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Helldén, Ulf

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

CASE STUDIES OF DESERTIFICATION MONITORING. A DISCUSSION OF EU INITIATIVES

U. HELLDÉN

Department of Physical Geography and Ecosystems Analysis, GeoBiosphere Science Centre, Lund University, Solvegatan 12, S-223 62 Lund, Sweden

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, ARCHAEOEDEDES, 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 Maghreb 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.

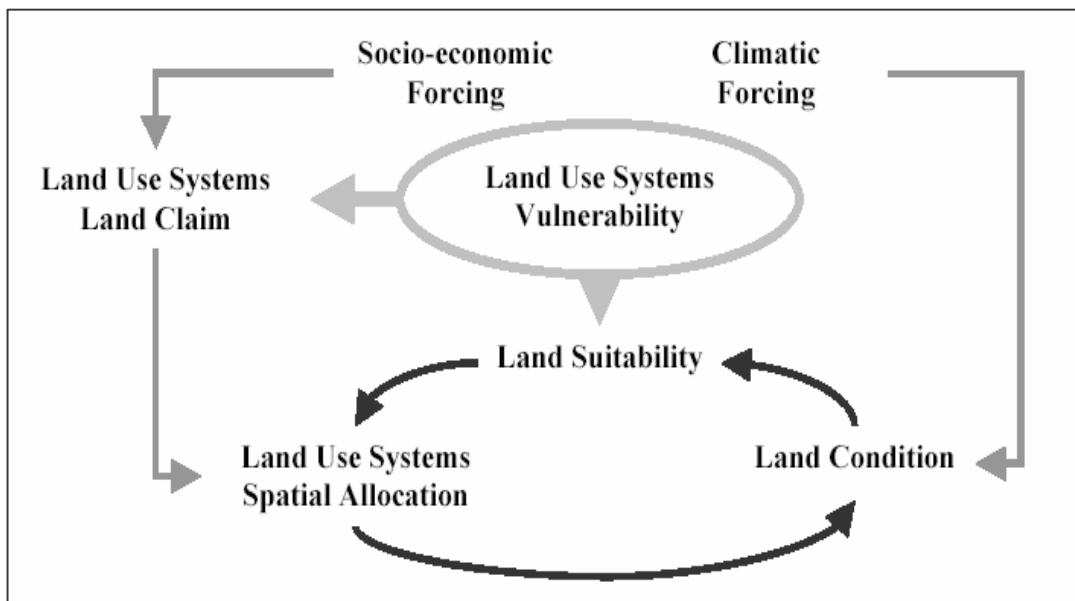


Fig. 1. Core relations in the DeSurvey Surveillance System for desertification assessment, monitoring and modelling.

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:

- (i) Coarse resolutions (~ 8 km or province-NUT equivalents) for preliminary surveys at the regional scale;
- (ii) standard resolutions (~ 1 km) for regional applications, and;
- (iii) 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:

- (i) development and parameterisation of models that evaluate land use and land degradation changes as well as vulnerability of land use systems to desertification;
- (ii) validation of the DeSurvey surveillance and assessment procedures, and;
- (iii) 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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ARCHAEOMEDES: Understanding anthropogenic causes of desertification and land degradation in the Mediterranean basin. <http://www.cranfield.ac.uk/sims/ecotech/projects/arch/archlinks.htm>

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>