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Working Group on
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1 Introduction

In response to a call for a concerted action on land degradation and desertification by the United Nations Conference on Environment and Development at Rio de Janeiro, Brazil, in 1992, the International Union of Soil Science (IUSS) established the Working Group on Land Degradation and Desertification (WGLDD). The charge of WGLDD is to help develop the 'science of land degradation' and rally the international scientific community to develop acceptable terms and definitions, concepts and methods, and frameworks and thresholds for countries and institutions to adopt common procedures in the assessment and monitoring of land degradation.

The first International Conference was held in Adana, Turkey and attended by 250 participants from 25 countries, mainly from the Mediterranean region. In this second Conference, a similar number of persons from 30 countries assembled at Khon Kaen, Thailand. The Conference theme was "Meeting the challenges of land degradation in the 21st Century". With the establishment of the United Nations Convention to Combat Desertification (CCD), the Conference hoped to address some of the issues confronting CCD and provide suggestions, recommendations, and potential sources of expertise for CCD to respond to its mandate. Eight themes were developed and for each theme a specialist was invited to present a 'state–of–the–art' paper. Information is excerpted from these papers and discussions to compile this report. The Proceedings of the Conference, to be published later, provide the original texts.

2 Dimensions of land degradation and desertification

Land degradation, declines in land quality due to natural processes and anthropic activities, is a major global issue for the 20th century and will remain high on the international agenda even for the 21st century. The importance of land degradation among global issues is enhanced because of its impact on world's food security and environment quality. The latter comprises important concerns related to eutrophication of surface water, contamination of ground water, and emissions of trace gases (CO_2, CH_4, N_2O, NO_x) from terrestrial/aquatic ecosystems to the atmosphere.

Land degradation can also be considered in terms of the loss of actual or potential productivity or utility as a result of natural or anthropic factors. Land degradation, is the decline in land quality or reduction in its productivity and environmental regulatory capacity. In the context of productivity, land degradation results from a mismatch between land quality and land use. Land degradation processes, mechanisms that set–in–motion the degradation trends, include physical, chemical and biological processes. Important among physical processes are decline in soil structure leading to crusting, compaction, erosion, desertification, anaerobiosis, environmental pollution, and unsustainable use of natural resources. Significant chemical processes include acidification and leaching, salinization, and decrease in cation retention capacity and fertility depletion. Biological processes include reduction in total and biomass carbon, and decline in land biodiversity. Soil structure is the important property that effects all three degradation processes.

Factors effecting land degradation are biophysical environments that determine the kind of degradation processes, e.g. erosion, salinization etc. These include land quality as affected by its intrinsic properties, climate, terrain and landscape position, and climax vegetation and biodiversity especially the soil biodiversity. Causes of land degradation are the agents that determine the rate of degradation. These are biophysical (land use and land management, including deforestation and tillage methods), socioeconomic (e.g. land tenure, marketing, institutional support, income and human health), and political (e.g. incentives, political stability) forces that influence the effectiveness of processes and factors of land degradation.

Land degradation is a biophysical process driven by socioeconomic and political causes. High population density is not necessarily related to land degradation. What the population does to itself and to the land that it depends on determine the extent of land degradation. People can be a major asset in reversing the degradation trend. However, subsistence agriculture, poverty and illiteracy are important causes of land and environmental degradation. People must be healthy and politically and economically motivated to care for the land. Lands, depending on their inherent characteristics and climatic conditions, range from highly resistant or stable to extremely sensitive and fragile. Fragility, extreme sensitivity to degradation processes, may refer to the whole land, a degradation process (e.g. erosion) or a property (e.g. soil structure). Stable or resistant lands do not necessarily resist change. They are in a stable steady state condition with the new environment. Fragile lands degrade to a new steady state under stress, and the altered state mat be unable to support plant growth and to perform environmental regulatory functions.

Information on the economic impact of land degradation by different processes on a global scale is only available for some localities. In Canada, for example, on–farm effects of land degradation were estimated to range from $700 to $915 million in 1984. Economic impact of land degradation is extremely severe in densely populated South Asia, and sub–Saharan Africa.

Soil compaction is a worldwide problem, especially with adoption of mechanized agriculture. Severe compaction has caused yield reductions of 25 to 50% in some regions of Europe and North America, and 40 to 90% in those of West Africa. In Ohio, reductions in crop yields are 25% in maize, 20% in soybeans, and 30% in oats over a 7 year period. On–farm losses due to land compaction in the United States alone have been estimated at $1.2 billion yr^{-1}.

Accelerated soil erosion is another principal land degradation process. Similar to compaction, few attempts have been made to assess the global economic impact of erosion. On plot and field scales, erosion can cause yield reductions of 30 to 90% in some root–restrictive shallow lands of West Africa. Yield reductions of 20 to 40% have been measured for row crops in Ohio and elsewhere in the Midwest USA. In the Andean region of Colombia, workers from the University of Hohenheim, Germany, have observed severe losses due to accelerated erosion on some lands. On a global scale, the productivity of some lands in Africa has declined by 50% due to soil erosion and desertification. Yield reduction in Africa due to past soil erosion may range from 2 to 40%, with a mean loss of 8.2% for the continent. If accelerated erosion continues unabated, yield reductions by the year 2020 may be 16.5%. Annual reduction in total production for 1989 due to accelerated erosion was 8.2 million mega grammes for cereals, 9.2 million mega grammes for roots and tubers, and 0.6 million mega grammes for pulses. There are also serious (20%) productivity losses due to erosion in Asia, especially in India, China, Iran, Israel, Jordan, Lebanon, Nepal and Pakistan. In south Asia, annual loss in productivity is estimated at 36 million tons of cereal with an equivalent valued of $5,400 million by water erosion, and $1,800 million due to wind erosion. It is estimated that total annual cost of erosion from agriculture in the USA is about $44 billion yr^{-1}, about $100 $acre^{-1}$ of cropland and pasture. On a global scale the annual loss of 75 billion tons of soil costs (at $3 ton^{-1} of soil for nutrients and $2 ton^{-1} of soil, for water) the world about $400 billion yr^{-1}, or more than $70 per person yr^{-1}.

Nutrient depletion is another principal process of land degradation with severe economic impact at a global scale, especially in sub–Saharan Africa. Dutch workers have estimated nutrient balance for 38 countries in sub–Saharan Africa. Annual soil fertility depletion rates were estimated at 22 Kg N, 3 Kg P, and 15 Kg K ha^{-1}. Soil erosion in Zimbabwe results in an annual loss of N and P alone totaled $1.5 billion. In south Asia, annual economic loss is estimated at $600 million for nutrient loss by erosion, and $1,200 million due to soil fertility depletion.

Salt affected lands occupy an estimated 950 million ha of land in arid and semi–arid regions, nearly 33% of the potentially arable land area of the world. Productivity of irrigated lands is severely threatened by build up of salt in the root zone. In south Asia, annual economic loss is estimated at $500 million from waterlogging, and $1,500 million due to salinization. Potential and actual economic impact globally is not known. Soil acidity and resultant toxicity due to high concentrations of Al and Mn in the root zone, is a serious problem in sub–humid and humid regions. Once again, the economic impact on a global scale is not known.

It is in the context of the global economic and environmental impacts of land degradation and numerous functions of value to humans that the land degradation, desertification, and resilience concepts are relevant. They are also important in developing technologies for reversing land degradation trends and mitigating the greenhouse effect through land and ecosystem restoration. Land resources are essentially non–renewable. Hence, it is necessary to adopt a positive approach to sustainable management of these finite resources.

Despite the voluminous literature, land degradation remains a debatable issue. There are two distinct schools regarding the severity and impact of land degradation. One school believes that it is a serious global threat posing a major challenge to the human race with regards to its adverse impact on biomass productivity and the environment quality. Ecologists, soil scientists and agronomists primarily support this argument. The second school, comprising primarily economists, believes that if land degradation were a severe issue, why have the market forces not taken it care of? Supporters of the second school argue that land managers (e.g., farmers) have vested interest in their land and will not let it degrade to the point that it is detrimental to their profit margin.

3 Research and development issues

Land degradation as occurring in various forms continues to pose a most serious challenge for the very survival, well–being and future of the whole humankind. Complicated by great uncertainty in climate change, unforeseen impact of human activities and inner interactions among the landscape system components, land degradation per se has become a phenomenon which combines various environmental controls. Consequently, rehabilitation of the degraded land must be comprehensive in nature, encompassing physical, biological and agricultural remedial measures whose implementation inevitably needs to be in line with what is now called the sustainable development principle. Yet, a lack of adequate quantitative as well as qualitative information about the causes, processes and patterns of land degradation, a deficiency of truly applicable rehabilitation techniques, programmes and strategies, and a perpetual ambiguity of the meaning of sustainability in relation to different spatial, temporal and human scales still defy efforts to solve the degradation malaise in many parts of the world.

To meet the land degradation challenge in the twenty–first century, a series of changes must be made to the way how the land is viewed, what strategy should be adopted for rehabilitation efforts and what aims should be served by the rehabilitation endeavors. In particular, several key needs are of vital importance:

1. The land should always been seen in its entirety and as a dynamic system whose resilience, recuperation and relaxation mechanisms in response to environmental disturbances form the foundation for land degradation and rehabilitation research. Therefore, the revelation of all such characteristics constitutes one central task of a distinctive land degradation science. Productivity of the land, factors affecting it and ways to improve it should become the basis for the conception of rehabilitation strategies and important scale controls must be duly considered to make the strategies relevant, workable and effective.

2. Man–land relationships should be one of harmony, mutual nurturing and progressive development. On the micro–scale, the land husbandry thinking may provide much of the intellectual groundwork for how land rehabilitation can be best approached in the field; while on the macro–scale, the sustainable development framework is essential for a concerted global effort to combat land degradation to succeed. In both cases, though, workable implementation strategies must be sought in the immediate future.

3. The problem of structurally upgrading the land economy has not received its due consideration in past land rehabilitation efforts and there is now a genuine need to redress the balance. The dual images of the land as a mere resource to conserve and the land as a versatile economic enterprise to harvest need to be carefully reconciled in all land degradation and rehabilitation research. Perhaps, the much–vaunted slogan of "Think globally and act locally" hangs its success here.

4 Environment, biodiversity, and food security issues

Land degradation has potentially severe implications for food security, rural livelihoods, and environmental attributes such as biological diversity. Not only does degradation diminish the quality of the remaining land resources but also it undermines the life–support functions of the soil for both human welfare and the health of the natural environment.

The challenge of African agriculture is not only of enhancing production to meet the increased food demands of the expanding population, but also the judicious use of soils so that their productivity is sustained in the foreseeable future. Continent–wise 55 % of land area in Africa is unsuitable for agriculture and 11 % of land area has high quality soils which can effectively be managed to sustain more than double its current population. These soils are spread among many countries making it difficult to develop a continent–level strategy to equitably help all countries. Africa has more than 8 million km2 of land with rainfed crop potential, however, much of it has not been used for this purpose. This potential land reserve needs to be carefully evaluated so that rational policies can be developed for their exploitation.

The studies of vulnerability to desertification clearly show:

1. Under low–input systems, the potential productivity of the soils cannot be realized and further that stability of production will be difficult to achieve. A systematic decline in productivity is the result of the degradation processes;

2. Desertification is rampant in much of the continent and will permanently destroy the agricultural production potential. Correcting the degradation effects will be more expensive and the low resilience characteristics of many of the soils suggests that high levels of productivity cannot be expected even after mitigation technology;

3. Under current systems, most of the countries will be unsustainable and if desertification is not controlled, their ability to attain sustainability is significantly reduced.

The challenge of enhancing the productivity of well endowed lands and reducing the pressures on the fragile ecosystems is the solution to putting Africa on the path to sustainability development. With appropriate capital infusion and support services, the efficiency of resource–poor farmers of Africa can be raised and the seeds to another Green Revolution sown.

The current population of Asia is about 3.2 billion and is expected to grow to 4.5 billion by the year 2025. Analysis clearly shows that most Asian countries will not be able to feed their projected populations without irreversibly degrading its land resources, even with high levels of management inputs. The overall prospects for food security in Asia are not encouraging. Only a few countries will be able to feed their growing populations without increasing land management input levels markedly. And most countries of the region lack the capital resources to make the financial investments required to increase land productivity. Nevertheless, the three largest and most populous countries of Asia, China, India and Indonesia, should be able to meet minimal food requirements, provided the level of management technology is increased. It appears unlikely, however, that countries like Afghanistan and Pakistan will be able to produce sufficient food now or in the future. Although the same is true for industrialized countries like Japan, Singapore and Taiwan, they can rely on non–agricultural industry, commerce and servicing functions to earn the money to import food.

There are several adverse aspects precipitated by the current and future situation of local and global environmental consequence. First, farmers in the poorer countries will be forced to eke out a living by exploiting fragile land resources, which often results in irreversible degradation and permanent loss of biodiversity. Second, the relative scarcity of prime agricultural land in Asia and the resulting imperative to preserve these areas for food production and optimize the land use of the remaining areas precludes more land for agricultural expansion. This implies that soil scientists must expand their horizons and explore all functions of the soil and land resource in support of food security and quality of life. Third, although there is nothing inherently wrong with importing food from elsewhere, this leads to the appropriation of natural resources in other countries, which may not be a sustainable procedure

To confront the problem of food security in Asia, massive infusions of capital are needed to support, inter alia,

1. agricultural research and development, particularly in biotechnology and other "cutting edge" technologies;
2. the development of policies and practices conducive to sustainable land management;
3. the development of indices of land quality and their monitoring; and
4. elaboration of early warning indicators of land degradation.

Asia will continue to be a tension zone for food security and depend on imports to feed its growing population, but there is hope that these requirements can be met from external sources. At a recent meeting on "Land Resources: At the Edge of the Malthusian Precipice," a group of experts concluded that "if all (of the world's) resources are harnessed to minimize soil degradation, sufficient food to feed the population in 2020 can be produced, and probably sufficient for a few billion more". Although continued population growth will inevitably have disagreeable consequences, it is thus unlikely that the Four Horsemen of the Apocalypse will pay a call in the foreseeable future. Should Malthusian scenarios emerge, they are less likely to be caused by global environmental collapse rather than by humankind's perennial inability to conduct its political affairs wisely.

Although it is not possible to be specific about the climate changes that will take place on an intra–regional basis, it is likely that most regions of the world will be affected in some way or other and will require an ongoing level of new understanding and readjustment. It is well known that climate is a major factor in soil erosion. Some areas of the world, e.g. Southern Asia, are predicted to have increased temperatures combined with increased rainfall. Such areas may become more prone to water erosion depending on the existing land use at the time. In many other areas, global warming is likely to lead to higher evaporation rates and drier soils. Cultivation of such soils or other changes in ecosystem could make them more prone to erosion both by water and wind.

The USLE and EPIC erosion models have been used in the USA to predict changes in erosion rates with different climate change scenarios. It is found that average rill and sheet erosion rates could increase by up to 22% depending on the climate change scenario. Given a 2C rise in temperature, wind erosion could increase by 15-8% while water erosion decreased by 3–5%. In most areas of the world, there will be a significant risk of increased erosion under the present climate change predictions.

Climate–related factors such as increased drought could lead to an increase in the vulnerability of some land to desertification and to escalation of the desertification process. Because arid and semi–arid land ecosystems have little ability to buffer the effects of climate variability relative to most other terrestrial ecosystems, they are particularly vulnerable to climate change and may be the first ecosystems to be affected by global environmental change. By coupling a vegetation model to the Hadley Centre Global climate model , it has been predicted that there will be a decline in tropical forests and grasslands from 2050 onwards and increasing development of deserts in Africa, India and parts of South America. In those areas affected by warmer, more droughty conditions, reversing the effects of desertification is not always possible and becomes more difficult in drier climates and where there are shallower soils. In those regions in which the climate is due to become warmer and more arid, e.g. northern and southern parts of Africa, northern part of South America, India and Southern Europe, salinization and alkalization are likely to increase because transpiration and capillary rise will be enhanced.

Climate is the most critical factor in determining the sustainability of agricultural systems, with hot, dry areas the most difficult in which to achieve sustainability. Much attention is being directed towards maintaining the multi–functionality of soils but this will become more difficult in warmer, drier climates. Climate change will almost certainly change a region's soils with respect to their carrying capacity, their resilience, sensitivity and susceptibility to stress, and the potential reversibility of damage to them. It is important that the impact of climate change on soils is considered in parallel with impacts caused by unsustainable land management. The two often interact leading to a greater cumulative effect on soils than would be predicted from a summation of their effects.

5 Land management, land laws, and policy issues

Environmental legislation and policies concerning the use of agricultural land have existed since early this century. Land degradation continues to expand worldwide suggesting that the existing environmental laws and policies have not been effective to prevent land degradation. Recently, international forums and conventions have provided impetus for some nations to prepare new environmental law, environmental policies and strategies, including the preparation of law and policy specifically aimed at the control and management of land degradation. The main type of legislation and policy material aimed at the control of soil and land degradation is 'soil conservation law. Many such laws focus on land utilization rather than on land conservation. However, in many cases, the effectiveness of legislation was overshadowed by agricultural production price support schemes for domestic and export needs, land settlement and land development schemes, rather than for ecological objectives. It is becoming evident that a wide range of programs, policies, educational initiatives and national and local laws are necessary to successfully achieve ecologically sustainable land management. The principal global environmental treaties, conventions, and strategies to achieve ecologically sustainable development, combat desertification, manage forests, control the effects of climate change, and to manage biodiversity, are beginning to be used to re–assess and reinvigorate domestic and international environmental laws and policies.

Results of recent environmental law and policy reform, particularly in developing countries, indicates that nations are committed to initiate and implement but lack guidance and information. There is an urgent need to assemble experts in this field and develop appropriate protocols and guidelines.

6 Tools for identification, assessment, and monitoring

Satellite Remote Sensing (SRS) and Geographic Information Systems (GIS) are widely used tools in various fields including land cover assessment and land use change. These are also studies used in land degradation studies, such as erosion prediction and nutrient depletion. However, their uses at the national scale in Asian context to–date have not gained popularity due to several reasons. The use of remote sensing data provides timely and reasonably reliable information for large area monitoring supported by sufficient ground data. Otherwise, large scale monitoring needs a considerable amount of human resources and time if generated through field survey only. As socioeconomic information is important in the process of land degradation monitoring, one of the reasons for potential use of these technologies is the increasing realization of geo–referencing of such data. Besides, the tool also allows the delineation and geographical distribution of different types of land degradation, which is not successfully achieved at the national scale until now. Global Positioning System (GPS) is another emerging tool that is very useful in land resources studies.

The unique feature of remote sensing, compared to other tools, such as GIS, thematic cartography, or statistics, is that it can be used to collect the data for baseline inventory or regular monitoring purposes which can be integrated with other tools for further analysis. The present remote sensing technologies can be broadly categorized into V/NIR and Microwave remote sensing. V/NIR sensing has received wider application acceptance compared to Microwave sensing. This is due to microwave remote sensing, being, weather independent, and lacking in adequate methodologies for specific application. There are number of currently operating and proposed satellite remote sensing systems, such as Landsat, MOSS, SPOT, NOAA, ERS, RASARSAT, JERS, MODIS, each of the sensors having different spectral and radiometric characteristics. Their potential uses depend upon the biophysical variables under study. The majority of remotely sensed data collected for earth resource applications is the result of satellite on–board sensors that record electromagnetic energy. Changes in the amount and properties of the electromagnetic radiation becomes, upon detection, a valuable source of data for interpreting important properties of the phenomena with which they interact. Since monitoring of land degradation is largely concerned with mapping the productivity status of land resources under a given socioeconomic setup, such areas can be easily identified, delineated and monitored with repetitive data collection using remote sensing techniques. Subsequently, it can be modeled using the data from other sources to understand the relationship between the degradation status and associated factors and actors. Such information is valuable to develop the strategies required by specific degraded areas. Satellite remote sensing, however is superior in many aspects such as cost effectiveness for large area monitoring, geo–referencing and near real–time monitoring of land degradation. The vegetation status of certain area reflects strong correlation with productivity status of the land, thus degradation status. As vegetation has a strong spectral response in NIR band, construction of vegetation indices is a usual practice to estimate the vegetation component of an area, thus assessing degradation status of the land on the basis of vegetation health. In the case of tropical wet–climates, one of the major shortcomings experienced in the use of V/NIR data is the problem of cloud cover affecting the data. Cloud free data are available only during the dry season, and such data contain little information on vegetation spectral responses. Among others are the temporal resolutions of most of the high–resolution sensors, which might not be efficient in reliably capturing critical greening of vegetation. There are also other considerations to be taken into account, such as the trade–off between spatial resolution and swath coverage, selection of appropriate analytical technique, timely data availability and delivery while using the remotely–sensed data for land degradation studies.

The main purpose of land degradation monitoring is to formulate conservation strategies to protect land resources for long–term sustainability. Experiences in some parts of the world have shown that without understanding the basic processes and values of degradation and how the communities are the part of it? How do they respond? The monitoring process simply does not carry much value. In general, Remote sensing is a very useful and efficient tool to in performing important steps during land degradation studies, such as identification, assessment and monitoring. However success depends upon several factors including natural status of the area, selection of appropriate remote sensing data and analysis techniques. As in situ information collection is essential in the process of remote sensing application for calibration purposes, integration of other tools, like GIS and GPS, is essential to improve the accuracy of the result than by using the remote sensing alone.

Soil erosion by water is the principal cause of land degradation, and it is a major constraint to agricultural development in many countries. Soil and water conservation measures have to be adopted not only to reduce on–site soil, water and nutrient losses, but also to diminish negative downstream effects, such as flooding and the silting up of reservoirs. It is however extremely difficult to evaluate such soil and water conservation measures economically, since neither their effects nor their beneficiaries can be easily detected. For the appraisal of soil and water conservation projects much attention needs therefore to be paid to the identification of target groups and other actors and to an assessment of all major on–site and downstream effects of the measures. This requires both socioeconomic research and hydrological and erosion research, and requires a thorough integration of physical and biological aspects with economic considerations. In the impact assessment use can be made of water and nutrient balances and yield response functions, which can be incorporated in spreadsheet modules and multiple spreadsheet models.

In the economic evaluation of projects use can be made of both cost–benefit analysis (CBA) and multi–criteria analysis (MCA). The efficiency of the projects can be conveniently assessed with CBA, when the effects can be quantified and valued. Whereas MCA can be used to assess scores on non–monetary attributes of the various evaluation criteria, and can also show how conflicting objectives of different actors affect these scores.

7 Mitigation technologies and implementation programs

Reversing global land degradation is about better and simpler technologies, better national policies, and much more. But ultimately it is about rural people and their institutions. The greatest prospect for reversing land degradation in the next century is the evolution of real farmer–led community institutions that take charge and transform the way research and extension in land management are done. Broad–based evidence for this is emerging. Examples of locally–led processes in natural resource conservation suggest two successful streams:

1. institutions that are developed independently by local communities and managed by them, whose subsequent activities may or may not be assisted by outside stakeholders, and

2. local conservation institutions that are initiated and guided by the public sector.

Four examples of locally created groups that have had remarkable success in attacking land degradation problems in different parts of the world were presented. These include the mwethya self–help work groups in the Machakos District in Kenya that released a huge voluntary effort that constructed large areas of terraces to control soil erosion over the years. Farmers' clubs that are a vehicle for widespread diffusion of soil and water conservation practices in southern Zimbabwe; the explosive development of 4,500 farmer–led community Land Care groups in Australia and include about a third of the country's farmers is a national success story. A similar Land Care movement that evolved in the uplands of the southern Philippines focussing on the spread of natural vegetative strips, farm forestry, and other agroforestry practices is another example. These farmer–led institutions are independent self–governing entities that may receive training and material support from outside, but they determine their agenda and implement it through their own efforts.

There are also important success stories emanating from the second stream of conservation institutions, that are locally–led but created and actively guided by the public sector. Examples include the Catchment Conservation Committees in Kenya, the Conservation Districts movement of over 3,000 self–governing districts in North America that have been supporting the spread of conservation practices among their members for decades; and the emergence of municipal natural resource management planning and implementation in the Philippines. The two streams of institutional approaches are not incompatible with each other. They may be integrated in the same area in mutually supportive ways, as seen in the confluence of Land Care and Conservation Districts in Western Australia.

These experiences are from both the temperate and tropical worlds. They indicate that community institutions are a vast underutilized resource for planning and implementing resource conservation at the global level. Outside support is often critical for leadership training and modest material support. Local labor and resources combined with modest external assistance through cost–sharing, foster sustainable development. And linkages to external sources of information and support are fundamental for long term sustainability of these institutions. A community–based strategy needs mechanisms to facilitate these links. Networks of farmer–led community groups will be needed within each country. Likewise, more networking between countries will also be crucial. These networks will accelerate the realization of the power of farmer–fed community institutions to reverse land degradation on a global scale during the 21st century.

Efforts to reverse natural resource degradation through international funded projects and many times due to an inability to develop the rapport with local communities, appear to have mixed results. Literally hundreds of thousands of projects have been implemented, although their impacts have been disappointing. There is no dearth of mitigating technologies that keep erosion in check and maintain soil fertility for sustainable agricultural production.

Recently recognition has grown that farmers do not benefit as much from adopting soil conserving practices and technologies as previously assumed. Economic analyses have indicated that while society may gain from a reduction in negative externalities, farmers have to pay the price. Many projects and programs attempt to bridge the conflict between the private and society's interests by enforcing either strict land use and management regulations or by offering subsidies to those farmers willing to farm their land according to mutually agreed conservation principles. For project intervention purposes, the two contrasting approaches also have been combined to the "stick and carrot" approach, where the carrot acts as a direct incentive stimulating the adoption of specific recommendations.

The use of direct incentives has limited potentials, often with only short–term and negligible impacts. What most of us perceive, as appropriate incentives are in fact inadequate measures for bringing about change. This change is what we should direct our attention at instead of focusing on making alternative technologies more profitable or palatable. The objective is to broaden the perspective of incentives. It specifically proposes the move away from using narrowly defined "carrots" designed to raise the attractiveness of mitigating technologies.

The consensus is growing that certain sectoral and macro–economic policies (subsidies, guaranteed prices, and income assistance programs), that affect especially farm incomes, are instrumental in contributing to the problem of land degradation. Just as natural resource degradation is policy–induced, its reversal also needs to be triggered and supported by policies. Instead of searching for more appropriate incentives, it is far more effective to accept that land degradation is caused by market failures and to find the disincentives that prevent farm households from adapting their livelihood strategies according to the requirement of sustainable land use.

With respect to limitations of direct incentives, the importance of differentiating between subsidies and compensation must be emphasized. Various studies indicate that the concept of "carrots" as incentives is much too limiting. Instead a whole jar of "mixed pickles" addresses the obstacles to resource conservation more effectively. Among those that should receive more consideration are sectoral and macro–economic variable incentives such as prices, and fiscal and monetary measures, as well as enabling incentives such as market development or the decentralization and devolution of natural resource management (cf. IFAD, 1998). As long as the framework conditions are not conducive to conservation, direct incentives will remain drops in the ocean and many incentives such as free input and food for work will continue to be misused as bribes for boosting the performance of projects.

8 Conclusion

Whereas land degradation remains a serious global threat, the science involved is still composed both myths and facts. The debate is perpetuated by several factors that have caused confusion, misunderstanding and misinterpretation of the available information. Important among these is:

1. A wide range of terminology and definitions with different meanings among different disciplines;
2. Lack of standard methods of assessment of the extent of land degradation;
3. Non–uniform criteria to assess the severity of land degradation;
4. Difficulty in evaluating the on–farm economic impact of land degradation on productivity;
5. A new emphasis on soil rehabilitation should be promoted, using measures that can be employed by farmers to improve soils;
6. Erosion–productivity and conservation–productivity research must be carried out on–farm with the immediate involvement of land users;
7. As an indicator of both soil productivity and sustainability, food security should be targeted at household, community, national, and regional levels, with researchers providing specific recommendations for particular soils, environments, and socioeconomic groups;
8. Soil fertility, productivity, and sustainability need to be incorporated into the current policy discourse concerning equitable and fair access to resources, advice, and subsidies to promote the wider benefits to society of the good management that is expected of farmers;

Key aspects of a reform strategy to achieve a goal of sustainable land management, includes:

- Recognizing and setting a realistic time frame which considers, what is to be sustained, the period to be sustained, the area of concern, and the impacts on the people;
- A review of institutional changes: institutional capabilities, resources and expertise to deal with sustainability, and limits of resource base;
- The approach in the preparation of the new policy considering interactions of resources and their linkages;
- Enhancing existing legislation, both national and international.

The Conference concluded that land degradation is not likely to be a serious threat to international food trade between now and 2020, due to the global capacity for substitution, and the dominance of temperate producers. But it could have significant effects on national agricultural supply (14–7% reduction by some estimates) in many countries, and on global, and particularly national prices (17–30%) increases by some estimates). The greatest impact of land degradation will be the dampened economic growth effects of lower farm incomes in the irrigated, high quality rainfed and densely–populated marginal lands, due to lost soil productivity. The major economic threat will be in those countries and sub–regions, which depend upon agriculture as the "engine of economic growth." The greatest threats to nutrition and food consumption by poor farmers in 2020 will be in the densely–populated marginal lands of sub–Saharan Africa, and to a lesser extent South and Southeast Asia. Total agricultural land loss predicted by 2020 does not pose a major threat to global wealth in soil assets, however for countries with a limited land base, conserving farmland quality is a strategic long–term food security issue.

The greatest problems of soil degradation for food security in developing countries in 2020 will be found in the densely populated marginal lands, which require mobilization of long–term investment and appropriate technology development. Second in importance will be degradation of irrigated lands through salinization and waterlogging. In high quality rainfed lands, farmers are likely to respond actively to degradation with improved land management, assuming general support for agricultural development. Agricultural land quality and preservation in urban and peri–urban areas will be much more problematic. Land degradation in lightly populated marginal lands is unlikely to pose major economic (as distinct from environmental) costs beyond producers themselves.

The current challenge we face is to:

1. Mobilize the scientific community to mount an integrated program for methods, standards, data collection and research networks for assessment and monitoring of soil and land degradation;
2. Develop land–use models that incorporate both natural and human–induced factors that contribute to land degradation and that could be used for land–use planning and management;
3. Develop information systems that link environmental monitoring, accounting, and impact assessment to land degradation;
4. Help develop policies that encourage sustainable land use and management and assist in the greater use of land resource information for sustainable agriculture; and
5. Develop economic instruments in the assessment of land degradation to encourage the sustainable use of land resources.

9 Working Group on Land Degradation and Desertification of the International Union of Soil Sciences

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