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REPORT OF THE STAP EXPERT GROUP WORKSHOP ON LAND DEGRADATION

BOLOGNA, ITALY
14-16 JUNE 1999

(Prepared by the Scientific and Technical Advisory Panel)

Report of the
STAP Expert Group Workshop on
Land Degradation Interlinkages

Bologna, Italy
14-16 June, 1999

Prepared by
The Scientific and Technical Advisory Panel (STAP)
of the Global Environment Facility (GEF)

STAP Secretariat
United Nations Environment Programme

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PREFACE

It is a pleasure to present the report of the STAP Expert Group Workshop on Land Degradation. The report is the product of over six month's discussion and analysis, which culminated in an Expert Group Workshop convened at the University, Bologna, Italy from June 14-16, 1999.

The workshop brought together international experts in the areas of land degradation, climate change, biodiversity, international waters and social sciences, as well as representatives from the GEF Secretariat, the CCD Secretariat.

A number of background papers prepared at the request of STAP, the GEF and CCD Secretariat provided the basis for much of the findings and recommendations contained in the report.

STAP initiative on Land Degradation Interlinkages took place within the overall context of a planned timetable agreed to between STAP and the GEF Secretariat. The outputs of the various STAP initiatives were therefore fed into the preparation of the GEF/CCD policy paper.

The workshop report was prepared by a team consisting of Prof. Paola Rossi Pisa, Dr. Mark Griffith and Dr. Raffaele Vignola with input from the experts who attended the meeting.

Prof. Madhav Gadgil
STAP Chairman

EXECUTIVE SUMMARY

The report is the product of over six month's discussion and analysis, which culminated in an Expert Workshop on Land Degradation Interlinkages convened in Bologna, Italy from June 14-16, 1999. It drew especially on the expert papers prepared for the workshop and the ensuing discussions. The goal was to:

(i) *Seek to better define, from a scientific and a technical viewpoint, the linkages between Land Degradation and GEF focal areas of Climate Change, Biodiversity and International Waters.*

(ii) *To explore possible interventions to address Land Degradation as it relates to GEF focal areas and the potential for achieving global benefits.*

(iii) *The identification of gaps, where targeted research is necessary.*

Discussion highlighted the complexity of the interactions between socio-economic and biophysical processes of land degradation. Land degradation was identified as an outcome of land-use change, which in many situations degrades soil and water resources and reduces bioactivity of flora and fauna. Changes in land cover and vegetation status contribute to climatic change, alter biodiversity and modifies hydrologic cycles which feed back to further influence land-use systems. The complexity of the driving forces was analysed and summarized (Table 1). These include economic, social, cultural, environmental, institutional and policy driving forces at a range of scales.

Strong linkages between land degradation and the GEF focal areas were identified particularly international waters, climate change and biodiversity. There are also strong overlaps between GEF focal areas in relation to land degradation. Biodiversity, land and water issues are often strongly linked with land degradation being the driving factor for these linkages. There are also strong links between climatic change and land degradation, especially as storm and rainfall intensity increases.

It was concluded that there were multiple opportunities for GEF intervention, which should not only address effects, but also the root causes and drivers. These interventions should be evaluated in the broader context of their multi-benefit potential. To be effective, however, these interventions will require a "people-centred" rather than a "land centred" approach.

Intervention strategies were identified in six areas as they related to one or more GEF focal areas. The strategies were as follows: (Table 6)

- *Vegetation/forest management; revegetation; indigenous vegetation maintenance and management (production technology)*
- *Sustainable rangeland/grassland management (production technology)*
- *Integrated catchment/watershed management/sustainable land and water management*
- *Sustainable agricultural practices/management (conservation technology)*
- *Energy related strategies*
- *Establishment of transboundary mechanisms for management of shared resources*

Criteria for assessing globally significant issues in relation to focal areas were developed, but that component probably needs more work.

Finally, gaps in knowledge and understanding of the inter linkages between land degradation and the GEF focal areas were identified and a targeted research programme to meet those gaps outlined.

SECTION 1: INTRODUCTION AND BACKGROUND

1.1. Background

The First Participants Assembly of the Global Environment Facility (GEF), held in New Delhi, India, in April 1998, in its final statement, recommended that *"…. the GEF should seek to better define the linkages between land degradation, particularly desertification and deforestation and its focal areas, and to increase GEF support for land degradation activities as they relate to the GEF focal areas"*. To assist the GEF in meeting this requirement, the Scientific and Technical Advisory Panel (STAP) to the GEF, convened an Expert Group Workshop on Land Degradation Interlinkages in Bologna, Italy from June, 14 to 16 1999. The agenda of the meeting is presented in Annex I.

In preparation for the workshop and as a means of ensuring input from a wider scientific community, a Brainstorming Session on Land Degradation Interlinkages was convened on December 4th 1998 in collaboration with the Committee of Science and Technology (CST) of the Convention to Combat Desertification (CCD). The brainstorming session was convened as a side event of the COP 2/CCD held in Dakar from November 30 to December 10, 1998. At the recommendation of the Brainstorming Session, a technical planning meeting was convened at the University of Reading, United Kingdom, with a small number of experts attending an International Geosphere-Biosphere Programme (IGBP) session. The technical planning meeting was convened in order to get the experts input, in light of their on-going research on global change issues. An analytical framework for considering the interlinkages between land degradation and the GEF focal areas was suggested by the experts'.

The analytical framework suggested by the Reading Planning Meeting was critically reviewed by the experts commissioned to prepare the background documentation for workshop at a synthesis convened from 10-14 May, 1999 in Washington, D.C. Though modified, the analytical framework provided a useful basis for the approach adopted by the experts in the preparation of their background papers for the workshop.

The STAP initiatives on the theme on land degradation interlinkages, took place within the overall context of a planned timetable agreed to between STAP and the GEF Secretariat. The outputs of STAP's initiatives were therefore, fed into the preparation of the GEF Secretariat/CCD policy paper[1].

1.2. Participation

The meeting was attended by experts from various countries, two members of STAP, representatives from the GEF Secretariat, the Implementing Agencies, CCD Secretariat, the Italian Ministries of Environment and Foreign Affairs (DGAE, DGCS-IAO), ENEA, CNR and a number of Italian Universities including the host institution, University of Bologna (see Annex II for the list of participants).

[1] GEF, 1999. Defining the linkages between Land Degradation and the GEF Focal Areas: An Action Strategy for Developing GEF Support. GEF/C.13/4, December, 8-10, 1999

1.3. Official Opening

The meeting was officially opened at 9.00 a.m., on June 14th 1999, at the Faculty of Agriculture, University of Bologna by Professor Gualtiero Baraldi, Dean of the Faculty of Agriculture. The participants were welcomed by Prof. Paola Rossi, STAP Member, Chairperson of the STAP Ad-hoc Working Group on Land Degradation and Workshop Co-ordinator.

After thanking the Chancellor of the University of Bologna and the Dean of the Faculty of Agriculture, for allowing STAP to convene the meeting in the ancient building of the Palazzina della Viola, Prof. Rossi extended her gratitude to the Italian Overseas Institute of Agronomy in Florence (IAO) and other sponsors for the assistance they have given in support of the workshop. She expressed confidence that the participants would learn a great deal from each other in view of the commitment to solving the pressing questions posed by land degradation and its interaction with other resources such as biodiversity, water resources and soils etc. She also emphasised the need for the workshop to clearly define what is meant by land degradation in the GEF context; establish the nature of the interlinkages, both in quantitative and qualitative terms between it and the GEF focal areas, (climate change, biodiversity and international waters,) and to propose practical strategies and solutions to halt and reverse the negative trends of Land Degradation world-wide.

Mr. Ndegwa Ndiangui of the Convention to Combat Dersertification (CCD) Secretariat also addressed the meeting. He emphasised the convergence of interest between the work of the GEF and that of the CCD. In illustrating this point, specific reference was made to the GEF Instrument which states that *"agreed incremental costs of activities concerning land degradation..... shall be eligible for funding"*, the New Delhi Statement of the First GEF Assembly adopted in April 1998 which called for a better definition of the linkages between land degradation and the GEF focal areas and the disappointment expressed by the GEF Council at its Thirteenth meeting about the lack of projects addressing the cross-cutting theme of land degradation in the GEF work programme. Notwithstanding the convergence of interest, he lamented the fact that GEF portfolio for land degradation is still rather limited. He also underlined the importance of the workshop in helping to further clarify issues which could in turn result in more GEF eligible projects in the cross-cutting theme of land degradation.

1.4. Aims and Objectives

The aims and objectives of the meeting were outlined by the workshop co-ordinator as:

(i) To seek and to better define, from a scientific and a technical view point, the linkages between Land Degradation and GEF focal areas of Climate Change, Biodiversity and International Waters.

(ii) To explore possible interventions to address Land Degradation as it relates to GEF focal areas and the potential for achieving global benefits.

(iii) The identification of gaps, where targeted research is necessary.

1.5. Technical Background Presentations

1.5.1. Land Degradation and the GEF

Dr. Andrea Merla of the GEF Secretariat provided an overview of the evolving policy direction within the GEF Secretariat on land degradation as it relates to the GEF focal areas of biodiversity, climate change and international waters. He indicated that two main lines of actions for GEF intervention are being contemplated: (a) remediation and rehabilitation: through localized interventions. In this respect, the STAP initiative on Land Degradation Interlinkages should be of great assistance and (b) prevention, reversing land degradation trends by regional interventions.

The overall objective of GEF intervention on land degradation was summarised as two-fold:

a) to accrue global environmental benefits by protecting biodiversity and ecosystems, decreasing GHG emissions, and addressing causes of transboundary water degradation, and
b) to reverse land degradation trends in selected regions, due to conflicting uses of transboundary resources (i.e. water/energy/irrigation/wildlife), deforestation, overgrazing, wetland reclamation.

It was emphasised, that in order to achieve the GEF objectives, emphasis will need to be placed by GEF on multiple complementary projects in different GEF focal areas supported by commitment on the part of various stakeholders including governments. The meeting was also informed of the recently established Land Degradation Working Group within the GEF Secretariat, to focus on issues relating to land degradation as well as the initial thinking on the proposed Land and Water Initiative for Africa.

1.5.2. Technical Papers

To provide the conceptual framework for the workshop discussion a number of technical presentations[2] were made. Dr. Paola Rossi in her paper entitled *"Elements and Drivers of Land Degradation: Appreciation of the Range of Definitions"* reviewed the range of definitions found in the literature on land degradation with the view of clearly outlining a working definition for the purpose of the workshop; Dr. Exequiel Ezcurra and Dr. Gufu Oba explored the "*Interlinkages Between Land Degradation and Biodiversity"* with particular reference to Africa and Latin America; Dr. Christopher Gordon addressed the issues of *"Land Degradation Interlinkages and International Waters";* Dr. David Campbell addressed the issue of "*Land Degradation and Linkage to the GEF Focal Areas: Climate Change, Biodiversity and International Waters"* from a socio-economic perspective; Dr. Jean Palutikof addressed the issue of *"Land Degradation and Climate Change";* Prof. Simeon K. Imbamba provided an overview of the *"Land Degradation and Implications for the GEF Focal Areas"*[3]

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[2] Copies of these papers are available from the STAP Secretariat GEF Coordination Office, UNEP, Nairobi, Kenya
[3] Papers commissioned by the CCD Secretariat

and Dr. N Salleh dealt with the *"Socio-Economic and Environmental Impact of Land Degradation"*[4] .

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[4] Papers commissioned by the CCD Secretariat

SECTION 2: INTERLINKAGES BETWEEN LAND DEGRADATION AND THE GEF FOCAL AREAS

2.1. Defining the scope of Land degradation Interlinkages

In addressing the issue of land degradation interlinkages, the complexity of interactions between the socio-economic and bio-physical proceses of land degradation was highlighted early in the discussion. Land degradation was considered as an outcome of land-use change that negatively impacts soil and water resources, and reduces biodiversity of flora and fauna. As a consequence, focus was placed on human-induced land transformation that contributes to, and represents a response to, loss of biodiversity, degradation of soil and water resources, and changes in land cover. It was recognised that changes in land cover contribute to climate change, altered biodiversity, and affect the hydrological cycle, and that these interactions feedback to influence land-use systems.

As a working definition, land degradation was defined in its broadest sense *as any form of deterioration of the natural potential of land that affect ecosystem integrity either in terms of reducing its sustainable ecological productivity or in terms of its native biological richness and maintenance of resilience*.

It was also recognised that whereas it is necessary to take account of the interaction between natural processes and human interference in degrading land, it is also important to recognise both the natural reproduction of capability and of human artifice in assisting this reproduction. It was emphasised that land degradation should not be seen to be a linear process, but as a result of a number of forces. To illustrate this, the following equation [5,6] was highlighted.

$$NetD = (NatD + HD) - (NR + HI)$$

Where:

NetD = Net degradation
NatD = Natural degradation
HD = Human induced degradation
NR = Natural recovery
HI = Human improvement

2.2. Drivers of land cover change/land degradation

Land degradation should not be considered as a physical process *per se*, but as the result of two initial forcing factors, which may act together or singly. These are climate change, including short term climate variability and socio-economic factors which include social/cultural (e.g.

[5] This has been re-labelled from an equation first presented in Blaikie, P. and H. Brookfield, 1987. Land Degradation and Society, London, Routledge

[6] A good example of the variation of natural reproduction and its impact upon net degradation is provided by a comparative study of Hurni (1983) in which he compares the soil-loss tolerance in the mountains of Ethiopia and the hills of Northern Thailand. In the former case, cultivation has been going on for 2000 years with a fairly low rate of soil loss. However, the cumulative loss and slow rates of natural soil formation have both served to produce very serious land degradation. In Northern Thailand, however, with higher rates of soil loss, the local and land-management system has ‘compensated’ for this and the capability of the land, in which soil formation is more rapid than in Ethiopia is maintained.

demographic trends, ethnic heterogeneity), economic, political and institutional forces) (see Table 1).

In the case of the former, climatologists usually distinguish between climate change and variability. Climate change associated with a known external forcing, such as the variations in the Earth's orbital parameters leading to the onset of glaciations and interglacial periods and, currently, the increase in greenhouse gas emissions. Climate change is generally taken to involve a shift to a new set of climate parameters which will persist until another external forcing causes the climate to move into a new long-term stable state. Climate variability, on the other hand, is generally considered to be the result of internal fluctuations of the semi-stochastic earth-atmosphere system, and as such involves a shift to a short-term new state without the imposition of any external forcing. Equally, the transition back to the initial state can generally be achieved as part of the natural internal variability of the system. The best example of this kind of high-frequency variability is the El Nino-Southern Oscillation phenomenon (ENSO).

In the case of socio-economic factors, the interactions that combine to influence land managers' decisions and create land-use patterns are complex. They include political and institutional processes, economic forces, cultural, social and demographic patterns and trends, and indigenous knowledge of biophysical processes that inform decisions on resource management. Land-use changes, therefore represent, the outcome of decisions of land managers acting as individuals or members of groups or societies, regarding the use of available land-based resources - soil, water, vegetation. These decisions are based on the resources (land, labour and capital) available to the land manager, interpretation of the cultural and political/institutional context that facilitate or constrain land managers' options, expectations of climatic conditions, and assessment of economic opportunities.

The specific combination of interactions and their relative influence on land use differs from place to place depending on socio-economic circumstances and resource endowments, and will change over time as a consequence of variations in climate, economic and political factors, and technology. Political ecologists[7] have sought to structure this process by defining major categories of processes that contribute to land-use patterns, and examining the processes of interaction between categories that represent the drivers of land use and land-use change. The major categories that apply are Social/Cultural Forces that include demographic trends, Economic Forces, Political/Institutional Forces, and Environmental Conditions, and these are illustrated for semi-arid areas of Africa in Table 1.

The human-induced conversion of land was identified as a major factor contributing to land degradation with associated processes of loss of ecosystem integrity, biodiversity loss, and irreversible loss of ecosystem functioning. The main processes of ecosystem conversion were classified according to their intensity - or degree - of conversion - from complete removal of natural resources (land, vegetation, soil, wildlife, water) - (destruction) to substitution of resources by other resources (replacement) and partial substitution (modification) of resources uses by other resources uses (Figure 1).

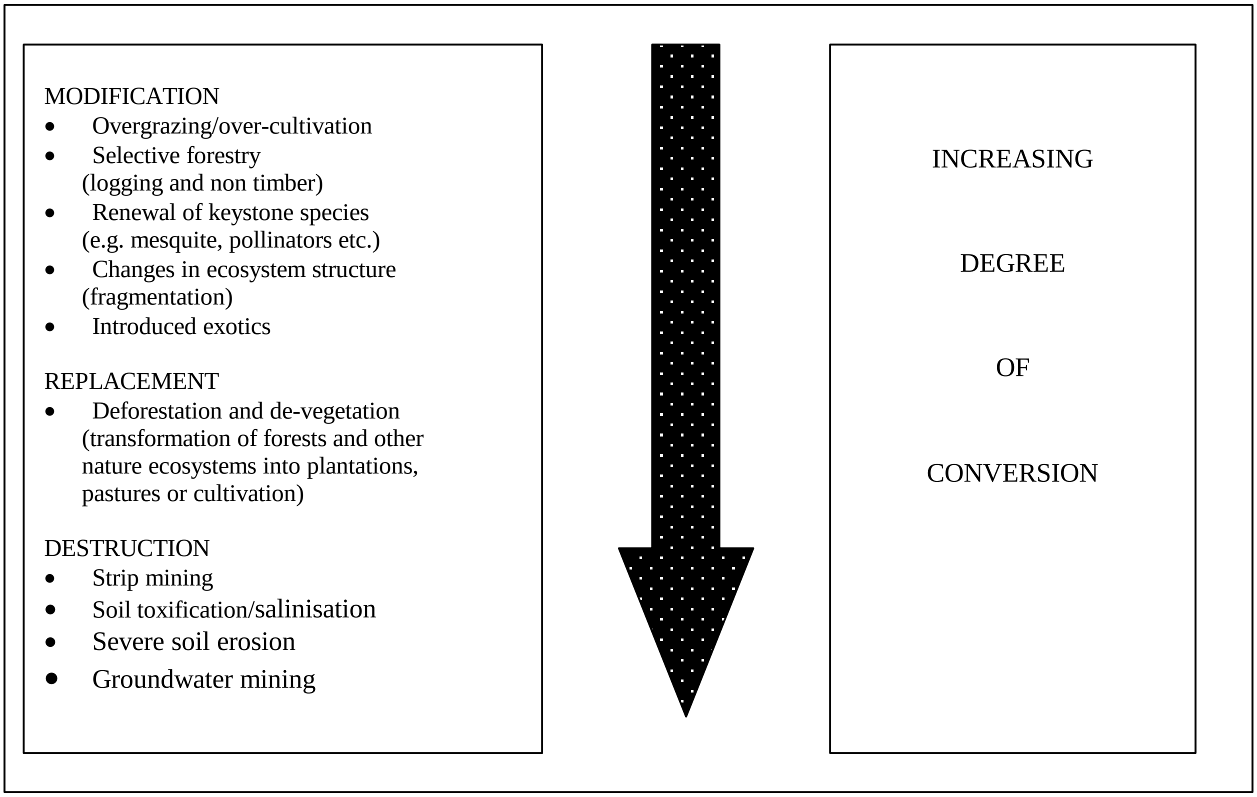
Interventions to address land degradation should therefore recognise the complex interactions impacting on land-use changes, which might be highly localised or extensive. The processes

[7] Two heuristic approaches, namely the Kite Framework (Campbell and Olson 1991) and the Chain of Explanation (Blackie, 1994) are addressed in greater detailed in the technical background paper by Campbell, 1994.

associated with these impacts may be local, proximate causes, which are often associated with root causes that may be distant in time and space from the effect.

Assessments of the interactions between societies and natural eco-systems need to carefully consider the characteristics of the communities involved and their linkages to the wider national context and to global economic and political systems. These characteristics and linkages are dynamic, and are neither unidirectional nor predictable.

Figure 1: Processes of Land-use Change / Land Degradation



2.3. Linkages between land degradation and the GEF focal areas

The linkages between land degradation and the GEF focal areas of international waters, climate change and biodiversity are significant. Figure 2 provides a systematic overview of the linkages between land cover change/land degradation and the GEF focal areas of international waters, climate change and biodiversity.

2.3.1. Land Degradation and International Waters

The watershed/catchment approach was considered to be the spatial scale best suited to addressing the interlinkages between land degradation and international waters[8] . Using this framework as a basis for analysis two related issues were highlighted (a) upstream and downstream effects (i.e. the view of water differs depending on where the user is located) and (b) source and sinks (i.e. a watershed can be viewed as a source i.e. inputs coming into the system which might have a negative or positive impact) or a sink (i.e. receives and accumulates upstream elements). Downstream sinks are characterised by high inputs and stresses and interventions are typically, remediative in nature, spatially focused, have high technological requirements and relatively high financial cost. Upstream sources are typically diffuse and can

[8] In the GEF context international waters is defined as "waters that include the oceans, large marine ecosystems, enclosed and semi-enclosed seas, estuaries as well as rivers, lakes groundwater systems and wetlands with transboundary drainage basins or common borders".

be addressed by preventive measures requiring relatively simple technologies and policy interventions.

Table 1. Examples of Drivers of Land-use Change in African Semi Arid Lands

ECONOMIC DRIVING FORCES

International

- Market Forces
- Trade Agreements
- Structural Adjustments

National

- *National Economic Policy* - agricultural pricing, transport, exchange rates
- *National Land-use Policy* – coherent land-use plan often lacking. Individual sectoral bureaucracies implement strategies in uncoordinated manner and with perhaps conflicting goals.
- *Land Tenure Policy* - Explicit and Perceptual

Land Tenure Laws

Customary Tenure: continuity and change - continuing national Land Ethos often based on ethnicity, roots in colonial land alienation and post-independence land acquisition by political class.

- *Dynamics of Primary Production* (dependent on soil and water resources)

Modified Subsistence –Dynamics of Cropping and Livestock Systems

SAP and economic liberalization

Exports: meat, vegetable, flower growing

- *Urbanization* - Urban demand for meat and vegetables encourages commercial production
- *Irrigation policy* - chemical pollution, salinization
- *Cash crops* - chemical pollution of water
- *Mineral production* - effluent, siltation

Local

- *Markets*
- *Herding* - diversifying to include agriculture, particularly at perennial water sites (fadama/bas fonds; swamp edges; streams; mountain slopes)
- *Rainfed agriculture* - immigration, intensification/

Extensification

- *Irrigated agriculture* - market demand, wholesalers
- *Economic differentiation* - options in land, labor and capital

INSTITUTIONAL/POLICY DRIVING FORCES

International

- International Conventions: Biodiversity, Climate Change, Desertification e.t.c.
- Bilateral and multilateral governmental and commercial interests; NGOs Warfare

National

- Centralization versus decentralization
- Uncoordinated policy framework - no land-use planning
- Land tenure policy
- Political and economic power: Intersecting interests of government policy, commercial institutions, NGOs, and individuals
- SAPs and Economic liberalization

Local

- Land tenure - communal versus individual rights to land, trees and water
- Social differentiation in land rights - gender, young/old, tenants and squatters
- Informal land claims: Tenants/renters/squatters claim land rights
- Local NGOs

SOCIAL CULTURAL DRIVING FORCES

National

- Urbanization
- Immigration
- Leadership - interference from "big men"

Local

- Population dynamics: growth, migration (gender and age specific), decline (AIDS) - intensification/extensification; maintenance of erosion control measures, cropping patterns, health and food security
- Diversification of herders into agriculture changes mobility and settlement patters. Altered vegetation complex and under reduced grazing pressure in rangelands; removal of riparian and swamp-edge vegetation for cultivation.
- Cultural change - leadership issues debated (age, gender)
- Violence in inter-ethnic conflict situations in all areas where heterogeneous populations - disruption of production, emigration
- Ethic heterogeneity - ethnic self-identification changing, particularly in farming areas
- Less trust in and recourse to traditional institutions. Disputes formerly settled by discussion; now more recourse to chiefs, police, courts and violence
- Redefinition of cultural and economic categories - e.g. herders become herder-farmers; farmers become farmer-herders.

ENVIRONMENTAL FACTORS

Rainfall

- Variability of Rainfall: long-term, inter-annual, seasonal, within growing season

Surface Water and Groundwater

- Swamp margins/ riparian zones/hillsides - occupied and crops vulnerable to damage by livestock and wildlife
- Water quality - chemical pollutions of water in irrigated areas - implications for the health of people, livestock and wildlife
- Water quantity - irrigation water in reduced supply
- Access to water more difficult for domestic use, agriculture, livestock and wildlife
- Change in hydrological cycle

Land Cover And Soils

- Vegetation - Dry savannah on

Soils :

Fertility decline- Evidence of land being taken out of production; enforced fallow Management - stall fed cattle - application of manure; chemical fertilizer

Soil Erosion - increased runoff, siltation, wind erosion, dust

- Woodland - change in species mix, change in spatial pattern - biodiversity of flora; potential for trees to replace grasses under less extensive grazing
- Habitat Depletion and Fragmentation - biodiversity of fauna

Source, After Campbell, 1999

In considering the interlinkages between land degradation and international waters, focus was placed on transboundary drainage basins, since many rivers, lakes and ground water basins fall under the jurisdiction of more than one country. Emphasis was also placed on "globally significant" impact; though difficulty was experienced in precisely determining what is "globally significant". Two major interlinkage paths were identified between land degradation and international waters: (i) The feed forward path which includes such processes as toxic/nutrient pollution, sediment loading, aquifer recharge and surface flow and (ii) feed back path which includes water quality, water flow and water table dynamics.

It was noted that the paths that operate in the feed forward direction are conceptually different from the paths that operate in the feed back direction. Table 2 gives a summary of the feed forward and feed back pathways as well as the mechanisms involved.

Table 2: Mechanisms of Linkage for Feed-forward/back paths

Feed Forward	**Feed Back**
Sediment Load Tillage Mining Poor irrigation/farming practice Change in Vegetation Cover Dredging Infrastructure	Regulation of Water Table • Extraction • Dams • River Diversion and channalisation • Infrastructure • Irrigation • Changes in infiltration
Surface Flow • Tillage • Water Extraction • Change in Vegetation Cover • Dredging	Regulation of Flow These mechanisms refer to the changes in the quantity of discharge, the rate of discharge and the flow regime • Dams • River Diversion and channalisation • Infrastructure • Extraction
Aquifer Recharge • Tillage • Changes in Vegetation cover • Dredging of rivers and lakes • Water extraction	Changes in Water Quality • Water Logging • Salinisation • Transport of Pollution (upstream/ Downstream)
Pollution (Toxics and Nutrients) • Agro-chemical Use • Mining • Animal Waster from intensive systems • Solid Waste • Industrial Waste • Dissolved and Particulate Organic Carbon • Major Natural Episodic Events (Landslides,Volcanoes,Hurricanes)	

The identified mechanisms can be used as entry/critical points where interventions could be usefully made by GEF.

Closely related to the pathways are the forces (i.e. drivers) which occur "outside" the systems which change the *status quo* at the catchment level. These drivers exert pressures which are internalised within the system as feedback loops. The drivers identified were physical climate change and short-term climatic variability on the one hand and socio-economic context of each given situation.

2.3.2. Land Degradation and Climate Change

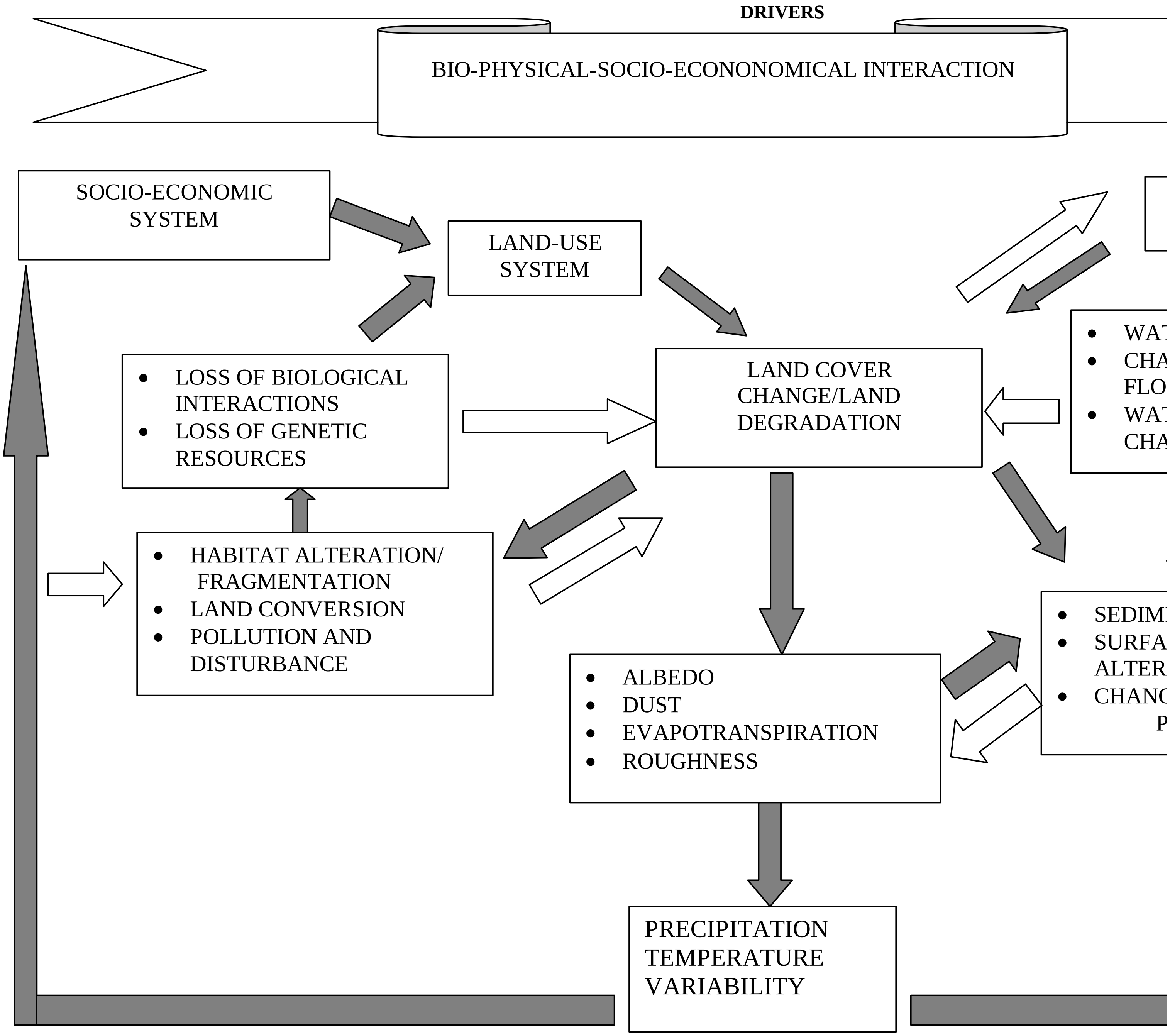
In the climate change focal area, interlinkages between land degradation and climate change were identified at the global, regional and local scales. At the global scale, emphasis centred on the implications of global climate change (i.e. enhanced greenhouse effect) for land-use systems and more particularly the direct effect on vegetation. In response to a warmer climate, migration of species towards higher latitudes and altitudes will occur in both hemispheres. Species composition and ecosystem functioning would also change in response to climate change and increasing concentrations of carbon dioxide. As a consequence, ecological stress is likely to result, which in turn will have implications for biodiversity.

The enhanced greenhouse effect is also expected to result in sea-level rise. Aquatic ecosystems such as mangrove swamps, coastal wetlands and coral reefs which are particularly sensitive to temperature variation are likely to be adversely affected. Water resources in the coastal zone will also be threatened by saline incursion. At its extreme, this groundwater contamination can cause salinization of the surface soils, with impacts for natural vegetation and for crops, especially where groundwater abstraction based irrigation is part of the agricultural economy.

The identification of the linkages between global climate and land degradation proved to be more problematic because of the weaknesses (see Table 3) in the current General Circulation Models (GCMs), the primary tools used by climatologist in climate studies. To be able to study those interlinkages with the greatest degree of precision, information would be required on the regional impacts of climate change, particularly as these affect the hydrological cycle. Presently this is not done accurately by GCMs.

Table 3: Weaknesses in Current Generation of GCMs in Relation To Land Degradation Studies

- GCM_s were not designed to accurately simulate climate at fine spatial scales (i.e. regional and local scales);
- climate variables (i.e. rainfall) of the greatest interest for land degradation studies, are poorly simulated at the regional scale by climate models; and
- the feedbacks between land degradation and climate change (due, for example, to changes in albedo) are not properly simulated by the current generation of climate models.


DRIVERS
BIO-PHYSICAL-SOCIO-ECONONOMICAL INTERACTION
SOCIO-ECONOMIC SYSTEM
LAND-USE SYSTEM
LOSS OF BIOLOGICAL INTERACTIONS
LOSS OF GENETIC RESOURCES
LAND COVER CHANGE/LAND DEGRADATION
HABITAT ALTERATION/ FRAGMENTATION
LAND CONVERSION
POLLUTION AND DISTURBANCE
ALBEDO
DUST
EVAPOTRANSPIRATION
ROUGHNESS
PRECIPITATION
TEMPERATURE
VARIABILITY

The principal manifestation of climate change impacts, especially as they relate to land cover changes are felt at the local level. On a closer examination of Figure 2, both negative and positive feed-backs can be identified in relation to climate systems. For example,

(i) Soil erosion may be enhanced by the actions of local climate change. Higher wind speeds would lead to wind erosion and, hence, higher concentrations of dust in the atmosphere. These dust aerosols act to reduce amounts of incoming solar radiation, therefore mitigating the effects of the greenhouse gases. This is an example of a negative feedback. However, the short residence time of these aerosols in the atmosphere limits their spatial distribution and hence their potential to affect the global climate system. In a second negative feedback loop, the dust aerosols can act as cloud condensation nuclei, thus leading to increased cloud cover and, possibly, higher rainfall. The resulting increased surface wetness would act to reduce wind erosion of the soil but would probably increase water erosion.

(ii) Changes in the vegetation cover will affect the surface roughness length. If trees are allowed or encouraged to grow in open grassland, for example, the climate becomes wetter and the surface becomes rougher. Surface wind speeds will decrease because of increased friction, which in turn will reduce evapotranspiration rates. This should lessen the drawdown on the soil moisture content, making more water available for plant growth. This is, therefore, a positive feedback; it will equally work in the reverse direction by transforming a wooded environment into an open grassland with a lower roughness length which, in turn, can lead to a reduction in soil moisture availability. Roughness length changes are also thought to affect rainfall amounts by altering the distribution of low-level convergence in the atmosphere, but this is likely to lead to increases in rainfall in some places and decreases in others.

2.3.3. Land degradation and biodiversity

In the biodiversity focal area, the general conclusion that emerged from the analysis of interlinkages between biodiversity and land degradation is that the feedbacks from biodiversity to land degradation are the subject of ongoing research, while feed-forwards are more well established. Table 4 gives a summary of the feed-forward and feedback pathways as well as the mechanisms involved.

In some cases, the relationships that link land degradation to biodiversity loss may be simple and straightforward, while in others, the linkages are more complex and less obvious. For example, in the simple and serious process of species extinction, habitat loss is recognized to be, in most cases, the main threat to extinction. Habitat loss, in turn, is often the direct consequence of land degradation.

At an ecological level, there are several processes involved in land degradation that ultimately result in loss of ecosystem integrity. This relationship directly connects land degradation through its inter-linkages with environmentally negative changes in atmospheric aerosols, CO_2 cycles, hydrologic cycles, geomorphologic processes, global climate variability and its influence on patterns of rainfall, and reduced capacity for carbon sequestration. All these in turn negatively affect species richness and biological diversity in general. Intricate linkages between the various processes may take place, each having an influence on others through negative and positive feedback.

In other cases, the inter-linkages are not so direct and not so simple to establish. For example, it has been demonstrated that grazing tends to maintain some grassland systems, while it is also known that fires tend to maintain some fire-adapted species and communities. In contrast, overgrazing or burning are also known to be major causes of land degradation and biodiversity loss. Thus, neither grazing nor fire can be cited as simple, linear interlinkage between land degradation and biodiversity, as the final outcome depends on the nature of the system and the intensity of the perturbation. In other cases, perturbations are natural processes that have been part of the native ecosystem for thousands of years, and have produced assemblages of disturbance-adapted species. In these disturbance-adapted systems, local extinction and a decline in biodiversity could result if management decisions disregard these natural perturbations —e.g., grazing and fire— that are a crucial element of ecosystem integrity.

Finally, land pollution arising from the incorporation of pesticides, agricultural chemicals, or industrial waste, usually has a direct effect on biological diversity, due to the fact that many of the native species of the original ecosystems cannot withstand the environmental pollutants. As in the case of habitat loss, accumulation of pollutants in the environment is also a major cause of species extinction, especially for animal species that feed high-up in the food chain.

Table 4: Mechanisms of Linkages for feed-forward/back paths

Feed-Forward	**Feed-Back**
Habitat loss • Deforestation • Erosion • Overgrazing • Silting of low-lands Ecosystem integrity • Ecological services • Resilience to change • Species interactions • Complexity of food chains • Positive species interactions Pollution and disturbance • Agro-chemicals • Industrial waste • Fertilizer leaching • Changes in frequency of natural disturbances	Loss of biological interactions • Increased land degradation through loss of positive biological interactions, such as pollinators, nurse plants, symbionts • Increased weeds through extinction of native competititors Loss of genetic resources • Loss of native crops results in more intensive agriculture • Loss of native fauna results in introduced species with capacity to overgraze • Loss of genetic diversity in the wild increases inbreeding and weakens wild populations • Loss of soil biota leads to reduced capacity for carbon sequestration

SECTION 3: INTERVENTIONS: OPPORTUNITIES FOR ACHIEVING GLOBAL BENEFITS

3.1. Identifying opportunities: Some Issues for consideration

3.1.1. People Centred Approach

The consideration of the interlinkages between land-use change/land degradation and the GEF focal areas logically led to the identification of opportunities for intervention. It was concluded however, that such interventions should not only focus on redressing the effects, such as soil erosion, vegetation destruction, and water pollution, but also the root causes - the drivers of land degradation. These reside in local land-use systems and in the interactions with the wider socio-economic system. To be effective, interventions require a “people-centred” rather than a “land-centred” approach. This implies a participatory approach that engages local communities in the definition of issues and in the design, implementation and evaluation of remediation policies, while taking into consideration that communities are not homogenous.

Though the interventions outlined in Table 6 are primarily “land-centred”, the assumption is that in implementing any of the interventions, the socio-economic drivers, outlined in Table 1, as an example, will be an integral part of that process.

3.1.2. Multi-Benefit Approach

Another conclusion which emerged from the discussion is that interventions aimed at land degradation remediation should be evaluated in the broader context of the multi-benefit potential of such interventions. As a consequence, a strong case was made for an approach which seeks to integrate benefits accruing from climate change, biodiversity and international waters, thus offering greater opportunities for GEF interventions, particularly in dryland ecosystems. The major interventions identified by the workshop and the global benefits resulting from those actions are summarized in Table 6. Though it was recognized that the interventions outlined in the Table 6 would yield domestic benefits, considerable global benefits would also result with implications for climate change, international waters and biodiversity.

3.1.2.1. Criteria for assessing global significance of biological diversity in drylands

In assessing the opportunities for achieving global benefits, the issue of what constitutes “globally significant biodiversity” in drylands and the criteria for assessing it was raised. It was concluded that the criteria that is often used for assessing biodiversity significance in forest ecosystem are not necessarily applicable to dryland ecosystems. To assist the GEF in determining “global significance” of proposed biodiversity land degradation projects, the workshop identified a number of questions which could be used as criteria for assessing “globally significant” biodiversity in drylands. These are outlined in Table 5.

Table 5: Suggested Criteria for Assessing Globally Significant Biodiversity in Drylands

a) Genetic Significance: Is the species or system of great genetic significance?
- Genetic values of dryland species (all cereal species in the world, most livestock species, many forage species); potential to exploit the genetic ability of dryland species to survive climate variability (stress genes) in the face of predicted variability due to climate change; value of indigenous knowledge/cultural practices in drylands for sustainable cropping and livestock management; carbon storage ability of dryland species and systems

b) Ecological Services: Does the species or system under study provide critical ecological goods and services either now or in the future?
- Note the importance of further defining critical: it could include services that support much larger areas (watershed protection, wetlands/riparian areas in drylands) or support globally important processes (carbon sequestration, dust reduction); or services that are transboundary or international
- Corridors that support migrants; wetlands/swamps in drylands, watersheds that flow into important, closed international water systems (Lake Victoria), systems that sequester significant amounts of carbon, mountain systems that protect important water sheds; species ability to stabilise soil and reduce distant effects of aquatic sedimentation and atmospheric dust

c) Unique Livelihoods: Does the system support especially sustainable livelihoods?
- some complex agricultural systems (chinampas in Mexico), hunter-gatherer societies (Sahel, Mexico), pastoral systems/ pastoral & wildlife systems

d) Unique Biota: Is the species or system rare on a global basis?
- High endemism in deserts and other drylands: fynbos in southern Africa, East African wildlife migration systems, endemic species of restricted distribution; insular drylands in the tropics of Latin America an Asia; cloud forests in drylands (Mt. Marsabit); Andean drylands

e) Representativity: Is the system particularly representative of wider areas?
- Sahelian transhumance systems

f) Ecosystems integrity: Does the existence of ecosystem integrity in one system support another system?
- Atlas mountains; Sahel and sub-humid system of transhumance

3.1.2.2. Carbon sequestration

Carbon sequestration featured prominently in the discussion on land degradation/climate interlinkages. A number of issues were identified which should be considered when designing interventions aimed at sequestering carbon. Though the issues raised have universal relevance, particular emphasis was placed on dryland ecosystems. These issues are summarised as follows:

(i) Proper baseline setting

Carbon sequestration in dry lands should be considered from a comprehensive perspective and not on a simplistic economic cost-benefit analysis, rather than on the basis of $10/per ton of carbon equivalent that has been used for short-term measures for climate change mitigation activities. While it is essential to establish an agreeable baseline for undertaking carbon sequestration activities in dry lands, a cost-benefit analysis which simply calculates the amount of carbon per hectare of land area or a unit cost, does not take into account other relevant economic factors as well as social and environmental aspects associated with carbon sequestration activities.

The economic analysis should not be an exclusive prevailing criteria and other relevant socio-economic and environmental factors should also be part of the criteria, to be developed and used on an equal footing, for carbon sequestration in drylands. The low economic opportunity cost of dry lands, low labour cost, income generation and mitigation of pressure for migration from rural to urban areas are some of these factors.

(ii) Grow and harvest approach

In the consideration of interventions aimed a sequestering CO_2, initial emphasis is likely to be placed on dry and waste land rehabilitation and afforestation of suitable lands in a "grow-and-store" approach (in which trees are not harvested when they reach maturity). Emphasis should also be placed on the "growth-and-harvest" approach and/or the "perpetual-rotation" approach where local populations grow trees and vegetation, harvest them for their use, as well as earn income from the sale of timber, pulpwoods and fuel woods to meet their livelihood needs. This approach would also be suitable for agroforestry projects in dryland areas as possible investment, with carbon sequestration benefits and other socio-eocnomic and environmental benefits.

(iii) Verification methodologies

In "afforestation and reforestation" interventions, one tends to emphasise plantation of tall trees, particularly in tropical and temperate forests. Carbon sequestration, particularly in the process of preventing desertification and restoring degraded dry lands needs to be seen from multifaceted dimensions, and proper methodologies need to be developed for these purposes. For instance, significant amelioration of agricultural practices will help enhance carbon storage above and underground. Soil improvement combined with water catchment and creation of small-scale reservoirs and irrigation systems will incur concomitant carbon storage in waters and their basins.

3.1.3. Intervention Strategies

3.1.3.1. Vegetation/forest management/re-vegetation

Vegetation/forest management strategies provide a range of agro-forestry intervention options that have the potential for securing multiple benefits in climate change, biodiversity and international waters at the ecosystem, catchment level and the biome levels. Research[9] has shown that in the Peruvian Amazon, primary forest ecosystems have sequestered 250 tonnes of carbon per hectare. In contrast, crops and pastures sequester 60 tonnes. But 10-year-old agroforests have sequestered 160 tonnes of carbon per hectare, or two thirds the amount of primary forest.

Tree-based systems also have the potential to maintain the beneficial methane 'sink' that is characteristic of natural forest systems, preventing this greenhouse gas from escaping into the atmosphere. Complex agroforests act as sinks to methane produced from other adjacent agricultural systems such as paddy rice, cattle grazing and fire itself. A combination of different land uses including a mosaic of agro-forests can also have climate change benefits.

[9] Sanchez P. 1999. Capping Greenhouse Gas Emissions Only a Partial Solution to Slow Down Global Warming ; International Centre for Research in Agroforestry; Nairobi, Kenya

Replenishing soil fertility in sub-humid and semi-arid degraded lands also plays a vital role in reducing carbon emissions. One study[10] estimates that as much as 66 tonnes of carbon per hectare can be sequestered in Africa over a 20-year period by replenishing soils through a combination of agro-forestry options and nutrient re-capitalization. Improvement of soil fertility not only results in improvement in CO_2 storage in the soil but also result in better water-holding capacity in the soil. This means that the water balance will be influenced and there will be fewer run-offs and less sediment transportation to the transboundary water bodies and aquatic and marine ecosystems.

Measures to rehabilitate degraded lands are compatible with those aimed at promoting the sequestration carbon in plants and soils in the context of mitigating greenhouse gases effects. With careful planning, measures to rehabilitate degraded lands can not only restore soil resilience and fertility, but also reduce climate change pressure and benefit the local inhabitants and the ecosystem. While there is a need to promote revegetation efforts in a cost-effective manner, such analysis should be undertaken from a holistic viewpoint, encompassing environmental dimensions, socio-economic and cultural conditions, and not from the perspective which merely calculates the cost of short-term investment vis-a-vis the amount of carbon to be sequestered.

Sustainable forest management strategies also result in biodiversity and international waters benefits. In the case of biodiversity, conservation of forests and/or regeneration are beneficial for habitat protection and this, in turn, support biodiversity. The increased water-holding capacity of soils associated with such interventions also results in multiple benefits to international waters; it reduces the impacts of extreme events such as flooding, reduces the potential for sediment transport, and it secures significant benefits to aquatic and marine ecosystems.

3.1.4. Sustainable Rangeland/Grassland/Dryland Management

Sustainable Rangeland/Grassland/Dryland Management can have multiple benefits for both the environment and the people who occupy those areas. Rangelands (grassland, shrubland, savannahs, hot and cold deserts and tundra) occupy 51% of the terrestrial land surface, contain 36% of the world's total carbon in above and below-ground biomass and include a large number of economically important species and ecotypes[11]. According to current estimates[12], the drylands of the world harbour 240 billion tonnes of organic carbon in their soil and vegetation, thereby constituting a large potential source of emissions into the atmosphere. Alternatively, they have considerable potential for sequestering carbon.

In addition to the climate change benefits, these ecosystems are also important for biodiversity in terms of the genetic significance, the ecological services they provide, the unique biota, their particularly high levels of endemism and rarity and the unique livelihoods they sustain. For example, the drylands of Mesoamerica and the Pacific Andes have been an extraordinary source

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[10] Op Cit

[11] STAP, 1996. Report of the Scientific and Technical Advisory Panel of the GEF Expert Group Workshop on Land Degradation, Dakar, Senegal, 18-20 September, 1996

[12] Watson, R.T., A. Dixon, S. P. Hamburg, A. C. Janetos and R. H. Moss, 1998, Protecting Our Planet Securing Our Future, Linkages Among Global Environmental Issues and Human Needs. United Nations Environment Programme, U.S. National Aeronautics and Space Administration and the World Bank

of cultivated plants. In the Pacific Andes, an important centre of origin of crop diversity in the American drylands, early expedition recorded a list of over 2000 species described as important sources of raw materials[13]. Like the Fertile Crescent, drylands play a very important role in maintaining the indigenous races of crops useful for the gene pools for new varieties. The destruction of these centres of diffusion would be a significant global-loss.

Significant international waters benefits can also be derived from the sustainable management of rangelands since they usually occupy headwater areas. The degradation has impacts on flow regimes, sediment transport and water quality of rivers, many of which are transboundary in nature. Rangelands, are often at the crossroads of integrated watershed management in arid climate, and as a consequence, have implications for aquifer recharge and downstream impacts.

3.1.5. Integrated Catchment/Watershed Management

The fact that many of the international waters are by definition shared by several countries and that management needs to be carried out at both the micro and macro levels indicate that interventions need to consider issues of spatial and temporal scales[14]. Since many of the shared water resources are under enormous stress, interventions in multi-country basins, need to be a cognisant of the upstream and downstream rights and responsibilities in river basin management, as this has implications for land degradation and impacts on water. This should be reflected in comprehensive land and water treaties between riparian states.

The use of catchment or basin approach as the analytical framework within which to address shared water basin could result in significant multi-benefits. Such an analytical framework could facilitate the integration of water management goals of countries sharing a resource with physical, social and economic planning, including agricultural management; habitat protection; sustainable use of biodiversity and the protection and sustainable utilisation of aquatic and marine ecosystems. Climate change benefits could also result from integrated watershed management. Most of the climate change benefits discussed under the various intervention strategies are also relevant to integrated watershed/catchment management. Intimately associated with the watershed management approach is the need to develop appropriate institutional and policy mechanism to facilitate a more rational and sustainable approach to the management of shared water resources.

3.1.6. Sustainable Agricultural Practices/Management

Agriculture contributes significantly to anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (NO_2). Agriculture accounts for about 20% of the annual increase in radiate forcing. Land-use changes related to agriculture especially in the tropics,

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[13] Goodspeed, T. H. Plant hunters in the Andes. University of California Press, Bekeley. 378 pp

[14] As an example, river for vie or more countries forming part of international water-basin includes Danube covering 12 with a basin area 817,000 Km^2;Niger covering 10 with a basin area 2.200,000 Km^2; Nile covering 9 with a basin area 3,030,700 Km^2 ;Congo covering 9 with a basin area 3,720,000 Km^2; Rhine covering 8 with a basin area 168,757 Km^2; Zambezi covering 8 with a basin area 1,419,960 Km^2; Amazon covering 7 with a basin area 5,870,000 Km^2; Mekong covering 6 with a basin area 786,000 Km^2; Chad covering 6 with a basin area 1,910,000 Km^2 ; Volta covering 6 with a basin area 379,000 Km^2; Ganges – Brahmaputra covering 5 with a basin area 1,600,400 Km^2; Elbe covering 5 with a basin area 144,500 Km^2; La Plata covering 5 with a basin area 3,200,000 Km^2.

including biomass burning and soil degradation are major contributors[15]. Biomass burning and loss of soil associated with the conversion of natural ecosystems to agricultural use in the tropics is believed to be the largest non-fossil fuel of CO_2 input to the atmosphere. Sustainable agricultural practices/management has the potential of mitigating CO_2 emissions through the reduction of emissions from present sources (i.e., storages in managed forests) and the creation and strengthening of carbon sinks.

In addition to climate change benefits, sustainable agriculture practices/management provide a wide range of non-food goods and services relating to the global environment including, but not limited to, pollution control, water resources, erosion control, biodiversity enhancement, ecosystem integrity (control on soil biodiversity ensures the resilience of the ecosystems) and improved population stabilisation (preventing migration that in other area can cause serious environmental disaster).

The potential of sustainable agriculture in producing multi-benefits is demonstrated by the Multi Functional Character of Agriculture and Land[16] (MFCAL) project of the FAO, in which 130 case studies were analysed to identify the environmental, social and economic services and goods produced by sustainable agriculture and rural development. The results indicate that in more than 60% of the cases, soil fertility, productivity and nutrients management have improved bringing clear benefits in the focal areas of international water and bio-diversity. In more than 50% of the cases, the ecosystem presented an improved resilience; around 65 cases showed an improvement in air, soil and water quality. In implementing sustainable agricultural options, it is important to consider the political-economic context in which the intervention is done. There is also a need to carefully consider the interface between local economic development and global environmental concerns if the goal of sustainabilty is to be reached.

3.1.7. Energy Related Strategies

A number of energy supply options were considered including improvement of efficiency of wood burning stoves, biomass production as a substitute for fossil fuels; the use of renewable energy technologies such as solar and wind power. Particular emphasis was however placed on biomass, because of its importance as an energy source in many developing countries. Annual consumption of biomass varies between 47EJ[17] to 55EJ[18], and is used primarily for cooking and heating in developing countries. While traditional biomass technologies tend to be very

[15] IPCC, Climate Change 1995: Impacts, Adaptation and Mitigation of Climate Change: Scientific Technical Analyses Contribution of Working Group 2 to the Second Assessment Report of the IPCC, SPCC, Cambridge University Press, 1995

[16] According to MFCAL database, the most important key-factors for the setting up of an effective sustainable agriculture and rural development are: exchange of information and experience (70% of the cases); strengthening of adaptive and applied research at pilot sites (more than 60% of the 130 case-studies); applied science and technology development (more than 60% of the 130 case-studies); mechanism to increase people participation (almost 60% of the cases)

[17] WEC, 1994: New Renewable Energy Resources - A Guide to the Future. Kogan Press, London, U.K., 391 pp.

[18] Hall, D.O., F. Rossillo-Calle, R.H. Williams and J. Woods, 1993: Biomass for energy: Supply prospects. In: Renewable Energy: Sources for Fuel and Electricity [Johansson, T.B., H. Kelly, A.K.N. Reddy, and R.H. Williams (eds.)]. Island Press, Washington, D.C., 593-652 pp.

polluting[19], many modernized biomass energy technologies are characterized by lower levels of air pollution than fossil fuels[20] .

Often the biomass grown on a fixed amount of land will serve multiple purposes simultaneously. However, the species selected and their growth rates, the prospective use of the biomass, the time horizon of interest, and the prior use of the site, acting together in complex ways, will determine the impact on the carbon cycle.

Large potential local benefits can be achieved with perpetual-rotation of biomass growth strategies without diminishing and often greatly enhancing climate-change benefits if the produced biomass can be sold profitably in energy markets. Use of biomass for energy would tend to be favored from both local and global perspectives over sequestration strategies (both grow-and-store and perpetual-rotation variants): *(i)* when the energy alternatives are based on coal and if advanced modern biomass energy conversion technologies are available; *(ii)* in areas where climatic and soil conditions are such as to make feasible high biomass yields; and *(iii)* where a long-term perspective is taken in considering climate-change benefits.

Growing biomass to sequester carbon (either a grow-and-store or a perpetual-rotation variant) would tend to be preferred over growing biomass for energy in areas where: *(i)* the high yields needed for profitable bioenergy applications are unachievable; *(ii)* harvesting costs are too high to make bioenergy strategies attractive (e.g., on steep hills); *(iii)* sites are remote from potential biomass energy markets; or *(iv)* conserved forests are deemed desirable for economic reasons, for preservation of wildlife sanctuaries, for biological diversity conservation, for watershed preservation, and/or for other environmental reasons[21].

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[19] Biomass cookstoves pose substantial risks to users for indoor air pollution generated

[20] For more detailed discussion on Biomass Energy see STAP, 1996. The Outlook for Renewable Energy Technologies, Strategic Considerations Relating to the GEF portfolio, and Priorities for Targeted Research, UNEP/STAP/GEF

[21] STAP Brainstorming on Carbon Sequestration: Final Report on STAP Working Group on Climate and Energy, 19 October, 1998

3.1.8. Establishment of Transboundary Mechanisms for the Management of Shared Resources

In situations where the resources and/or ecosystems - be it a river basin, underground aquifer or a forest ecosystem - are shared by more than one country, a strong case was made for the establishment of transboundary mechanisms to facilitate joint management. Such an approach is deemed necessary as it provides a framework within which the combined benefits of biodiversity, climate change and international waters can be realized.

Table 6: Intervention Strategies and their Implications for the Global Environment

INTERVENTION STRATEGIES	TYPE OF INTERVENTION (ACTIVITIES)	GLOBAL BENEFITS	
		BIODIVERSITY	**CLIMATE CHANGE**
Energy Related Strategies	• Improvements of efficiency of woodburning stoves/fuel substitution • Biomass production as a substitute for fossil fuels • Solar as an alternative to biomass consumption • Other locally appropriate measures i.e. wind power	• Enhancement of biodiversity conservation areas	• Carbon sink enhancement/reduction o GHG emissions. • Reduction of GHG emissions
Vegetation/Forest Management; Revegetation; Indigenous Vegetation Maintenance and Management (production technology)	• Agro forestry initiatives • Rehabilitation/revegetation of degraded lands • Protection of riparian forest and ecosystems • Protection/conservation of indigenous species	• Provision of ecological services - pollination, maintenance of soil fertility cycling of carbon and other nutrients • conservation of biodiversity, genetic diversity etc • conserve/protection of gene pool • Increase resilience of ecosystem to environmental stresses • Improvement of ecosystem functioning following maintenance of biodiversity	• Agroforestry types offer potential for carbon sink enhancement • Reduction of GHG emissions to atmosphere • Carbon sink enhanceme

Sustainable Agricultural Practices/Management including agro-biodiversity strategies (Conservation technology)	• Adopt erosion control measures e.g. terraces, law impact clearing techniques etc. • Improve tillage methods • Diversified rotation with forage crops • Improve the complexity (genetic, species etc) of agro-ecosystems • Use of Integrated Pest Management (IPM) technology Utilization of diversified practices including those associated with traditional systems (polyculture, old management methods in Central Ghana, S.E. Asia)	• Enhancement of below and above ground biodiversity • Improvement in soil fertility • Improvement in genetically diverse crops • Protection of important centres of domestication of plants and crop diversity • Enhancement of ecosystem integrity	• Maintenance of soil organic carbon (soil) • reduction of GHG emissions to the atmosphere • agricultural sink management • increase storage in soil
Sustainable Rangeland/grassland management (production technology)	• Mixed wildlife/pastoral systems • Rotational grazing • Rehabilitation of degraded areas • Reseeding using suitable/Indigenous perennial grasses • Incentives to invest in rehabilitation, maintenance e.t.c. • Improve management of ruminant animals	• Enhancement of herbaceous species biodiversity • Above and below ground biodiversity maintained and enhanced • Ecosystem ecological services improved • Improvement of stakeholders' capacity to manage biodiversity sustainably/alternative livelihood	• Carbon sink enhancemen • Reduction of GHG emissions

Integrated Catchment/Watershed Management/Sustainable Land and Water Management	• Reduce sediment load through improved conservation and production technologies • maintenance of stream flow and reduction of flow variability • Regulation of water flow • Habitat modification • Maintain aquifer recharge (i.e. protection of aquifers and aquatic ecosystems) • optimising irrigation • Minimise polution (i.e. reduction in use of agro-chemicals)	• Improvement of ecosystem functioning favouring maintenance of biodiversity • protection of wetlands and coastal ecosystems/habitats • Protection of endemic species/ecological corridors • protection of habitats for diverse group of species • Aquatic and marine ecosystems enhanced	• Reduction in GHG emissions • Reduction in GHG emissions
Establishment of Transboundary Mechanisms for Management of shared resources	• Co-ordinated land-use plan • Establishment of user-rights	• Provides a framework for ensuring protection and/or conservation of biological resources	• Provides a framework within which climate benefit can be delivered

N.B: Entries in the boxes are meant to be illustrative and not exhaustive. Though the intervention strategies “land-centred”. Each intervention should be designed with its socio-economic context. As a consequence, tl as illustrated in Table 2 should also join an integral part of the overall intervention strategy.

SECTION 4: THE NEED FOR TARGETED RESEARCH

4.1. There is obviously a great need for a better understanding of many scientific, technical and socio-economic issues to do with land degradation interlinkages, particularly in dryland ecosystems. The workshop identified the need for the GEF to invest more resources on targeted research, to further enhance understanding of the linkages between land degradation and the GEF focal areas of climate change, biodiversity and international waters. In this regard, a number of potential areas for targeted research were highlighted, which the GEF could consider for financing.

4.1.1. Cross-Sectoral

- **Targeted/Applied Policy Research:** There is recognition that policy to remediate land degradation should be devised in a context that provides understanding of the complexities of the drivers of degradation. Identification of entry points of intervention strategies requires critical analysis that differentiates symptoms from root causes. Many studies have identified linkages between socio-economic processes, land degradation, and other GEF focal areas. Additional targeted policies research is required to provide methods and information that establishes a basis for long term assessment of implications of intervening in complex systems to remedy land degradation. This will entail a long term commitment to provide a basis for policy-focused research, identify interventions, and allow evaluation of the impact of intervention strategies over time on both socio-economic and environmental conditions.

  The programme might include support for existing programmes that are dedicated to the goal of defining critical linkages between the management of dynamic land and biotic resources and socio-economic systems.

- **People-Centred Approach:** It was concluded that a "people-centred" approach which engages local communities in the definition of issues, and in the design, implementation, and evaluation of remediation measures is central to addressing land degradation issues successfully. In this context, the need for targeted research that focuses on "best bet" solutions was highlighted. That is targeted research that relies on the indigenous knowledge of local stakeholders and enables the researcher to explicitly draw on the development values of the existing results. The full participation of local stakeholders in the planning, execution and evaluation of such activities is essential.

- **Nutrient Depletion:** Nutrient depletion is an important element in the land degradation equation. In this regard, the need for a better understanding of the role of vegetaion as the provider of organic material for soil improvement and the canopy interception of rainfall was highlighted.

4.1.2 International Waters

- **Full understanding of Land/Water degradation processes:** A lack of the understanding of the complexities of the land and water degradation processes exist, especially where the degradation of land or water are intimately linked. The interaction for example, between land degradation events such as water logging, salinisation and acidification is still not perfectly clear. One specific gap recognised was the lack of robust models on land degradation - it is clear that effort needs to be spent on modelling. Not enough is known on the rates of response and the tele-connections.

- **Quantify the Extent/Intensity of Land/Water Degradation:** "Guesstimates" are often used to arrive at the quantum of negative change that could be attributed to land degradation processes. Precise figures are available for small plots, streams etc., which are then scaled up to cover large areas. Such an approach often gives misleading figures, which scientist realise are incorrect, but due to the lack of more accurate data, these figures become enshrined in the literature. There is therefore a need to obtain "real" estimates of land degradation, not only on the spatial scale but also some indication on the temporal scale. Modern techniques such as remote sensing and Geographical Information Systems (GIS) should be employed in such an exercise .

- **Relationship Between Intensive/Extensive Water and Land-use:** Issues relating to the intensification - extensification continuum are complex and not fully understood. Conceptually, there must be a point in the I - E continuum where there is balance leading to optimal land use for any particular habitat/eco-region/biome. Adding a long-term temporal dimension to this concept leads to issues relating to the sustainable use of resources (permaculture etc.). An attempt has been made to illustrate this with Figure 3.

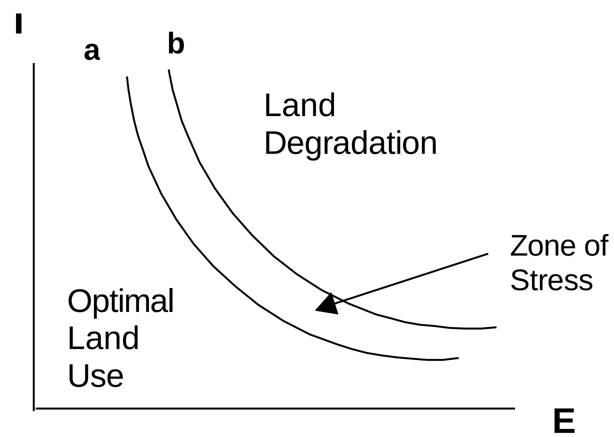

Figure 3. The Intensification/Extensification Continuum

Targeted Research needs to be carried out to find out how to optimise the balance between Extensification (**E**) and Intensification (**I**). Under different environmental and socio-economic conditions.

- **Thresholds/Critical Loads:** There are also data gaps in the area of thresholds or critical loads of land degradation. It is recognised that there is a time scale response and also a spatial scale response. In the diagram presented in Fig 3, the curves **a** and **b** represent the lower and upper thresholds of response of land or water to intensity of resource use. The zone between the curves is the area of stress where interventions need to be taken to reverse the trend to move to the land/water degraded area above curve **b**. In the area below curve **a**, there would be a point where there actually is balance in the use of resources.

4.1.3 Climate Change

- **Flux measurements:** Target research is required on flux measurements including carbon fluxes in arid, semi-arid and tropical environments in both forested and non-forested sectors; the effects of species, landscapes and weather on fluxes and the effects of various interventions on GHG emissions.

- **Development and validation of carbon management models:** The need for the development and validation of carbon management models for biomass production and use, with particular emphasis on applications to degraded lands on a region-by-region basis was emphasized. Such models should take into consideration a wide range of societal goals for the growing of biomass on such lands, including local development, biological diversity conservation, water resources enhancement and local environmental protection, as well as carbon emissions reduction goals.

- **Inventories of degraded lands:** The development of inventories of degraded lands suitable for restoration to more productive uses - including the production for biomass for CO_2 sequestration, for energy and other uses - in conjunction with perpetual - rotation management strategies for biomass.

- **Environmentally sound and sustainable biomass production strategies:** The need was identified for multi-disciplinary targeted research to develop environmentally sound and sustainable biomass production strategies as well as the most effective strategies for restoring degraded lands to productive use.

4.1.4 Biodiversity

- **Feedback Linkages from biodiversity to land degradation:** The general conclusion which emerged from the analysis of linkages between biodiversity and land degradation is that the feed-forwards linkages are more established than the feedback (biodiversity to land degradation) linkage. Additional targeted research is required to enhance knowledge in feedback linkages. Additional information is also required on feed-forward and feedback linkages, especially in relation to cropping systems.

- **Intensification and Extensification:** How can intensification (in high potential areas) and extensification (in drylands) be realised.

- **Ecosystem resilience:** Ecosystem resilience and the resilience of diverse management systems was identified as an important area in need of targeted research since a significant amount of biodiversity occurs in managed land. More understanding is required on how and why ecosystems are resilient.

- **Genetic Improvement in drylands:** With respect to indigenous fruit trees and other useful plants, activities are required to promote genetic improvement of these crops, to ensure proper propagation of planting materials and to develop improved capping systems that utilise these indigenous food crops. Associated with this is the genetic pool in drylands and how it can be utilized sustainbly.

- **Mitigation of social driving forces:** How are social driving forces linked to land degradation, biodiversity, climate change and water resources and how can these forces be deflected/mitigated.

- **Economic Incentives for Biodiversity Conservation:** What is the value of different aspects of biodiversity and how can value be added to biodiversity to create economic incentives for conservation.

PROGRAM

Monday 14 June 1999

8.30 Participant registration
9.00 Official Opening: Welcome by the Chancellor of the University of Bologna - Statements: STAP
GEF
9.45 Aims and Objectives of the Workshop:
– Elements and Drivers of Land Degradation: Appreciation of the range of definitions – Paola Rossi Pisa
– Land Degradation and implications for the GEF Focal Areas
– GEF Secretariat
– Convention to Combat Desertification and implications for the GEF Focal Areas - CCD Secretariat
10.40 Coffee break
11.00 Climate Change – Jean Palutikof
11.30 Discussion
11.45 Biodiversity in Africa – Gufu Oba
12.00 Biodiversity in South America – Exequiel Ezcurra
12.30 Discussion
1.00 Lunch
2.30 International waters – Christopher Gordon
3.00 The socio-economic dimensions of Land Degradation – David Campbell
3.30 Discussion
4.00 Tea break
4.20 Suggestions for interventions: Implications for each focal area. Feed-forward and feedback at Global and No global scale.
5.30 Formation of Working Groups
6.0 Closure of Meeting

A visit of Bologna is organized for the participants on Tuesday 15 June, 1999 at 5.00 pm starting from the Palazzina della Viola.
A visit of the Erosion experimental facility of the Agronomy Department is organized for the participants on Wednesday 16 June, 1999 at 4.00 pm starting from the Palazzina della Viola

Tuesday 15 June 1999

9.00 Working Groups to continue
11.00 Coffee break
11.20 Working Groups to continue
1.00 Lunch
2.30 Working Groups to continue
3.30 Tea break
3.45 Working Groups to continue
5.00 Closure of the meeting

Wednesday 16 June 1999

9.00 Plenary session
9.30 Working Groups to continue
11.00 Coffee break
11.20 Working Groups to continue
1.00 Lunch
2.00 Consideration of Areas of Intervention by GEF in Land Degradation Interface Activities
4.00 Closure of the meeting

ANNEX II

STAP Expert Group Workshop on
Land Degradation Interlinkages
List of Participants

Dr. Christopher Gordon
Volta Basin Research Project
O. Box 209
University of Ghana, Legon, Accra
Ghana
Tel: 233-21-500467
Fax: 233-21-500382
Email: chrisgordon@ighmail.com

Dr. Gufu Oba
University of Oslo
O. Box 1050
Blindern, N-0316
Oslo, Norway
Tel: (47) 22 854561
Fax: (47) 22 854605
Email: gufu.oba@bio.uio.no

Dr. Rokhaya Daba Fall
Technical Advisor
Ministry of Agriculture
President Sahel Enviroment Consult
BP 6225, Dakar-Etoile
Senegal
Tel: (221) 8323762/8232876/8321660
Fax: (221) 8233268
Email: rodabafa@telecomplus.sn

Mr. Mahendra Kumar
International Negotiations Officer
South Pacific Regional Environmental
Programme (SPREP)
P O Box 240
Apia, Samoa
Tel: 685 21 929
Fax: 685 20 231
Email: sprep@sprep.org.ws
mahendrak@sprep.org.ws

Dr. Liana Talaue-McManus
Associate Professor
Marine Science Institute
University of the Philippines
Diliman, Quezon City 1101
Philippines
Tel: (63 2) 922 3921
Fax: (63 2) 924 7678
Email: liana@msi01.cs.upd.edu.ph

Prof Gong Woi Koon
University of Malaysia
Tel: (604) 657 2960
Fax: (604) 657 2960

Dr. Maryam Fuller
Range Ecologist
SHIS QI 25, conjunto 10,
casa 21, Brasilia,
DF, 70660-300
Brazil
Tel: (55 61) 367 2228
Fax: (55 61) 367 2228
Email: mfuller@abordo.com.br

Mr. Luis Guillermo Baptiste
Coordinador Programa Uso y Valoracion de
Biodiversidad
Instituto de Investigaciones de Recursos
Biologicos
Alexander von Humbold
Calle 37 Na 8-40 Mezzanine
Santafe de Bogota, DC, Colombia
Tel: (571) 338 3900 ext. 388
Fax: (571) 288 9564
Email: baptiste@openway.com.co

Dr. Exequiel Ezcurra
Deputy Director of Research and Collections
San Diego Natural History Museum
El Prado
P O Box 121390
San Diego, California 92112-1390
Tel: (619) 232 3821
Fax: (619) 232 0248
Email: eezcurra@sdnhm.org

Prof. David Campbell
Geography and African Studies
Michigan State University
Natural Science Building
East Lansing, MI 48824-1115
Tel: (517) 355 1628 (D)/517 355 4649
Fax:(517) 432 1671
Email: djc@pilot.msu.edu

Prof. Leonard Berry
Director
Florida Centre for Environmental Studies
Florida Atlantic University
RCA Blvd, Suite 7401
Palm Beach Gardens Fl 33410
Tel: (561) 691 8554
Fax: (561) 691 8540
Email: berry@fau.edu

Dr. Jean Palutikof
University of East Anglia
Norwich
NR4 7JT
Tel: (44) 1603 593647
Fax: (44) 1603 507784
Email: j.palutikof@uea.ac.uk

Prof. D. O. Hall
Division of Life Sciences
King's College London
University of London
Campden Hill Road
London W8 7AH, U.K.
Tel: (44) 171 333 4317
Fax: (44) 171 333 4500
Email: d.hall@kcl.ac.uk

Dr. Gunilla Bjorklund
Director
Gewa Consulting
Marmorv, 16A
44 Uppsala, Sweden
Tel: 46-18-516522
Fax: 46-18-508445
Email: gunilla.bjorklund@telia.com

Dr. John Ingram
NERC Centre for Ecology and Hydrology
Crowmarsh Gifford, Wallingford
OX10 8BB
London, U.K.
Tel: 44 1491 692410
Fax: 44 1491 692313
Email: j.ingram@ioh.ac.uk

Dr. John Gash
Institute of Hydrology
Maclean Building, Crowmarsh Gifford
Wallingford, Oxfordshire
London, U.K.
Tel: 44-1491 838800
Fax: 44-1491692338/2331
Email: j.gash@ioh.ac.uk

Prof. Harold Brookfield
PLEC Project
Department of Anthropology, RSPAS
Australian National University
Canberra, 0200
Australia
Tel: (61) 2 624 4348
Fax: (61) 2 6249 4688
Email: hbrook@coombs.anu.edu.au

Dr. Robin Reid
International Livestock Research Institute
P O Box 30709
Nairobi, Kenya
Tel: (254 2) 630743
Fax: (254 2) 631499)
Email: r.reid@cgnet.com

Mr. Stefano Pagiola
Environment Department
The World Bank
1818H Street NW
Washington DC 20433, U.S.A
Tel: (202) 458 2997
Fax: (202) 522 1735
Email: spagiola@worldbank.org

Dr. Lual A. Deng
Managing Director
African Development Center (ADC)
Gainborough Dr.
Fairfax, VA 22032-2742
Tel: (703) 323-5688
Fax: (703) 323-9410
Email: LualDeng@aol.com

Dr. Govind B. Pant
Indian Institute of Tropical Meteorology
Pashan, Pune 411 005
India
Tel: (91 20) 5893924
Fax: (91 20) 5893825
Email: gbpant@tropmet.ernet.in

Mr. Ndegwa Ndiang'ui
Scientific Advisor
United Nations Convention to
Combat Desertification
P O Box 260129
Haus Carstanjen,
Martin-Luther-King-Strasse 8,
D-53175 Bonn, Germany
Fax: 49-228-815-2898/99
Tel: 49-228-815-2821
Email: nndiangui@unccd.de

Mr. Masanori Kobayashi
Programme Officer
United Nations Convention to
Combat Desertification
P O Box 260129
Haus Carstanjen,
Martin-Luther-King-Strasse 8,
D-53175 Bonn, Germany
Fax: 49-228-815-2898/99
Tel: 49-228-815-2829
Email: mkobayashi@unccd.de

Prof. Simeon K. Imbamba
Environmental Consultant
United Nations Environment Programme
P O Box 30552
Nairobi, Kenya
Tel: 254-2-624187

Dr. Mohd Nor Salleh
Executive Director
Tropbio Research SDN BHD
Level 2, Enterprise 2
Technology Park Malaysia
57000 Bukit Jalit, Kuala Lumpur
West Malaysia
Tel: 603 968 2003
Fax: 603 968 2888
Email: drsalleh@tropbio.po.my

Prof. Gualtiero Baraldi
University Bologna:
Dean of the faculty of Agriculture
Via Filippo Re 4
40126 Bologna, Italy
Tel: 0039 051 2091472
Fax: 0039 051 2091473

Prof. Alberto Vicari
Via Filippo Re 6
40126 Bologna, Italy
Tel: 0039 051 2091525
Fax: 0039 051 2091545
E-mail: avicari@pop:agrsci.unibo.it

Prof. Maria Speranza
Dipartimento di Biologia Evoluzionistica
University Bologna
Via Irnerio 40
40126 Bologna, Italy
Tel: 0039 051 2091311
E-mail: speranza-m@biblio.cineca.it

Prof. Enzo Farabegoli
Soil Science Department
University of Bologna
40126 Bologna, Italy
Tel: 0039 051 2094565
E-mail: fara@geomin.unibo.it

Dr. Mauro Casadei
Dipartimento di Scienze del Suolo
Università di Bologna
Via Zamboni 67
40126 Bologna, Italy
Tel: 0039 051 2094597

Dr. Maurizio Sciortino
ENEA C.R. Casaccia
Rep of Ministry of Environment
Via Anguillarese 301
00060 S.M. di Galeria
Roma, Italy
tel + 39 06 30484213
fax + 39 06 30483591
Email: sciortino@casaccia.enea.it

Dr. Marcello Pagliai
Direttore
Ministry of Agriculture
Italian Institute of Soil Science
Piazza D'Azeglio 30
50121 Firenze, Italy
Tel: 0039 055 2491252
Fax: 0039 055249125211
E-mail ldirissds@dada.it

Prof. Enzo Farabegoli
University of Bologna
Soil Science Department
40126 Bologna, Italy
Tel: 0039 051 2094565
E-mail: fara@geomin.unibo.it

Dr. Mauro Casadei
Dipartimento di Scienze del Suolo
Università di Bologna
Via Zamboni 67
40126 Bologna, Italy

Dr. Ing. Claudio Conese
IATA –CNR
Institute of Environmental Analysis and Remote Sensing for Agriculture
Via Caproni 8
50100 Firenze, Italy
e-mail: iat2@sunserver.iata.fi.cnr.it
Consiglere Dr. Davide Morante
Ministry of Foreign Affairs, DGCS
Piazzale della Farnesina
00194- Roma, Italy

Dr. Paolo Sarfatti
Istituto Agronomico per l'Oltremare (IAO)
Via Cocchi, 4-50131
Firenze, Italy
Email: environ@iao.florence.it

Dr. Raffaele Vignola
Natural Resources
Ministero degli Affari Esteri
Istituto Agronomico Per L'Oltremare
Agricoltura Ambiente Sviluppo
Via A. Cocchi, 4-50131
Firenze, Italy
Tel: 39-055-50611
Fax: 39-055-5061333
Email: environ@iao.florence.it

Ing. Prof. Mario Falciai
University of Florence
Dipartimento Ingegneria Agraria e Forestale
Via S. Bonaventura,13
50145 Firenze, Italy

Prof Giuliano Rodolfi
University of Florence
Dipartimento di Scienza del Suolo e Nutrizione Delle Piante
Piazzale delle Cascine, 28
50144-Firenze, Italy

Prof. Andrea Giordano
University of Turin
Dipartimento di Economia ed idraulica Agraria
Via Leonardo da Vinci 40
10095 Grugliasco
Torino
Tel: 0039 011 6708614

Prof. Eric Odada
Professor of Geo-limnology and Programme Director, Pan-African START Secretariat
Kenya National Academy of Sciences/ University of Nairobi
P O Box 30197
Nairobi,Kenya
Tel: (254) 2 447740
Fax: (254) 2 449539
Email: pagesnbo@form-net.com

Prof. Paola Rossi Pisa
Agricultural Faculty, Agronomy Department
University of Bologna
Via Filippo Re 6
Bologna, Italy
Tel: (39) 51 351526
Fax: (39) 51 351545
Email: ppisa@pop.agrsic.unibo.it

Dr. Mark Griffith
STAP Secretary
STAP Secretariat
UNEP/GEF
Nairobi, Kenya
Tel: (254 2) 623424
Fax: (254 2) 623140
Email: Mark.Griffith@unep.org

Ms. Anne-Marie Verbeken
Programme Officer
STAP Secretariat
UNEP/GEF
Nairobi, Kenya
Tel: (254 2) 623250
Fax: (254 2) 623140
Email: Anne-Marie.Verbeken@unep.org