Desert Margins Initiative

An integrated national, regional, and international research program for developing sustainable natural resource management options to combat land degradation in sub-Saharan Africa

Revised Proposal
for a
Systemwide Ecoregional Initiative

Submitted by
International Crops Research Institute for the Semi-Arid Tropics
the Convening Center, on behalf of a
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Executive Summary

Desertification is now recognized as a major global problem following the international profile given to the issue by the United Nations Blueprint for the Environment, AGENDA 21, and the International Convention to Combat Desertification. The revised definition of desertification clarifies that it is a form of progressive soil and vegetation degradation in arid lands, not just an outright conversion to desert, to which both human and climatic factors may be contributing.

The scale of desertification, also referred to as 'dryland degradation', is immense. The total area of arid, semi-arid, and dry sub-humid drylands covers 40% of the earth's land surface. Vast areas of these drylands, between 1 and 3.6 billion ha, are thought to be experiencing some degree of degradation. Over 100 countries and approximately 900 million people may be suffering from the adverse social and economic impacts of dryland degradation. The extent of land degradation is most severe in the arid and semi-arid regions of sub-Saharan Africa, where one-third of the global area of dryland soil degradation is to be found.

The converse of land degradation is the process by which the biological and economic potential of an area are conserved or improved. This concept is effectively the definition of sustainable resource management. If natural resources are sustainably managed, land degradation can be arrested. Improving natural resource management as a means to combat desertification is an important, if not essential, step forward. It gives a much clearer focus to defining the problem on a local scale and highlights the need for more effective integration of local, national, and regional institutions responsible for natural resource management. This 'bottom up' approach is the basic premise for the Desert Margins Initiative (DMI) as an integrated national, sub-Regional, and international research program for developing sustainable natural resource management options to combat desertification in sub-Saharan Africa.

In the nine countries of sub-Saharan Africa participating in the DMI (Botswana, Burkina Faso, Kenya, Mali, Namibia, Niger, Senegal, and South Africa), population growth rates are among the highest in the world. Cereal production per unit area of land in most of these countries is very low, so there is an escalating pressure to increase food production, even at the cost of depleting natural resources. The need to find sustainable solutions is highly acute in these countries.

The key goal of the DMI is to enhance the food security of poor rural populations and alleviate poverty by halting or reversing desertification.

The planning process for the DMI, extending over a 2-year period from September 1993 to September 1995, involved consultations at the global level, preparation of a background document, organization of an initial International Planning Workshop, followed by three sub-Regional Workshops in Western, Southern, and Eastern Africa. The consortium of partners is shown in the table on page 2.

During the planning phase of the DMI, three priority research themes were identified:

- Develop sustainable pastoral grazing systems for dryland regions.
- Manage water and nutrient resources more effectively within the rainfed farming, mixed tree/crop/livestock systems, and natural and plantation woodlands.
- Design policies and institutional options for improved natural resource management.

During the planning process, it was agreed that an integrated, multidisciplinary approach to the management of all land-use systems within an entire ecosystem offers many potential benefits. The planning and consultation process led to the identification of specific objectives that focus on the following key areas in dryland natural resource management:

1. Understanding land degradation
2. Assessing dryland management practices
3. Improving natural resource management
4. Designing policies, programs and institutional options
5. Formulating drought management strategies
6. Enhancing institutional capacities
7. Exchanging technologies and information

National, sub-Regional, and International Partners in the DMI Consortium

Focal Institution	Country/region
1. NARS/NGOs	
Institut d'études et de recherches agricoles (INERA) Association Six-S (NGO)	Burkina Faso
Agricultural Research Department Thusano Lefatsheng (NGO)	Botswana
Canadian Hunger Foundation (NGO)	Canada
Kenya Agricultural Research Institute (KARI) Environment Liaison Center International (NGO)	Kenya
Institut d'économie rurale (IER)	Mali
Institut national de recherches agronomiques du Niger (INRAN)	Niger
Ministry of Agriculture, Water and Rural Development, Research and Training	Namibia
Institut sénégalais de recherches agricoles (ISRA) Bureau pédologie Plateforme rurale des paysans des état membres du CILSS (NGO)	Senegal
Agricultural Research Council	South Africa
Department of Research and Special Services ENDA-Zimbabwe (NGO)	Zimbabwe
2. Sub-Regional Organizations	
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)	Eastern and Central Africa
Intergovernmental Authority on Drought and Development (IGADD)	Eastern Africa
Southern African Centre for Cooperation in Agricultural Research (SACCAR)	Southern Africa
Institut du Sahel (INSAH)	Western Africa
3. International Institutes / United Nations Agencies	
International Board for Soil Research and Management (IBSRAM)	Bangkok, Thailand
International Center for Agricultural Research in the Dry Areas (ICARDA)	Aleppo, Syria
International Centre for Research in Agroforestry (ICRAF)	Nairobi, Kenya
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Patancheru, India
International Fertilizer Development Center (IFDC)	Muscle Shoals, AL, USA
International Food Policy Research Institute (IFPRI)	Washington, DC, USA
International Livestock Research Institute (ILRI)	Nairobi, Kenya
International Plant Genetic Resources Institute (IPGRI)	Rome, Italy
United Nations Development Programme (UNDP)	New York, NY, USA
United Nations Environment Programme (UNEP)	Nairobi, Kenya
4. Advanced Research Organizations	
Centre de coopèration internationale en recherche agronomique pour le dèveloppement (CIRAD)	Montpellier, France
Institute of Hydrology (IH)	Wallingford, UK
Institute of Terrestrial Ecology (ITE)	Edinburgh, UK
Institut français de recherche scientifique pour le développement en coopération (ORSTOM)	Paris, France

A better understanding of the underlying mechanisms of land degradation will allow us to recognize and distinguish between natural climate variability (e.g., drought), human activity (e.g., over-cultivation, overgrazing), and climatic change. A clear definition of the quantitative indicators of degradation will emerge, which can be used to assess more accurately the extent and rate of change of degradation in dryland areas. Integrated studies of the options to improve land degradation will provide the technologies to arrest and reverse land degradation in the areas where it is necessary and cost effective to do so.

The global benefits of the DMI are its potential to enhance the regional capacity to combat desertification, mitigate global warming, conserve biodiversity, protect international waters, and increase food security. Improved understanding of the contributions of climatic and human factors to dryland degradation will be used to develop technologies (e.g., remote sensing) and models to extrapolate local results on national, regional, and global scales. Studies of soil erosion and technologies for soil conservation and improvement should increase carbon sequestration.

Biodiversity conservation is also a major theme in the DMI. Inventories will be compiled of dryland species and other relevant natural resources. Tree and crop improvement and diversification will conserve and enhance biodiversity; genetic resources of trees and crops will be conserved. International waters will benefit from the knowledge and techniques developed by studying soil erosion. All these aspects will be integrated with results on policies and institutional options. The involvement of local farmers will ensure that the results will lead to models for the necessary institutional changes.

The strategy proposed for choosing operational sites within the DMI is to build on existing work, and concentrates most of the effort on a few well-monitored sites. The activities of soil, plant, and animal scientists can be integrated with those of socioeconomists, and policy and institutional analysts. Interactions can be established between researchers, development workers, and farmers. These 'partnership' sites will also act as sub-Regional 'field laboratories' where standardized monitoring of land degradation can be carried out parallel to establishing rehabilitation areas. The unique and major strengths of the DMI are the partnerships that are created by integrating research disciplines with development work. The strategy of focusing on a few partnership sites will avoid duplication of effort and will provide a critical mass to achieve the progress necessary to tackle the complex problem of land degradation.

Another major aim of the DMI is improved assembly and increased availability of data on land degradation and natural resources. Institutions in each of the three sub-Regions will set up computer-based natural resource information databases to combine key information with new data.

The governing mechanism of the DMI is an Interim Steering Committee that will provide policy guidance and direction during the interim phase. NARS and NGOs are at the center of the organizational structure, and their role and partnerships with other DMI organizations will be discussed at the forthcoming National Workshops. The governing mechanism for the DMI has four distinct and complementary levels: National, sub-Regional (Western, Southern, and Eastern Africa), Regional (Africa), and Global. Furthermore, collaborative links will be established with other relevant Systemwide Initiatives — Systemwide Livestock Initiative and Systemwide Soil, Water, and Nutrient Management Research Initiative — and global initiatives.

An initial funding of US$ 5,000,000 per annum for a 5-year project will be requested from the CGIAR donors and the Global Environment Facility of the UNDP on a cost sharing basis. A preliminary breakdown indicates that 41% of the total research budget will go to national and sub-Regional organizations. International institutes will receive 38% of the research budget, and 15% will be allocated to Advanced Research Organizations. Approximately 65% of the budget will be spent on research and development and 35% on policy, enhancing national institutional capacity, and exchanging technologies and information. Further co-financing by the partner institutions and budget details will be discussed at the National Workshops.

Introduction

Historical background

Desertification became a major worldwide issue following the disastrous droughts in the Sahel during the early 1970s. This led to the United Nations Conference On Desertification (UNCOD) held in Nairobi in 1977, which formulated the Plan of Action to Combat Desertification (PACD). PACD contains 28 recommendations for action at national, regional, and international levels and was the primary framework for anti-desertification measures during the period 1977 to 1992. Although progress in implementing the PACD has been limited, international concern, particularly from developing countries, has continued to increase. The UN Conference on Environment and Development (UNCED or 'The Earth Summit') in 1992 in Rio de Janeiro, adopted AGENDA 21, which included a chapter specifically on desertification and drought. A high priority program for AGENDA 21 is concerned with strengthening the knowledge base and developing information and monitoring systems for regions that are prone to drought and desertification.

Another important outcome of the Earth Summit was an agreement to draw up an International Convention to Combat Desertification (CCD), which was elaborated by the Intergovernmental Negotiating Committee on Desertification (INCD), and agreed in June 1994. This Convention recognizes that the desertification issue is on par with such global issues as climate change and loss of biological diversity. About 90 countries have signed the CCD since January 1995. The CCD specifies the scientific and technical cooperation required to combat desertification through: Article 16 - *Information collection, analysis and exchange*; Article 17 - *Research and development*; and Article 18 - *Transfer, acquisition, adaption and development of technology*. Article 19 recognizes the importance of *Capacity building, education and public awareness* in the countries affected by desertification. The Desert Margins Initiative (DMI) was developed to respond to these guidelines.

Desertification and natural resource management

Numerous definitions of desertification and a lack of reliable quantitative information, have helped create the image of ever-expanding natural deserts. This is now believed to be largely a misconception, or at most, only a small part of the problem. Desertification is currently perceived as the degradation of drylands, which occurs as a subtle, dispersed, and continuous process, mainly far away from the desert fringes; only rarely does fertile land become desert. Major processes are loss or reduction of vegetation cover and species diversity, loss of soil structure which may lead to erosion and dust storms, decrease of soil fertility, an altered hydrological cycle, and reduced crop yields and livestock production.

Desertification is defined (INCD 1994) as '*land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities*'.

This definition recognizes that desertification is a form of land degradation, not just outright conversion to desert. It allows for the possibility that both human and climatic factors may be associated with land degradation and it defines the geographical extent of the areas affected. Arid, semi-arid, and dry sub-humid areas are defined according to their 'aridity index', the ratio of annual precipitation to potential evaporation. The annual atmospheric demand for water exceeds the rainfall supply for the three areas (aridity index ranges from 0.05 to 0.65). Land degradation is seen as a reduction or loss of biological or economic potential. According to the CCD, degradation includes economic loss as well as ecological deterioration.

The converse of land degradation is a situation where the biological and economic potential of an area are conserved or improved, which is effectively a definition of the concept of sustainable natural resource management. If natural resources are sustainably managed then there should be no land degradation. The shift in approach towards combatting desertification in terms of improving natural resource management is seen as an important, if not essential, step forward (Toulmin 1992). It allows the problem to be defined at the local level and a more effective integration of resource management by local, national, and regional institutions. The DMI has adopted this approach, since its philosophy is to

form a consortium of national, sub-Regional, and international institutes to develop sustainable natural resource management options that can alleviate land degradation.

The dryland regions of the world support a variety of closely interlinked land-use systems and practices: pastoralism; rainfed farming; mixed tree, crop, and livestock production; and natural woodlands. In addition to knowing how these systems respond to degradation pressures, it is necessary to investigate the response to human action aimed at countering degradation. Examples of such remedial measures include improved grazing patterns, more sustainable dryland farming systems, small scale or supplementary irrigation, tree planting, and agroforestry. There are three priority research themes in dryland natural resource management.

- Developing sustainable pastoral grazing systems for dryland regions.
- Managing water and nutrient resources within rainfed farming, mixed tree/crop/livestock systems, and natural and plantation woodlands.
- Designing policies and institutional options for improved natural resource management.

It is also necessary to study the potential benefits of taking an integrated, multidisciplinary approach to the management of all types of land resources within an entire ecosystem.

Current state of knowledge

Geographical extent of desertification

The true extent of desertification, also referred to as dryland degradation, is not known; nor are the relative contributions of the various human and climatic factors understood well enough to prescribe sustainable long-term counter measures (Williams and Balling 1994). However, during the past two decades there have been several attempts to assess the global extent and severity of desertification. Unfortunately there were different definitions regarding the geographical extent of drylands and different criteria were used to describe degradation, e.g., whether it included soil degradation or vegetation degradation or both (UNEP 1992). The information collected in some cases was little more than 'expert opinion' and some recent assessments of desertification have avoided statistics on extent and severity of degradation (e.g., Warren and Khogali 1992).

Arid, semi-arid, and dry sub-humid drylands (as defined by the aridity index criterion) cover 40% of the earth's land surface. Vast areas of these drylands, perhaps as much as 70% (3.6 billion ha), suffer from some degree of degradation (Table 1). Over 100 countries and about 900 million people may be suffering from the adverse social and economic impacts of dryland degradation (UNEP 1992, Hare and Ogallo 1993). The smallest estimates of dryland degradation
(1 billion ha) are still larger than the entire area of tropical deforestation, making degradation a global problem even though its precise extent is uncertain.

The large difference between estimates of area subject to degradation arises from the debate about whether or not to include vegetation degradation, which is thought to account for 50% of the total. However, even the soil and vegetation estimates are only crude qualitative assessments. The huge uncertainty in the different estimates reflects the lack of reliable quantitative data on land degradation, and reaffirms the crucial need to develop and apply uniform criteria for assessing dryland degradation (e.g., Williams and Balling 1994).

The need for monitoring dryland degradation exists on three distinct scales: local, sub-Regional, and global. On a local scale, reliable information on the rate of degradation is essential, not only to support process-oriented research into the mechanisms of degradation, but also to identify remedial action. At a sub-Regional level, assessments of the extent of degradation are often undertaken for purposes of national planning (e.g., Ottichilo 1991) and to indicate the economic implications of continued resource degradation. Globally, the extent and rate of dryland degradation identified the magnitude of the problem in the context of other global environmental concerns, including climate change and loss of biological diversity (e.g., the 1977, 1984, and 1992 UNEP assessments; Odingo 1991). Current estimates of the areas affected by dryland degradation are based on highly subjective qualitative

Table 1. Worldwide status of desertification (UNEP 1992).

Classification	Area (m ha)	Total drylands (%)
Rangelands with soil degradation	757	14.6
Rainfed croplands with soil degradation	216	4.1
Irrigated lands with soil degradation	43	0.8
Total drylands with soil degradation (GLASOD)[1]	1,016	19.5
Rangelands with vegetation degradation only	2,576	50.0
Total degraded lands (ICASALS)[2]	3,592	69.5
Non-degraded drylands	1,580	30.5
Total dryland area (excluding hyper-arid deserts)	5,172	100.0

1. Global Assessment of Soil Degradation, ISRIC, The Netherlands.
2. International Center for Arid and Semi-Arid Land Studies, Texas Technical University, Texas, USA.

information; this method must be improved if the problem is to be properly addressed. Quantitative indicators of degradation will be easier to define when the determining mechanisms are better understood.

According to Williams and Balling (1994), 332 million ha of African drylands are subject to soil degradation. This represents one-third of the entire area of dryland soil degradation in the world. Areas of high degradation are extensive in sub-Saharan Africa in the regions bordering the Sahara and Kalahari deserts, which is why the DMI focuses on these areas. As shown in Figure 1, there is a strong correspondence between the areas of land degradation and the arid (100–400 mm rainfall per year) and semi-arid zones (400–600 mm rainfall per year), emphasizing the close relationship between land degradation and drought. In the nine countries participating in the DMI (Table 2), there are 120 million people, with some of the highest population growth rates in the world. At the same time cereal production per unit area of land in the driest countries is very low, as is the amount of fertilizer used.

Table 2. Area, population, per capita income, and agricultural statistics in the nine DMI countries.

Country	Total area (m ha)	Population			Fertilizer use (kg ha^{-1})	Millet yield (t ha^{-1})	Sorghum yield (t ha^{-1})	Agricultural contribution to GNP (%)	Per capita GNP (US$)
		Number (million)	Density (km^{-2})	Growth (%)					
Botswana	60037	1.3	2	2.7	0.9	0.38	0.38	12	1149
Burkina Faso	27420	10.0	34	3.1	2.9	0.64	0.89	41	321
Kenya	58265	27.1	43	3.6	25.8	0.67	1.08	33	376
Mali	124000	8.7	7	2.4	5.7	0.71	0.89	43	268
Namibia	82430	1.6	2	3.6		0.74	0.71		1028
Niger	126700	8.7	6	3.4	0.8	0.35	0.18	31	262
Senegal	19619	8.5	41	3.1	4.6	0.59	0.93	22	632
South Africa	122104	42.8	33	2.7		1.27	2.68		2183
Zimbabwe	39058	11.4	27	2.9	59.3	0.30	0.52	15	596

Sources
Crop production and area: FAO (1995).
Fertilizers: Mokwunye and Vlek (1986).

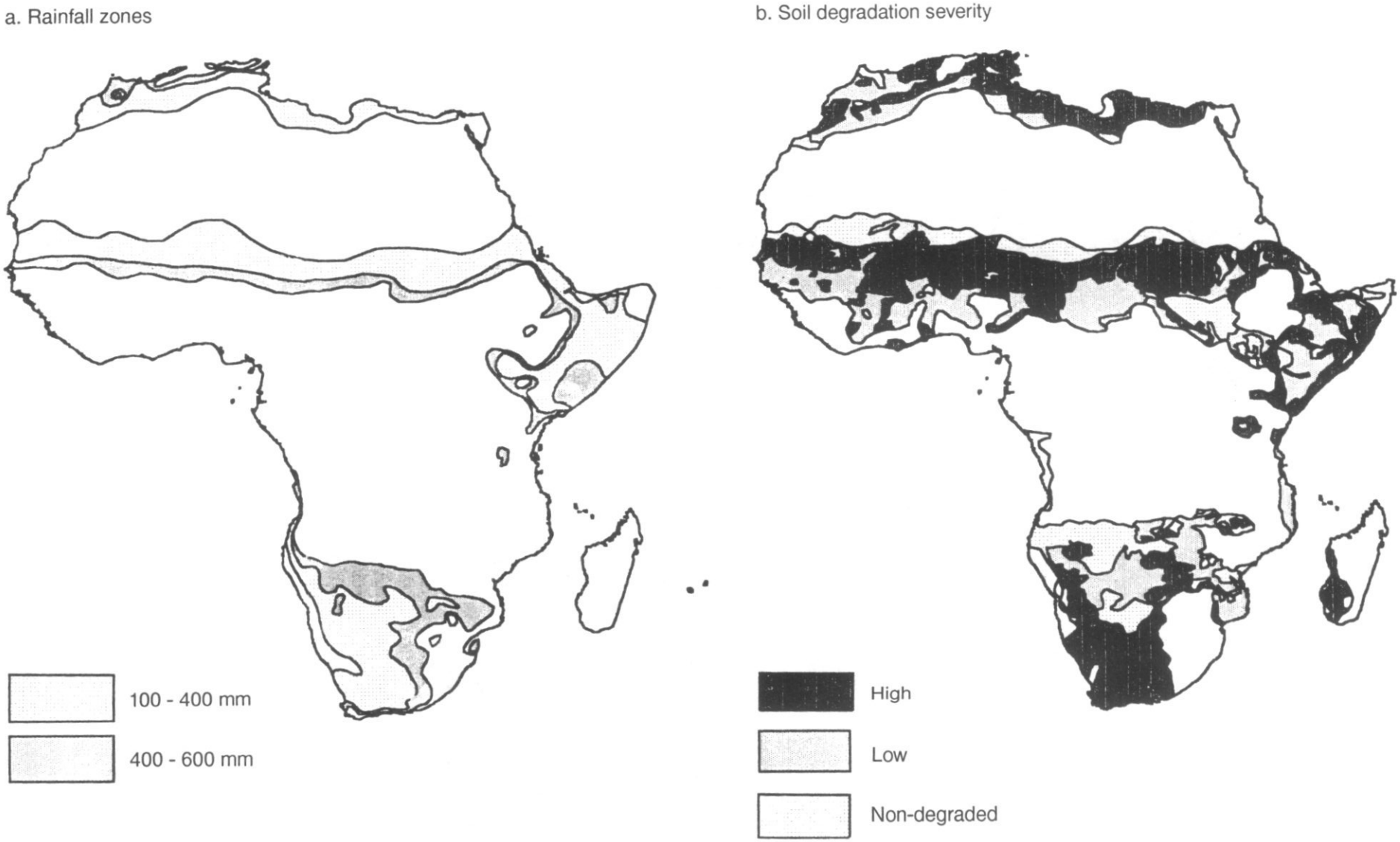


Figure 1a. 100 – 600 mm rainfall zones, and b. Soil degradation severity in sub-Saharan Africa

Desertification processes

Human and climatic factors can contribute to dryland degradation in a number of complex, interactive ways. First, direct anthropogenic pressures such as overgrazing, over-cultivation, and deforestation can cause a decrease in vegetation cover and expose vulnerable soils to erosion due to their low moisture content, low levels of organic matter, and weak structural stability. This erosion can lead to a loss of nutrients and water storage, thereby reducing the potential for plant growth. Dryland soils are known to be particularly sensitive to erosion and several studies have shown that most cultivated land in sub-Saharan Africa loses more nutrients than it gains (e.g., Van der Pol 1992), causing large decreases in crop yields. Christol (1966) reported that in Burkina Faso the increase in soil loss from 1.4 to 13 t ha^{-1} yr^{-1} due to water erosion decreased pearl millet yields by a factor of two. As yields decrease, there is even further pressure on the land when fallow periods are reduced or abandoned. Overgrazing by livestock is also associated with land degradation; however, the picture is not simply one of too many animals. There are strong linkages between the arid and semi-arid zones of Africa. For example, livestock movements across the inter-zonal boundary exploit the different seasonal production of pastures in the two regions. However, increased population and the occurence of drought upsets the natural balance between these regions and can lead to land degradation in some areas and under-utilization of pastures in others.

A second mechanism can be triggered by a loss of vegetation, which can propagate further land degradation via the land surface-atmosphere feedback. This occurs when a decrease in the vegetation reduces evaporation and increases the radiation reflected back to the atmosphere (albedo). The consequent reduction in cloud formation and rainfall causes a positive feedback which further reduces vegetation. This mechanism was initially demonstrated by Charney (1975), but he used extreme geographical and land surface conditions to illustrate the effect. However, more recent simulations of desertification in Western Africa, using much more realistic changes to represent land degradation, still show a positive link between land degradation and Sahel rainfall (Xue et al. 1990).

A third possible mechanism contributing to dryland degradation is hydrological. This can occur when the decrease in ground cover associated with vegetation degradation results in increased water runoff and decreased soil moisture storage (Wallace 1992). In this situation less of the rain that falls on degraded land is available for plant growth and survival.

Climate change is the fourth mechanism proposed to contribute to dryland degradation. External influences from anomalies in sea surface temperature, humid tropical deforestation, and/or CO_2 induced climate change are thought to be associated with drought and degradation in arid zones such as the Western African Sahel (see Glantz et al. 1991).

According to the World Meterological Organization (WMO) and UNEP, interactions between desertification and climate confirm that both human and climatic factors are associated with dryland degradation (Williams and Balling 1994). The scientific challenge is to understand the functioning of dryland ecosystems in order to recognize and distinguish between changes resulting from three factors— natural climate variability (e.g., drought), human activity (e.g., over-cultivation, overgrazing), and climatic change induced 'internally' by large scale land degradation, or 'externally' by sea surface temperature anomalies, tropical deforestation, or enhanced ambient CO_2 concentration. As these processes become clearer this will lead to better definition of quantitative indicators of degradation which can be used to assess more accurately the extent and rate of degradation change in dryland areas. Sustainable management of natural resources (soil, water, crops, trees, and livestock) will also depend on this improved understanding of the interactions between the various processes that can lead to land degradation.

Definition of DMI goals and research philosophy

Insufficient information about, and understanding of, degradation processes underlies the failure to tackle the desertification problem effectively. This was recognized in Chapter 12 of AGENDA 21 (UNCED 1992) and has been confirmed in several reviews of desertification (Warren and Khogali 1992, Williams and Balling 1994) and in the recently concluded UN Convention on Desertification (INCD

1994). The physical mechanisms by which desertification is propagated are natural scientific phenomena, but these are driven by social and economic forces. The key contribution that science and technology can make to combat dryland degradation is through a blend of natural sciences and socioeconomic research.

The integrated research program proposed in the DMI is aimed at increasing our understanding of the physical, biological, and socioeconomic processes associated with this grave environmental problem so that we can distinguish between the different causes of degradation and produce effective solutions through improved natural resource management. Halting or reversing dryland degradation will enhance the food security of poor rural populations and contribute to poverty alleviation. This defines the key overriding goal of the DMI.

The lessons from past attempts to arrest desertification have demonstrated the clear need for national institutions to be centrally involved in the planning and execution of research and development projects if effective and sustainable achievements are to be gained (Warren and Khogali 1992). This is recognized in the Desertification Convention under Article 19, where the need is identified for institution building, training, and development of relevant local and national capacities. It is an essential principle of the DMI to fully involve national and regional organizations that have a mandate to study natural resources, and to ensure that these activities are compatible with the national action plans of the Desertification Convention.

Goal, Overall Objective, Strategy, and Specific Objectives

Goal—To contribute to sustainable food security and poverty alleviation.

Overall objective—To promote innovative and action-oriented dryland management research to arrest land degradation.

Strategy—The research strategy will follow a participatory and multi-disciplinary approach, with an emphasis on on-farm research, social issues, local needs, and institutional options.

The overall research strategy may be summarized as follows:

- Review and analysis of the extent and nature of land degradation and its socioeconomic and biophysical causes.
- Identification and testing of available solutions (indigenous, new technologies, and policy and institutional changes) through participatory research with farmers, NGOs, and NARS.
- Development of improved solutions (technologies, policies, institutions) through participatory research.
- Assessment of the likely impact of solutions in solving degradation problems and designing monitoring systems for measuring impact.
- Collaboration with researchers, farmers, communities, NGOs, policymakers, and donors in implementing and monitoring the findings and recommendations from the DMI.

Specific Objectives

1 To develop a better understanding of the causes, extent, severity, and physical processes of land degradation in traditional crop, tree, and livestock production systems in the desert margins, and the impact, relative importance, and relationship between natural and human factors.

2 To evaluate, with the participation of farmers, NGOs, and NARS, current indigenous soil, water, nutrient, vegetation, and livestock management practices for arresting land degradation and to identify socioeconomic constraints to the adoption of improved management practices.

3 To develop and foster improved and integrated soil, water, nutrient, vegetation, and livestock management technologies and policies to achieve greater productivity of crops, trees, and animals to enhance food security, income generation, and ecosystem resilience in the desert margins.

4 To evaluate the impact and assist in designing policies, programs, and institutional options that influence the incentives for farmers and communities to adopt improved resource management practices.

5 To promote more efficient drought management policies and strategies.

6 To enhance the institutional capacity of countries participating in the DMI to undertake land degradation research and the extension of improved technologies, with particular regard to multi-disciplinary and participative socioeconomic research.

7 To facilitate the exchange of technologies and information among farmers, communities, scientists, development practitioners, and policy makers.

Planning and Consultation Process

The planning and consultation process for the DMI extended over a 2-year period from September 1993 to September 1995 and involved the following steps:

- Consultations at the global level and preparation of a background document for the Initiative
- Organization of an International Planning Workshop at the Regional level
- Organization of sub-Regional Workshops
- Planning the National Workshops

Global level consultations and preparation of the background document

When world leaders reached a consensus on AGENDA 21 at the UNCED meeting in Rio de Janeiro in June 1992, they requested the international research community to consider specific contributions for implementation. Based on AGENDA 21 and the three International Conventions on Biodiversity, Climate Change, and Desertification, three key areas were identified:

- Poverty alleviation
- Increased agricultural production
- Environmental protection

Following this step, a CGIAR Task Force was appointed to prepare a report on the CGIAR response. The Task Force recommended that the CGIAR should undertake four Global Initiatives including a Global Marginal Soils Initiative. The DMI has been developed in response to this recommendation and also directly addresses the international concerns reflected in Chapter 12 of AGENDA 21 and the Desertification Convention.

Desertification Convention and the DMI

Following the invitation in July 1993 to participate in the United Nations sessions of INCD to prepare the Desertification Convention; the CGIAR nominated ICRISAT as the lead Center to take part in the elaboration of the Convention; and ICRISAT was accredited as an Intergovernmental Organization to the INCD. ICRISAT took an active part in the INCD process and was represented at the INCD sessions held in Geneva (13-24 Sep 1993), New York (17-28 Jan 1994), and Paris (6-17 June 1994). To facilitate the Convention negotiations, several workshops / conferences were held between September 1993 and June 1994. ICRISAT representatives participated in the 'Conference on Human Livelihoods in Drylands - Constraints and Possibilities' held in Sweden from 23-25 November 1993; the IDRC-sponsored workshop on 'Impact of Indigenous Knowledge and Traditional Coping Strategies for the Prevention or Mitigation of Land Degradation and the Desertification Process in Africa' held in Cairo from 3-5 Jan 1994; the IDRC-sponsored workshop on 'Impact of Land Systems and Forms of Property and Resource Access (land, forests, and water) on Degradation of Lands and Desertification' held from 7-11 March 1994 at Dakar, Senegal; and the IDRC workshop on 'Impacts of Trade, Economic Policies, and Structural Adjustment Programs on Desertification in Africa' held in Nairobi and Lake Nakuru, Kenya, from 17-20 May 1994.

The implementation of the DMI will be coordinated with the consultative process leading to national and sub-Regional action programs to combat desertification with a view to ensuring:

- Better coordination of strategic frameworks to combat drought and desertification
- Improved complementarity between research and development activities at the local level
- Development of incentive systems to secure long-term sustainability of field-level multisectoral research programs
- Enhanced resource mobilization within the framework of the partnership arrangements of the Convention.

To ensure that the DMI is compatible with the priorities of the Desertification Convention, appropriate interactions will take place with the Committee on Science and Technology, as defined under Article 24 of the CCD.

Preparation of the background document for the Initiative

The first effort at assessing the value and desirability of developing a DMI started in June 1993, just around the time negotiations for the INCD got under way. The United Nations Environment Programme (UNEP) engaged Dr Wolfgang Baier of Agriculture Canada as a consultant to prepare a background document based on extensive discussions with National Agricultural Research Systems (NARS), Non-governmental Organizations (NGOs), sub-Regional organizations, and International Agricultural Research Centers (IARCs).

During February-March 1994, Dr Baier travelled to the following countries for consultations:

- Kenya – NARS, Intergovernmental Authority on Drought and Development (IGADD), UNEP, and International Centre for Research in Agroforestry (ICRAF)
- Ethiopia – International Livestock Research Institute (ILRI)
- Niger – ICRISAT Sahelian Center (ISC), Institut national de recherches agronomiques du Niger (INRAN), and Institute of Hydrology (IH)

- Burkina Faso – Institut d'études et de recherches agricoles (INERA), Centre nationale de recherche scientifique et technologique (CNRST), and various NGOs
- Botswana
- Namibia

He submitted his final report at the end of April 1994 (Baier 1994), which was modified in August 1994 after comments had been received from several partners interested in the Initiative (ICRISAT 1994). The purpose of this background document was to highlight the current understanding of sustainable natural resource management options to arrest land degradation in the desert margins of sub-Saharan Africa, and thus guide the discussions during the International Planning Workshop for the DMI held in Nairobi in January 1995.

International Planning Workshop at the Regional level

The International Planning Workshop, held in Nairobi from 23-26 January 1995, provided the first opportunity for individuals and institutions to establish direct contact and exchange their views. Contributions from NARS and regional organizations were key elements. This meeting represented the first step in bringing together participants from different and complementary disciplines, all of whom were seeking a common approach and practical solutions.

Over 80 participants from international, Regional, national, and non-governmental organizations attended the Workshop. Based on the background paper and presentations from the various countries and institutions, the major constraints to sustainable natural resource management in the desert margins were identified and included in the Specific Objectives for the Initiative (Sivakumar and Wills 1995a).

The significant result of the Workshop was an overriding consensus among the participants that there is considerable value in pursuing the DMI and that it is an important ecoregional Initiative. Participants agreed on the preamble, goal, overall objective, strategy, specific objectives, and provisional outcomes. They also recommended an organization and management structure and the constitution of an Interim Steering Committee (InSC) to guide the future development of the DMI (Sivakumar and Wills 1995b).

Defining the Desert Margins Ecosystem

The Nairobi workshop agreed that the INCD definition of areas affected by desertification should be used—the concern should be with land degradation in the arid, semi-arid, and sub-humid areas where the aridity index is between 0.05 and 0.65. This represents an approximate annual rainfall of 100–1300 mm, which covers a very wide area in sub-Saharan Africa. Widening the scope of the DMI to such a large area carries technical, logistical, and management implications. Subsequent discussions at the first meeting of the InSC led to a recommendation that the INCD definition of affected areas would be adopted, but the focus of the DMI should be on the rainfed crop, tree, and livestock production systems in dryland areas with an annual rainfall between 100–600 mm (Fig. 1a).

Sub-Regional Workshops

At its first meeting in June 1995, the InSC recommended the organization of sub-Regional Workshops for each of the three regions within the DMI: Western Africa, Southern Africa, and Eastern Africa; and that the appropriate regional organizations in the DMI should coordinate these meetings. As a consequence, the following sub-Regional Workshops for the DMI were conducted in September 1995:

- Western Africa, 4-6 Sep 1995 at Niamey, Niger
- Southern Africa, 11-13 Sep 1995 at Gaborone, Botswana
- Eastern Africa, 18-20 Sep 1995 at Nairobi, Kenya

Western Africa

Dr Gaoussou Traoré, Institut du Sahel (INSAH)/Comité permanent inter-états de lutte contre la sécheresse dans le Sahel (CILSS), coordinated the workshop with the DMI Coordination Unit at ISC.

The workshop was opened by the Minister of Water Management and Environment of the Government of Niger, who was accompanied by the Nigerien Minister of Higher Education.

There were 48 participants from:

- NARS in Burkina Faso, Niger, Mali, and Senegal
- NGOs
- Regional organizations
  - Centre régional de formation et d'application en agrométéorologie et hydrologie operationnelle (AGRHYMET)
  - African Centre of Meteorological Applications for Development (ACMAD)
- IARCs
  - ICRAF
  - ICRISAT
  - ILRI
  - International Food Policy Research Institute (IFPRI)
  - International Fertilizer Development Center (IFDC)
- AROs
  - Centre de coopération internationale en recherche agronomique pour le développement (CIRAD)
  - Institut français de recherche scientifique pour le développement en coopération (ORSTOM)
  - Institute of Hydrology (IH)
  - Institute of Terrestrial Ecology (ITE)
- United Nations agencies
  - United Nations Development Programme (UNDP)
  - UNDP Global Environment Facility (GEF)

Participants from each of the four DMI countries prepared reports outlining their research priorities and specific objectives. Representatives from the IARCs and AROs presented their activities of special interest. One of the major recommendations of this workshop consolidated the specific objectives dealing with livestock and trees to improve natural resource management. This consolidation reduced the number of objectives from nine to seven. The Working Group also recognized that certain activities were of interest to many of the partners and resolved to identify these sub-Regional activities as 'global themes'. The workshop endorsed the formation of a DMI National Coordination Committee (NCC) for each country and resolved that the NCCs in Western Africa would organize meetings in their countries to develop workplans and budgets. IARCs and AROs would be invited to these national meetings.

A Workshop report was finalized by the end of the meeting. It summarized the recommendations and outlined priority activities for the outputs identified for each of the specific objectives. The report will be published by ICRISAT as a part of the Summary Proceedings for the sub-Regional Workshops (Sivakumar et al. 1995).

Southern Africa

Dr B Ndunguru, Director, and Dr C T Nkwanyana, Principal Programme Officer, Southern African Centre for Cooperation in Agricultural Research (SACCAR), coordinated the organization of this sub-Regional workshop. Dr L Gakale, Director of the Agricultural Research Department of Botswana and Chairman of the Governing Board of SACCAR inaugurated the Workshop.

There were 23 representatives from:

- NARS in Botswana, Namibia, South Africa, and Zimbabwe
- SACCAR
- NGOs
- ICRISAT
- IFDC
- UNEP
- UNDP/GEF

Participants from each of the four Southern African DMI countries presented priority activities for each of their specific objectives; ICRISAT and IFDC described their areas of special interest. The workshop endorsed the idea of a NCC for each country and resolved that these organisms would coordinate workshops in their countries to develop workplans and budgets for their participation in the DMI. IARCs and AROs would be invited to the national workshops. The workshop produced a summary report which will be included in Sivakumar et al. (1995).

Eastern Africa

Twenty participants from the following institutions attended the Eastern Africa sub-Regional Workshop at ICRAF:

- NARS in Kenya
- IGADD
- NGOs
- ICRISAT
- ICRAF
- IFDC
- UNEP
- UNDP/GEF

Participants agreed with the recommendation to merge the specific objectives for livestock and trees with the one on improving natural resource management. They presented priority activities for each of the specific objectives in the DMI. A NCC for the DMI was endorsed and participants agreed to organize a national workshop to develop detailed workplans and budgets for the participation of Kenya in the DMI. Tentatively, it was agreed that the meeting will be held from 5-6 Dec.1995 in Nairobi, and a draft program for the workshop was finalized.

IGADD recommended including Eritrea, Ethiopia, and Sudan in the DMI as they have major dryland research programs and recommended that the DMI Coordination Unit should formally approach the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) to write to the authorities in these three countries inviting them to join. As in the other two sub-Regional Workshops, a synthesis report was discussed and finalized during the final session of the Workshop (Sivakumar et al. 1995).

Planning the National Workshops

During the sub-Regional Workshops, the participants endorsed the idea of organizing National Workshops, to identify national coordinators, and a NCC, and to define details of DMI research activities, consistent with the National Action Plans as envisaged in the regional implementation annex for Africa of the INCD. Because of the wide interest in the DMI, the National Workshops will include, in addition to the NARS, a range of such other organizations as relevant government departments, universities, NGOs, and regional and international organizations. It is expected that detailed workplans and budgets will be developed for the participation of partners interested in the DMI. A tentative schedule for these meetings in 1995 was established as follows:

10-12	Oct	Pretoria	South Africa
7-8	Nov	Windhoek	Namibia
14-15	Nov	Harare or Bulawayo	Zimbabwe
21-22	Nov	Gaborone	Botswana
5-6	Dec	Nairobi	Kenya
	Dec	Ouagadougou	Burkina Faso
	Dec	Niamey	Niger
	Dec	Bamako	Mali
	Dec	Dakar	Senegal

DMI Consortium

The Consortium of partners (Table 3) is unique as it pools resources and expertise of 10 NARS and NGOs, four sub-Regional Organizations (CILSS/INSAH for Western Africa, SADC/SACCAR for Southern Africa, and IGADD and ASARECA for Eastern Africa), eight IARCs (IBSRAM, ICARDA, ICRAF, ICRISAT, IFDC, IFPRI, ILRI, and IPGRI), and four AROs (CIRAD, IH, ITE, and ORSTOM), with the experience of UNEP and UNDP in the implementation of the UN Plan of Action to Combat Desertification. Other CGIAR centers addressing desert margin problems throughout the world will be consulted as appropriate.

NARS and NGOs

NARS and NGOs of the selected countries affected by desertification are at the heart of the DMI. NARS include all of a country's public and private agricultural research institutions, such as government departments, universities, and non-profit establishments that conduct research or contribute to the development or adaptation of technology and policies that support agricultural and rural development. The NARS form the essential links with extension services, the private sector, educational institutions and government ministries. They work with farmers and farmers' organizations on the identification of research problems and on technology transfer. For the purpose of this Initiative, NARS will be the focal point of agricultural research in each country.

NGOs have a catalytic role in this Initiative. They function best at the grassroots level and work with farmers and farmers' organizations, developing new approaches to agricultural and environmental problems. There have been examples of NGOs assisting governments in experimenting with establishing community extension systems and transferring responsibilities to them.

Sub-Regional Organizations

The task of sub-Regional coordination for Western Africa is assumed by CILSS/INSAH. CILSS is an inter-state permanent committee to fight drought in the Sahel and was set up by the Western African states (Burkina Faso, Cape Verde, Chad, The Gambia, Guinea Bissau, Mali, Mauritania, Niger, and Senegal) to evolve a common strategy to deal with problems of drought in Western Africa. Two main organizations operating under the auspices of CILSS in Western Africa are INSAH in Mali, and AGRHYMET in Niger. AGRHYMET is the WMO Regional Center for training in Agricultural Meteorology and Hydrology.

SACCAR, under the Southern Africa Development Community (SADC), undertakes the sub-Regional coordination for Southern Africa. The Southern African Development Coordination Conference (SADCC) was established in 1980 and was transformed into the Southern African Development Community (SADC) in 1992 to reflect the economic integration of SADC member states. SACCAR, which is a commission of SADC, was established in 1984 to coordinate research, training, and extension in the SADC region of Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

The sub-Regional coordination for Eastern Africa is handled jointly by IGADD and ASARECA. The objectives and functions of IGADD, established in 1986, are designed to help six Eastern African countries (Djibouti, Ethiopia, Kenya, Somalia, the Sudan, and Uganda) to further their development despite the effects of drought and other adverse environmental conditions. Eritrea was recently added to this list of countries. IGADD works with the governments and departments of its member nations, and with national, regional, and international agencies and organizations to promote development. ASARECA, currently comprising NARS from 10 countries (Burundi, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, Uganda, and Zaire), was established in 1994. It was built in response to the desire of the NARS in the region to collaborate in agricultural research in order to foster effectiveness, responsiveness, complementarity, economies of scale, and to reinforce each other. This coincided with the political leaders' encouragement for regional collaboration and the desire of the donor community to facilitate regional efforts.

Table 3. National, sub-Regional, and International Partners in the DMI Consortium

Focal institution	Country/region
1. NARS/NGOs	
Institut d'études et de recherches agricoles (INERA) Association Six-S (NGO)	Burkina Faso
Agricultural Research Department Thusano Lefatsheng (NGO)	Botswana
Canadian Hunger Foundation (NGO)	Canada
Kenya Agricultural Research Institute (KARI) Environment Liaison Center International (NGO)	Kenya
Institut d'économie rurale (IER)	Mali
Institut national de recherches agronomiques du Niger (INRAN)	Niger
Ministry of Agriculture, Water and Rural Development, Research and Training	Namibia
Institut sénégalais de recherches agricoles (ISRA) Bureau pédologie Plateforme rurale des paysans des état membres du CILSS (NGO)	Senegal
Agricultural Research Council	South Africa
Department of Research and Special Services ENDA-Zimbabwe (NGO)	Zimbabwe
2. Sub-Regional Organizations	
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)	Eastern and Central Africa
Intergovernmental Authority on Drought and Development (IGADD)	Eastern Africa
Southern African Centre for Cooperation in Agricultural Research (SACCAR)	Southern Africa
Institut du Sahel (INSAH)	Western Africa
3. International Institutes / United Nations Agencies	
International Board for Soil Research and Management (IBSRAM)	Bangkok, Thailand
International Center for Agricultural Research in the Dry Areas (ICARDA)	Aleppo, Syria
International Centre for Research in Agroforestry (ICRAF)	Nairobi, Kenya
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Patancheru, India
International Fertilizer Development Center (IFDC)	Muscle Shoals, AL, USA
International Food Policy Research Institute (IFPRI)	Washington, DC, USA
International Livestock Research Institute (ILRI)	Nairobi, Kenya
International Plant Genetic Resources Institute (IPGRI)	Rome, Italy
United Nations Development Programme (UNDP)	New York, NY, USA
United Nations Environment Programme (UNEP)	Nairobi, Kenya
4. Advanced Research Organizations	
Centre de coopèration internationale en recherche agronomique pour le dèveloppement (CIRAD)	Montpellier, France
Institute of Hydrology (IH)	Wallingford, UK
Institute of Terrestrial Ecology (ITE)	Edinburgh, UK
Institut français de recherche scientifique pour le développement en coopération (ORSTOM)	Paris, France

International Institutes/United Nations Agencies

The IARCs under the CGIAR participating in the DMI include ICARDA, ICRAF, ICRISAT, IFPRI, ILRI, and IPGRI. ICRISAT, on behalf of the Consortium, is taking a leadership role in the development and implementation of this Initiative. ICRISAT's regional mandate is to improve agriculture in the semi-arid tropics (SAT) and its global mandate is to conduct research on six food crops—sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut. ICRISAT's scientists in sub-Saharan Africa are located in Niger (ISC), Mali, Nigeria, Zimbabwe, Malawi, and Kenya. ICRAF's mission, as stated in its charter, is 'to increase the social, economic and nutritional well-being of peoples of developing countries through the use of research and related activities to integrate woody perennial species in farming and related land-use systems in order to increase productivity, profitability, sustainability, diversity of output, and the conservation of natural resources'. This mandate is pursued in 13 African countries and 6 countries in Southeast Asia and Latin America. The relevant countries of the DMI are Burkina Faso, Kenya, Mali, Niger, and Senegal.

Much of ILRI's research is long-term, but key areas in which research and associated activities have had an early impact on agro-ecological research and sustainable agricultural production in sub-Saharan Africa relevant to this Initiative include studies on: the development of feed resources suited to the specific needs of various agro-ecological zones; the role of crop residues and manure for nutrient cycling in crop-livestock systems; and the influence of policies on farmers' land-use decisions and their consequences for resource productivity and land degradation.

IFPRI was established to undertake research on food policy issues and help developing countries devise appropriate policies to ensure the optimum use of new agricultural and resource management technologies. With its national and international collaborators, IFPRI has been conducting agricultural policy research in the Sahel for over a decade. IFPRI's research conducted under this Initiative would comprise part of its broader research program on 'Policies for Sustainable Development of Fragile Rainfed Lands'. Thus, insights and methods from work being carried out in other parts of the world on similar issues can contribute to the DMI.

ICARDA, as the Convening Center for a Systemwide Initiative for an ecoregional program for the West Asia North Africa (WANA) region, is submitting a proposal for the northern margins of the Sahara which complements the DMI.

IFDC and the International Board for Soil Research and Management (IBSRAM), associated members of the CGIAR, are also member of the DMI consortium. IFDC undertakes research and provides assistance, advisory services, and training for the transfer and use of improved fertilizer and related technology, and for the implementation of appropriate economic policies. IBSRAM conducts adaptive research in 23 countries in Africa and Southeast Asia.

UNEP, created after UNCOD in 1977, was assigned the task of coordinating and assisting governments to implement the PACD at the national level. UNEP was associated with the conceptualization and planning process of the DMI from the beginning. Effective links were established with the Dryland Ecosystems and Desertification Control Programme Activity Centre (DEDC-PAC) of UNEP.

Since 1978, UNEP and UNDP, in a joint venture, have assisted countries in the Sudano-Sahelian region to develop and initiate national action plans to combat desertification. This partnership has now been extended to assist all developing countries in designing their national action plans under the CCD.

UNEP and UNDP are two of the three implementating agencies for the GEF, which was created to assist developing countries to respond to global environmental concerns. Following the Earth Summit in Rio, the global Conventions on Climate Change and Biodiversity chose GEF as their funding mechanism.

Advanced Research Organizations

Advanced Research Organizations (AROs) associated with the DMI include the Institute of Hydrology (UK), the Institute of Terrestrial Ecology (UK), Centre de coopération internationale en recherche

agronomique pour le développement (CIRAD), and Institut français de recherche scientifique pour le développement en coopération (ORSTOM).

The Institute of Hydrology, UK (IH) has been studying the water balance of dryland systems since the early 1980s and have developed considerable expertise in the measurement and modelling of the water and energy balance of sparse vegetation including crops, natural savannas, forests, and agroforestry systems. IH also played a leading role in large-scale land surface-atmosphere interaction experiments such as HAPEX-Sahel (Hydrological Atmospheric Pilot Experiment in the Sahel), part of the World Climate Research Programme (WCRP), which aims to improve our understanding and ability to predict the climatic consequences of large-scale land-use change, including dryland degradation. The Institute of Terrestrial Ecology, UK (ITE) has worked extensively on the selection of drought- and salt-tolerant shrubs and trees for semi-arid regions, the role of mycorrhizas in the establishment of trees in degraded land, and modelling the structure and dynamics of plant communities in dryland habitats.

CIRAD specializes in agriculture in the tropics and sub-tropics and contributes to the economic development of these regions through research, experiments, training, and dissemination of scientific and technical information. ORSTOM brings its long-standing expertise in the monitoring of dryland climate, soils, and vegetation using ground-based measurements and remote sensing.

Conceptual framework of the DMI

Prior to the new process of revitalizing the CGIAR, IARCs worked more or less independently, but with linkages through the NARS (Fig. 2). AROs also operated in bilateral projects with the NARS. Although this approach served the purpose of each IARC and ARO, it failed to recognize the considerable benefits of synergy that could be derived from integrating individual research interests into a more holistic approach.

In developing the DMI, a multi-institutional research approach was proposed in which the NARS together with NGOs, IARCs, and AROs are fully integrated within one program. This approach brings together the research expertise of the different partners in a multi-disciplinary framework, where all the partners will work together at a small number of sites (Fig. 3). The AROs, in particular, bring in specific expertise in environmental science that is not available in the IARCs. This programmatic integration is one of the major innovations of the DMI and represents the added value arising from the revitalization of the CGIAR.

As a part of the revitalization of the CGIAR and the development of ecoregional and systemwide intiatives of the CGIAR, a new and important perspective of the DMI is also a change from the commodity/land-use approach (Fig. 3) to one of natural resource management to gain a better understanding of the value of the land, tree, crop, livestock, and water resources and to work towards their sustainable use (Fig. 4). This emphasizes the need for comprehensive and interactive research in five major areas, with a simultaneous emphasis on enhancing institutional capacity, and technology and information exchange.

The concept of partnership in the DMI places a clear emphasis on ensuring the participation of local people and communities who work under difficult conditions, with fragile soils, harsh climate, and few resources. The participatory research approach envisaged in the conduct of research under the different specific objectives in the DMI involves consultations with local people, learning about their problems, techniques, and priorities, and working out solutions with them. NGOs have a special role to play in this process and hence are actively involved in the DMI, right from the phase of conceptualization and designing of research to its implementation in different countries.

Specific Objectives, Expected Outcomes, and Activities

Specific Objective 1—Understanding land degradation

This specific objective is central to the DMI as it is aimed at improving our knowledge about the physical processes leading to dryland degradation, in particular the relative importance of human and

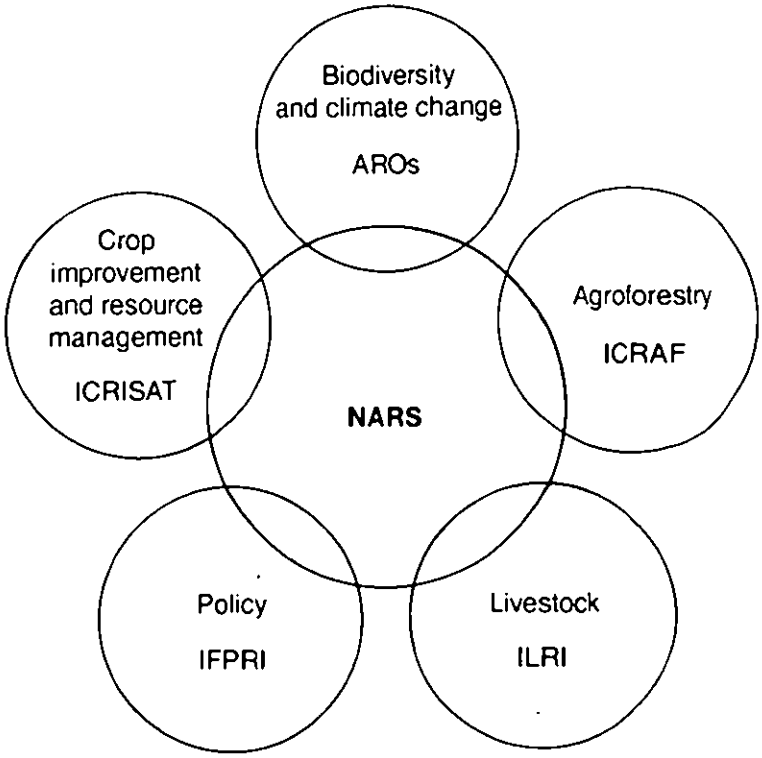


Figure 2 Historical perspective of CGIAR research in sub-Saharan Africa

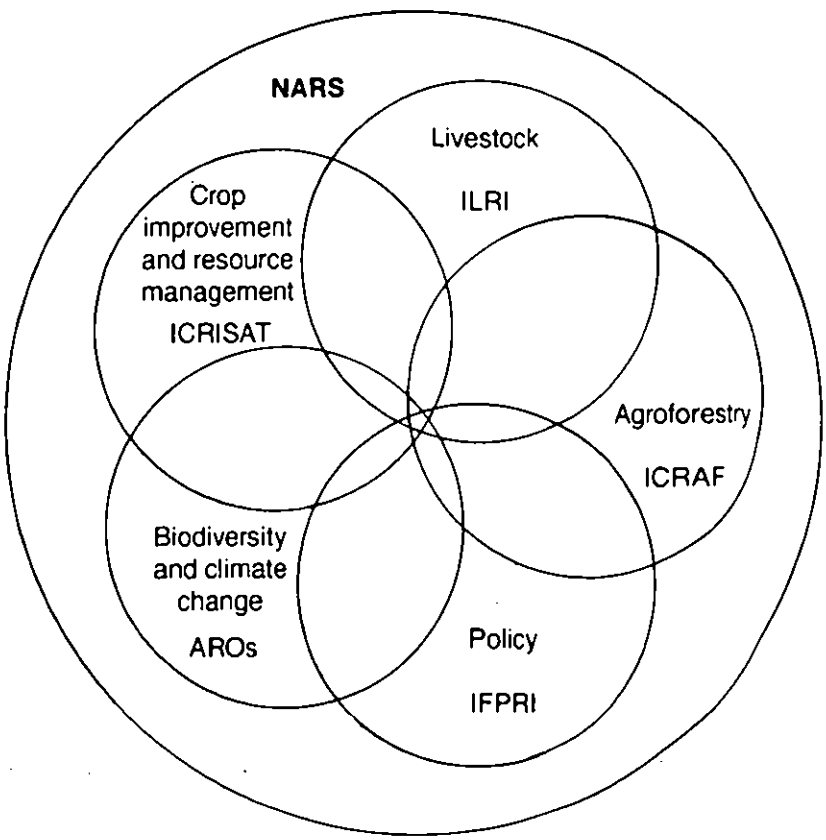


Figure 3 Commodity/land use perspective in CGIAR research

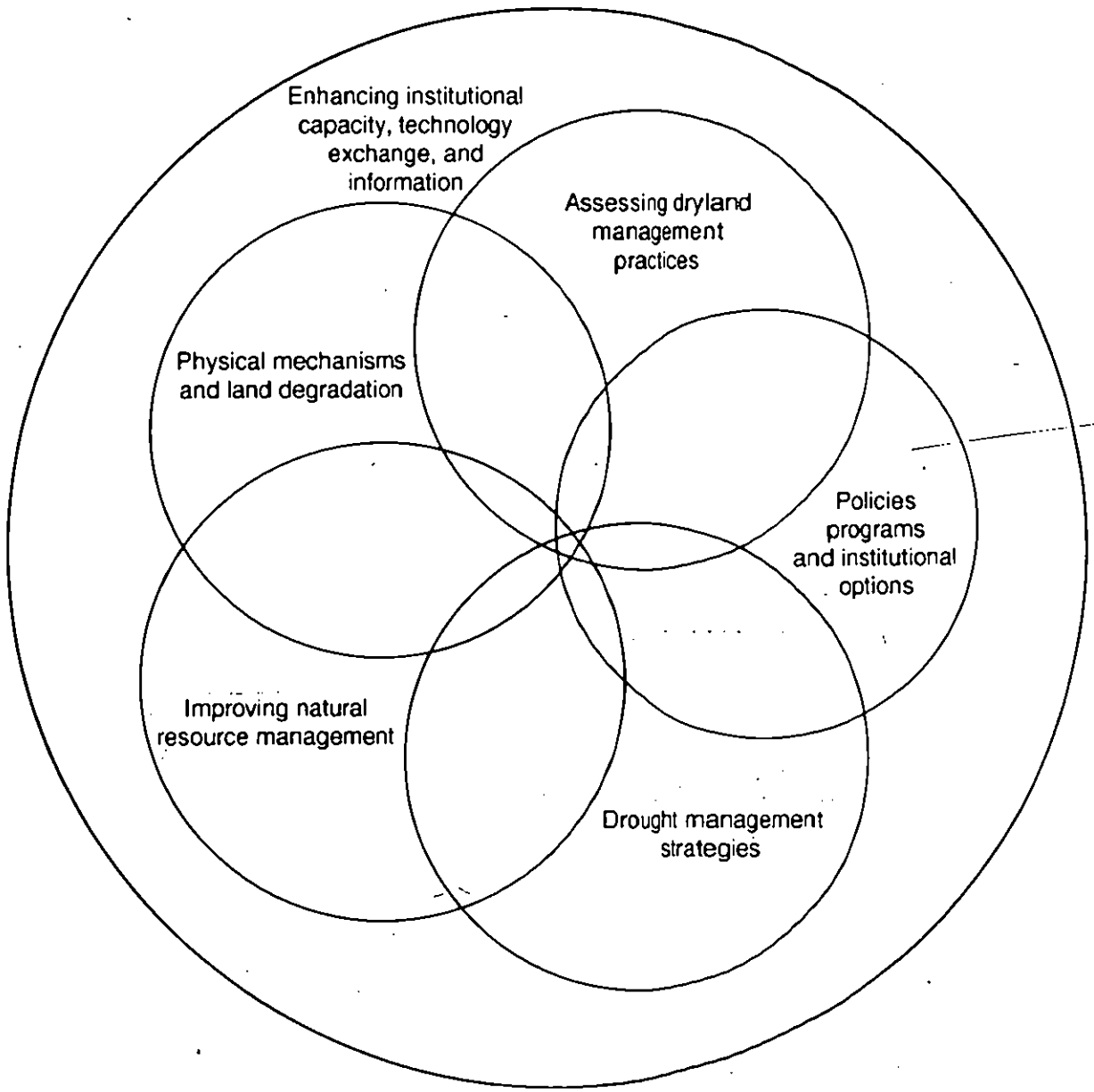


Figure 4 Natural resource management perspective in the DMI

climatic factors, the development of quantitative indicators of degradation, and improved monitoring techniques. The key objective is:

To develop a better understanding of the causes, extent, severity and physical processes of land degradation in traditional crop, tree, and livestock production systems in the desert margins, and the impact, relative importance, and relationship between natural and human factors.

This objective has three primary outputs:

- **Improved knowledge of the relative contributions of climatic and human factors to dryland degradation**

Human and climatic factors can contribute to dryland degradation in a number of complex, interactive ways. The scientific challenge is to understand the functioning of dryland ecosystems so that we can recognize and distinguish between changes resulting from natural climate variability (e.g., drought), human activity (e.g., over-cultivation, overgrazing), and climatic change induced 'internally' by large scale land degradation, or 'externally' by sea surface temperature anomalies, tropical deforestation or enhanced ambient CO_2 concentration. The proposed activities in this output address these issues and cover four areas.

- Databases will be created containing inventories of existing information including 'grey' literature, on the biophysical resources in dryland areas (e.g., soils, soil mycorrhiza, vegetation, lost or endangered species, etc.) which will allow gaps in key information to be identified.
- Identification and assessment of physical and biological factors contributing to land degradation (e.g., climate; physical, chemical and biotic properties of soils; vegetation characteristics; and livestock). These include the long-term effects of different forms of land management on soil fertility and plant growth and the interactions of different climates with the degree and duration of anthropogenic pressures.
- Studies of the processes of soil erosion, including the effects of different types and intensity of land use on the water balance, the sensitivity of different soils to erosion, factors which affect soil infiltration and runoff (e.g., soil type, surface crust, topographical position, vegetation cover, livestock grazing, faunal activity, etc.) and hence the siltation of rivers and lakes. There are also studies of the amount of and processes controlling wind erosion of dryland soils.
- Development of models and use of remote sensing techniques to extrapolate results to national and regional scales. These include hydrological models for predicting runoff and sediment transport, large scale carbon and nutrient balance models of dryland areas, and General Circulation Modelling of the effects of land-use change on rainfall.

- **Improved understanding of the temporal and spatial variability of dryland climates and improved methods for weather monitoring and forecasting of seasonal rainfall**

It is recognized that shortage of rainfall can be an important factor in land degradation. Rainfall is highly variable in dryland regions, yet its monitoring and modelling is poor. The activities of this objective are concerned with:

- Studies of rainfall variability, rainfall generating systems, and the implementation of improved weather monitoring systems at selected benchmark locations in Western, Southern, and Eastern Africa.

- **A set of consistent and objective criteria to evaluate and monitor the present status and severity of land degradation in dryland areas**

Monitoring the severity, extent, and expansion of dryland degradation is probably the most difficult area of degradation research, yet it is the one likely to yield the highest dividends. This area of the DMI is therefore focused on developing reliable quantitative measures of degradation. Many possibilities are

now emerging from advances in remote sensing for a range of relevant physical parameters, e.g., soil type, moisture and infiltration characteristics, sparse vegetation cover (especially woody perennial species), and soil erosion. There are also ground-based techniques to measure the amount of vegetation and species diversity, soil fertility and mychorrhizal populations, etc. This area of the DMI has specific activities associated with:

- The development of quantitative indicators of land degradation and the monitoring of land degradation (including sand dune dynamics) over long periods using field observations, aerial photography, satellite imagery, and geographical information systems (GIS). Activities also include long-term observations of species composition and the identification of 'resilience' indicators.

Specific Objective 2—Assessing dryland management practices

The purpose of this specific objective is to assess current natural resource management practices used by dryland farmers and to understand the physical and socioeconomic constraints. The key objective is:

To evaluate, with the participation of farmers, NGOs, and NARS, current indigenous soil, water, nutrient, vegetation, and livestock management practices for arresting land degradation; and to identify socioeconomic constraints to the adoption of improved management practices.

This objective has three primary outputs:

- **Inventory of soil and water conservation and nutrient management practices in traditional systems, including integration of trees and livestock with crops.**

Valuable knowledge exists with the current practitioners of dryland farming. Much of this information has not been recorded and is widely dispersed in the different dryland regions. This output is focused on the collection of indigenous information to find practical and socially acceptable solutions to the problems of dryland resource management.

- Compilation of an inventory of indigenous farming and agroforestry techniques currently used to improve productivity (crop, tree, and animal) and conserve soil, water, nutrients, and biodiversity.
- Documentation of indigenous knowledge about traditional dryland production systems (crops, agroforestry, livestock).
- Inventory of previous soil, water, and nutrient management research results, including 'grey' literature, and the identification of gaps in knowledge.
- Collection of information on spatial variations and temporal changes in soil fertility in relation to land use, and evaluation of their role in land degradation management.

- **Information on traditional and modern practices for natural resource management and their effectiveness in arresting land degradation, as well as their impact on the resilience of dryland ecosystems**

Farming systems in dryland regions are inherently complex mixtures of arable cropping, agroforestry, and livestock production. These are usually interconnected and require study as holistic systems if the true nature of the natural resource balance is to be understood. The only realistic environments where all the appropriate interactions occur are in traditional farmers' fields. It is therefore crucial to study these systems in situ, and the first step is to assess current practices. The activities in this area therefore include:

- Assessment of traditional cropping systems, parklands, fallows, and other communal lands (e.g., type, extent, state of degradation, etc.) and identification of biophysical and socioeconomic factors that determine their natural resource balance and degree of degradation.
- Assessment of agroforestry techniques using indigenous and exotic species, including their introduction in parklands under different management systems to assess their effectiveness for preventing degradation and to support cropping.

- **An understanding and inventory of the constraints to adoption of existing technologies**

In some areas techniques have been developed which should help prevent land degradation. However, in many cases these technologies are not being adopted by the local farmers. There are a variety of possible reasons which may vary from region to region. These activities are directed towards evaluating exactly why new technologies are not being adopted in different dryland areas and include:

- Identification and analysis of the constraints to the adoption of alternative technologies to control land degradation.
- Understanding the spatial suitability of land for different farming and land-use practices.

Specific Objective 3—Improving natural resource management

This is a logical follow-up to the specific objectives 1 and 2. Review and analysis of the extent and nature of the land degradation problem in specific objective 1, and the assessment of current dryland management practices in specific objective 2, will form a basis to define improved and sustainable, natural resource management options. This objective will emphasize participatory research with farmers and NGOs to design the improved solutions in order to ensure that they are socially acceptable and attract a higher rate of adoption. The key objective is:

> *To develop and foster improved and integrated soil, water, nutrient, vegetation, and livestock management technologies and policies to achieve greater productivity of crops, trees, and animals to enhance food security, income generation and ecosystem resilience in the desert margins.*

This objective has six major outputs:

- **Improving the role of livestock in the rangeland/arable land continuum**

Historically there are strong trade, demographic, and productive linkages between the arid and semi-arid zones of Africa. Livestock movements across the semi-arid/arid boundary exploit the different seasonal potential of pastures in these two zones, thereby increasing the overall production potential of livestock in the region. The past two decades of recurrent droughts have shown how interrelated the development futures of these two zones are. Semi-arid zone cultivators, pushed by demographic pressure, expanded the cultivated front into the arid zone prior to the drought. Since the recent droughts, there has been a reverse movement of people from the arid to the semi-arid zone. As a result of these and other changes, there is a growing concern about the non-optimal and inefficient utilization of resources by existing agropastoral and pastoral systems in the arid zone and the sustainability of existing agropastoral systems in the semi-arid zone. The proposed studies will address the following key issues:

- Identification of livestock management practices that preserve biodiversity and resilience of natural vegetation in the arid zone and minimize land degradation in the semi-arid zone.
- Technologies, policies, and local institutional innovations directed at sustaining livestock-derived income in arid zone production systems and improving the effectiveness of indigenous coping mechanisms to production and capital shortfalls.
- Assessing the potential for improving the beneficial inter-zonal interactions to enhance regional livestock and crop productivity.

- **Improved methods for restoring and sustaining long-term fertility in dryland areas, to effectively combat land degradation**

Several studies in sub-Saharan Africa have shown that most cultivated lands are losing more nutrients than they gain. Long-term field trials have also shown that the use of mineral fertilizers without the recycling of organic materials to the system resulted in higher yields, but this increase was not sustainable. Hence there is a need for integrated nutrient management strategies, seen as the judicious

manipulation of the complete range of nutrient input and output processes. Such strategies should consider carefully the socioeconomic base of the rural communities in sub-Saharan Africa and should emphasize indigenous nutrient materials and biological nitrogen fixation. The proposed activities in this area focus on:

- Development of improved nutrient cycling methods by efficient exploitation of the interactions between organic and inorganic nutrient sources and the relationships between system inputs, soil organic matter characteristics, soil properties and crop productivity.
- Studies of organic matter, including manure and slurries, and phosphate rock combinations and analysis of conditions to favor investments in the use of phosphate rock.
- Use of multipurpose trees for the development of agroforestry technologies that can maintain or enhance soil fertility through biological nitrogen fixation or nutrient pumping.
- Efficient utilization of stover and other vegetable matter from food crops and tree species as compost, mulch, and animal feed.

- **Improved soil and water management techniques for increasing plant water-use efficiency and arresting land degradation**

Even on moderately sloping and light textured soils much of the rain that falls in drylands runs off, leading to soil degradation and further aggravating the moisture constraints in these areas. Appropriate soil and water management practices are crucial for efficient use of the limited and variable rainfall and to arrest land degradation. The main activities here are:

- Development and evaluation of appropriate technologies for soil and water conservation (e.g., surface tillage, animal traction, mulching, contour hedgerows, grass strips, etc.).
- Development and evaluation of improved technologies for sustained productivity in the seasonally waterlogged lands in the arid regions.
- Development and evaluation of water harvesting techniques.

- **Sustainable crop production technologies that conserve the environment are socially and economically acceptable, and meet the food and fodder needs of local populations in the dryland areas**

This research will focus on the development and evaluation of the long-term biophysical and economic impact of alternative crop management strategies which mitigate soil erosion, enhance fertility, and address the problems of food and fodder production. Technologies that require farmer acceptability for their success will be evaluated on-farm from an early stage of development in order to achieve early impact. Studies will focus on:

- Introduction of improved cropping systems and crop/fallow rotations and conditions for acceptable and rapid diffusion of improved technologies.
- Development of integrated pest management strategies by optimizing crop management technologies, e.g., crop residue management, crop rotation and intercropping, including catch and trap crops for parasitic weed (*Striga*) management.
- Evaluation of simulation models relevant to dryland management for use in decision support systems to target research, identify areas for spillover, and predict benefits.
- Implementation of pilot schemes with alternative crop technologies that have proved to be successful in several regions for sustainable utilization of existing inputs and enhancing productivity.

- **Availability of tree species and agroforestry systems that use limited water more efficiently and sequester carbon below ground**

  - Screening and identification of appropriate species (fruit, timber, fodder, etc.) with economic value for agroforestry systems including species, provenance, and clonal trials in a range of different environments and cropping systems.

- Regeneration and management of parklands by incorporation of selected multipurpose trees for fodder, fruits, and living fences (hedges).
- Role of parkland trees and agroforestry systems in nutrient cycling/pumping, for enhancing water-use efficiency and control of wind and water erosion, including the assessment of the distribution of tree roots, soil moisture, organic matter, carbon and nitrate from the surface layers down to the water table.
- Quantification of the competition between trees and crops for light, water, nutrients, and modelling of the hydrological and nutrient limitations to forestry and agroforestry in semi-arid lands.

- **Strategies for enhancing ecosystem resilience through optimization of biodiversity**

In the desert margins of sub-Saharan Africa, over-exploitation and habitat degradation is a major cause of the loss of biodiversity. It is therefore important to conserve and enhance biodiversity through promotion of appropriate natural resource management techniques and participatory approaches. Proposed activities in this area are:

- Conservation of trees, shrubs, and other plant species and their microsymbionts threatened by over-utilization and habitat degradation through germplasm collection, indigenous knowledge selection, vegetative propagation, and clonal selection.
- Promotion of strategies for enhancing biodiversity and ecosystem resilience, e.g., introduce alternative crop and tree species.
- Promotion of range management practices that improve the carrying capacities of the rangeland and maintain plant species diversity.
- Development of participatory approaches to vegetation management and biodiversity conservation.
- Evaluation and development of integrated mixed farming systems, e.g., game and domestic livestock.

Specific Objective 4— Designing policies, programs, and institutional options

In addition to the technological issues discussed in the preceeding section, farmer and community incentives and the preservation and depletion of natural resources are influenced by a variety of social, economic and political factors. These include micro- and macroeconomic policies, legal rules of access to resources, direct public investment, institutional mechanisms put into place to support these policies, and access to technical information. A major challenge for public policy in the drylands is to establish conditions which will encourage large-scale transition to more intensive and environmentally sustainable resource management and production systems. This section of the DMI addresses these issues with the following objective:

> *To evaluate the impact and assist in the design of policies, programs, and institutional options that influence the incentives for farmers and communities to adopt improved resource management practices.*

This objective has four primary outputs:

- **Improved understanding of the social, economic, and policy factors which affect land degradation**

This addresses the social, economic, and policy conditions that lead to degradation of natural resources at the household, community, catchment, and regional levels. Proposed activities include:

- Examination of the dynamics of household and community responses to resource degradation under fragile land conditions, and identification of successful patterns of resource investment through technical, policy, and institutional innovation.
- Study of the socioeconomic linkages of land use in the upper and lower slopes along a toposequence to design appropriate policy interventions to promote sustainable land management practices in the drier areas.

- Examination of the dynamics of population migration which can cause land degradation and deforestation of communal areas.
- Comparative studies of regional land use policy to identify and analyze points of synergy/conflict with a view to adopt a synergistic regional approach.
- Evaluation of the role of women in natural resource management and development of policies to enhance their role in sustainable natural resource management strategies.

- **Guidelines for policy and institutional changes to improve incentives for the adoption of sustainable technologies and natural resource management practices**

This section reviews existing policy and institutional arrangements and their effect on natural resource management and land degradation, and identifies institutional and policy measures at the local and national levels to promote more sustainable use of resources. Proposed activities include:

- Analysis of the role and impact of local and national policies on the incentives for sustainable, resource use in arable cropping, agroforestry, and livestock husbandry; including the effects of sectoral, public investment, credit, trade and exchange rate policies; the pricing and marketing of agricultural inputs and outputs; and drought relief measures.
- Analysis of the role and impact of institutional options on the incentives for households and communities to manage crop, tree and animal resources in sustainable ways; including the impact of property rights, tenure systems, land use regulation and legislation and the role and effectiveness of local government and community management initiatives.
- Analysis of contractual relationships affecting livestock mobility and of factors that lead to conflicts of natural resources.
- Creating an environment to adoption improved plant nutrient technologies through programs that promote a more efficient procurement, distribution, and marketing of inputs and programs that enhance effective utilization of farm outputs through the development of microenterprises.
- Cost/benefit analyses for natural resource auditing and impact assessment.

- **Methodologies and models to assess the impact of policies on natural resource management**

This section is concerned with the development of methods and models that could assist local communities, planners, and policy makers to assess the effects of different climate, economic and policy scenarios on natural resources and environmental degradation. Planned activities include:

- Development of combined hydrological and socioeconomic models to study the feedback mechanisms between climate, agricultural development and land degradation.
- Development of new methodologies and models to enhance the ability of policy makers and local communities to monitor and evaluate effects of policies and programs on food security, human welfare, economic activity, and natural resource conditions.

- **Priorities for a long-term growth strategy for the drylands, including improved market opportunities for the products of drylands.**

One way of improving the number of options available to resource-poor farmers is to expand the opportunities they have for traditional and new products. This section looks at the possibilities for improving the markets for a range of dryland products. Activities include:

- Analysis of the impact of improved technologies and resource management practices on farm households—including direct impacts on their own farm productivity and indirect impacts arising through changes in off-farm employment, non-farm earnings, and food prices.
- Increasing the local awareness and use of the indigenous dryland products, processing, and enhanced marketing strategies.
- Developing markets for nontimber forest products and other dryland products.

- Examining ways to add value to the outputs from the farm in order to increase the farmers' income (fattening livestock, dairy etc.).

Specific Objective 5—Formulating drought management strategies

The degree of resource degradation is often highest during drought, when pasture growth and establishment is more limited and arable crop yields are depressed. The combined pressure for food and fodder during periods of rainfall shortage is a major factor in land degradation. It is therefore important to formulate drought management strategies which minimize land degradation. This section of the DMI focuses on this issue with the following objective:

To promote more efficient drought management polices and strategies.

This objective has three primary outputs:

- **Knowledge of historical response to agricultural drought and policies to plan and prepare for future droughts**

Droughts are an inherent and recurring feature of drylands, and many examples exist where the national and community response has succeeded or failed in its response to a particular drought. Substantial lessons can be learned from past experiences and the aim is to assess this historical information in order to develop better strategies for responding to future droughts. Activities in this section include:

- Identification of strategies adopted by farmers and rural communities for coping with drought such as herd mobility, livestock sales/loans, slaughter, etc., and its implications for crop and animal productivity, capital losses, and biodiversity.
- Development of policies and institutional arrangements to promote technologies and resource management practices that help rural households to better cope with droughts, including the implementation of pilot schemes to verify their effectiveness.
- Development of policies to encourage efficient production and use of available food resources (e.g., reduction of food losses) and diversification of the food base through popularization of other foods using improved processing and packaging.

- **Availability of crop and tree varieties tolerant of drought with acceptable functional and food properties**

Dryland plants have developed elaborate mechanisms for coping with drought and there is a wide range of physiological attributes and plant combinations suitable for drylands. This section deals with the identification of key characteristics that influence drought resistance and the selection of species and farming systems which are best adapted to drought. Activities include:

- Evaluation of traditional and nontraditional genotypes of crops, fodder, and fuel wood species to identify cultivars with high yield and tolerant of moisture stress and salinity, and testing their performance under communal farmer management.
- Development of drought resistance tests for selected multipurpose trees for integration into different agroforestry technologies, including assessment for improved water-use with and without mycorrhizas.
- Determination of the biochemical and physiological characters that influence drought resistance at different stages of plant growth.
- Evaluation of existing germplasm for identification of sources tolerant of drought and grazing.
- Evaluation and development of alternative crop management strategies such as farming response to minimize effects of drought.

- **Availability of modern and traditional early-warning systems and biophysical models relevant to climate in the areas susceptible to drought**

Early warning of an impending drought is crucial to the ability to instigate a suitable response. The network for collecting drought information in dryland regions is poor and the models needed to predict

appropriate responses require further development. This section covers drought monitoring enhancements and associated natural resource management models.

- Strengthening of drought monitoring and information systems to facilitate decision-making.
- Development of dryland catchment models for use in decision support systems under different climatic conditions.
- Development of early-warning systems for local populations.
- Coordinated drought and pest management at the regional level (e.g., armyworm, locusts, etc.).
- Development of infrastructure, resources, and procedures to manage drought disasters and linkage to existing knowledge base.

Specific Objective 6—Enhancing institutional capacities

The overall success of efforts to combat land degradation in sub-Saharan Africa depends on a long-term sustained effort by all agencies. Given the lack of appropriate personnel and facilities to design and effectively implement natural resource management strategies, it is important to enhance institutional capacities. This section addresses the following objective:

To enhance the institutional capacity of countries participating in the DMI to undertake land degradation research and the extension of improved technologies, with particular regard to multi-disciplinary and participative socioeconomic research.

This objective has four major outputs:

- **Availability of opportunities for institutional and human resource capacity building**

Although land degradation is recognized as a major problem, many of the national programs are not in a position to carefully monitor climate, soil, vegetation, and livestock because of lack of basic tools. Standardization of methodologies and ensuring data quality is necessary in the three DMI regions. Emphasis will be placed on enhancing the ability of national programs to participate in the planning and execution of dryland research. Proposed activities to achieve this output include:

- Reinforcement of national capacities, including equipment, communication, human resources, infrastructure, etc.
- Evaluation of and incentives to attract and retain qualified research and development staff.

- **Availability of training opportunities and training manuals on improved land management practices for farmers, technicians, and scientists**

Sustained training at all levels is essential to ensure that the results of research are successfully transferred and implemented at the farm level. This requires an analysis of training needs and the design of appropriate training strategies. The following activities are proposed to address this issue:

- Undertaking an analysis of existing training programs, qualifications, and requirements of field personnel and managers in the region. Developing appropriate inter- and intra-regional training programs which are designed to address any identified areas.
- Long-term, degree-oriented training (MSc and PhD) and short-term courses in agriculture, agroforestry, and natural resource management.
- Short-term training on natural resource management issues for the staff of the National Agricultural Research and Extension Systems (NARES) and policy-makers.
- Training of technicians and producers in natural resource management, including NGO personnel.

- **Effective partnership of national, regional, and international institutions to create a continuum from strategic, applied, and adaptive research to extension and adoption of technologies for arresting land degradation**

International cooperation and partnership is essential to implement the Desertification Convention. Programs and priorities should be worked out jointly to avoid duplication and ensure coordination. This

is a complex process which requires the participation of all the key actors—donors, regional organizations, national programs, NGOs, and the local population. The DMI emphasizes effective partnership through the following activities:

- Developing partnerships through the reinforcement of producer capacities and organization of Regional Technical Committees and research partner forums.
- Promoting global partnerships through inter- and intra-Regional workshops, seminars, and conferences.
- Developing participatory approaches to improve the extension delivery system.
- Reinforcing national and Regional centers of excellence in land degradation research.
- Developing linkages with regional telematic networks.

- **Harmonization and rationalization of the land degradation programs of relevant national, regional, and international institutions to ensure complementary and optimal use of the available capacity**

Effective implementation of land degradation programs at the farm level requires harmonization of programs of relevant organizations at different levels. As the available resources are limited, efforts should be made to ensure complementarity and rationalization of activities. The following activities are proposed to achieve this output:

- Development of consultation, conflict resolution, and information structures at national, regional, and sub-Regional levels.
- Implementation of arbitration councils for conflict resolution at the grassroots level.
- Strengthening governmental and nongovernmental agencies for effective mediation between researchers and farmers to facilitate the exchange and adoption of technologies.
- Promotion of demonstration strategies managed by NGOs and producers showing the restoration, conservation, and protection of lands against soil degradation.

Specific Objective 7—Exchanging technologies and information

The DMI brings together national, regional, and international research organizations, NGOs, and farmer communities in three regions of sub-Saharan Africa. Substantial progress can be made through an effective mechanism of exchanging technologies and information on an efficient and regular basis. This requires the development of an inter- and intra-Regional strategy. This section focuses on the following objective:

To facilitate the exchange of technologies and information among farmers, communities, scientists, development practitioners, and policy-makers.

There are three major outputs in this area:

- **Community-based groups involving local farmers, pastoralists, and extension officers focused on improving land management practices**

Effective uptake of improved land management practices is dependent on local farmers understanding and being willing to take on the recommended technologies. This section deals with mechanisms for improving the communication of new ideas to local communities.

- Evaluation of the existing interface between experts and rural communities and development of effective mechanisms.
- Constitution of working groups, especially women, and promotion of effective linkages between researchers and agencies within the region.
- Identification and coordination of pilot activities with community-based groups.
- Formulation of strategies for protecting indigenous technology and systems to facilitate free exchange of information.

- **Availability of information, including training manuals, workshops, conferences, and symposia aimed at various audiences (policy-makers, scientists, development practitioners, farmers, NGOs) which contribute to a better understanding of the processes of land degradation and means of arresting it**

The DMI activities will generate information on various aspects of natural resource management. Its value will be enhanced through dissemination to researchers, policy-makers, extension and farming communities, and womens' groups.

  - Development of didactic manuals in national and official languages.
  - Editing and production of scientific publications, multimedia outputs, and organization of local, national, and sub-Regional workshops and international meetings.
  - Developing tools for community self-evaluation of national resource management (NRM) problems, progress, and policy effects for use by communities in planning local action.
  - Establishment and maintenance of a database network for natural resource management information (soil, climate, plants, production systems, methods, etc.) and policy analysis to exchange results and methodologies.
  - Participatory rural appraisal procedures to get local issues onto the prioritized research agenda.
  - Exchange of technologies among different regions, i.e., Western Africa, Southern Africa, Eastern Africa, and Asia.

- **Natural resource councils at national and regional levels involving representatives from ministries and other relevant government agencies, and officials from implementing agencies including the private sector, to create an enabling policy environment for the generation, exchange, and adoption of technologies for arresting land degradation**

  - Establishment of national and sub-regional technical committees which are properly coordinated with existing national and regional natural resource management committee structures.

Operational Sites and Desertification Database

The strategy proposed for choosing sites within the DMI is to focus most of the effort on a small number of well-monitored sites where the work of the soil, plant, and animal scientists can be integrated with the studies performed by the socioeconomists, policy, and institutional analysts. These sites will also act as sub-regional 'field laboratories' where the necessary interactions can be established between researchers, development workers, and farmers. It is the partnerships formed by this integration of disciplines and combination of research and development which is the strength of the DMI. The strategy of focusing on a few sites of this kind will also avoid duplication of effort and will give a critical mass of work which can achieve the progress necessary to tackle the complex problem of land degradation.

It is recognized that there are already some areas in the DMI countries where there has been significant relevant study and assessment of sites for their suitability for studying land degradation and natural resource management. The DMI will capitalise on this by linking its activities to build on what has already been done. There are a number of candidate sites; however, the final selection will be resolved at the National Workshops. To obtain standardization across sub-Regions, guiding principles were recommended by the InSc:

- Build on areas where substantial relevant studies already exist.
- Work in areas where there are interactions between facets of natural resource management — land use, farmers' fields, pastures, trees, etc.
- Use areas which are physically and geographically well defined (e.g., watersheds), where most of the key natural resource and socioeconomic phenomena occur.
- Select areas which are accessible and have the basic facilities to allow the efficient conduct of multi-disciplinary research and development activities.

These 'partnership' sites are seen as places where the systematic and standardized monitoring of land degradation can be carried out in parallel with the establishment of rehabilitation areas which capitalize

on the improved natural resource management techniques. An important role of the DMI is helping to create standardized monitoring techniques and sites which demonstrate the options and utility of improved resource management. These DMI sites will build on pre-existing work, integrate disciplines and should be a major asset to the participating countries by enhancing the indigenous capacity to improve natural resource management and combat desertification.

Increased availability of data on land degradation and natural resources is another major aim of the DMI. Institutions in each of the three sub-Regions will undertake the task of setting up a database to combine key information already available with new data collected during the DMI. Several activities are concerned with the collection and analysis of natural resource management information, and the database will serve as a focal point to compile this information. Modern computer networks are seen as important tools for managing and disseminating these data, and significant effort will be put into setting up these sub-Regional natural resource information networks.

Organization and Management of the DMI

At the International Planning Workshop and in the three sub-Regional Workshops, the governing mechanism for the DMI was discussed and the following consensus was reached:

- The DMI must be organized with structures and decision-making and monitoring mechanisms that are efficient and operational.
- These structures and mechanisms should be simple and linked with the existing coordination structures.
- The mechanism should be organized according to four distinct and complementary levels:
  - national
  - sub-Regional (Eastern, Southern, and Western Africa)
  - Regional (sub-Saharan Africa)
  - global (e.g., UNEP, Systemwide Soil, Water, and Nutrient Management Research Initiative (SSWNMRI), Systemwide Livestock Initiative (SLI), CCD).
- Links and collaborative processes should be established with thematic sub-Regional initiatives and institutions.

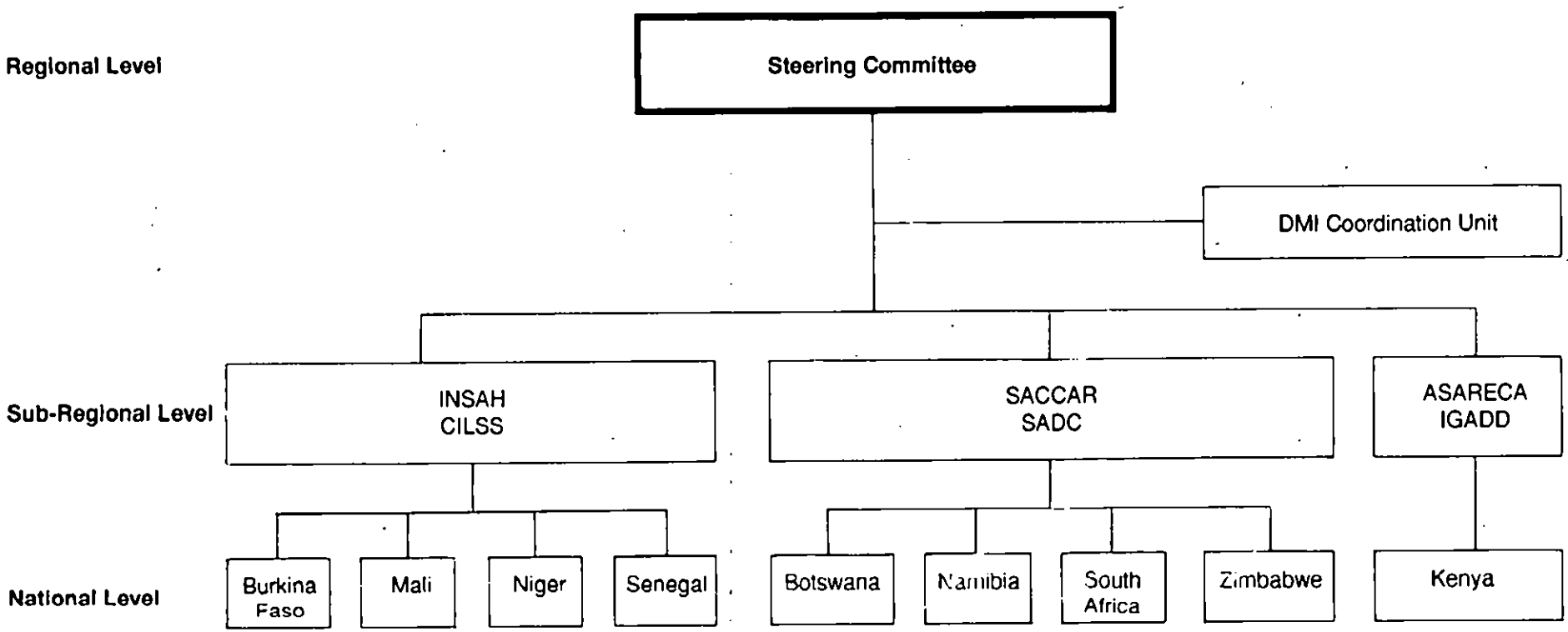
An organogram representing the organization and management structure for the DMI is shown in Figure 5.

National level

As explained earlier, NCCs, established during the National Workshops will identify and prioritize their research problems in collaboration with all partners in the Initiative, including research and extension institutions, local NGOs and universities. A convenor will be designated by each NCC in the Consortium to coordinate the planned national program in the DMI, allocate research tasks, and share information and resources across the national institutions.

Sub-Regional level

At the sub-Regional level, coordination of the activities will be carried out by INSAH/CILSS (Western Africa), SACCAR (Southern Africa) and IGADD and ASARECA (Eastern Africa). Among the principal activities at this level are the organization of sub-Regional Training Workshops and establishment of Natural Resource Information Centers.



Each National Level Committee will include representatives from

- NARS
- Universities
- NGOs
- Extension Services
- National Environment Departments
- International Institutes
- Advanced Research Organizations (AROs)

Figure 5 Organization and management structure for the DMI

Regional level

A Steering Committee comprised of representatives from the participating national, regional, and international institutions, NGOs, and UNEP, and chaired by ICRISAT, provides the overall policy guidance for the Initiative. The Steering Committee will meet at least twice a year to finalize work plans and budgets for the coming year, to review progress, publications and reports, and approve workshop and training activities.

Global coordination

The overall coordination and responsibility for the project will be carried out by a Global Coordinator, to ensure linkages among the participating NARS, international and regional institutions, donor organizations and stakeholders. The Coordinator will plan and manage the work of the Coordination Unit, located at the ICRISAT Sahelian Center in Niger and will be responsible to the Steering Committee and act as its ex-officio Member-Secretary. The Coordinator will organize meetings, interact with the NCCs and regional organizations to ensure that the research results are effectively synthesized and reported, review the research, report to the Steering Committee and assist them in their work.

Linkages with other Initiatives and Programs

Global initiatives

There are Systemwide Initiatives of the CGIAR that have been designed to address specific issues affecting natural resource management within the DMI ecoregion. SLI and SSWNMRI are two such Systemwide Initiatives. The DMI will provide the framework within which these Initiatives will operate to ensure that:

- Duplication of activities is avoided.
- The necessary disciplinary mix to address the objective of natural resource management is brought together.
- Joint workplans are established and carried out based on priorities assessed by the ecoregional program.
- Implementation of activities is collaborative and participatory and is based on comparative advantage of the different partners.

Global programs

IGBP/GCTE

The ability of societies to improve, adopt, and benefit from rapid environmental change requires knowledge of the responses of terrestrial ecosystems to the forces of global change. To respond to this major research challenge, the International Geosphere Biosphere Programme (IGBP) has established a core project on Global Change in Terrestrial Ecosystems (GCTE). Establishment of IGBP transects for global change research was initiated by GCTE. Each transect has a coherent set of research sites along a gradient of a major global change (e.g., precipitation, land-use intensity, etc.). One of these transects, called Savannas in the Long Term (SALT) , is in Western Africa and is one of the most advanced of the GCTE transects. It covers 1000 km, and extends from Niger to Côte d'Ivorie.

WCRP/GEWEX

The World Climate Research Programme (WCRP) has established a program of research to examine the ways in which large-scale changes on the land surface can influence climate. This program,

called the Global Energy and Water Balance Experiments (GEWEX), has promoted a number of large-scale land surface-atmosphere experiments in different global biomes. One of the biggest of these experiments was HAPEX-Sahel, the Hydrological Atmospheric Pilot Experiment in the Sahel, which was carried out in Niger in 1992. This experiment generated a large amount of data which is currently being used to characterize dryland vegetation and to develop a better means of representing it in General Circulation Models which can be used to study the links between land degradation and climate. The DMI is well connected with these global programs as its members are active in both the GCTE SALT transect and HAPEX-Sahel.

Interim Arrangements for the DMI

The International Planning Workshop for the DMI adopted the principle of the InSC to continue the planning process; prepare a more detailed document for submission to donors; organize regular discussion of some specific and general issues; and implement an effective consultation process between relevant countries and institutions. Membership of the InSC includes representatives from the participating national, regional, and international institutions, NGOs, and UNEP.

At the first meeting of the InSC which was held at the ICRISAT Sahelian Center from 14 to 15 June 1995, the following terms of reference were adopted:

- To provide policy guidance and direction for the Initiative until the initiation phase of the DMI project.
- To appoint an Interim Coordinator who will continue the planning process in consultation with the InSC and stimulate regional cooperation through interaction with the appropriate national, regional, and international research agencies and NGOs.
- To review and approve the schedule of activities leading to the preparation of the final project proposal.
- To constitute working groups to facilitate further discussion among the national, regional, and international partners on the activities and workplans for inclusion in the final project document and provide guiding principles to the working groups.
- To review and approve the final project document for submission to appropriate donor agencies.
- To clarify the relation of DMI to other emerging ecoregional initiatives.

The InSc met twice during 1995 to discuss a range of policy matters and to review a draft version of the proposal for the DMI. Dr F. Lompo from Burkina Faso was appointed Interim Coordinator for the DMI for a period of six months, from July–December 1995.

Funding Arrangements

Considering the need for a long-term perspective in combatting land degradation, the DMI Consortium partners propose a 10-year project with two phases of 5 years each.

Funding for the first 5-year phase, estimated at US$ 5 000 000 per annum, will be requested from the CGIAR donors and the GEF on a cost-sharing basis. A preliminary breakdown of how this annual budget will be shared between the national, sub-Regional, international, and Advanced Research Organizations is shown in Table 4a. The detailed composition of these budgets will be discussed at the national workshops. However, an initial assessment shows that a total of 21 organizations are involved in nine different countries. It also indicates that 41% of the total research budget (total–coordination costs) will go to national and sub-Regional organizations. International institutes account for 38% of the research budget, with Advanced Research Organizations receiving 15% of the budget (Table 4a).

Table 4b shows the provisional allocation of the total research budget by specific objective and the phasing of the funding during the 5 years of the project. Some activities, such as the assessment of current dryland management practices (specific objective 2), and understanding land degradation (specific objective 1), require more funds in their initial years than in later phases. Follow-up work on improving natural resource management (specific objective 3) and formulation of drought management

Interim Steering Committee of the DMI

The following representatives were nominated by the Heads of their Institutions:

CNRST, Ouagadougou, Burkina Faso
(representing Niger, Mali, and Burkina Faso)

Kenya Agricultural Research Institute, Nairobi, Kenya

Agricultural Research Department, Gaborone, Botswana
(representing Namibia and Botswana)

Institut du Sahel (INSAH)/CILSS, Bamako, Mali

IGADD, Djibouti, Djibouti

SACCAR, Gaborone, Botswana

International Association Six-S, Ouagadougou, Burkina Faso

Canadian Hunger Foundation, Ottawa, Canada

ENDA-Zimbabwe, Harare, Zimbabwe

Dryland Ecosystems and Desertification Control Program Activity Centre, UNEP, Nairobi, Kenya

ICRISAT, Patancheru, India (Convenor)

ICRAF, Nairobi, Kenya

ILRI, Nairobi, Kenya

IFPRI, Washington DC, USA

IFDC, Muscle Shoals, Alabama, USA
(representing IFDC, ICARDA, and IBSRAM)

ORSTOM, Paris, France
(representing IH, ITE, and CIRAD)

Table 4a. Preliminary DMI annual budget (US$ thousands) proposed at the sub-Regional Workshops by national and sub-Regional Organizations, IARCs, and AROs.

Institutional groups	Western Africa	Southern Africa	Eastern Africa	Global	Total
National organizations	710	710	180		1600
Sub-Regional organizations	100	100	20		220
International Agricultural Research Centers	970	350	380		1700
Advanced Research Organizations	490	70	120		680
Regional Information Networks	100	100	100		300
Coordination				500	500
Total	2370	1330	800	500	5000

Table 4b. Percentage allocation of total research budget (total–coordination costs) by specific objective and phasing of the funding during the 5 years of the project.

Specific objective	1996 (%)	1997 (%)	1998 (%)	1999 (%)	2000 (%)	Total (%)
1	6	6	4.5	2	1.5	20
2	4	4	3	2	2	15
3	1.5	3	4.5	8	8	25
4	3	3	3	3	3	15
5	0.5	0.5	1	1.5	1.5	5
6	4	2	2	1	1	10
7	1	1.5	2	2.5	3	10
Total	20	20	20	20	20	100

strategies (specific objective 5) starts at a lower level of funding in the initial stages, but builds up during the project as the information required to achieve these objectives comes on line. About 65% of the total research budget is to be spent on research and development and 35% on policy, enhancing national institutional capacity, and exchanging technologies and information.

Further co-financing by the partner institutions will be discussed at the national workshops. The commitments sought from each institution will be mainly in terms of staff costs of scientists participating in the DMI. It is expected that the personnel costs from national and sub-Regional organizations will form a substantial contribution to the DMI. In order to enable NARS, NGOs, and sub-Regional organizations to achieve the global DMI objectives, it is proposed to request funding from the GEF for the additional costs.

Monitoring and Reporting

The research outputs of the project will be monitored annually through the individual reports presented by the collaborating institutions at the Annual Technical Meetings and by the combined Annual Project Reports.

At each Annual Meeting, the participating institutions will present their workplans and budgets for the following year. The Steering Committee will evaluate the documents for consistency with the goals and objectives of the DMI and will approve the annual budgets. The entire Initiative will be subject to an external, mid-term review to obtain an independent assessment of progress and recommendations for completion of the Initiative.

References

Baier, W. 1994. Designing natural resource management options to combat desertification. Draft Report. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution).

Charney, J.G. 1975. Dynamics of deserts and drought in the Sahel. Quarterly Journal of Royal Meteorological Society 101:193-202.

Christol, R. 1966. Mesure de l'érosion et du ruissellement en Haute Volta. Oléagineux 21:531-534.

Food and Agriculture Organization (FAO). 1995. FAO Production Year Book 1994. Rome, Italy: FAO.

Glantz, M.H., Katz, R.W., and Nicholls, N. (eds.) 1991. Teleconnections linking worldwide climate anomalies. Cambridge, UK: Cambridge University Press.

Hare, F.K., and Ogallo, L.A. 1993. Climate variations, drought and desertification. Geneva, Switzerland: World Meteorological Organization.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 1994. Sustainable natural resource management options to arrest land degradation in the desert margins of sub-Saharan Africa: a proposal for a Systemwide Ecoregional Initiative. Patancheru 502 324, Andhra Pradesh, India: ICRISAT (Limited distribution).

International Convention to Combat Desertification (INCD). 1994. International Convention to Combat Desertification. Final text of the Convention. New York, USA: United Nations Department of Public Information.

Mokwunye, A.U., and Vlek, P.L.G. 1986. Management of nitrogen and phosphorus fertilizers in sub-Saharan Africa: Development in Plant and Soil Sciences, Vol. 24. Dordrecht, Netherlands: Martinus Nijhoff Publications, 374 pp.

Odingo, R.S. (ed.) 1991. Desertification revisited: proceedings of an Ad hoc Consultative Meeting on the Assessment of Desertification, Feb 1990, Nairobi, Kenya. Nairobi, Kenya: United Nations Environment Programme.

Ottichilo, W.K. (ed.) 1991. A methodology for the assessment and mapping of desertification - report of the Kenya pilot study. Pages 125-180 *in* Desertification revisited: proceedings of an Ad hoc Consultative Meeting on the Assessment of Desertification, Feb 1990, Nairobi, Kenya (Odingo, R.S., ed.). Nairobi, Kenya: United Nations Environment Programme.

Sivakumar, M.V.K., and Wills, J.B (compilers). 1995a. Papers presented at the International Planning Workshop for a Desert Margins Initiative, 23-26 Jan 1995, Nairobi, Kenya. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 298 pp.

Sivakumar, M.V.K., and Wills, J.B (eds). 1995b. Combatting land degradation in sub-Saharan Africa: summary proceedings of the International Planning Workshop for a Desert Margins Initiative, 23-26 Jan 1995, Nairobi, Kenya. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 49 pp.

Sivakumar, M.V.K., Lompo, F., and Harmsen, K. 1995. Desert Margins Initiative: summary proceedings of the sub-Regional Workshops, Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Toulmin, C. 1992. From 'Combatting desertification' to improving natural resource management–a significant advance? London, UK: International Institute for Environment and Development. 26 pp. (Limited distribution).

The UN Conference on Environment and Development (UNCED). 1992. Earth Summit '92. The UN Conference on Environment and Development, Rio de Janeiro. New York, USA: United Nations Department of Public Information.

United Nations Environment Programme (UNEP). 1992. Status of desertification and implementation of the United Nations Plan of Action to Combat Desertification. Report of the Executive Director. Nairobi, Kenya: United Nations Environment Programme.

Wallace, J.S. 1994 Hydrological processes and dryland degradation. World Meteorological Organization (WMO) Bulletin 10:23-25.

Warren, A., and Khogali, M. 1992. Assessment of desertification and drought in the Sudano-Sahelian region 1985–91. New York, USA: United Nations Sudano-Sahelian Office (UNSO). 102 pp.

Williams, M.A.J., and Balling, R.C. 1994. Interactions of desertification and climate. Geneva, Switzerland. 230 pp.

Xue, Y., Liou, K-N., and Kasahara, A., 1990. Investigation of the biogeophysical feedback on the African climate using a two-dimensional model. Journal of Climate 3:337–352.

Acronyms and Abbreviations

ACMAD	African Centre of Meteorological Applications for Development
AGRHYMET	Centre régional de formation et d'application en agrométéorologie et hydrologie opérationnelle
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CAZRI	Central Arid Zone Research Institute
CCD	Convention to Combat Desertification
CGIAR	Consultative Group on International Agricultural Research
CILSS	Comité permanent inter-états de lutte contre la sécheresse dans le Sahel
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CNRST	Centre national de la recherche scientifique et technologique
DEDC-PAC	Dryland Ecosystems and Desertification Control Programme Activity Centre
DMI	Desert Margins Initiative
ENDA	Environment and Development Activities
FFA	Framework for Action
GCM	General Circulation Model
GCTE	Global Change in Terrestrial Ecosystems
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEWEX	Global Energy and Water Balance Experiments
GLASOD	Global Assessment of Soil Degradation
GNP	Gross National Product
HAPEX-Sahel	Hydrological Atmospheric Pilot Experiment in the Sahel
IAWGD	Interagency Working Group on Desertification
IARC	International Agricultural Research Center
IBSRAM	International Board for Soil Research and Management
ICARDA	International Center for Agricultural Research in the Dry Areas
ICASALS	International Center for Arid and Semi-Arid Land Studies
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IER	Institut d'économie rurale
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IGADD	Intergovernmental Authority on Drought and Development
IGBP	International Geosphere Biosphere Programme
IH	Institute of Hydrology (UK)
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INCD	Intergovernmental Negotiating Committee to Combat Desertification
INERA	Institut national d'études et de recherches agricoles
INRAN	Institut national de recherches agronomiques du Niger
INSAH	Institut du Sahel
InSC	Interim Steering Committee
IPCC	Inter-governmental Panel on Climate Change
IPGRI	International Plant Genetic Resources Institute
ISC	ICRISAT Sahelian Center
ISNAR	International Service for National Agricultural Research
ISRA	Institut sénégalais de recherche agricole
ISRIC	International Soil Reference and Information Centre
ITE	Institute of Terrestrial Ecology
KARI	Kenya Agricultural Research Institute

KEFRI	Kenya Forestry Research Institute
NARS	national agricultural research systems
NARES	National Agricultural Research and Extension Systems
NCC	National Coordination Committee
NGO	non-governmental organization
NRM	natural resource management
ORSTOM	Institut français de recherche scientifque pour le développement en coopération
PACD	Plan of Action to Combat Desertification
SACCAR	Southern African Centre for Cooperation in Agricultural Research
SADC	Southern African Development Community
SADCC	Southern African Development Coordination Conference
SALWA	Semi-Arid Lowlands of Western Africa
SALT	Savannas in the long-term
SAT	semi-arid tropics
SPAAR	Special Program for African Agricultural Research
SSWNMRI	Systemwide Soil, Water and Nutrient Management Research Initiative
TAC	Technical Advisory Committee
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCOD	United Nations Conference on Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNSO	United Nations Sudano-Sahelian Office
WANA	West Asia North Africa
WCRP	World Climate Research Programme
WMO	World Meteorological Organization

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