Land Degradation: A Global and Regional Problem

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Today, about 1.9 billion hectares of land worldwide (an area approximately the size of Canada and the USA) are affected by land degradation (United Nations, 1997). This year, as in previous years, about 21 million hectares of land will become so degraded that crop production becomes uneconomic and about 6 million hectares of land will be irreversibly lost for production (von Baratta, 1998; UNEP, 1986). These figures have serious implications for the future of humanity. The livelihoods of more than 900 million people in some 100 countries are now directly and adversely affected by land degradation (United Nations, 1994). Unless the current rate of land degradation is slowed and reversed, the food security of humanity will be threatened and the ability of poor nations to increase their wealth through improved productivity will be impeded. Land degradation can be observed in all agro-climatic regions on all continents. Although climatic conditions, such as drought and floods, contribute to degradation, the main causes are human activities. Land degradation is a local problem in a vast number of locations, but it has cumulative effects at regional and global scales. The countries of the developing world, and particularly those in the arid and semi-arid zones, are the most seriously affected (UNEP, 1986).

Land degradation is a universal problem. We must not be misled into thinking it is restricted to agricultural land or agricultural livelihoods, although it is in these areas that the effects of land degradation are immediately apparent and most dramatic. In the developing world, land degradation is a symptom of under-development. It results from a combination of social and economic factors, such as poverty and inequitable distribution of the land resources, inappropriate land use systems and farming methods. In the dry areas, these factors are exacerbated by climate and the fragility of ecosystems (UNEP, 1986). Because agriculture in the poorer countries is the principal employer of labour and generator of income, the effects of land degradation are often disastrous and lead to famine and political turmoil (UNEP, 1986).

Food security

Food security is directly related to the ability of land to support its populations (Eswaran and Kapur, 1997). Should land degradation continue at the current rate, many regions will never achieve food security. Current estimates predict that food production in the developing world will have to double in the next 30 years to meet the needs of growing populations. Much of this population expansion is urban (UNSO, 1997), not least because declining quality and productivity of the land is driving migration to cities upwards in almost every country of the world. The increased demand for food in both rural regions and urban centers cannot be met by expanding the agricultural area because – in most cases – the remaining land is not suitable for sustainable crop production (Dregne, 1997). At the national level, intensification is often the only viable solution for meeting food demand, and the best land on which to intensify production is inevitably the highest quality land.

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This intensification can increase food production in the higher potential areas, simultaneously strengthening the regional and national economies and providing more food on a regional or national scale. However, it is the land users in the marginal areas who are most seriously affected by land degradation. The opportunity for intensification on their land is low. This often leaves the users and owners of the more marginal land with no prospect of developing their limited land resources, and therefore frequently dependent on government subsidies. Such policies condemn the people living in low potential areas to continued reliance on outside funds and to a low standard of living (Dregne, 1997). This problem of food security for the future is of prime importance. It is a challenge, even for the most favorable and productive agricultural areas. If land degradation, especially in marginal areas, is not stopped – and, if possible, reversed – food yields in many parts of the world will decline (United Nations, 1997).

The nature of land degradation

An examination of the nature of land degradation is required. In general terms, land degradation is the decline of the natural land resources, commonly caused by improper use of the land (Bergsma et al., 1996). It is also defined as the reduction or loss of the biological or economic productivity and complexity of land, resulting from human activities (United Nations, 1994). The more degradation is allowed to advance, the more difficult and costly it gets to restore the land to its original state. If the land becomes irreversibly degraded, its potential for agricultural production is permanently lowered or even destroyed (Dregne, 1995; Middleton and Thomas, 1997). Land degradation encompasses ***soil degradation*** and the deterioration or loss of ***vegetation*** and ***landscape functions***. These components do not act separately, but they are intrinsically linked to each other and may act as mutual supporters and accelerators of the degradation process.

Soil degradation has physical, chemical and biological dimensions (Lal, 1998). The breakdown of soil structure affects the buffering, filtering, and moisture-retaining properties of soils. This breakdown may be caused by factors such as inappropriate tillage practices (Unger, 1991) and excessive trampling by grazing animals. Lack of replenishment of plant nutrients and organic matter leads to soil fertility decline and decreased biomass production (FAO, 1991). Yields will decrease and the protective groundcover on cropland and rangeland will be reduced. On bare, unprotected soils, the processes of soil erosion remove large quantities of fertile topsoil (Batjes, 1996; Mainguet and Da Silva, 1998). In sloping areas, water-induced erosion processes dominate, while on flatter land and in drier environments, wind-induced erosion can be significant. Soil removed by erosion processes is permanently lost, as are the nutrients and organic matter that are essential components of soil fertility. The increase in suspended matter in the atmosphere from wind erosion enhances greenhouse effects thereby contributing to global warming (von Baratta, 1998). In irrigated areas, inappropriate irrigation and drainage practices and the use of saline water lead to soil salinization. Without appropriate preventive measures, salt-sensitive crops will disappear and be replaced by increasingly salt-tolerant plant species until the land is rendered unsuitable for any useful crop production (Williams and Balling, 1996).

Prolonged overgrazing of rangeland and of crop residues in harvested fields weakens and degrades the ***vegetation*** and results in the depletion of plant diversity, and reduced biomass

production (Herbel and Pieper, 1991). The latter in turn leads to reduced soil organic matter and the deterioration of the soil structure.

The most significant ***landscape function*** affected by land degradation is the hydrologic balance of catchments. Unfavorable soil-surface characteristics of degraded lands and a lack of adequate plant cover lead to reduced surface retention and infiltration, and to higher surface runoff. This results not only in reduced soil moisture content in the soil profile, but also increased rates of soil erosion (Lal, 1990). Especially in dry areas, reduced available soil moisture in turn negatively affects plant growth and thus further reduces biomass production and protective soil cover.

Depending on climate, landforms and land use, land degradation takes different forms and manifestations in different regions and land-use systems. It is the result of complex causes and processes, and oversimplification of the environmental, climatic and land-use factors involved can mislead to the conclusion that rehabilitation of degraded land is easy and simple. Typical forms of degradation, predominant under certain conditions, can be identified.

- In the more humid areas, rainfall can occur in heavy erosive showers. Especially in the sloping areas of the tropics and subtropics, these may cause serious soil erosion by runoff. High rainfall can also lead to high rates of nutrient leaching and to soil acidification in many tropical regions.
- In the drier environments, vegetation cover is sparse on large areas of land. In these areas, strong seasonal winds can cause serious wind erosion, especially where the terrain is flat and the lack of standing plants or residues – due to overgrazing – leaves the soil vulnerable to the wind.
- In irrigated agriculture, inappropriate soil and water management practices and irrigation and drainage methods, and the use of marginal quality waters without proper management lead to the accumulation of salts in the soil. Plant growth is affected by this soil salinization, which has disastrous effects on the productivity of the land in areas where irrigation is essential for crop production.
- On rangelands, overgrazing will not only reduce the overall protective soil cover but also lead to a long-term change in the composition of the vegetation. Plant biodiversity will change over time, unpalatable species will dominate, and total biomass production will be reduced. The degradation of vegetation affects millions of people in the traditional range-grazing lands of the drier part of the globe.

In principal, the main causes and initiators of land degradation processes are inappropriate land-use practices that fail to take into account the capabilities and the limitations of the land. Depending on the dominant processes, land degradation displays different forms and effects on the land's productivity. All forms of land degradation will ultimately lead to a reduction of the soils' fertility and productivity (Blum, 1998). The general overall effect is reduced plant growth, leading to loss of protective soil cover and increased vulnerability of soil and vegetation to further degradation. To break this self-accelerating, cause-and-effect chain, it is important to have a good understanding of the underlying causes of land use practices leading to degradation

Degradation in dry areas

Land degradation in drylands is usually described as 'desertification', because it ultimately leads to the formation of deserts. More than 47 % of the earth's surface (i.e., 6.1 billion hectares) is dryland. These lands are the habitat and source of living for about a fifth of the world's population. The marginal drylands of the world experience enormous pressure on the environment, caused by human mismanagement and recurrent droughts (Middleton and Thomas, 1997). The resilience of dryland resources (i.e., soil and vegetation) is usually low and this is why drylands are particularly susceptible to degradation (Blum, 1998).
In the drylands, two forms of degradation are dominant: In the rangelands and rainfed arable areas, wind erosion is characteristic, while in the irrigated areas, soil salinization due to unsuitable irrigation-farming practices can be widely observed.

Soil erosion

Drylands are more susceptible to wind erosion than any other form of degradation because soils tend to be dry, poorly structured and sparsely covered by vegetation (Middleton and Thomas, 1997). A major limitation in these areas is the lack of adequate and reliable rainfall to support a sustainable and protective land cover against the erosive forces of the wind. According to earlier studies, wind erosion only reaches threatening proportions when people disturb the balance of the ecosystem (Mainguet and Da Silva, 1998). This is particularly true for areas where, due to growing population pressure, traditional practices of fallowing are replaced with slash-and-burn practices and continuous cultivation. Wind-erosion measurements by ICARDA in Syria revealed soil losses of up to 60 tons per hectare (which is equivalent to a loss of approximately 3 mm soil depth) during the windy season (from July to September) in areas, which had been opened for rainfed cereal cultivation without erosion-protection measures (ICARDA, 1991).

In regions where little or no nutrient amendments are used to replace the rapidly declining soil-nutrient pool, soil cover is declining rapidly, leading to wind erosion and land degradation. Wind erosion causes loss of soil depth, organic matter, clay content, nutrients, and indigenous seeds. Downstream effects, such as an increase of atmospheric dust, reduced visibility, blockage of roads and railway lines, and health problems are also causing considerable concern. In Morocco, for example, ICARDA research revealed that seasonal hot winds not only carry away soil but also affect crop performance through excessive evapotranspiration and the direct effect of the wind (ICARDA, 1997). In the oasis regions, sand encroachment affects wells, palm-tree plantations and traditional irrigation systems (Sivakumar et al., 1998). In the southern and southwestern parts of Tunisia, e.g., the movement of sand dunes poses a major threat to farmland (Khatteli and Gabriels, 1998). Over considerable parts of Central and Western Asia and North Africa, large areas of the traditional semi-nomadic rangelands, the steppe, are being opened for barley cultivation. The consequent removal of the vegetation cover has exposed the soil surface, leading to the loss of the fine fertile fraction of the shallow soils through wind erosion. This has led to a tremendous decline of soil productivity and quality of life of the land users (Mainguet and Da Silva, 1998; Sivakumar et al. (1998). An important conclusion of ICARDA's research is that there is no easy solution to reduce wind erosion in rainfed annual cropping systems (Timmerman, 1993).

Salinization

The second most important land degradation process, after soil erosion, is soil salinization. Salt-affected soils occur in different environmental, geographical and topographical conditions and they exist in all five continents. Salinization processes are dynamic, and Buringh (1977) estimated that due to salinization, the world loses at least 1.6 million hectares of fertile arable land every year. Two types of soil salinization can be distinguished: Primary salinization is a natural process caused by movement of saline water in the soil originating from saline springs, saline seepage or groundwater upward fluxes (capillary movement), driven by climatic dryness, or due to coastal influence in surrounding lands. Secondary salinization, on the other hand, is caused by improper human activities, such as excessive or inadequate irrigation and the lack of proper drainage.

Salinity -whether primary or secondary- is undoubtedly affecting the livelihood of many people. Ghassemi et al. (1995) estimated that about 20% -or about 45.4 million hectares- of irrigated land are salt affected. The 1977 United Nations Conference on Desertification estimated that 22 million hectares of the world's irrigated lands are waterlogged (Holdgate et al., 1982). Rhoades (1998) estimated that, in the Near East Region, 83.4 million hectares of land (not necessarily arable land) are salt affected. The major effects of salinity on soil properties are swelling of clay soils, dispersion of fine soil particles, crust formation, and a decrease in water movement within the soil profile. The amount of sodium adsorbed to the soil particles and the amount of sodium in the irrigation water greatly influences the degree to which salinity affects soil properties. Options for the management of salinization are determined by the salinity or sodicity of the soil and the water. The major determinant for reclamation of salt-affected soils is the presence and functioning of proper drainage systems, which are critical for adequate leaching of accumulated salts.

The improper use of marginal waters for agriculture may also accelerate land degradation. Since the use of marginal-quality water is picking-up in dry regions, sustainable strategies to facilitate such practices are needed. ICARDA, in collaboration with NARS and other national and regional organizations, is working on developing such strategies.

Biodiversity depletion

The dry areas of the world are the origin of a large number of globally important cereals and food legumes, such as barley, wheat, faba beans and lentils. In these dry areas, biodiversity is seriously eroding through the degradation of natural habitats, the intensification and expansion of cultivation and the overgrazing in natural rangelands. The result is that now, wild relatives of crop species grow only in marginal areas such as field borders, shallow soils and remnants of natural vegetation. The type of habitat supporting these precious resources is either patchy or degraded. Traditionally, farming systems have maintained diversity in order to preserve stability of production under the climatic, disease and pest risks. Wild relatives of crops, such as wild fruit trees for example, used to be left growing on field borders to supply seeds or rootstocks for planting. The replacement of traditional farming systems with modern agricultural practices is endangering these wild relatives. Increased food demands and market forces have encouraged the replacement of the locally adapted varieties of both fruit trees and field crops with high-yielding cultivars, hence hampering the gene pools of these crops. Over time, genetic diversity has eroded, and agriculture is now based on fewer and fewer crops,

and fewer and fewer genotypes. This genetic uniformity and the tendency to monocropping make them more vulnerable to disease and pest epidemics and weather extremes. Addressing the loss ob biodiversity in these areas is therefore of global importance.

In dry areas, the depletion of biodiversity is most clearly visible in the degraded natural rangelands, which lose their productivity quickly due to heavy grazing pressure and inadequate grazing management. To manage the natural vegetation and plan the rehabilitation of degraded range areas efficiently, ICARDA has implemented a rangeland-monitoring project, integrating the use of satellite imagery, field surveys and Geographic Information Systems. This project enables the estimation of biomass (i.e., feed) availability. Through a participatory approach and in collaboration with the pastoral communities and the government authorities, adequate range-grazing schemes can be developed, which will protect the plant resources of the rangelands (ICARDA, 1996).

For periods of low feed availability on the rangelands, additional feed resources need to be available. In a collaborative project with Jordan, Syria and Iraq, ICARDA has developed feed blocks from agro-industrial by-products, such as straw, poultry litter, olive seed cake, beet pulp, date pulp, etc. These feed blocks are now being produced by the private sector in these countries and they contribute significantly to the protection of the range resources at critical periods, and they also generate additional income (Haddad et al., 1997).

For severely degraded rangelands, reseeding has shown to be a feasible option to restore plant productivity and biodiversity. Over the past 6 years, ICARDA has developed and improved range-reseeding systems using a range-pitting machine, which are economic and can cover large areas in a short time. The systems are based on trapping the scarce rainfall near the seeds so that the plants have sufficient moisture concentrated at their roots for their early development. Seeds of locally adapted range species are used (ICARDA, 1997). With this system, large areas of severely degraded rangelands have been put back to productive use.

The cost of land degradation

It is difficult to detail the economic losses resulting from land degradation. At the global level, it is estimated that the direct costs in terms of annual income forgone in areas directly affected by land degradation is about US$ 44 billion per year. The indirect economic and social costs suffered outside the affected areas, including the displacement of people affected by loss of productive land resources, and coupled to losses to national food production, may be much greater (United Nations, 1997). For example, the social damage, the damage to future generations of people, and the loss of biodiversity cannot be estimated in monetary terms (Kharin, 1998). In addition, it is difficult to estimate the costs of dealing with the environmental refugees who have lost their homes and economic base in degraded lands. Not only do they add to the pressure on the resources in their refuge areas, they are also responsible for invoking degradation there (United Nations, 1997).

Any costing of land degradation must include the cost for the reclamation of degraded land, i.e., the reversal of degradation. The options and requirements for reversing degradation depend on the degree of degradation. The earlier degradation processes are recognized and reversed, the more efficient and cost-effective is the rehabilitation. As land degradation and rehabilitation are also very location-specific, there is no universally valid estimate of cost per

unit area of land degraded or reclaimed (Kharin, 1998). Another important cost factor is the off-site effect costs. These include the siltation of dams and watercourses that reduce the economic life of irrigation systems and power stations, and dust emissions that affect public transportation (e.g. roads and railways) and are health hazards (Eswaran and Reich, 1997). In the US, it has been estimated that the off-site costs of degradation may be 45-times greater than the direct cost of the loss of the land's productivity (Dregne, 1997).

The global concern

Global concern about land degradation has grown mainly because of: (i) an increasing trend towards responsibility on the part of the global community – industrialized and developed – to secure a decent life for all world citizens; and (ii) the direct global effects of land degradation beyond national and regional boundaries. Through the emission of greenhouse gases and changes in the ecosystems that contribute to the reduction in carbon sinks, it contributes to climate change. It contributes to the depletion of biodiversity, directly through the degradation and destruction of lands, and indirectly by accentuating the need to expand cropping into natural forests and rangelands. It affects water resources through river and reservoir sedimentation and the change in the hydrological cycles of degraded catchments (Pagiola, 1997). These global concerns open up the possibility of international cooperation in land degradation control. The direct and immediate causes, nature, and perception of land degradation are site-specific. Conventional approaches to land conservation and rehabilitation are local. Now, as land degradation poses a threat to the sustainable welfare of many people across geopolitical boundaries, it is a cause for regional and global concern.

Impact of globalization

Globalization of trade and the removal of barriers for the movement of commodities and information in response to economic growth have important implications for the future sustainability of present land use systems. Farmers, pastoralists, and other agricultural users of land resources may be guided more by considerations of immediate economic return than by longer-term concerns for resource husbandry, conservation, and sustainable production practices. However, globalization of information and knowledge systems may heighten awareness of the need for environmental protection and bring international attention to bear on rehabilitation and preventive measures at the local level. The world community has witnessed within the past decade a significant manifestation of concern for environmental health, and a reversal of alarming trends in land degradation through landmark conventions on biodiversity, desertification, and climate.

Key medium- and long-term policy challenges

What are the key challenges from a policy perspective? How can global conventions be made more effective by policy reforms? What policy elements can encourage sustainable land-use practices that are of benefit to poor people? Improvements in land use need the interest of all involved individuals and groups. A multi-level stakeholder approach for the planning process is essential to obtain socially balanced results, which balance economic and ecological goals. All stakeholders – from the land-user level to the policymaker level should take part in a broad participatory process to identify problems, constraints, needs, interests and aims. On the basis of this process, options and priorities for action should be negotiated.

National policies affect land users directly and many governments integrate environmental, economic and social concerns into the national planning process. National policies on sustainable land use can help to induce the necessary political, institutional and economic changes. There is a need for coherent natural resources policies and frameworks that support regional autonomy and delegation of responsibility for natural resources management to the communal and local levels. They should also support and enforce the productive, sustainable use of the natural resources in the local communities. Medium- and long-term policy changes require the creation of incentives for the affected land users, who are not able to invest in and sustain land-rehabilitation measures:

- A secure land-tenure system assuring long-term access to land and also allowing inheritance to following generations (Hallsworth, 1987) is of great importance because many of the investments necessary to maintain land quality and productivity are very long-term.
- Land users in affected areas must have the financial capacity to make necessary investments for proper land husbandry. A re-evaluation of market prices is required to ensure fair and adequate valuation of agricultural goods and products.
- Alternatively, land users can become 'land wardens' who take care of the land and its functions on behalf society at large and are paid for their services from public funds.

An important role should be given to the *in situ* preservation of plant biodiversity and maintenance of the genetic pool. These practices have to be based on reliable public development policies and nations (i.e., governments) will have to accept these as 'overhead cost' for maintaining environmentally sustainable land quality as a general service to society.

Addressing the challenges at national and international level

In areas endangered by land degradation, the land is being severely overused and will not be able to sustain growing population pressures without further – possibly irreversible – degradation. This will seriously affect the livelihood of people and may lead in the long run to social conflict and unrest. As degradation, rehabilitation and social and economic development are tightly interdependent, several pathways are suggested to address the challenges on national and international levels:

National level:

- direct intervention in the affected areas
- the development of non-agricultural employment opportunities
- population planning to give population densities compatible with the population-carrying capacities of the region

International level:

- mobilization of intellectual, institutional, and financial resources
- greater efforts to implement provisions of international conventions
- support to successful interventions at local levels that can be replicated across wider locations

The disparities that exist among countries in terms of their natural resources, economic status, and educational level should be reflected in policies and action plans to be implemented (ISCO, 1996). This refers in particular to (i) land ownership, (ii) population planning, and (iii) nature conservation policies. The policies and strategies must be directly linked to the use of and access to the natural resources by the land users and other stakeholders. The involvement of informal and formal institutions in land rehabilitation and sustainable land use can only be sustained if they are accepted and actively supported by the land users. This implies that local norms and values must be respected and indigenous knowledge accepted. The development process among stakeholders will be enhanced by better information exchange and improved knowledge of land users' limitations, needs, options and visions with respect to sustainable land use (ISCO, 1996).

The role of the United Nations

There are organizations and initiatives at the international level, which are concerned with land degradation and its control. At the level of the United Nations, FAO, UNEP and UNDP are the main stakeholders. These organizations have gained significant expertise and experience with land degradation at the regional and global scales. They are development-oriented institutions contributing to global development mainly through global resource inventories, collection and provision of environmental and socio-economic data, and the assessment of global trends.

Because of the increasing significance of environmental degradation and its negative effects and impacts on the long-term ability of land to produce food and fibre for the future – especially in the marginal areas with high population pressures – the UN has established global conventions, including the Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (UNCBD), and the Framework Convention on Climatic Change (UNFCCC). A large number of UN member countries have signed these conventions. This is a sign of increasing national concern for degradation and the need of countries, in cooperation with fellow UN member states, to address degradation at the national level with international cooperation and support. The aim of these conventions is to facilitate and foster interstate and regional cooperation for the sustainable management of fragile environments at the international scale. All these conventions emphasize global solidarity and initiate action programs on sustainable land management (United Nations, 1994). However, these global conventions have three major deficiencies: (i) They are far from the world of local land users, (ii) they have been poorly financed to date; and (iii) there is little coordination between their action plans at the local level (ISCO, 1996).

These conventions could coordinate eco-regional approaches to land rehabilitation and management, and to basin-wide watershed development, combined with land-use planning towards sustainable land management.

The Global Environment Facility (GEF) is a funding mechanism of the UN. It is specifically designed to facilitate the tackling of environmental problems – such as climate change, biodiversity depletion, and international waters – on a global scale, i.e., tasks beyond the responsibility and capacity of single states. This facility provides funding to cover the incremental cost of additional measures, whose expected effects will go beyond state boundaries to generate global benefits (United Nations, 1994). Although land-degradation control activi-

ties are not directly eligible for funding by GEF, the effects of degradation on biodiversity, climate change and international waters are covered. An important focus of GEF-funded projects is the participation and cooperation of land users as main stakeholders in environmental management (Pagiola, 1997).

The role of the CGIAR in research and technology development

The causes and effects of land degradation are complex. The fight against land degradation cannot be won at the land-user level alone. Holistic approaches will have to be developed that, besides implementing direct biophysical measures on the land, take into consideration the living conditions and the socio-economic setting of the rural areas and all the external forces and constraints directly and indirectly linked to the pressure on the land and its use. Solutions do not lie in the direct influence of the land user alone, but to a large extent in the general framework within which rural people live and have to produce to survive. This framework is largely determined by the state and its policies. General policy frameworks should emphasize and favour environmental conservation, encourage good stewardship of the land, and provide scope and opportunities for agricultural development.

Research into degradation processes, their underlying causes and their long-term effects and consequences on the land and the environment should be solution-oriented. The study of the processes of degradation should not be a purpose unto itself, masking the need to develop solutions that will lead to resource-protecting, productive and sustainable land utilization (Zöbisch, 1998). Therefore, within the context of the land use system, the term 'research' is more appropriately replaced with the term 'technology development.' Technology development encompasses packages of measures within the context of the land-use system, and has a spatial dimension. It involves components of traditional research, exchange of knowledge, and testing under 'real-world' conditions, and implies the involvement of all stakeholders crucial for the appropriate management of the land.

To lead and assist technology development, the CGIAR – a World Bank initiative – has established research centers throughout the developing world whose aim is to support national institutions in the development of improved and adapted sustainable land-use technologies. In collaboration with national research and development institutions, these research institutes have had a significant impact on the development of improved land-use practices in many regions.

Each of these institutes has a particular mandate for research and technology development related to the improvement of the livelihood and the natural resource environment of rural people in developing countries. Some institutes have regional mandates (e.g. drylands, humid tropics, semiarid areas), some are commodity-oriented (e.g. rice, potatoes, wheat and maize), and some have thematic mandates (e.g. food policy, agroforestry, livestock, forestry, aquatic resources). Over the past decades, these institutes have become centers of excellence in their fields of specialization. The comparative advantages of these institutes lie mainly in their high level of expertise, excellent research facilities, good regional knowledge and experience, and their independence from local governments. This makes them ideal partners for cooperation with local research and extension institutions (i.e., National Agricultural Research and Extension Services - NARES). Through partnerships with CGIAR Centers, many NARES have carried out research to an improvement of land use and the livelihood of rural people.

The Centers' role in capacity building for NARES research and extension staff has been highly successful. Through training programs, NARES have become more qualified – and thus independent – to address environmental problems of national concern. Besides cooperation with NARES, excellent inter-center collaboration has been developed to complement capacities and experiences in tackling specific problems of regional and global significance. This inter-center collaboration also encompasses the involvement of NARES at the national levels. The main mechanisms of inter-center cooperation are ***Consortia*** and ***Eco-Regional Initiatives***.

For the drylands, The International Center for Agricultural Research in the Dry Areas (ICARDA) has developed an approach to sustainable land management based on the principles of holism, integration and participation. ICARDA has shown that addressing single components of a degrading land-use system will not solve land degradation. Only holistic approaches which address the entirety of the landscape and the land-use system will have a chance of success. The multidisciplinary dimension of land degradation also calls for integration. Only integrated approaches for research and cooperation will lead to success. Land degradation is intrinsically linked to the land users and the institutions and other parties directly or indirectly involved in land use. ICARDA's experience had shown that all these parties must be involved in solving land-degradation problems. Therefore, only participatory approaches will be successful. Recently, ICARDA with NARES of Jordan, Lebanon, the Palestinian Authority and Syria have launched a project funded by the Global Environment Facility (GEF) and the United Nations Development Fund (UNDP) that promotes community-driven conservation of agro-biodiversity. The focus is on seventeen crop species (i.e., cereals, legumes and fruit trees) and their wild relatives, for which the Near East region constitute an important center of diversity. The participation of the local communities is the main thrust of this project.

Important principles of the inter-center cooperation are stakeholder participation, a focus on policy and institutional issues, consideration of equity concerns, interdisciplinarity, use of local-knowledge systems, acknowledgement of scale dependencies, and awareness of productivity expectations. The outputs are economically viable, socially acceptable and environmentally sound technologies, improved methodologies and diagnostic tools, improved indicators for degradation and sustainability, decision-support systems for generating, testing and extrapolating land-management options, improved frameworks for information exchange and policy dialogues (Craswell, 1997).

There are four main consortia that aim at the conservation and enhancement of land and water resources and prevent land degradation. The *Combating Nutrient Depletion Consortium* focuses on the conservation of soil fertility through improved nutrient management practices. The *Managing Acid Soils Consortium* focuses on the rehabilitation of degraded acid savannas using agro-sylvo-pastoral technologies. The *Managing Soil Erosion Consortium* develops acceptable land-management practices that minimize soil erosion and its off-site impacts on catchment scales. The *Optimising Water Use Consortium* focuses on crop water-use efficiency and water harvesting in semiarid areas of North and Sub-Saharan Africa and in West Asia. Each of these consortia addresses problems of global importance, initially focusing on a single eco-region and eventually expanding to other areas with similar constraints and problems. An important overall aim is to exploit synergies between the different consortia through standardized methods and information exchange (Craswell, 1997).

Presently, there are four *Eco-regional Initiatives* relevant to sustainable land management. The *Desert Margin Initiative for Sub-Saharan Africa* involves three centers. Its objective is to promote innovative and action-oriented dryland-management research to arrest land degradation in the region. The *Alternatives to Slash-and-Burn Program* aims at modifying and developing land-use systems and technologies that lead to sustainable alternatives to slash-and-burn agriculture and to the reclamation of degraded land. Research sites are located in eight countries in Latin America, Southeast Asia and Sub-Saharan Africa. The initiative is implemented by nine International Research Centers. The *African Highlands Initiative* is a consortium of nine International Centers working in five African countries. The main objective is to improve the nutritional security and income of the communities in the densely settled highlands by developing productive land-use systems and practices which protect the fragile ecosystem and prevent further degradation of the land resources. The *Consortium for the Sustainable Management of the Andean Region* is an eco-regional initiative for four Andean countries focusing on the management of soil and water resources and of agrobiodiversity for the purpose of enhancing productivity and protecting the environment from further degradation.

The contribution of the CGIAR and its collaborating national institutions, especially through the consortia and eco-regional initiatives, has had and will continue to have a significant impact on the management of the natural resources in fragile, degraded environments. The centers cannot solve land degradation *per se*, but they are able to show suitable pathways for managing land resources. And they have an important function in advising governments on the policy guidelines that put the land user in a central position as manager or steward of the land. The land user may cause and accept degradation but is also capable of productive and sustainable use of the land resources, if the general conditions of rural livelihood are conducive to adequate land care. Another important function of the centers is to provide decision-makers with decision-support systems that will help not only to detect hazards of land degradation but also show pathways (avenues) for productive sustainable land management at the local, national and regional scale.

Potential partnerships to address these challenges

The problem of land degradation is not new. However, the magnitude of degradation demands collective action at various levels of society. The present extent and complexity of land degradation processes, their causes and effects, need the attention of all players, from the local to the global level. A main first objective should be learning from each other's experience and giving transparency to the 'lines of thought' of all stakeholders, from the directly-affected land users to the global community-at-large. This will reveal reasons behind actions – or resistance to actions – at the various levels, and help with developing appropriate land-husbandry strategies and technologies.

A major precondition for partnership is that the stakeholders (at all levels) need to have incentives – in the form of a benefit – from land-rehabilitation measures and efforts to achieve sustainable land management. These benefits can be monetary, e.g. through stabilized or increased land productivity, social, or idealistic. The potentials for such mutual benefits can only be identified and understood if all the players get together in forums to discuss land degradation and plan jointly supported actions for its control. Because of the wide diversity of

stakeholders, a 'common language' is needed to facilitate communication and minimize misunderstanding. Because of the different types and levels of interest, partnerships will take place on layers of 'maximum common interest and benefit.' These will normally be arranged along spatial units and at different scales. In a spatial hierarchy – from local to global level, stakeholders that are close to each other will have a high degree of communality – in terms of socio-cultural congruence and economic and biophysical constraints, aims and opportunities. This will make them potentially good partners in development.

Land degradation can only be fought at the source, but it must also be within the conditions, constraints and opportunities set by the larger government, society and environment.

Science and technology on their own cannot solve land-degradation problems. In our ICARDA experience, strong partnerships are crucial preconditions for success, and these partnerships must be based on an accepted common philosophy. People must work together in the mutual understanding that only collectively, they will achieve their aim of sustainable land management.

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