

# **The Need for Systematic Monitoring and Assessment of Land Degradation/Desertification in the Sudan**

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## **Abstract**

Literature review of the studies of desertification monitoring and assessment in the Sudan shows a great deal of controversy. The first signs of serious land degradation were reported in 1944 using simple field observations. Sporadic studies of land degradation followed in 1950s and 1960s as a result of that report. Lamprey in 1975 reported his widely cited but controversial finding that the Sahara desert was marching southwards in Kordofan at the rate of 5.5 km/yr. This finding was contested by a team of Swedish scientists who used remote sensing techniques. US scientists using satellite data of 1980s and 1990s from NASA and NDVI data comparing the drought of 1984 of the Sudan with the wet season of 1985 derived from NOAA reported that the biomass fluctuated in response to annual rainfall, and that the Sahara desert was oscillating north and south depending on the annual rainfall, Kordofan and Darfur areas included.

Though the 1984 drought had triggered a recent process of desertification in the Sudan, there exist gaps in our knowledge on the process of desertification. The awareness towards the issue of desertification in the Sudan has been growing since 1970s, yet the impacts of desertification are felt by the day. Sudanese scientists undertook some small scale and sectoral work on desertification assessment in the late 1984 and 1990 in response to the drought incidents of the 1980s, and 1990s and to the requests of Agenda 21 and the UN Convention to Combat Desertification. The work done by English *et al.* (1997) was systematic and could provide a base and a starting point for continued monitoring and assessment of desertification in the Sudan

## **Introduction**

The Sudan is one of the wealthiest countries in Africa in terms of natural resources. With less than four per cent of the continent's population, it has seven per cent of the continent's cropland, 13 per cent of its pasture land, and ten per cent of its livestock population (WRI/UNEP/WB/UNDP, 1996). The Sudan was also known for its variety of wildlife. In 1980, the Sudan had ten per cent of the elephant population in Africa (de Jong-Boon, 1990). The depletion and pollution of the Sudan's limited water resources are awaiting crisis.

These resources are degrading very rapidly. A recent report (Abdel Ati, 2002) stated that 50.5% of the total area of the country was affected by desertification. The Sudan has been classified as 92% dry country, mostly dominated by hyper arid, arid and semi-arid

regions (UNSO/UNDP, 1997, Ayoub, 1998a). Such drylands are susceptible to desertification (UN, 1994, UNEP, 1997). The drylands of the Sudan are subjected to annual rainfall variability, recurring droughts and mounting human and livestock pressures. The current annual renewable water, other than the direct rainwater, available to the Sudan from all internal and external sources amount to about 30 billion m<sup>3</sup>. This amount may irrigate about 6 million feddans (2.5 million hectares), which is less than five per cent of the Sudan's arable land (de Jong-Boon, 1990).

The vegetation of the Sudan ranges from extremely scanty in the far north to short grass and sparse thorn scrub to open grassland plains dominated by gum Arabic producing *acacia*. The more humid part of the country contains a variety of vegetation types from savannah to broken woodland and tropical forests. Woody biomass comprised 71% of the energy supply in 1999 in the Sudan (Abdel Ati, 2002). This is equivalent to about 400 million *Acacia* trees being uprooted annually. Rangelands in the arid and semi-arid zones carry over 70% of Sudan's livestock. This is more than double their carrying capacity (Ayoub, 1998b). Range fires, mostly deliberately set by herders and honey collectors, consumed annually about 35% of the natural range productivity, estimated to be about 300 million tonnes (Atta El Mouta, 1985). Being dry and hot most of the year, livestock in the Sudan concentrates around boreholes and other water sources during the dry periods leading to vegetation denudation and soil pulverization by tramping (de Jong-Boon, 1990).

The bio-physical and socio-economic indicators of desertification in the Sudan can be monitored in the destruction of soil productivity, erosion of top soil, gullyng, dust storms, moving sand dunes, declining crop yields, loss of biodiversity, diminishing of surface water resources, localized areas of food insecurity, poverty, mal-nutrition, conflicts and mass migration. The situation has been aggravated by the devastating droughts of 1984 and 1990 which came after a long period of average or even above average rainfall conditions (Karrar, 2002). These droughts had triggered recent processes of desertification in the Sudan, which were difficult to comprehend. There is a need for better field measurements of desertification and its effect upon production. We need to do research to identify where desertification is happening, how it is happening and why it is occurring.

This paper is intended to highlight the importance of devising a conceptual framework for long-term systematic diagnostic and monitoring techniques for appraising the status and trends of desertification. Such work must be specified to guide policy and decision making at both local and national scales.

### **Examples of global and national attempts to assess desertification**

A look at previous and recently reported global and national assessments of desertification might give us some insight on the issue and how to approach it. Since the UN Conference on Desertification (UNCOD) in 1977, desertification has become

surrounded in uncertainty over its nature, extent, causes and effects, and even its very definition (Middleton, 1995). UNEP, FAO and UNESCO have collaborated on desertification issues since the mid 1970's. The first attempt to define and assess the severity of desertification was done by FAO/UNESCO/WMO (1977) in preparation for the UNCOD when the first world map of desertification was produced. The methodology was for the national governments to adopt a UNCOD requested member governments to adopt the methodology, and report on the status of desertification in their countries. Many believed that these estimates were not based on scientific data, and this led others to question the mere existence of desertification and called it a myth (Middleton, 1997).

In 1984, UNEP evaluated the implementation of the UNCOD's Plan of Action. To UNEP's dismay, no country was able to provide data on its desertification assessment (UNEP, 1984). A second attempt to assess the general status and trend of desertification was undertaken by UNEP and FAO in 1984 (FAO/UNEP, 1984). The third assessment of the world status of desertification was done by UNEP in preparation for the Rio Summit (UNEP, 1992). This was based on the Global Assessment of Human-Induced Soil Degradation (GLASOD) database, and the Soils and Terrain Digital Database (SOTER), which provided considerable information for the database of the 2<sup>nd</sup> edition of the World Atlas of Desertification (UNEP, 1997) was based on the GLASOD and SOTER databases, among others.

Agenda 21 (UN, 1993) and the UN Convention to Combat Desertification (UN, 1994) called for "Strengthening the knowledge base and developing information systems for regions prone to desertification and drought, including the economic and social aspects of these ecosystems". The World Bank (1995) jointly with FAO, UNDP and UNEP produced land quality indicators in response to these requests. The United States Environmental Protection Agency developed a strategic plan for the monitoring of arid ecosystems (EPA, 1991). Indicators for desertification monitoring were also developed for South Asia (UNEP, UNDP, and FAO, 1994), Latin America and the Caribbean (Winograd, 1994) and Kenya (1997). The new approach called by Agenda 21 and the CCD to assess and monitor desertification was to move from global assessment to national and local levels assessments. Integration of key social, economic and demographic factors with the full range of physical factors and indicators, as appropriate to the local conditions, is essential. Past assessments have focused on the global picture and the physical parameters; future assessments should be much more integrated and directed more to people issues and be linked from local to national levels. The purpose of this activity is, therefore, to put the priority assessment at the local level to be undertaken with the help of the local people.

The first serious sign of land degradation in the Sudan was reported by Kennedy-Cooke (1944) using simple field observations. It was reported that rapid deteriorations of soil and vegetation were occurring in parts of the Red Sea Hills and around town peripheries and settlement areas in Kordofan and Darfur. In the 1950s and 1960s, the Department of Land Use and Rural Development undertook sporadic studies of land use and resources degradation. In 1975, The National Council for Research and the Ministry of Agriculture with financial assistance from the UN and IUCN conducted an air and car field survey to

provide information on the most recent changes in the desert encroachment situation in northern Sudan (Lamprey, 1975). Lamprey reported his well-known study that the southern margin of the Sahara Desert in western Sudan was advancing at the rate of 5.5 km per year between the years 1958 and 1975. This study was not supported by enough scientific evidence (Middleton, 1997). Lamprey's conclusions were scrutinized by a team from the University of Lund, Sweden in co-operation with the University of Khartoum who carried out during the period 1981-85 a series of systematic studies under a project "Regional Studies of Desertification and its Control". The general goal was to develop, test and apply monitoring methods for the understanding and prediction of desertification (Hellden, 1988). Detailed studies combining air photograph analysis, satellite data, published records and field studies showed no progressive spread of desertification (Hellden, 1984, 1988) and Olsson (1983).

While such controversy was going on in the eastern part of the southern fringes of the Sahara, a team of German and African scientists working in western part of the southern fringes of the Sahara concluded that the desert advanced to the south over the period 1961-87 in the order of 10 km/year (Tolba and El-Kholy, 1992). Tucker *et al.* (1991), however, reported that the southern border of the Sahara desert was oscillating during the 1980s within a range of 130 km, and those oscillations depended on the annual rainfall.

Recent socio-economic changes such as the abolition of traditional land use systems in the early 1970s, and the provision of permanent drinking water and thereby eliminating seasonal grazing which was controlled by the seasonal fluctuations in the availability of drinking water have resulted in several indicators of plant cover degradation (Akhtar *et al.*, 1997). These have resulted in serious decline in important dry season grazing plants and marked increase in annual and often noxious grasses and herbs.

El Siddig and Hamad (2000) reported that the steady deterioration of the arid and semi-arid zones and the southern expansion of the desert call for an emergency tree restoration plan. Awouda (2000) reported that there was evidence of recent changes in the vegetation from a mesophytic type to a more xerophytic type.

### **Desertification risk monitoring and assessment**

Despite the seriousness of the environmental and socio-economic impacts of desertification and drought in the Sudan, few efforts have been made to devise diagnostic and monitoring techniques for appraising the status and trends of desertification. Different methods exist for evaluating desertification. Such methods include the use of direct observation and measurement, mathematical models and parametric equations, estimates, remote sensing, and indicators. The overall goal of the process is to: Provide an unbiased estimate with known confidence of the current and changing conditions of ecological resources in the Sudan. The specific objectives of desertification monitoring and assessment should be:

- To assess the current environmental and economic state;
- To determine trends over time;
- To detect detrimental changes in early stages to prevent irreversible damage;
- To identify causes in order to specify proper management actions.

Several questions are important to guide research in the monitoring and assessment processes. Some of these questions are:

- Are vegetation productivity and species composition changing due to natural or anthropogenic factors?
- What is the status and rate of change/replacement of native versus exotic species?
- Is soils fertility changing, and is soil erosion occurring in association with management?
- What are the status and what trends are being observed in surface and ground water quality and quantity?
- To what extent are fire incidents associated with weather, vegetation characteristics, and management practices, and what are their impacts?
- Are there dust transport, and shifting sand dunes?
- What are the distribution, migration, and abundance of wildlife?
- What is the condition of livestock?

Based on these questions a monitoring programme can be designed. This programme could include the following processes.

Regional and national planning can be performed more efficiently if accurate information about which areas are affected by desertification, where it is spreading, and which areas are at risk from desertification in the future is available. Maps which show such changes in desertification through time, and areas, can be produced through the use of satellite images and digital data and field indicators. Rubio *et al.* (1997) have emphasized the need for developing a system of desertification evaluation by using indicators.

With the increase in the complexity of human impacts on the process of desertification, we urgently need to improve our monitoring and assessment methodologies with a view to more efficient environmental management strategies. The importance of indigenous knowledge as a major source of important information, and as a framework for interpreting information, and as a way of solving some problems in the field can not be overemphasized. Developing remedial action plans to combat desertification must be at the grassroots level (UN, 1994).

The experience gained by the Europeans in desertification assessment, for example through MEDALUS project (UNEP, 1997) will be of much help to developing countries, the Sudan included.

Combining information on these and other factors could allow the prediction of sites vulnerable to the degradation menace. This is where a geographic information system (GIS) can play a role. There is no agreed methodology for making reasonably rapid

assessment and monitoring of desertification at national and local levels. Some relevant research data on desertification are available, but dispersed. Such data should be compiled, harmonized, stored, linked electronically and shared among institutions. The need for basic research as well as operational monitoring is obvious. Since desertification is defined as land degradation in arid, semi-arid and dry sub-humid zones (UN, 1994), aridity zonation of the Sudan is a prerequisite to any research in the area of desertification. According to the improved UNESCO arid land map (UNEP, 1992b), hyper-arid area is precipitation over potential evapo-transpiration (P/PET) < 0.05; arid area is 0.05-0.2; semi-arid area is 0.2-0.5; and dry sub-humid area is 0.5-0.65. Land falling within arid, semi-arid, dry sub-humid should be delineated according to the improved UNESCO arid land map (UNEP, 1992b). One way to improve the database is to collect quantitative data in pilot areas representative of major aridity zones throughout the country. It must be a long-term process. The pilot studies will provide on-going data for monitoring and assessment. Such pilot studies can be built into existing situations (on-going projects). Another possible approach is to establish a network of observation sites, located in critical desertification areas (hot spots), with a focus on monitoring changes in indicators. Monitoring pilot areas in major aridity zones might be combined with satellite imagery of high resolution to actually determine the extent of change in the pilot areas.

Much information is already in a form that can be used in a GIS, and more can be added continually – including that produced by Landsat. As the databases and prediction techniques improve, policy-makers and land management institutions will be better placed to combat desertification.

Monitoring and assessment must yield information on the functioning of the ecosystem as much as on the physical structure and composition of the ecosystem. Nutrient loss from the ecosystem through soil erosion, for example, is an indicative of an unhealthy ecosystem, unable to support itself and often leading to accelerated changes in ecosystem community composition and ecosystem dynamics (De Soyza *et al.*, 1997).

### **The first steps**

- 1) First define the magnitude and impact of desertification in different ecological zones by:
  - Appraisal of data needs and sources should be conducted;
  - Determining the criteria for identifying and assessing desertification and its causes;
  - Assessing the problem on the basis of the criteria and techniques adopted, particularly to determine what land uses lead to desertification and where.

The assembly and evaluation of information should be a continuous process providing a feedback mechanism for national planning and action. They should

indicate the relative seriousness of the situation for all the regions affected, with a view to establish priorities and degrees of urgency.

- Desertification indicators for different aridity zones (arid, semi-arid, and dry sub-humid) have to be formulated;
- The application of such indicators at local, province, state and national levels have to be recognized, and should be compatible at different scales;
- Desertification indicators must be specified to guide policy and decision making at the required scales;
- The indicators should be cost-effective and must be internationally agreeable. The broader objective is to build a strong global, regional and national coalition;
- The indicators should aim towards the establishment of decision-support tools that integrate biophysical and socioeconomic information requirements for undertaking sustainable land management;
- Indicators should cover all major natural resources, including soils, water and vegetation;
- Indicators should have standards and threshold limits;

The extensive Libyan and Nubian deserts are the source of sand in northern Sudan. Sand is being blown southwards on a broad front by the northerly winds. Mobile sand dunes pose major threats to the agricultural land, villages and other infrastructure in the southern edge of the Sahara desert and along the Nile from Kosti to the Sudan's northern frontier. The alluvial strip and depressions along the Nile is being steadily reduced by the encroachment of the drifting sand from the north and the east. Research work is needed to combat desert encroachment and stabilization of sand dunes. Akhtar *et al.* (1997) using multitemporal analyses of satellite images reported that dune systems stabilized from the late Pleistocene period have been reactivated, and as a result sands have alarmingly intruded into agricultural areas.

## **Conclusions**

English *et al.* (1997) using GIS and remote sensing have produced vegetation occurrence map for the period 1982-93 in the Sahelian zone of the Sudan between latitudes 10 and 18° N of the entire Sudanese territory. This work could provide a starting point for systematic monitoring and assessment of desertification in the Sudan. Any future work in this area could be based on this work.

## **References**

- 1) Abdel Ati, Hassan A., (2002). Sustainable Development in Sudan, Ten Years After Rio Summit: A Civil Society Perspective. Solo Publishers, Khartoum, Sudan.
- 2) Akhtar, Mariam, Mensching, H. G., and Domnik, E. (1994). Methods applied for recording desertification and their results from the Sahel region of the Republic of Sudan. *Desertification Bulletin* **25**: 40-47.
- 3) Akhtar, M. , Mensching, H. G. and Poertge, K. H. (1997). Effective techniques for monitoring and assessing desertification: in McGinty (ed.) International Symposium and Workshop on Combating Desertification: Connecting Science with Community Action, Tucson, Arizona, USA.
- 4) Atta El Moula, M.E., (1985). On the Problem of Resource Management in the Sudan. Environmental Monograph Series No. 4. Institute of Environmental Studies, University of Khartoum, Sudan.
- 5) Ayoub, Ali T., (1998a). Extent, severity and causative factors of land degradation in the Sudan, *Journal of Arid Environment*, **138**, 397-409.
- 6) Ayoub, Ali T. (1998b). Degradation of dryland ecosystems: Assessment and suggested action to combat it, *Advances in GeoEcology* 31, 457-463.
- 7) Awouda, Elhaj Makki (2000), Gum Arabic production and marketing. Paper presented at a Workshop on Management of Trees for Farmland Rehabilitation and Development, 27 October-7 November 2000, Khartoum, Sudan.
- 8) de Jong-Boon, Caroline, (1990). Environmental Problems in the Sudan, Part I, The Hague.
- 9) El Siddig, El Nour and Hamad Kamal (2000), Research and development programmes for rehabilitation of the clay plains of the Sudan. Paper presented at a Workshop on Management of Trees for Farmland Rehabilitation and Development, 27 October-7 November 2000, Khartoum, Sudan.
- 10) English, C. Richards, T. S., and Moheidin, Y. Elgenaid (1997). GIS and remote sensing applications to desert margin vegetation and land use monitoring in Sahelian Sudan: methodology, data integration problems, and solutions: in McGinty (ed.) International Symposium and Workshop on Combating Desertification: Connecting Science with Community Action, Tucson, Arizona, USA.
- 11) FAO/UNEP. (1984). *Map of Desertification Hazards: explanatory note*. Nairobi, Kenya: United Nations Environment Programme.
- 12) FAO/UNESCO/WMO (1977). World Map of Desertification, United Nations Conference on Desertification, Nairobi, Kenya.
- 13) Hellden, U. (1984). Drought impact monitoring- a remote sensing study of desertification in Kordofan, Sudan. *Rapporter ach Natiser* 61. Lund Universitetes Natugeografiska Institution.
- 14) Hellden, U., (1988). Desertification monitoring: is the desert encroaching? *Desertification Control Bulletin* 17: 8-12.
- 15) ISRIC, (1993). Global and national soils and terrain digital databases (SOTER). Procedures manual. ISRIC, Wageningen, The Netherlands.
- 16) Karrar, Gaafar, (2002). Long Term Plans for Drought Mitigation and Management in the Near East – A Policy Paper Prepared for the FAO Near East Regional Office, Cairo.

- 17) Kennedy-Cooke, B., (1944). Sudan Government Soil Conservation Committee's Report, McCorquodale & Co., Khartoum, Sudan.
- 18) Lamprey, H. F., (1975). Report on the desert encroachment reconnaissance in northern Sudan, October 21-November 10, 1975, National Council for Research, Ministry of Agriculture, Food and Resources, Khartoum.
- 19) Middleton, Nick, (1997). The Global Casino – An Introduction to Environmental Issues, Edward Arnold, London.
- 20) Olsson, L. (1983). Desertification or Climate? Investigation regarding the relationship between land degradation and climate in the central Sudan. Lund series in Geography, series A, 60, Lund.
- 21) Rozanov, Boris G. (1990). Global assessment of desertification: Status and methodologies. Proceedings of an Ad-Hoc Consultative Meeting on the Assessment of Desertification, UNEP, Nairobi.
- 22) Tolba, Mostafa K., and El-Kholy, Osama A. (1992). The World Environment 1972-1992: Two decades of challenge, Chapman and Hall, London, U.K.
- 23) Tucker, C.J., Dregne, H.E. and Newcombe, W.W. (1991). Expansion and contraction of the Sahara Desert from 1980 to 1990. *Science* 253: 299-301.
- 24) UNEP (1984). General Assessment of Progress in the Implementation of the Plan of Action to Combat Desertification 1978-84, Nairobi, Kenya.
- 25) UNEP, (1992 a). Status of Desertification and Implementation of the United Nations Plan of Action to Combat Desertification, Nairobi, Kenya.
- 26) UNEP, (1997). World Atlas of Desertification, 2<sup>nd</sup> edn, Edward Arnold, London, UK.
- 27) UNEP/GOK/RNG, (1997). National land degradation and mapping in Kenya, UN Office, Nairobi, Kenya.
- 28) UNEP/UNDP/FAO, (1994). Land degradation in South Asia: its severity causes and effects upon the people. World Soil Resources Report 78. FAO, Rome.
- 29) United Nations, (1978). United Nations Conference on Desertification 29 August-9 September 1977 in Nairobi, New York.
- 30) United Nations, (1993). Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992, Volume I Resolutions adopted by the Conference.
- 31) UN, (1994). United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, UNEP/IPA, Nairobi.
- 32) UNSO/UNDO, (1997). Aridity Zones and Dryland Populations: an assessment of population levels in the world's drylands with reference to Africa. Discussion Paper prepared by UNDP Office to Combat Desertification and Drought (UNSO), New York.
- 33) Winograd, M., (1994). Environmental indicators for Latin America and the Caribbean: towards land use sustainability. World Resources Institute, Washington, D.C.
- 34) World Bank, (1995). Land Quality Indicators, W B Discussion Paper # 315, Washington, D. C.
- 35) WRI/UNEP/WB/UNDP (1996). World Resources: a guide to the global environment, Oxford University Press, Oxford, U.K.

