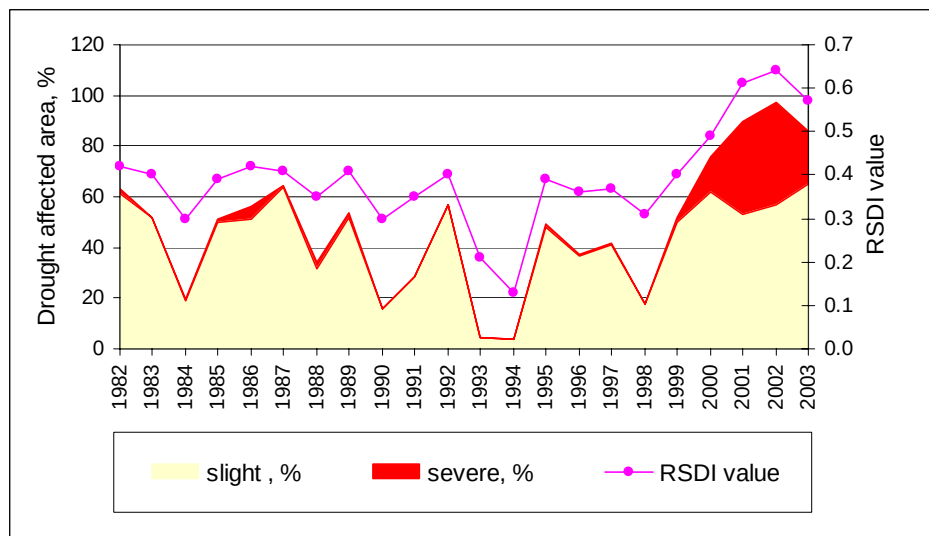


Figure 1. RSDI value and drought affected area percentage

Remote Sensing based Index –RSDI was examined by other Drought indexes based on meteorological parameters used in places with similar meteorological condition as Mongolia and calculated by meteorological data and such as PDI Index-Si which is used widely in Former Soviet Union countries and Palmer Drought Severity Index used in USA and Canada.

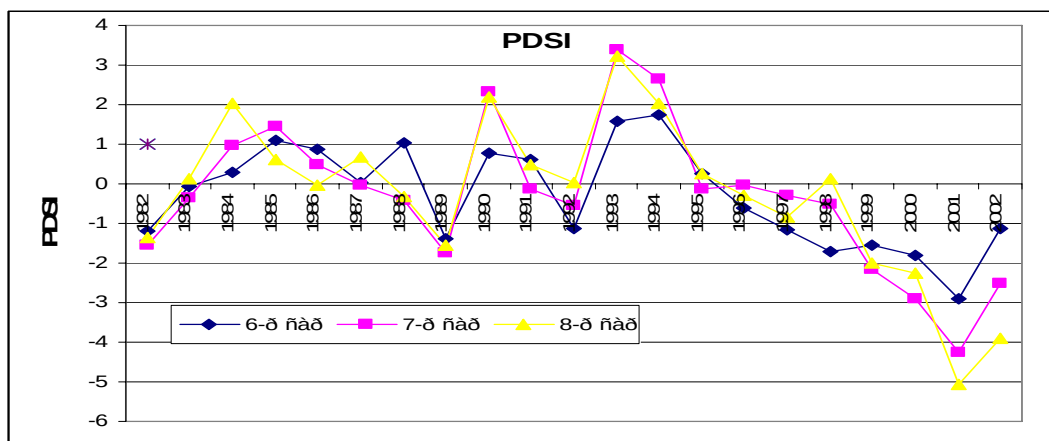


Figure 2. Palmer drought severity index(PDSI)

Correlation between Remote Sensing based and meteorological drought indexes were 0.49-0.88 with best correlation in steppe area and worst in mountain forest area.

Pasture monitoring

78% total land of Mongolia is grassland and there feed 25-32 million head of livestock. Therefore instead of vegetation is used pasture.

Bare soil area

The NDVI <0.06 was chosen as the threshold value of bare soil. Bare soil are size and distribution ranges in 3-25% depending on weather conditions.

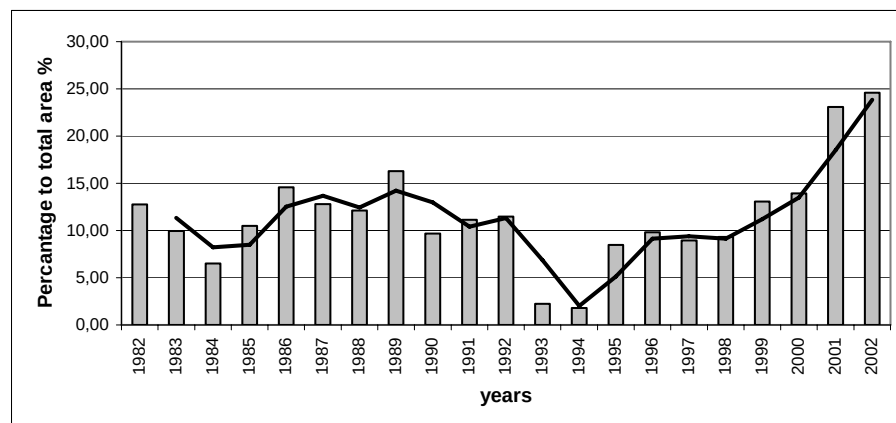


Figure 3. Bare soil area percentage

Distribution of bare soil area in case with best summer and the worst summer conditions is presented in fig.4 Bare soil area overlaps with light sandy soil and strong wind zone. Such scenery increases the risk of desertification.

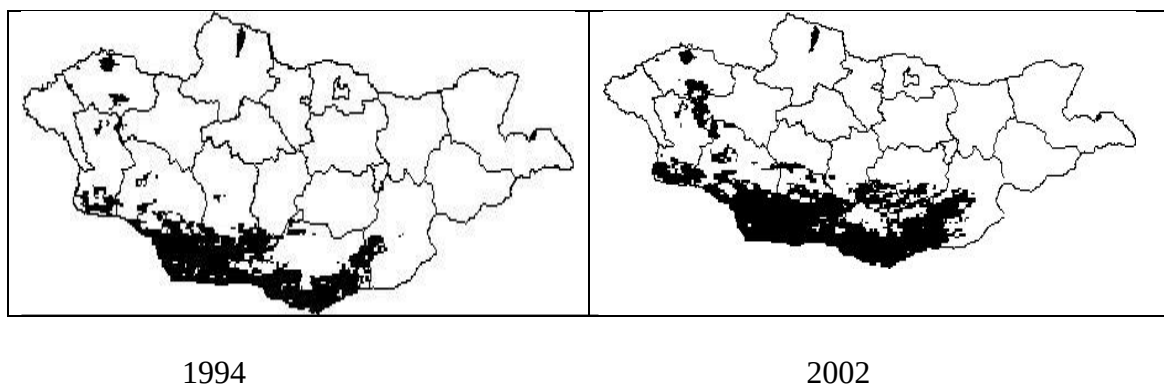


Figure 4 . Bare soil area distribution in drought(2002) and very wet(1994) years.

Vegetation coverage

Vegetation coverage was calculated by NDV data using the following expression founded by Dr. Purevdorj, 1999. Vegetation coverage in average is 26 %, but ranges from 16 in 2002 to 32% in 1994. There is clear tendency to decrease since 1994.

$$VC = -4.33 - 3.73 \cdot NDVI + 161 \cdot NDVI^2$$

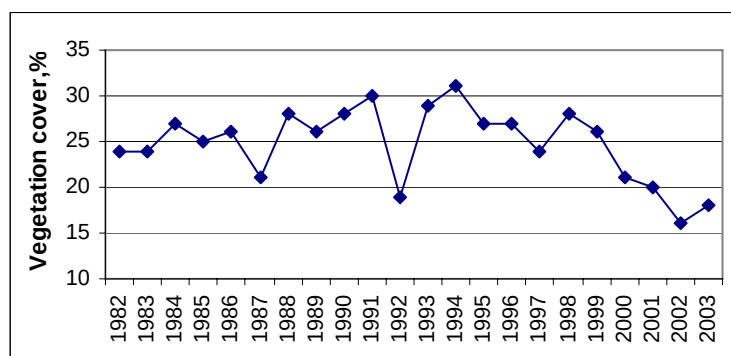


Figure 5 . Vegetation coverage changes, 1982-2003

Carrying capacity

Carrying capacity was expressed by number of livestock acceptable according to fodder resources mostly depending on meteorological condition through drought index. Overexceeding was calculated as ratio of acceptable number to real number of livestock. Value more than 100% means carrying capacity exceed.

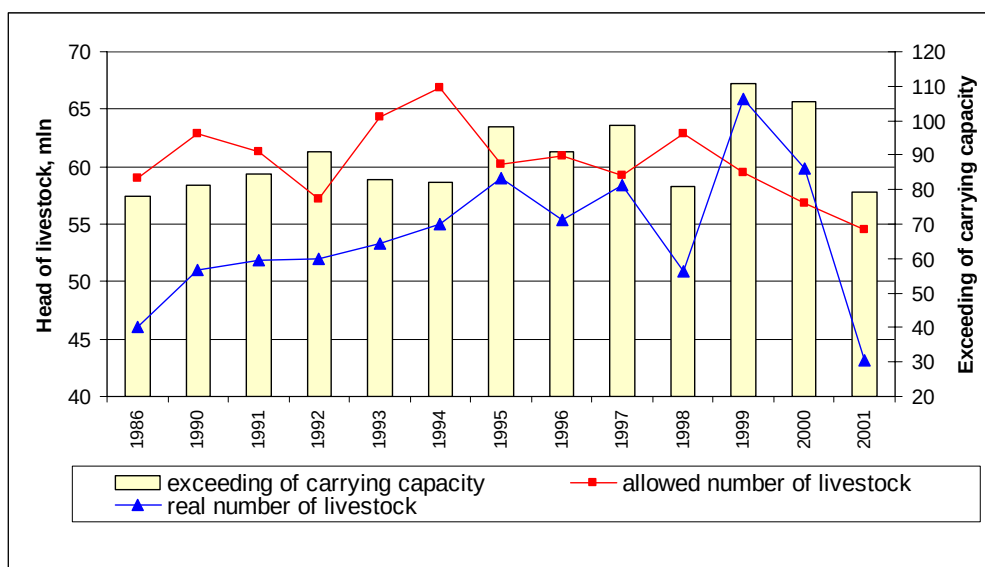


Figure 6 . Carrying capacity exceeding

The number of allowed livestock, the actual number and carrying capacity exceeding are shown in Fig.6. Since 1995 except 1998 allowed number of livestock has been decreased, but real number of livestock has increased. Carrying capacity is estimated at maximum on 67 mln, severe drought years it was decreased to 55 mln of sheeps. For 1986-1994 carrying capacity was approximately 89% not exceeding the allowed number, then increases significantly since 1995 due to increasing number of livestock and carrying capacity decreasing. Carrying capacity was exceeded in 1999, 2000 by 3-7 mln. In other years not exceeded in total, but number of Soums where carrying capacity exceeded was between 135-180 of total 329 sums, also exceeding of carrying capacity

is more stable more than 8 years of 13 years studied. Results shows that west and central regions have a limited fodder resources exceeding carrying capacity, other areas still have carrying capacity to be used.

Conclusions

Results of this study showed that desertification indicators such as bare soil, vegetation coverage and pasture carrying capacity can be defined and monitored using Remote Sensing data. In Mongolia drought is natural factor, overgrazing is main human induced factor for desertification. Therefore drought index and carrying capacity based was monitored using Remote Sensing data. Since 1995 drought intensity and area affected have been increased significantly causing pasture worsening. Overexceeding of carrying capacity exists many years in most of area.

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SESSION VI

***Reinforcing North-South, South-South cooperation on desertification B&I
taking into account the case studies presented***

NEEDS AND EXPERIENCES IN ACCESSING CAPACITY BUILDING PROGRAMMES IN ASIA

R ZHENG
UNCCD SECRETARIAT

The United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD) was a concrete outcome of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992; the Convention was adopted on 17 June 1994 and opened for signature in October the same year, after 11 rounds of arduous international negotiations, and came into force in 1996. To date 191 countries have ratified or acceded to the UNCCD.

The convention considers desertification as the land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. But desertification really highlights a global problem that affects more than a third of the Earth's landmass, it affects the means of subsistence of more than a billion people or one fifth of the world population in more than 100 countries worldwide. The economic losses resulting from this phenomenon are estimated at 42 billion dollars per year.

The text of the Convention identifies the causes of desertification as:

- Drought and climate change
- Population dynamics
- Poverty
- External constraints imposed by the Global Economy
- Urban bias

Looking at all factors in harmony and not in isolation. It takes into account not only physical factors, such as the soil content and climate - it also looks at cultural and political factors. The problem of migration caused by wars and floods.

I agree with the above analysis. However, we have to admit, desertification and all of these factors are mutually root causes as well as consequences. In another word, combating desertification without combating poverty, or eradicating poverty without putting desertification under control, the efforts will lead us to no where.

UNCCD is the only environment convention that has its implementation annexes.

Under the Convention, there are 5 Regional Annexes, namely:

I. Africa; II. Asia (and the Pacific); III. Latin America and Caribbean; IV. Northern Mediterranean; V. Central & Eastern Europe.

By now, each Annex has formed a Regional Action Programme (RAP); Each RAP contains a few priority activities in the region. Asia for example, has six Thematic Programme Networks (TPNs).

- TPN1 Desertification Monitoring and Assessment;
- TPN2 Agroforestry and soil conservation in arid, semi-arid and dry sub-humid areas.
- TPN3 rangeland management in arid areas including the fixation of shifting sand dunes.
- TPN4 water resource management for agriculture in arid, semi-arid and dry sub-humid areas.
- TPN5 strengthening capacities for drought impact mitigating and desertification combating.

- TPN6 assistance for development of integrated local area development programmes initiatives.

Note: similar CCD networks also exist in Africa and Latin America

TPN1 was launched in 1999; its objective is to monitor the dynamic changes of ground desertification or vegetation. So as to provide decision makers with updated and quantified data for wise solutions. The process is based on remote sensing technology; changes are monitored by comparing relevant satellite images from different time, over the same region. Local expertise is important for image interpretation. So far the Network has:

- Established TPN1 website and communication network with Asia member countries and interested international institutions;
- Asian countries conducted a workshop in 2000, co-sponsored by Japan, involving experts from Germany, Russia, USA; country delegates reviewed the existing institutional strength in the region, and discussed about future work programmes and timetable; the proceedings from this workshop collected reports from 24 countries on their national capacity and on going activities related to land degradation monitoring and assessment;
- Due to the shortage of funds, the initial draft of benchmarks and indicators (B&I) on desertification monitoring and mapping was developed by an ad hoc working group composed of Chinese, Japanese and Indian experts. Experts from FAO and an European company associated with ESA were involved in the process. The B&I was circulated via internet among all Asian member Parties, as well as interested non Asian institutions, such as FAO and GTZ, for comments. After nearly two years of exchange of views and debates through e-mails, TPN1 reached initial consensus on the B&I. A final review meeting was held in 2003, attended by Asian member countries and representatives from ACSAD, ESA, EU and UNCCD.
- Based on the B&I adopted, the Chinese Task Manager institute undertook the developing the Desertification Status Map for the entire Asia region at 1:2.5 million scale. The mapping was done by the Chinese host institute at their own expense, by using MODIS data received from their own ground station. The generous input of funds and human resources was greatly appreciated by the Asian TPN1 members.

The next steps will be (pending on availability of resources):

- Ground control wherever necessary; using local expertise or sending experts to the relevant sites;
- Compare with higher resolution maps for corrections, for limited crucial spots;
- Training for member countries that do not have the full capacity to do image interpretation and digitizing, etc.
- Assist all relevant countries to produce larger scale desertification status maps (1 : 1 million or 1 : 500,000)
- Conduct regular survey and mapping, to monitor the dynamic changes;

South-North Cooperation

- Technical cooperation in countries and subregions by implementing joint projects;
- Financial assistance to regional networks such as TPN1, through GM and Bonn Fun;
- Offering free satellite data to developing countries and potential technical support;
- Training course for technical staff in developing countries;
- Scholarships in the “south” countries;

- Participated and contributed in the benchmark and indicator formulation process;
- Japan is an important and active member of the TPN, and participated the activities through out the process;
- Experts from European Space Agency, Germany, Switzerland, USA, Russia and EC attended the activities at various stages;
- International and regional organizations such as FAO and ACIAD also offered their support.

South-South Cooperation

- African representatives for different subregional monitoring centers were invited to attend the launching of Asia TPN1. Scientists exchanged views and experience on monitoring methodology and the future early warning system for droughts;
- Asia Regional desertification monitoring and assessment networks (20 developing country members);
- Representatives of the African subregional centers attended the initial activity of TPN1;
- Training courses for technical staff in LDCs;
- Providing free desertification maps to LDCs while involving the local experts with image interpretations and ground data amendments;
- Workshops and seminars for awareness raising for the decision makers, which is essential to secure necessary human and financial resources in those countries.

Difficulties and bottlenecks

- Severe Shortage of financial resources; developed countries have little interest in providing substantive technical and financial support to the affected developing countries in their land degradation control activities;
- Many developing countries do not have adequate facilities and trained personnel; Decision makers have not yet been made aware of the importance of land degradation monitoring and assessment;
- Inter institutional coordination/cooperation is often a problem; information monopoly and competition for power are important obstacles for information sharing, and causing duplication of work, providing contradictory and confusing data to the world;
- Lack of commonly accepted benchmarks and indicators, as well as unified methodologies; TPN1 B&I is a significant step forward, yet to have the entire region using the same B&I and the same methodology, there is still a long way to go.
- For Western countries, data from many satellites are already freely available, but for most of the Asian countries, it is still very difficult to get adequate satellite data free of charge or at nominal costs;
- Certain rules and regulations in Europe and North America prevent or prohibit the competent agencies to offer desired assistance to the developing world;

Setback

Generous offer from ESA for assistance to Asian Parties (free EnviSat data and possible funding) once inspired the Asia Parties; the fact that ESA officers attended the meeting and discussion in Beijing, was very much appreciated by the TPN1 members. Unfortunately, the two sides failed to reach an agreement on future cooperation, due to a sudden change of policy that the contract could only be given to a company within a EU member country. In another word, the entire job would be done a European company,

while Asian countries are required to provide this company with all ground data for the mapping; in return, the Asian countries get their free maps.

Analysis

- In most of the Asian countries, ground data is a sensitive issue, clearance from the governments won't be easy;
- Many Asian countries have the capability of doing the job by themselves, with easier and cheaper interpretation and processing;
- Asian countries, based on their previous experience, are fed up by providing endless requests of all kinds of data, including non-essential items;
- High costs and slow outcome from European partners;
- Culturally, it is difficult for Europeans to understand why such a generous offer was refused; thus, further discussion became difficult;
- Likewise, it is difficult for the Asian to accept a "free lunch" which is given in a less equal manner.

Recommendations

More frequent dialogue between S/N partners is essential for the future cooperation. Mutual understanding and trust are the basic elements for a fruitful cooperation; LADA is a perfect platform for bringing together the regional initiatives, and lead the teams to the final objective of the Convention in establishing an efficient global monitoring system.

Note: This paper represents an intellectual and autonomous contribution of the Author and does not necessarily represent the official position of the UNCCD Secretariat.

CONCLUSIONS OF THE INTERNATIONAL SEMINAR

G. ENNE

Centro Interdipartimentale di Ateneo NRD – Nucleo Ricerca Desertificazione, Università di Sassari

The international seminar on “Local and Regional Desertification indicators and benchmarks” was held in Beijing from 16th to 18th May 2005 in the framework of the EU Accompanying Measure named AIDCCD – Active exchange of experience on indicators and development of perspectives in the context of UNCCD.

The seminar was attended by about 50 participants from the UNCCD Annexes among project members, experts, UNCCD Focal Points and representatives from international organisations, such as FAO and UNCCD. It is worth highlighting the participation of the scientific officer representative of the EU delegation in China, Prof. Jurgen Sanders, who attended the final session of the seminar and praised the results obtained; the scientific officer representative of the Italian Embassy in China, Prof. Roberto Coisson, also attended the seminar in its opening session.

Almost all participants presented their projects and experiences on desertification B&I researches enabling the understanding of the progress made, the techniques used and the common knowledge obtained in this field.

Several issues were highlighted by the participants during the six seminar sessions that deserve attention, and in particular:

About Benchmarks and Indicators

Benchmarks must be considered within the context of indicators and indicators are not relevant without benchmarks.

Benchmarks and Indicators often result in a list of important elements although not always characterised by their implementation; in this context:

- Socioeconomic indicators have to be checked not once in a decade (e.g. censuses), but in shorter time periods, such as every 2-3 years.
- Successful relevant experiences on B&I utilisation in pilot areas or in dynamic approaches for a better identification of B&I must be considered useful models to be promoted in larger areas (as is the case of Niger in the ROSELT programme) or improved with more socioeconomic indicators and adopted in sub-regional areas (as is the case of DIS4ME in the Mediterranean area);
- Connection problems between biophysical indicators and socioeconomic ones must be removed and solved;
- Traditional approaches on B&I must be progressively integrated with remote sensing approaches and, *vice versa*, remote sensing approaches must be completed with the utilisation of traditional approaches to better identify and describe desertification phenomena.
- A sustainable platform is required to ensure the function of developed indicators and monitoring systems after the end of the projects.

In order to understand and to consider the enormous complexity of desertification, traditional approaches based on thematic and sectorial analysis proved to be not adequate. It is essential to develop new approaches for the integrated evolution, based on the new perspective of complex systems. A pilot experience in this direction was presented during the seminar. A multi step integrated participatory procedure was elaborated and tested at the local scale in Argentina. This procedure starts from the prioritization of problems and objectives and from the selection of suitable indicators

for each of them. This is followed by the identification of impact and implementation hypotheses and the definition and implementation of concrete actions to set up Desertification Monitoring System (DMS) in the frame of NAPs. The indicators obtained this way can be derived, or shared, with the other Conventions, but must be aimed to the final users and to the decision makers of affected regions.

About people involved/stakeholders/decision makers/users

A large number of representative users must be consulted and involved since the beginning of the phase of definition of the approaches to identify benchmarks and indicators. This way, we can guarantee that this process is really able to identify, select and adopt the appropriate indicators.

About research

There is a urgent need for integrated research about the impact of climate change over desertification processes in arid and semi-arid lands taking into account the highly complex coupled physical and socioeconomic system.

About the data

Data availability is mostly limited by institutional constraints, but also by economic and technical factors (e.g. cost of soil data, too aggregated census data and too limited frequency); furthermore, the standardization of data is necessary in order to be able to speak the same language when talking about the same things.

Even successful experiences such as ROSELT still do not show evident strategy for generating national relevance of the networks.

Operational cost and technical requirements still make the utilisations of remote sensing data expensive. Many consolidated algorithms now exist for land degradation mapping and land use change monitoring, based on different sensors and approaches. Intercalibration and comparisons are necessary to make them exportable from Country to Country. Methods for validation and ground truth collections should be better defined. Procedures should be more objective.

About PRSP

Poverty Reduction Strategy Papers (PRSP) must be considered as a ToR for future studies or action on desertification but also for better focusing on the choice of the most adequate indicators and their benchmarks.

About climate change impact on desertification

Models for land sustainable development should be more dynamic to take into account climate change and climate change scenarios. Anyway, also socioeconomic systems are dynamic, even more than the climate ones and the capacity to predict them is very limited.

Synergies must be found among the Conventions and common indicators, although they will have different applications and use: most of the data needed are the same.

In this context, there is a urgent need of coherent measurement networks, associated facilities and skills, to have an homogeneous view of the processes at stake and to be able to predict evolutions of desertification under climate change both on benchmarks and indicators.

The study of evolution of desertification indicators (and benchmarks) under climate change conditions must address sensitivity, adaptive capacity and vulnerability.

Climate change could be mainly characterised at the proper scale by:

- Temperature evolution;
- Rainfall patterns evolution; extreme events occurrence (including wind);
- Intrinsic variability of these features.

Some direct impacts (e.g. glacier melting) have to be taken into account.

Defining sustainable development policies in arid and semi arid lands prone to desertification requires that the evolution of desertification indicators under climate change conditions could be evaluated qualitatively and, if possible, quantitatively. Policy makers must be made aware of these impacts on the indicators that they use.

About Rio-markers

To strengthen systemic analysis of ecosystem to provide a good basis for guiding the formulation of climate change mitigation policies and projects, conservation of biodiversity and combating desertification and adaptation strategies.

To reinforce harmonized methodologies for data collection in order to identify a core set of data common to the three Conventions in close relationship with existing data gathering mechanisms and systems.

To promote and/or strengthen integrated approaches combining both biophysical and socio-economic indicators.

About Cooperation

To develop tools and indicators in response to the need expressed by end users to better fit with reality.

To develop cooperation between annexes and to promote south-south research programmes.

It is necessary that NAPs in different Countries take into account not only local but also global issues. South-North but also South-South cooperation need to be implemented on equal terms.



**Active exchange of experience on
indicators and development of
perspectives in the context of UNCCD**



European Union

International Seminar on
Local & Regional Desertification Indicators in a Global Perspective
Beijing – China 16-18 May 2005

Conference venue:
Beijing Dong Jiao Min Xiang Hotel
No 23A, Dong Jiao Min Xiang, Dongcheng District, Beijing

16 MAY

Opening session

- 08.30 - Welcome address
- AIDCCD: its objectives and its expected results, by *Prof. Giuseppe Enne, AIDCCD Coordinator – NRD University of Sassari, Italy*
- Guidelines for an integrated approach of the desertification B&I and the Climate Change issues, by *Prof. Gerard Begni – MEDIAS France*

Session I: Integrated approach for the Development of Desertification B& I

Chairman: *Prof. Elena Abraham - Argentinean Institute for Drylands Investigation, Argentina*

- 09.00 Addressing the session topic in the AIDCCD perspective, by *Prof. Elena Abraham - Argentinean Institute for Drylands Investigation, Argentina*
09.20 Desertification monitoring and evaluation indicators in China, by *Dr Wu Jianwei China National Desertification Monitoring Center*
09.40 The experience of the TPN1 of Asia, by *Prof. Hongbo Ju - Chinese Academy of Forestry*
10.00 Desertification Indicator System for Mediterranean Europe (DIS4ME), by *Dr. Claudio Zucca - NRD University of Sassari, Italy*
10.20 **Coffee Break**
10.50 General Discussion with interventions max. 5 min.
12.30 **Lunch Break**

Session II: Integrated Approach for the Use of Desertification B& I

Chairman: *Dr. Youssef Brahimi - Sahara and Sahel Observatory, Tunisia*

- 14.00 Addressing the session topic in the AIDCCD perspective by *Dr. Youssef Brahimi - Sahara and Sahel Observatory, Tunisia*
14.20 Integrated approach for the use of desertification B&I: an example from Namibia, by *Prof. Mary Seely – Desert Research Foundation, Namibia*
14.40 Establishing a common set of Benchmarks and Indicators for desertification monitoring and evaluation: OSS and CILSS experience in Niger, by *Dr. Youssef Brahimi - Sahara and Sahel Observatory, Tunisia and Dr François Tapsoba - CILSS, Burkina Faso*
15.00 Indicator toolbox for the land degradation assessment in drylands project, by *Dr Clemencia Licona-Manzur - FAO*
15.20 **Coffee Break**
15.50 General Discussion with interventions max. 5 min.
17.40 End of Session II

17 MAY

Session III: Data gathering for the development of the reference B& I for monitoring and assessing desertification

Co-Chairman: *Dr Esshali Wafa - Sahara and Sahel Observatory, Tunisia and Prof. Sun Siheng - China National Desertification Monitoring Center*

Sub-session A: Traditional approach

- 08.30 Addressing the session topic in the AIDCCD perspective, by *Dr Esshali Wafa - Sahara and Sahel Observatory, Tunisia*
- 08.50 The ROSELT/OSS experience in data gathering from local to regional level, by *Dr Sandrine Jauffret - Sahara and Sahel Observatory, Tunisia*
- 09.10 Indicator systems on Desertification in Chile, by *Dr Wilfredo Alfaro - UNCCD National Focal Point for Chile*

Sub-session B: Remote Sensing

- 09.30 Addressing the session topic in the AIDCCD perspective, by *Prof. Sun Siheng - China National Desertification Monitoring Center*
- 09.50 Remote Sensing and geomatics strategies for desertification and land degradation monitoring assessment, by *Prof. Ulf Helldén - Lund University, Sweden*
- 10.10 Desertification indicators and status mapping in the context of satellite Remote Sensing: Indian experience, by *Dr. Ashutosh Arya - Space Applications Centre, India*
- 10.30 The Land Degradation Assessment in Drylands (LADA) project: Establishment of a baseline and monitoring system through use of remote sensing and traditional data gathering, by *Dr Clemencia Licona-Manzur - FAO*
- 10.50 **Coffee Break**
- 11.10 General Discussion with interventions max. 5 min.
- 13.00 **Lunch Break**

Session IV: Climate change impact on Desertification – what B&I should be used

Chairman: *Prof. Gerard Begni – MEDIAS France*

- 14.00 Addressing the session topic in the AIDCCD perspective, by *Prof. Gerard Begni – MEDIAS France*
- 14.20 Synergy between climate change and desertification, by *Dr Youba Sokona - Sahara and Sahel Observatory, Tunisia*
- 14.40 Climate change impact on desertification – Experiences of development of benchmarks and indicators in East Africa, by *Dr Jesse Nyoka – University of Nairobi, Kenya*
- 15.00 General Discussion with interventions max. 5 min.
- 16.00 **Coffee Break**

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Session V: Case studies of B&I operational monitoring initiatives at various scales

Chairman: *Dr. Patrick Klintenberg – Desert Research Foundation, Namibia*

- 08.30 Addressing the session topic in the AID-CCD perspective by *Dr. Patrick Klintenberg – Desert Research Foundation, Namibia*
- 08.50 Case studies of desertification monitoring. A discussion of EU initiatives, by *Prof. Ulf Helldén - Lund University, Sweden*
- 09.10 The Programme to combat desertification and mitigate the effects of droughts in South America, by *Dr. Gertjan Beekman - Coordinador Programa BID /IICA*
- 09.30 Desertification classification in Horqin area by using Remote Sensing technology, by *Prof. Wang Changyao - Institute of Remote Sensing Application, Chinese Academy of Sciences*
- 09.50 Indicators used for desertification monitoring in Mongolia, by *Dr Mijiddorj Bayasgalan - Ministry of Nature and Environment, Mongolia*
- 10.10 **Coffee Break**

Session VI: Reinforcing North-South, South-South cooperation on desertification B&I taking into account the case studies presented

Chairman: *Prof. Giuseppe Enne, AIDCCD Coordinator – NRD University of Sassari, Italy*

- 10.20 Needs and Experiences in accessing capacity building programmes in Asia, by *Dr. Rui Zheng – UNCCD Secretariat*
- 10.40 General and integrated discussion on the achievements of the Seminar sessions
- 13.00 **Lunch Break**
- 14.00 Conclusions, by *Prof. Giuseppe Enne, AIDCCD Coordinator – NRD University of Sassari, Italy*
- 15.00 End of the Seminar

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This volume contains the proceedings of the International Seminar on *Local and Regional Desertification Indicators in a Global Perspective* held in Beijing, China, in May 2005.

Aim of the seminar was to provide a precious opportunity to exchange information and experiences about the identification and use of desertification B&I among representatives of UNCCD Annexes, while contributing to strengthen linkages among them and exploring possible synergies.

The seminar was organised in the framework of the AIDCCD project (Active Exchange of Experiences on Indicators and Development of Perspective in the Context of UNCCD), aiming at developing and co-ordinating exchange of experience across the world among institutions involved in the implementation of the UNCCD regional Annexes.

AIDCCD is a project funded by the European Commission, Research Directorate-General under the Fifth Framework Programme (Natural Resources Management and Services).

The excellent support of Prof. Sun Siheng and his colleagues in the organisation and realisation of the seminar is gratefully acknowledged. The scientific and technical support of Dr. Chiara Zanolle, Dr. Claudio Zucca and Dr. Valeria Petrucci is also gratefully acknowledged.

These documents are also available on the project web site: www.nrd.uniss.it/sections/aid-cdd/