Assessing The Extent, Cost And Impact Of Land Degradation At The National Level: Findings And Lessons Learned...

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ASSESSING THE EXTENT, COST AND IMPACT OF LAND DEGRADATION AT THE NATIONAL LEVEL: FINDINGS AND LESSONS LEARNED FROM SEVEN PILOT CASE STUDIES

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TABLE OF CONTENTS

Assessing the Extent Cost and Impact of Land Degradation at the National Level: Overview: Findings and Lessons Learned

TABLE OF CONTENTS

LIST OF TABLES

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Executive Summary

This study, commissioned by the Global Mechanism with support from the World Bank examined available national data on the extent, costs and current remedial actions concerning land degradation and sustainable land management in seven pilot countries. This was a desk study, but included countries where the authors had detailed long term knowledge. The results of the work are presented in seven case studies of China, Ethiopia, Mexico, Uganda, Rwanda, Chile and Indonesia; and this overview paper, which presents a synthesis of the lessons learned from the cases and from a review of the current academic and report literature.

Both encouraging and cautionary lessons can be drawn from this work. There are situations in the seven pilot countries and others cited in the literature, where sustainable and economic levels of productivity have been achieved under conditions of ongoing soil and water conservation. There are even stories of good application of low cost technologies. There are however other situations where poverty and land degradation appear to feed off each other in a downward spiral with the disruption of both farming and socio-economic systems.

In most cases the best available national assessments suggested that agricultural productivity is reduced by land degradation at a minimum rate of 3 to 7% and that investment in remedial action was an order of magnitude smaller than estimated costs. Governments were aware of the problem but responses especially in the past were typically top-down and directed to the on-site physical problems of soil and nutrient loss. On the other hand it is clear that policy issues can be critical factors in causing or reducing land degradation.

One of the concerns raised by the study was the incompleteness and inconsistency in the basic data on costs of land degradation and there is a case for a more comprehensive approach to this topic. However, information is sufficient to open up initial dialogues with respective governments on new approaches and increased investment in sustainable land management, targeting more integrated and holistic approaches and involving local and regional stakeholders in the activity at all stages.

One key recommendation suggests that the most efficient approach to mitigation would include a careful analysis of the policy framework most likely to facilitate mitigation through direct and indirect measures, capacity building and a focus on alternative livelihoods that would improve rural conditions and address poverty – degradation linkages.

Table 1 summarizes the data from the case studies. It should be noted that in almost all instances the data refers to the cost of direct components of soil and nutrient loss. Only in a few cases are indirect costs and benefits considered.

Table 2 summarizes the country findings. In general the problem of land degradation and sustainable land management is identified as a national problem but responses have in the past focused on physical remedies to soil and nutrient loss, much less on the policy, institutional, and socio-economic parameters of the problem.

TABLE 1. DATA FROM CASE STUDIES

Country	Extent of land degradation	Cost of land degradation	Level of Response	Type of response
China	Widespread, especially North & West	$7.76 Direct $ 31 billion Indirect 4% GDP	$ 1-2 billion annually	Forestry, Physical Structures
Ethiopia	Highlands and Drier Areas 50% highlands	4% GDP Direct, Acute poverty	0.2 –0.5 % Ag GDP	Fertilizer, Physical Structures
Mexico	65% of land area	$3.5 billion Migration	Varied over time. Hard to quantify	Policy change. Reforestation
Uganda	Varied 60% land area	4% GNP?	Hard to quantify	Policy, Terracing in SW
Rwanda	Extreme especially SW	3.5% Ag GDP Direct, acute poverty	Hard to quantify	Centralized terracing policy
Chile (Coquimbo)	Widespread	50% on wheat 23% goat	Not known	Not known
Indonesia	Varied	0-4% crop value	Not known	Long term soil & water management

TABLE 2. COUNTRY FINDINGS

China -- Problem identified as important by government especially for north and west of the country. Some major remediation projects under way, but top down approaches still prevail and policy issues and stakeholder involvement not emphasized.

Ethiopia -- Sustainable rural production is critical for the future of the economy. However, land degradation remains as major problem in the highlands. Past remedial measures have focused on terracing but have only begun to address the basic issues. The need for a more integrated rural economy is a critical component of the problem as is the uncertainty in many areas of the ownership context of land management issues.

Mexico -- Mexico is a case where land degradation is an important problem for the rural economy and a major backdrop to migration of rural workers to other marginal areas, to urban areas and to the US. Policy issues are very critical with NAFTA and SAP imposing new constraints, and diverting attention from rural investment. Most recent policies begin to support integrated rural approaches.

UgandaU -- While in general Uganda is perceived to have a strong land base, land degradation is an important and widespread, though poorly documented problem. In the highlands, some areas near the farmstead are quite well maintained while outer fields are experiencing steady degradation. Policy is well articulated but concentrated action is embryonic.

Rwanda -- Rwanda experiences important land degradation especially in the southwest of the country. Detailed economic data is sparse but there are wide differences between the perceptions of government and farmers about the most important components and remedies to the problem. Responses need to include a comprehensive approach to a revitalized rural economy.

Chile -- The regional Chile case study shows that at a detailed specific level, particular regions and sectors of the economy are impacted to a much higher degree than national levels. Wheat production in the province is impacted in a major way and goat production reduced by 23 %.

Indonesia -- Shows that despite earlier fears of severe erosion, long-term investment in soil and water management in the highlands of Java has resulted in relatively stable land and water systems with nutrient loss replaced by fertilizer in an ongoing productive system. In the

Overall Findings of the Case Studies

General

All have important problems of sustainable land management impacting the economy negatively at a rate of 3-7% of agricultural GDP.

- The case studies demonstrate a close link between poverty and land degradation.
- The poverty-degradation link is particularly evident where there is a lack of diversification, of alternative livelihoods, and the ability of land managers to invest in mitigation is limited.
- The policy environment is critical. Policy can **cause or reduce** land degradation through directly targeting proximate mitigation efforts such as terracing and reafforestation, which may or may not elicit positive responses from land managers, and through its indirect impact on the economic and social context within which land degradation is embedded.
- The responses to the problem emphasize local physical measures and do not address policy or related poverty issues.
- In all cases the responses appear to be an order of magnitude less than the economic impact of the problem.
- Countries vary widely in their databases on this issue. Many components of impact are not precisely measured or not taken into account.

Methods and Data

- Methods for assessing on-site costs such as decline in the availability and quality of water, and the loss of production in land-based activities (agriculture, livestock, fishing, forestry), are -documented if not consistent.
- The literature on assessing costs of soil degradation and land degradation recognizes the importance of differentiating between on-site and off-site costs.
- Methods for assessing off-site costs are limited both by data and information, and by the lack of a comprehensive conceptual framework that would define the variety of off-site costs.
- Many of the key processes are difficult to measure in terms of individual components and the interactions between them over time and across space.
- There is a recognition, both in the scientific literature (Barbier, Pagliola, Scherr, Warren) and in government and NGO reports cited in our country studies, that approaches to assessment of the costs of land degradation need to go beyond on-site assessment to examine the variety of off-site costs of land degradation, including environmental costs such as siltation of reservoirs and disruption of streamflow and replenishment of aquifers, and societal costs, such as those associated with poverty and the differential impact of government policy and trade agreements.
- There is a need to define a comprehensive framework for assessment that would include consideration of environmental, social, institutional and economic factors. Such a framework would enable identification of both proximate and root causes of land degradation
- There is need for partnership building to enhance capacities at national and sub-regional levels for updating and/or replication of country studies, as an ongoing contribution to processes related to elaboration of poverty reduction strategies and resource mobilization for their implementation.

INTRODUCTION

A number of events have focused attention on land degradation and sustainable land management. For example:

- The work of the UNCCD since the convention was ratified.
- The emphasis on sustainability in the preparation for Johannesburg and in the meeting itself.
- The GEF initiative to create a land degradation/sustainable land management focal area resulting in OP 15.
- The strong links between land degradation and poverty.

Many countries while being aware of the problem have not found effective ways to prioritize land degradation and sustainable land management – sometimes because of data problems – sometimes for other reasons. Basic questions are posed at a country level such as:

- How severe is the problem?
- What does it cost the economy?
- How best can we invest in remedial measures?
- What have been the returns from past investment?

A series of case studies were funded by the Global Mechanism (GM) with World Bank support to identify some of the answers to these questions in a small, varied sample of countries. These are desk studies and obviously preliminary and incomplete. They should provide a good basis for identifying the major opportunities and problems of this approach. Country case studies on costs of land degradation constitute a critical input in advocacy work for directing adequate technical and financial resources to address this problem, in the context of poverty reduction strategies.

A number of target countries were identified and case studies for China, Uganda, Mexico, Ethiopia, Rwanda, Chile and Indonesia have been completed.

This overview is based on a detailed desk analysis of the extent and costs of land degradation in these seven pilot countries and a review of the level and nature of current efforts of remediation. It is also supported by an extensive review of the academic and agency report literature. In almost all cases in-country documents and data were not available.

BACKGROUND

Over the past 50 years a variety of changes have occurred in environmental, political, and socio-economic conditions that build upon the earlier history. In some cases these have produced productive viable rural economies, but elsewhere many believe that these have combined to lower productivity, increase degradation and reduce the viability of livelihood systems in many areas, especially in Africa.

Drawing on the case studies and the literature the remainder of this paper summarizes the state of understanding of the problem and provides indications of potential future approaches.

Among the most frequently identified contributors to land degradation are:

- Changes in land use and pressures on land resources due to a variety of factors such as altered fallow regimes, adoption of new technology, altered grazing patterns, and cultivation on marginal lands.
- Changes in cropping patterns and in the crop-livestock mix.
- Economic change as local systems have become more integrated into national and global markets.
- Population growth and migration, including to marginal or vulnerable land.
- Changes in rural demographic characteristics - age and gender distributions.
- A dramatic growth in the number and size of towns increasing demands for rural resources, such as food and wood fuel, without the parallel emergence of a productive rural economy.
- The emergence of new governmental and institutional frameworks, including changes in land tenure structures, market liberalization, and a greater role for the private sector and NGOs.
- Local, national and international policies, which adversely impact rural economies.
- Increasing variability in rainfall both between and within years.

These changes provide the context for defining the baseline from which to measure trends in processes contributing to land degradation. An understanding of these trends will assist in the selection of appropriate indicators for evaluating the costs of land degradation, and devising appropriate remediation strategies.

EXISTING ASSESSMENT OF THE COSTS OF LAND DEGRADATION

Land degradation represents a loss of *Natural Capital*, the value to society of land, water, plant, and animal resources. The value includes:

- The direct contribution to primary production in crop agriculture, livestock raising, fishing, and related industries such as commodity marketing and processing. Indicators include reduced yield, change in land use, change in crops, abandonment of fields, and altered livestock mixes and patterns of grazing.
- The quality of environmental services indicated by such processes as changes in stream flow, silting of dams, reliability of irrigation water flow, decline in quality of drinking water, etc.
- Biodiversity, both natural (flora and fauna) and agricultural (genetic diversity of crops and domestic livestock).

These losses also result in costs related to changes in rural society due to processes such as migration and associated loss of human capital and break up of communities, social costs of poverty, and reduced ability to invest in anti-degradation activities.

The costs of loss of natural capital are borne at the level of individuals (farmers, herders, fishers and firms such as commodity processing and lumber companies), communities (bound together by relations among individual producers and by relations with commercial enterprises) and by the broader economy. But this loss of natural capital also results in changes in economic, human, social, and landesque capital, the value of investment in land management.

However, much of the discussion on estimation of the costs of land degradation has focused upon those associated with soil erosion and its control. For example, Barbier (1995) has provided a theoretical and methodological framework for estimating soil erosion at the household and community levels, a framework that could provide the basis for on-site estimation of other components of land degradation. He argues that the soil is a renewable resource that in farming systems is depleted at rates that exceed those background rates that would occur in the absence of human use. Soil conservation therefore implies investments that would extend the productive life of the soil farther into the future than would be the case in the absence of conservation.

Investment in measures to reduce degradation (landesque capital) is expensive both in terms of improving soil (fertilizers, manure, crop residues) and structures such as terraces, grass lines and hedges that all require investments in labor. Decisions to invest therefore have to be made relative to the benefits that are both on-farm (individual) and off-farm (social), while the investment costs are usually borne on-farm (individual). Should on-farm costs exceed benefits over a farmer's time horizon, investment is unlikely. The issue of the effective time horizon is an important one as those of farmers and herders are seen as usually being relatively short. However, the social costs are often viewed in a longer time horizon and were the social benefits seen as outweighing costs then government subsidy of conservation measures would be appropriate.

Most current evaluations of the costs of land degradation have focused on the loss of soil from farm plots and the loss of nutrients resulting in decreased productivity or the need for increased inputs to maintain productivity. The impacts of the sediment streams resulting from these losses are harder to measure but have been part of some accounting with both positive components (deposition of fertile material downstream) or negative factors (farmland covered by sand, increased sediment, load in stream, impacting dam life and turbine efficiency, etc.).

Scherr (1999, and in Bridges 2001) summarized the available assessments of the magnitude of economic losses from soil degradation as a percentage of agricultural gross domestic products (Table 3). Her findings show a variation in estimates from the same country, but in general they are the same order of magnitude as found in the case studies (see Tables 1 and 2).

Findings of the Case Studies

A summary of the overall findings of the case studies is:

General

All have important problems of sustainable land management impacting the economy negatively at a rate of 3-7% of agricultural GDP.

- The case studies demonstrate a close link between poverty and land degradation.
- The poverty-degradation link is particularly evident where there is a lack of diversification, of alternative livelihoods, and the ability of land managers to invest in mitigation is limited.
- The policy environment is critical. Policy can **cause or reduce** land degradation through directly targeting proximate mitigation efforts such as terracing and reafforestation, which may or may not elicit positive responses from land managers, and through its indirect impact on the economic and social context within which land degradation is embedded.
- The responses to the problem emphasize local physical measures and do not address policy or related poverty issues.

TABLE 3. MAGNITUDE OF ECONOMIC LOSSES FROM SOIL DEGRADATION, AS % AGDP*

Study region	Authors	Types of degradation	Annual loss (or GAIL) as % AGDP	Discounted future loss as % AGDP
South And Southeast Asia	Young (1993)	Soil erosion, fertility decline, salinization and waterlogging	7	-
China	Huang and Rozelle (1994) Huang *et al.* (1996)	Soil erosion, salinization, fertility decline	<1	-
Costa Rica	Solorzano *et al.* (1991)	Soil erosion	5-13.3% of annual value-added in agriculture	
Ethiopian Highlands	FAO(1986)	Soil erosion	<1 (GAIL)	44 (GDCL)
	Sutcliffe (1993)	Soil erosion	5 (GAIL)	<1 (GDFL)
	Bojö and Cassells (1995)	Soil erosion	4 (GAIL)	<1 (GDFL) 36 (GDCL)
	Drechsel and Gyiele (1999)	Soil erosion, nutrient depletion	10-11	-
Ghana	Alfsen *et al.* (1997)	Soil erosion		
	Convery and Tutu (1990)	Soil erosion	5 (GAIL)	-
	Drechsel and Gylele (1999)	Soil erosion, nutrient depletion	4-5	
India	Young (1993)	Soil erosion, fertility decline, salinization, and waterlogging	5	
Java (Indonesia)	Magrath and Arens (1989)	Soil erosion	3	-
	Repetto *et al.* (1989)	Soil erosion	?	40 (CLFP)
Lesotho	Bojö (1991)	Soil erosion	<1 (GAIL)	5 (GDFL) 5 (GDCL)
	Drechsel and Gyiele (1999)	Soil erosion, nutrient depletion	5-7	
Madagascar	World Bank (1988)	Soil erosion	<1 (GAIL)	-
	Drechsel and Gyiele (1999)	Soil erosion, nutrient depletion	6-9	-
Malawi	World Bank (1992)	Soil erosion	3 (GAIL)	18 (GDFL)
	Drechsel and Gyiele (1999)	Soil erosion, nutrient depletion	9.5-11	-
Mali	Bishop and Allen (1989)	Soil erosion	<1 (GAIL)	4 (GDFL)
	Drechsel and Gylele (1999)	Soil erosion, nutrient depletion	5.5-6.5	
Mexico	Mclntire (1994)	Soil erosion	2.7 of 1988 crop value for maize (max. of 12.3 where erosion is highest)	-
Pakistan	Young (1993)	Soil erosion, salinization	5	
South Africa	McKenzie (1994)	Soil erosion	<1 (GAIL)	4 (GDFL) <1 (GDCL)
Zimbabwe	Grohs (1994)	Soil erosion	<1 (GAIL)	<1 (GDFL)
	Norse and Saigal (1992)	Soil erosion	8 (GAIL)	<1 (GDCL)
	Stocking (1986)	Soil erosion	9 (GAIL)	
	Drechsel and Gyiele (1999)	Soil erosion, nutrient depletion	2.5-4	

* Estimates of GAIL, GDCL, GDFL presented here were calculated and reported by Bojö (1996). CLFP presented here was calculated and reported by Repetto et al. (1989). Figures from Drechsel and Gyiele (1999) Convery and Tutu, Stocking and Norse and Saigal are based on the estimated cost of replacing lost nutrients; others reflect loss in productivity. The range in Drechsel and Gyiele estimates considers price variations of available fertilizers and transport.

Annual loss = the lost value for that year due to soil degradation.
CLFP: Capitalized Loss of Future Productivity (the value of the stream of future losses due to a particular year's soil degradation; similar to GDFL).
GAIL: Gross Annual Immediate Loss (the lost value for gross cropland output in a single year due to land degradation in the previous year).
GDFL: Gross Discounted Future Loss (the value of the stream of constant future annual losses due to soil degradation in a given year).
GDCL: Gross Discounted Cumulative Loss (the cumulative value of the stream of future losses due to continued soil degradation over time).
From Scherr. 1999.

Findings of the Case Studies

- In all cases the responses appear to be an order of magnitude less than the economic impact of the problem.
- Countries vary widely in their databases on this issue. Many components of impact are not precisely measured or not taken into account.

Methods and Data

- Methods for assessing on-site costs such as decline in the availability and quality of water, and the loss of production in land-based activities (agriculture, livestock, fishing, forestry), are -documented if not consistent.
- The literature on assessing costs of soil degradation and land degradation recognizes the importance of differentiating between on-site and off-site costs.
- Methods for assessing off-site costs are limited both by data and information, and by the lack of a comprehensive conceptual framework that would define the variety of off-site costs.
- Many of the key processes are difficult to measure in terms of individual components and the interactions between them over time and across space.
- There is a recognition, both in the scientific literature (Barbier, Pagliola, Scherr, Warren) and in government and NGO reports cited in our country studies, that approaches to assessment of the costs of land degradation need to go beyond on-site assessment to examine the variety of off-site costs of land degradation, including environmental costs such as siltation of reservoirs and disruption of streamflow and replenishment of aquifers, and societal costs, such as those associated with poverty and the differential impact of government policy and trade agreements.
- There is a need to define a comprehensive framework for assessment that would include consideration of environmental, social, institutional and economic factors. Such a framework would enable identification of both proximate and root causes of land degradation
- There is need for partnership building to enhance capacities at national and sub-regional levels for updating and/or replication of country studies, as an ongoing contribution to processes related to elaboration of poverty reduction strategies and resource mobilization for their implementation.

LESSONS FROM COST ASSESSMENTS OF LAND DEGRADATION

General Lessons Learned

A number of general lessons can be drawn from the case studies and the literature.

1. Investments to mitigate degradation may be economically profitable at the *farm* level where markets and other economic conditions create sufficient returns (eg Yangtze Valley, Indonesia).

2. Investments to mitigate degradation are often not profitable at the *farm* level, especially in areas already highly degraded or with fragile land, where crop production is not highly remunerative, or where labor costs are relatively high (Ethiopia, Chile).

3. Governmental or other societal investments in land degradation mitigation have often not been sustained by land managers in the long-term because the governmental programs:

- used a top-down approach, with the proposed practice not adoptable/ adaptable considering local economic, labor and other conditions;
- were limited to short-term solutions (e.g., placing terraces, providing agricultural inputs) without addressing the socioeconomic causes and context of degradation
- emphasized surface erosion control over other aspects of degradation and productivity improvements (e.g., water management, organic matter enhancement, green, chemical or other fertilizers), or broad improved land management (type of crop, crop/livestock mix, alternative uses of the land, etc.).

4. Existing cost assessments have used methods and approaches that vary widely and their results are thus difficult to directly compare. They vary from cost assessments based on plot-level soil analyses to economic calculations of production losses to the national economy, usually based on large assumptions.

5. The cost assessments based on plot level analyses:

    - tend to emphasize losses due to surface erosion on one plot without including sediment gains to other plots, other off-site impacts, or other types of degradation (e.g., wind erosion, weed invasion);
    - rarely conduct a comprehensive, or long-term, assessment of the impact of degradation on crop production (e.g., differential impacts by type of crops or farming systems)
    - are almost always conducted on research stations with production conditions that might be very different from on-farm conditions;
    - while the few long-term studies indicate that in situations of newly cultivated areas with limited soil management, there is a rapid loss of production initially, and an eventual plateau at a low, degraded level. Mitigating the degradation at that point requires much more and longer-term investment. This is often in areas where poverty is severe, as well.

6. The cost assessments at the regional or national level:

    - are usually limited to assessing losses to crop production, and often do not include the cost of rangeland degradation, loss of biodiversity, off-site costs or other direct costs of degradation, much less the indirect costs (poverty, malnutrition, etc.);
    - rarely assess the impact of degradation on households and people within households differentiated by income level, gender, ethnicity etc. It is important to develop programs that recognize these differences and the importance of the poverty/ degradation link;
    - rarely (ever?) assess the lost opportunity cost to production of higher value crops, or to investment in non-farm activities;
    - tend to indicate that large zones of some semi-arid areas (e.g. in China, Mexico) are badly degradated. The level of degradation in more humid areas (Uganda, Rwanda, Ethiopia etc) varies widely depending on the socio-political context.

7. These assessments at both levels do not usually account for

- the differential negative impact of degradation on poor households, especially women-headed households, on women farmers, on agricultural laborers, and on other socially disadvantaged groups;
- the impact of degradation on stymieing agricultural intensification and increased productivity due to the lack of economic incentives to invest in the land and in agriculture and lack of incentive to upgrade technology;
- the local population being affected in, for example, its reduced ability to invest in non-farm activities, education or other activities in order to thrive. Effects are also felt in the regional and national economies due to reduced investments in agricultural and non-agricultural sectors;
- the impact of land degradation on ecological services besides agricultural production, including off-site impacts of increased sedimentation, the loss of local biodiversity, and effects due to out-migration from degraded areas to ecologically sensitive agricultural frontiers.

Mitigation Assessments

By not including this broader array of impacts, making decisions on investments to mitigate land degradation using the results of the traditional valuation approach may not lead to the reduction of poverty or other intended benefits. For example, by not valuing the impact of degradation on malnutrition, the potential benefit of reducing degradation in a particularly poor region or among poor people would be underestimated. Also, by not fully valuing the impact of degradation on agricultural investment in a high-potential region, the full benefit of reducing degradation would also be underestimated.

A second limitation to using degradation valuation results for targeting mitigation investment is that valuation results do not reflect the fundamental causes of degradation. The danger of using valuation results for policy or program decisions is that one risks addressing the symptoms of degradation while not addressing the causal factors and societal impacts. Both need to be addressed. The causes and impacts of degradation that could be expected to particularly affect the success of investments in degradation programs include:

- past and current policies and programs affecting the agricultural and land sectors;
- the poverty/ degradation relationship;
- the differential impact of degradation on disadvantaged segments of society;
- the feedback between the agricultural and non-agricultural sectors in causing degradation and affecting the success of mitigation programs. For example, programs to mitigate degradation by increasing soil fertility might be successful in the long-term only in conjunction with initiatives that promote growth in incomes such as commodity marketing and non-farm income opportunities.

The goals of poverty alleviation and sustainable livelihoods are part and parcel of an integrated approach that views mitigation of land degradation in a broader context.

SUSTAINABLE LIVELIHOODS AND LAND DEGRADATION: WHICH FACTORS ARE IMPORTANT?

An integrated assessment of the costs of degradation can be informed by scientific studies and policy documents. In many parts of the world, as illustrated by the case studies, production systems and their environments have come under much stress, due to many causes including changing land tenure regimes, population growth, climatic fluctuations, overuse of natural resources especially in marginal environments, and a lack of appropriate policies or financial resources for sustainable development.

Many of the regions with the highest levels of degradation have some of the highest rural population densities in the world directly dependent on the productivity of the land and highly vulnerable to the effects of degradation. The population growth rates in many marginal lands are also among the world's highest, thus increasing the pressure on the natural resource base. Additionally, many drylands are experiencing a period of long-term below average rainfall, which has resulted in a decrease in natural resource productivity.

The result of all these changes is that current livelihood and resource use systems are not able to maintain, let alone improve, living standards in marginal areas and there is already a reduction of the productivity of land, water and vegetation systems. In some cases the changes have been so rapid and large-scale that modifications in traditional systems have not been able to keep pace. New strategies are needed to increase the productivity of agricultural and rangeland systems in an environmentally sustainable manner that reduces poverty. It may involve reducing the number of people directly dependent upon primary resource systems, and providing them with alternative or supplementary means of livelihood.

Almost all rural areas already generate wealth from activities in addition to income from crops and livestock. In this context, policy options should be explored which give greater attention to the rural non-farm sector and to activities, which link villages to regional and national economic networks. (Berry et. al. 1991; Tiffen 2003).

As discussed above, the contemporary circumstances affecting land degradation are the outcome of a variety of proximate and exogenous factors and processes.

Policies and Programs

Past and current policies and programs that affect the agricultural and land sectors need to be analyzed in terms of their contribution to and remediation of land degradation. These can be direct, for example mandating land managers' to maintain anti-erosion structures, or indirect through their contribution to poverty alleviation and to the feedback between the agricultural and non-agricultural sectors. The Ethiopian case illustrates the role of the government's philosophy towards rural development as at different times reducing or exacerbating land degradation; the experience of Uganda and Rwanda exemplifies the impact of conflict and ineffective governmental institutions; while in Mexico the links between international agreements, changing government policy towards land tenure and rural investment, migration, and marketing illustrate the national and international context within which local land degradation is occurring.

As noted by Repetto (1986), Barbier and Burgess (1992: 5) and others, public policy can have a number of influences including:

- higher aggregate crop prices and lower agricultural input costs increase the profitability of crop production, thus encouraging an aggregate expansion of agricultural production onto marginal or more erodible land;
- the impact of agricultural pricing on the relative returns to agricultural production can influence long-run decisions to invest in sustainable land management and conservation;
- changes in the relative prices of crops (and crop inputs) can influence the substitution of more environmentally benign cropping and farm production systems for systems that are more environmentally damaging; and
- the variability of crop prices and crop price inputs can affect farmers' choice of crops and cultivation practices, and decisions to invest in sustainable land management, by affecting the risks associated with alternative agricultural investments and production systems
- economic and social policies regarding migration, land distribution, urban employment, infrastructure development, the value of the currency, etc..

Population Growth

Some argue that population growth is a major driving force of processes that result in land degradation. While fertility rates are falling worldwide, there is a “demographic commitment”, an inertia in current demographic dynamics, that will inevitably lead to further population growth well into the present century.

Often associated with rapid increases in population densities is migration from rural areas to other rural areas, including to more marginal environments such as forest edges, the margins of rangelands, high altitude areas, and steeply sloping land. Long and short distance migration to marginal environments are often the result of changes in land tenure or ownership patterns in the more productive source areas. Out-migration from rural areas is also headed to towns, and internationally as people seek to improve their livelihoods. Urbanization, with its attendant social and ecological stresses, often also contributes to land degradation.

In a detailed comparative study of East African agricultural systems Olson (1998) demonstrated that population growth does not inevitably lead to intensification, and intensification does not necessarily lead to successful environmental management and increased productivity. Rather the outcomes are dependent upon institutional and economic policy, land tenure arrangements, and the wealth and demographic composition of households (Table 4).

The third intensification scenario outlined in Table 4 indicates the conditions under which the threat of land degradation is highest. The conditions described for Rwanda and Western Kenya represent a combination of factors that might accelerate land degradation. Were critical conditions to alter, these factors may appear in areas addressed in the fourth scenario and lead to a reduction in intensive land management and worsening land degradation. Areas do not inevitably move from lower to higher intensification with improved land management.

Land Tenure

There is an active debate on the relationship between land tenure and resource productivity (Bromley 1992; Deininger 2003), illustrated for Africa by Bruce and Migot-Adholla (1994) and Bassett and Crummey (1993). The debate focuses on the relative merits of communal systems, common property resources, and private property in raising productivity and limiting environmental degradation.

An important conclusion of research on land rights is that security of tenure is more important to land management than specific forms of tenure. Security provides a basis for land managers to invest in landesque capital (Blaikie and Brookfield 1987), including "leveling, destumping, terracing, drainage, ditching, farm road building, well digging, irrigation works, tree planting and fencing, as well as the construction of farm buildings." (Bruce 1993:38).

Security is however complicated when land tenure policy transforms customary rights into individual holdings. The transition can create or exacerbate social and economic differentiation. There are often winners and losers. Women, the young, and ethnic minorities tend to lose relative to local elites and their counterparts in urban areas for whom land represents a means for accumulating wealth as much as a basis for production. Lack of security is linked to poverty, and poverty to a lack of options that contributes to land degradation. This may in some cases be a proximate cause.

Local Factors

In addition to the factors commonly discussed in the intensification literature such as population density, extensification, commercialization, and privatization of land, Olson found that adoption of more intense land management practices varies with both farm and non-farm economic opportunity. This depends upon both local circumstances, including wealth differentiation at the farm level, and factors affecting economic circumstances at other levels, such as peace/war, marketing, and road infrastructure that are dependent upon government economic policy and national and international political conditions.

Urbanization

Land degradation has also been identified with urbanization. Rural to urban migration is currently most rapid in countries of the South (UNEP 1997). It contributes to land degradation through land conversion, deforestation for lumber and fuel, and through the effluents that urban and industrial activities produce that contaminate land, air and water. Rapidly growing urban areas also impact land use in a wide surrounding zone. These impacts are seen as accelerating in the next few decades as urbanization and industrialization continues. The dynamics of rural and urban change are often accompanied by social stress.

Poverty

The effects of poverty can severely constrain the mitigation of land degradation. Poverty becomes a contributory cause of degradation when it limits farmer investment in maintaining land productivity, and it becomes a consequence of degradation as productivity declines reduce income. Studies show that poor households often have farms with degraded soil due to a combination of factors including:

- a labor shortage since members of the household work off-farm or have migrated in search of income;
- low investment in the farm such as enlarging the farm size, purchasing animals or soil inputs, or building terraces. Low investments are due to a lack of labor and capital resources and/or, in the case of female-headed households, purchasing land or animals being socially unacceptable. The lack of resources and inability to invest leads to unsustainable practices such as reduced fallowing, nutrient mining and poor erosion control;
- cultivating or grazing land that may be the most vulnerable to degradation, such as steep slopes or naturally poor soils;
- restricted access to social goods such as agricultural extension, credit, education, and communal water and grazing land.

The causes of poverty and unsustainable practices are, however, seldom only local and often being related to the national and regional economic situation, and the distribution of resources.

The experience of land degradation mitigation programs is that techniques and policies to reduce degradation are not scale neutral (e.g., farm size affects the profitability of a proposed practice) nor have a neutral societal effect (e.g., programs affect male and female headed households differently). This renders necessary the assessment of differential impacts of proposed techniques and policies. Techniques to reduce degradation are rarely maintained especially by poor farmers after projects end, unless the practices do not risk production to the existing farming system, and result in reliable income gains that offset the cost of the practice. Reducing both poverty and land degradation may require strategic investment and the stimulation of secondary and tertiary activities, particularly those that use primary products as raw materials.

Political Conflict and Warfare

Political conflict and warfare may provoke migration and emergence of refugee populations, undermine economic advancement, and destroy infrastructure. These disturbances of the socio-economic system have potentially dire implications for land degradation as they disrupt commodity and input markets, and environmental management; lead to the destruction of forests, infrastructure such as dams; and the use of toxic agents.

Complexity

The complexity inherent in such a comprehensive approach is recognized in a number of scientific fields that contribute to our understanding of complex systems (Holling). These include ecology, landscape ecology, political ecology and more recently "new" ecology (Balikie and Brookfield 1987; Peet and Watts 1996; Zimmerer 1994, 2000; Scoones 1998). All emphasize that complex systems, including the society-environment systems that are implicated in land degradation and its remediation, have to address:

- the uncertainty in systems dynamics that arise from the fact that ecological and human systems are intrinsically non-equilibrium (Botkin 1990; Zimmerer 1994, 2000);
- the importance of interactions between societal and ecological processes, over time and across scales from the local to the global (Campbell and Olson 1991; Campbell 1998);

- the fact that societies are not homogeneous and that issues of class, gender, age, and wealth are among the important characteristics that differentiate individuals and groups in communities and influence their land management strategies (Carney 1993; Watts 1987);
- the role of power in individuals and institutions within and external to communities in affecting access to resources (Orstom 1993);
- the essential role of land managers in determining land use, within the constraints of local and external societal, economic, political/institutional, and environmental conditions – structure and agency (Blaikie and Brookfield 1987; Giddens 1991).

ALTERNATIVE ASSESSMENT OF THE COSTS OF LAND DEGRADATION

Existing methods provide a basis for estimation of in-situ costs of land degradation and its remediation though data is seldom adequate. Many authors recognize the need for a broader approach that includes definition and enumeration of private and social costs, while acknowledging that existing constraints of availability of information and data would be compounded (Barbier 1997, Pagliola 1999, Scheer 1999, Warren 2002). A more integrated approach would derive from an explanatory framework where reducing land degradation was one component of a sustainable livelihood system. It would lead to an evaluation that would include reducing land degradation and promoting sustainable livelihoods, with increasing production, as co-objectives. Estimating the costs of land degradation and its remediation would include a more comprehensive definition of key variables and of methods for evaluating costs and benefits of environmental management.

It is in this context that the following section provides a framework for a more comprehensive assessment of private and social issues related to land degradation and its remediation, and discusses some of the important components that need to be enumerated.

Different types of capital and their role in valuing land degradation

The importance of a broader approach to evaluating the cost of degradation is recognized by many of the authors who have conducted quantitative assessment of the costs of land degradation, including Barbier, Scherr, and Pagliola Serageldin and Sfer-Younis (1996) argue that one approach to a assessment of sustainability in society-environment systems is to categorize costs and benefits as four capitals.

Social capital – family, friends, community, country.
Human capital – knowledge, skills, techniques.
Fixed capital – houses, roads, factories, machines, tools.
Natural capital – fisheries, forests, minerals, soils, climate regulation, pollutant disposal, natural beauty.

For the purposes of this study we draw upon this sustainability literature and propose the following as a means of differentiating the variety of components that make up an assessment of land degradation:

<u>Natural Capital</u>

- On and off-site effects on the soil, forests, water, fisheries, minerals, flora and fauna (famine foods).

- Environmental services, climate regulation, pollution disposal, natural beauty.
- *Genetic capital* including natural and agrobiodiversity

Economic Capital

- Fixed capital – houses, roads, factories, machines, tools.
- Direct costs in production.
- Indirect costs in production such as lower value crops being produced.
- Lost opportunity costs from lower investment in farm and non-farm sector.
- Costs of remediation – labor, technology.
- Varies by socio-econ status, gender, class etc.

Landesque Capital

- Value of existing and new investment in remediation measures.
- Costs of their maintenance.

Human Capital

- Costs of investment in population – health, education (formal and informal/indigenous knowledge and techniques), feeding and clothing.
- Availability of labor.
- Implications of emigration/ remittances.
- Costs of malnutrition, food insecurity.

Social Capital – to include:

- Indigenous knowledge of natural and managed systems.
- Differential impacts of degradation on segments of society.
- Institutions – both rural and national.

Pretty (1999) summarizes this issue succinctly (quoted from McDonald and Brown 2000):

> ***Capital assets and natural resource improvements: linkages and new challenges***
>
> *Five capital assets are vital for sustainable development – natural, social, human, physical and financial capital. Sustainable systems, whether farms, firms, communities or economies, accumulate stocks of these five assets. They increase the capital base over time. But unsustainable systems deplete or run down capital. They spend capital assets as if there were income, so liquidating assets and leaving less for future generations.*
>
> *In practice, it is common to find trade-offs between the capital assets, with gains in one or more capitals resulting in losses of another. What characterizes non-sustainable and vulnerable systems, therefore, is that there is some imbalance between the capitals, leaving inadequate levels of one or more to produce the desired outcomes. Natural and social capital is also largely public*

goods. They are easily run down by those who under invest in them and overuse them. They can, however, be regenerated.

Social capital is fundamental for economic growth. It lowers the costs of working together and so facilitates cooperation between people. In the past, it has been commonly overlooked. But it is becoming increasingly clear that social capital is a vital prerequisite for sustainable, productive and long-term management of natural resources. Development assistance has long recognized the fundamental challenge of finding solutions that persist beyond the lifetime of projects and external assistance. But despite the widespread adoption of the language of "sustainability" and "participation", too few sustainable solutions have emerged. Too little attention has been paid hitherto to the forms of social capital necessary for the emergence of sustainable solutions to natural resource management.

Recent years have seen remarkable advances in social capital creation in a variety of resource management sectors. Group-based programmes centred on participatory and deliberative learning processes leading to social capital formation have brought substantial welfare gains in watershed/ catchment management, in irrigation management, in micro finance delivery, in forest management, in integrated pest management and in farmers' research groups. In the past decade, many new groups have arisen in these sectors - mostly in developing countries.

From this and other comparative evidence, it is clear that social capital pays. Group-based programmes are more likely to deliver substantial private and public benefits than those with an individual focus. It is also true that social capital will not appear without investment in participatory learning processes.

POLICY IMPLICATIONS

Investments made in-situ to reduce losses of natural capital (input of fertilizers, building of terraces to control erosion, controlled grazing, reafforestation, etc) depend upon the capability of livelihood systems to invest in landesque capital and maintain it. This capability is conditional upon the availability of inputs (labor, fertilizer), a perception that the investment will provide private and social gains to the community, and a external context that depends upon the ability of the private sector and government policy to provide a facilitative framework.
Over the past 20 years there has been lively debate over the relative roles of the private and public sectors in such facilitation, for example in the context of SAPs and strategies to decentralize government functions and promote private sector provision of services. While in the 1980s and 1990s there was a strong emphasis upon transfer of public services to the private sector and decentralization of government, the contemporary discussion indicates that the private sector has to be actively supported by public policy and strategic investment in government services.

Rural development aims to provide for sustainable livelihoods, mitigate the impact of environmental constraints, such as recurrent drought, and conserve natural resources. While the private sector can facilitate important economic goals, there is a continued role for the state. A mix of policy incentives is seen as desirable that promotes agricultural production in years of adequate rainfall through SAP objectives of private sector provision of credit, farm inputs, and marketing, while the government needs to invest in structural support such as the road infrastructure and establishing a legal framework that assures security of land rights and instituting "insurance" policies that will offset environmental constraints and have strong welfare effects (Kuyvenhoven et al 1998; Ruben et al 2001). Such an approach conforms to the principles outlined by the World Bank World Development Report of 2000.

A number of studies of farmer responses to strategies to reduce land degradation have established that the more effective approaches integrate land conservation within a broad strategy for improving rural livelihoods. This will include investment in education and health (human capital) and require that local institutions (social capital) address the issues of equity, changing gender roles (Lilj and Sanders 1998), and provide the necessary security in land rights to encourage the investments that reduce land degradation and increase productivity (landesque capital) (Enyong et al 1999).

Such an approach requires the positive involvement of the government alongside local institutions and the private sector. As discussed above land managers will not invest in landesque capital to reduce degradation and increase production in the absence of security of land rights, sufficient price incentives, and an effective marketing infrastructure. These demand the involvement of local institutions to implement land laws, government investment in roads, and reliable availability of inputs such as credit and fertilizers and purchasing of crops through the private sector.

Studies by Reij and Steeds (2003) show that under the right conditions indigenous successes can be achieved. Part of the answer is in obtaining those "right conditions".

RECOMMENDATIONS

The lack of a consistent approach to valuing degradation within regions of countries, and certainly between countries, limits the ability to assess the relative severity of the problem at this time. It is recommended that in future assessments of the cost of degradation, the approach include both direct and indirect costs of degradation at the affected area. Where degradation at the affected area leads to off-site costs, for example due to the impact of downstream sedimentation or from out-migration, these need to be included. Some of the direct and indirect, on and off-sites costs to include are outlined in the "capitals" section V.A. above.

Results of any assessment of degradation costs should be used in conjunction with other information in making strategic decisions about where and how to invest to reduce land degradation. This other information would form a more integrated analysis that would:

- identify the socioeconomic and environmental causes and context of degradation, including analyzing past and current policies, to better target those factors;
- identify the differential impact of degradation and of potential programs on segments of society;
- recognize that land degradation mitigation programs are sustainable only when the rural socio-economic context evolves so that the new practices are economical for the land managers;
- build on beneficial farm/ non-farm sector feedbacks.

The analysis of the case studies provided the following lessons from past land degradation experiences:

- Some of the most rapid degradation occurred as a result of policy changes. Examples of this include the expansion of agriculture to extremely vulnerable areas, such as to the loess plateau in China.
- Rural poverty, especially in the context of a stagnant or declining national economy, has frequently prevented capital or labor investments in land management from being cost-effective. This was the case in Rwanda, Ethiopia and Mexico. Improvements in the non-agricultural economy can have positive effects on agricultural productivity and land management, as in Uganda. Within areas, poorer households often suffered the worst degradation and were the least able to prevent degradation, yet may potentially benefit the most from degradation mitigation programs if the programs are so designed.
- Land degradation mitigation programs that were not sustainable often:
    - adopted a top-down approach, with the proposed practice not adoptable/ adaptable considering local markets, labor and other conditions
    - were limited to short-term solutions (e.g., placing terraces, providing agricultural inputs) without changing socioeconomic causes and context of degradation
    - emphasized surface erosion control over other aspects of degradation and productivity improvements (e.g., water management, organic matter enhancement, or broad improved land management)

In short, the most effective approach to mitigation would include a careful analysis of the policy framework most likely to facilitate mitigation through direct and indirect measures, capacity building, and a focus on alternative livelihoods that would improve rural conditions and address the poverty-degradation linkages.

TABLE 4. INTENSIFICATION CONTINUUM FOR THE HIGHLANDS OF EAST AFRICA

FACTORS, INDICATORS	I. SHIFTING CULT KABALE 50 YRS AGO	II. PERMANENT CULT. KABALE TODAY	III. INTENSIFICATION RWANDA TODAY	IV. INTENSIFIED EMBU TODAY
LAND TENURE	Communal land holding.	Most land privately held. Much land fragmentation.	Land privately held. Consolidated, small farms.	Land privately held. Consolidated, small farms.
CROPPING SYSTEM	Shifting cultivation, long fallows. Low value food crops (sorghum).	Permanent cultivation, short fallows important. Low/med value food crops (sorghum, beans).	Permanent cultivation, little fallowing. Low value food, med value cash crops (maize, tubers, coffee).	Permanent cultivation, no fallowing. Medium value food and high value cash crops (coffee, tea, maize).
LIVESTOCK SYSTEM	Free grazing of many local cattle, goats and sheep.	Loosely controlled grazing of fewer local animals.	Few cattle for cultural use and manure. Small livestock important. Controlled grazing mostly on own land.	Zero grazed dairy cows fed with planted fodder and purchased meal.
TREES IN SYSTEM	Needs met by wild sources.	Fuelwood deficit; plant fuelwood spp. in woodlots and boundaries, fruit/ medical spp. near house.	Fuelwood needs met. Plant for local market (fuel, fruit, construction).	Plant for regional market (fruit, nuts, medicine) and for fodder.
SOIL MANAGEMENT	No inputs; crop residues burned. Terracing enforced by colonial government.	Widespread use of crop residues, some manure used. Terraces used as boundary markers.	Crop residues and manure highly valued (moved within farm). Few chemical inputs (low cash returns). Soil conservation important.	On-farm manure used but not managed. Off-farm manure and chemical fertilizer purchased. Erosion controlled.
LINKS WITH NATIONAL/ INTERNATIONAL ECONOMY, CHANGES IN TERMS OF TRADE	Few.	National level growing in importance. Low value food products sold but little regional specialization.	Medium value export crop (e.g., coffee) and low value food crops traded.	Important: med/high value products sold, low value food products bought.
LAND, LABOR, CAPITAL PRODUCTIVITY	High labor prod. Low land productivity. Low capital prod.	Medium labor productivity Medium land productivity Low capital productivity	Low labor productivity Medium land productivity Medium capital productivity	Medium labor prod. High land productivity Medium capital prod.
LAND DEGRADATION	Low	Rapid degradation	Degraded	Degradation reversed
LAND USE	Much grassland and fallowed land, patches of open woodland, scattered fields.	Much conversion to cropland, some fallow land, large patches of grass & woods on marginal land.	Conversion to cropland almost complete; little fallow, few patches of grass or woods, increased planting of trees.	Landscape of densely planted crops and trees, increase in built-up land.
REGIONAL MIGRATION	Little out-migration, some for political or social reasons.	Much short distance rural-rural for settling land. Much long distance to seek land. Some rural-urban.	Much long distance rural-rural to frontier land. Rural-urban increasing.	Slackening rural-rural movement. Much rural-urban.

Source: Olson 1998

Annes 1. BASIC CONCEPTS

Important concepts in assessing private and public costs and benefits of land degradation and its remediation include:

Nature of Private and Public Costs

Individual producers are concerned mainly with on-site issues such as the loss/gain relation associated with decisions whether or not to invest in landesque capital, largely in terms of production. Public costs benefits include not only the aggregation of the private on-site costs/benefits, but also externalities.

Uncertainty

What Campbell (1998) wrote on uncertainty in the context of global change applies to the types of analyses that would employ the comprehensive framework for assessment of land degradation proposed in this study:

> *Unpredictability of future outcomes is a feature of models prepared by many different disciplines to examine aspects of global change (Hanninen, 1995). Given that these models reflect only parts of a common greater whole, in which the parts interact, the level of uncertainty in understanding and predicting the larger system is great (see Faucheux and Froger [1995] for a discussion of modalities of uncertainty).*
>
> *Further, many regional/local case studies of society-environment interaction offer examples of conjunctural explanations or of what are termed in the philosophy of science 'Cournot processes' where an event is produced by the intersection of two or more independent causal chains. Because of the independence of the causes and the dependence of the outcome on the specific point at which they meet, there is a large element of chance and unpredictability about the result and a consequently low likelihood of successfully generalizing the findings to other situations or of forecasting change in the future.*
>
> *Future interdisciplinary work will be well served by acknowledgment that all models, based on different information and methods of analysis, are subject to uncertainty. The challenge thereafter is to devise approaches, which can provide alternative scenarios with different degrees of probability of future occurrence. These can then inform policy choices which would be better served by strategies that maintain flexibility to adapt in the event of changes in the predicted future context, where flexibility can be defined as (Lev and Campbell, 1987:126):*
>
> > *the resulting ability of the system as a whole to take a variety of subsequent directions which define different resource configurations. When flexibility is taken into account it becomes evident that it is not optimal to seek the "best" decision on a period by period basis. Rather, it is necessary to trace through an optimum overall strategy which weighs both short and long run consequences.*

Time and Spatial Scale

Individual producers are seen as having a shorter time horizon over which they discount the investment in landesque capital than that adopted at the societal level. At the same time different biophysical and societal processes that contribute to or ameliorate land degradation function at different time scales. For example national elections tend to follow a 5-year cycle and in Africa some have argued a 10-15 year periodicity in the occurrence of droughts. These and other events and processes have implications at a variety of spatial scales from the local to the global (Campbell and Olson 1991; Figure 1). As these biophysical and societal processes interact over space and through time, understanding the complexities involved in their temporal and spatial characteristics is important.

Externalities

These may include impact of siltation on the longevity of dams and electricity production, alteration of local climate, and availability of wood-based fuel sources. Externalities are difficult to measure as they are not included in the decision-making of, or price of the commodities produced by, farmers, herders or companies processing primary products. However they can have significant costs to society at large. Under these circumstances there can be considerable divergence between private and public costs of land degradation, and government policy (e.g. taxes and laws) may be required to encourage private producers to bear some of the societal costs of their activities.

Externalities are seen to derive from the divergence between private and social costs of erosion. Government intervention in the form of laws, taxes etc can be enacted as a means of reducing public costs. At the same time it is recognized that actions taken within the public and private sector can influence the land management decisions of producers, and thus influence the degree and cost of land degradation.

Social Differentiation

Social differentiation according to economic status, gender, and stage in family life cycle can all influence the ability of producers to initiate measures to combat land degradation.

Measures to combat land degradation require labor and capital; the decision to invest in landesque capital is influenced by producers' ability to access inputs such as fertilizers and machinery, by security of land rights, and by security of markets and prices for products. The ability of land managers to address land degradation is influenced by their resource access, by the biophysical environment, and by external policy. For example in countries such as Mali and Mexico the most vulnerable people – poor, female-headed households, those with little access to labor – have developed livelihoods that try to minimize the risks associated with their own resource access and an unpredictable biophysical environment where droughts and floods are recurrent hazards. Government policy initiatives such as SAP in Mali, and the impact of NAFTA in Mexico, have constrained the ability of the poor to maintain productive livelihoods and migration to marginal land, to forests, and to cities has ensued. This illustrates that policy can have a dramatic impact upon the ability of some groups to maintain sustainable livelihoods, and by extension to reduce or exacerbate processes of land degradation.

Figure 1

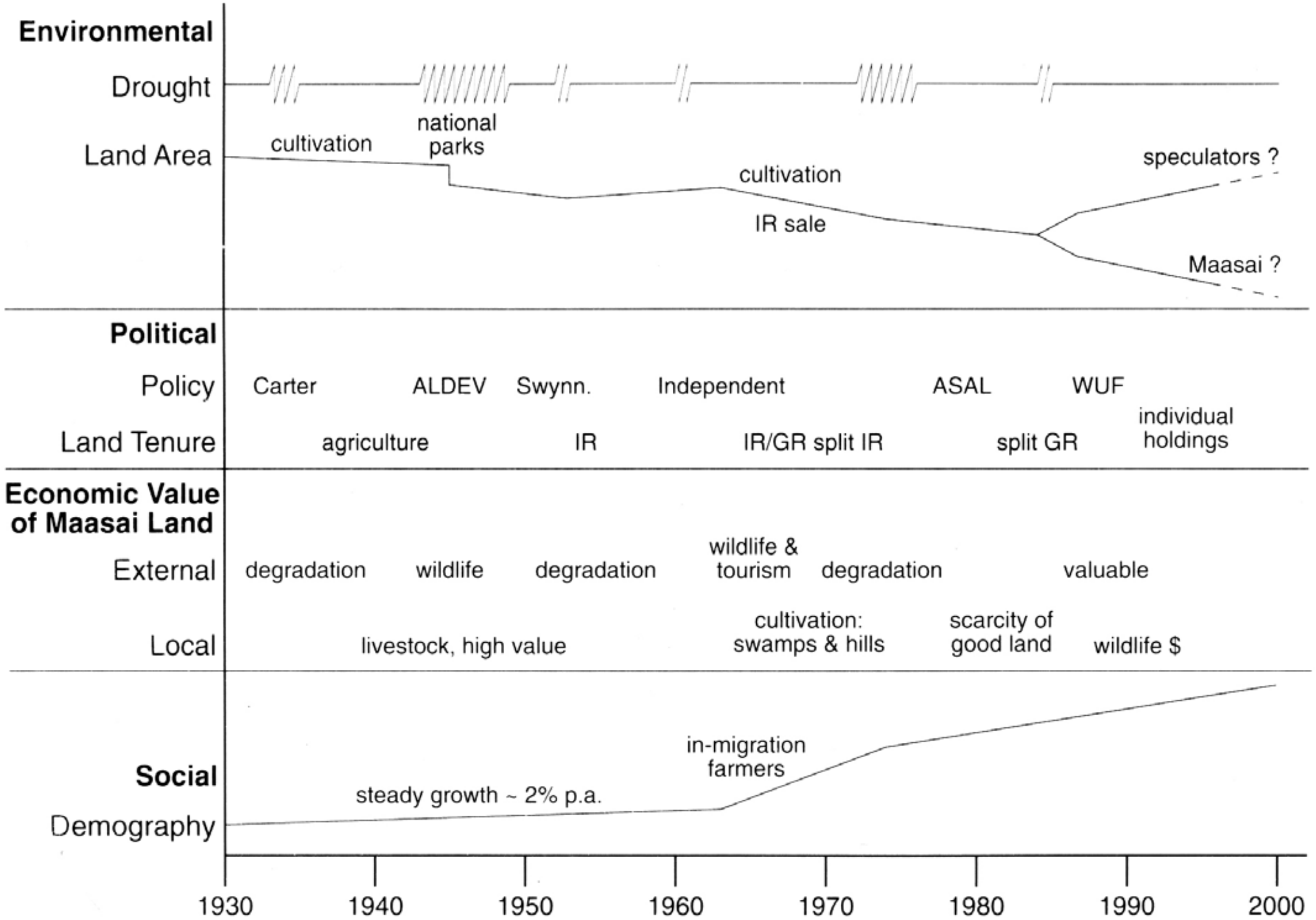

Fig. 19.4. A braid of time for the Kajiado District in Kenya (from Campbell, 1993). ALDEV, African Land Development in Kenya; ASAL, arid and semiarid lands; GR, group ranches; IR, individual ranches; WUF, wildlife utilization fees.

Annex 2. ALTERNATIVES TO PRIMARY PRODUCTION ACTIVITIES

Many authors recognize that private attitudes towards land management derive from the continued dependence of rural societies upon land-based activities. With increasing population growth intensification of land use represented by declining fallow periods, and extensification into more marginal lands are occurring. Were alternative secondary and tertiary economic opportunities available then the dependence of a growing population on natural capital might be alleviated (Berry et al. 1991; Scoones 1999).

Further, a significant conceptual innovation among planners would be to investigate alternative livelihood systems that reduce the population dependent upon land-based resources. Alternatives can be found in secondary and tertiary economic activities that would allow diversification of livelihood systems, together with opportunities for decreased pressure on the resource base (Berry et al 1991).

The general goal of alternative systems is to improve the ability of local people to maintain and increase economic well-being in an environmentally sound way. Concern with increasing populations dependent upon primary, land based resources, indicates the desirability of interventions that will reduce the proportion of the population engaged in these activities.

The quality of natural resources limits the ability of resource management strategies alone to improve the quality of life of the people. There is therefore a need to explore other livelihood and production systems not so dependent upon the vulnerable natural resource base. Investment in secondary activities (processing, manufacturing) that use as inputs products that farmers and herders are producing provides off-farm employment. The resultant value added will contribute to the wealth of the community. A second possible alternative is encouragement of production in the community of products that are currently imported but for which an effective demand exists that would support local production.

This implies that improving incomes and sustaining the resource base are interrelated components of a broad-based rural development strategy. Specific goals include environmental rehabilitation and enhancement particularly of degraded areas, employment generation on site or in nearby market towns, and raising value added benefits through increased local processing to enhance the overall economic viability and environmental sustainability of these strategies.

One expectation of such strategies is that they will contribute to an increase in the wealth of the community. Were this to be distributed among the society (class, gender issues), it would facilitate economic conditions that have been shown to foster reduction in birth rates, and thus over the long term further contribute to a decline in population pressure on land and alter resources.

The most important environmental implications of such strategies is that they reduce population pressure on land and water resources by allowing rural systems to support a growing population by providing employment in activities other than, but based upon the area's primary production potential in agriculture, herding, forestry, etc.

It must be recognized that such small-scale industrialization has the potential to create land degradation, for example by increasing the demand for fuel wood or lumber, raising demand for water, and creating wastes that may pollute land, air, and/or water. Reducing such negative environmental externalities should be a complementary goal of such strategies.

REFERENCES

Barbier, E. 1997 "The economic determinants of land degradation in developing countries." Philosophical Transactions of the Royal Society, B., 352: 891-899.

Barbier, B. 1998. "Induced innovation and land degradation: Results from a bioeconomic model of a village in West Africa." Agricultural Economics, 19: 15-25.

Barbier, E. and J. Burgess 1992. Agricultural pricing and environmental degradation." Washington: The World Bank, Policy Research Working Papers, World Development Report.

Bassett, T. and D. Crummey 1993. Land in African Agrarian Systems. Madison, Wis.: University of Wisconsin Press

Berry L., D. Campbell, and J. Olson. 1991. "Alternative and Sustainable Systems of Production and Livelihoods in Marginal Lands." Background Document, UN Conference on Environment and Development, Rio de Janeiro, UN Sudano-Sahelian Office.

Blaikie, P. and H. Brookfield. 1987. Land Degradation and Society. London: Methuen.

Botkin, D. B. 1990. Discordant Harmonies : A New Ecology for the Twenty-first Century. New York : Oxford University Press.

Bridges, E. et al. 2001. Response to Land Degradation. Oxford and IBH press, pp 507.

Bromley, Daniel W. Making the commons work: theory, practice and policy. San Francisco: ICS; 1992.

Brown, D.G.; Olson, J.M; Campbell, D.J.; Berry, L. A hierarchical approach to the integration of social and physical data sets: the case of the Rwanda Society-Environment Project. Human Dimensions Quarterly 1(4):14-17; 1996.

Bruce, J.W. and R. Mearns. 2002. "Natural resource management and land policy in developing countries : Lessons learned and new challenges for the World Bank." London : International Institute for Environment and Development, Drylands Programme.

Bruce, John W.; Migot-Adholla, Shem E., editors. Searching for land tenure security in Africa. Dubuque, Iowa: Kendall/Hunt; 1994.

Campbell, David J. Towards An Analytical Framework For Land Use Change. In: Bergstrom; Kirschmann, eds. Carbon and Nutrient Dynamics in Tropical Agro-Ecosystems. Wallingford, UK: CAB International; pp. 281-301; 1998.

Campbell, D.J.; Olson, J.M. Framework for environment and development: the Kite. CASID Occasional Paper No. 10. Center for Advanced Study of International Development, Michigan State University, East Lansing, MI. 1991

Carney, J. 1993. Converting the wetlands, engendering the environment: The intersection of gender with agrarian change in The Gambia." Economic Geography, 69 (4): 329-348.

Deininger, K. 2003. "Land Policies for Growth and Poverty Reduction." The World Bank: Washington, D.C.

Dixon, J. and S. Pagliola. 1998. "Economic assessment and environmental assessment." The World Bank: Environmental Economics and Indicators Unit, Environment Department. April 1998.

Enyong, L. A., S. K. Debrah, and A. Batiano. 1999. "Farmers' perceptions and attitudes towards introduced soil-fertility enhancing technologies in western Africa." Nutrient Cycling in Agroecosystems, 53, 2: 177-187.

Fairhead, J.and M. Leach. 1998. Reframing Deforestation : Global Analyses and Local Realities with Studies in West Africa. London ; New York : Routledge

Faucheux, S. and Froger, G. 1995. Decision-making under environmental uncertainty. *Ecological Economics*, 15, 29-42.

Fratkin, Elliot. Pastoralism: governance and development issues. Annual Review of Anthropology 26: 235-261; 1997.

Folke, C, C.S. Holling, and C. Perrings. 1996. “Biological diversity, ecosystems, and the human scale.” Ecological Applications, 6, 4: 1018-1024.
Giddens, A. 1979. *Central Problems in Social Theory: Actions, Structure, and Contradictions in Social Analysis*. Berkeley: University of California Press.
Giddens, A. 1992. Classes, Power, and Conflict: Classical and Contemporary Debates. Berkeley: University of California Press.
Hanninen, H. 1995. Analysing the conflicting requirements of the Framework Convention on Climate Change. *Climatic Change*, 1995, 31, 1-4.
Homer-Dixon, T.F. 1999. Environment, Scarcity, and Violence. Princeton, N.J.: Princeton University Press
Kuyvenhoven, A, R. Ruben, and Kruseman, G. 1998. “Technology, market policies and institutional reform for sustainable land use in southern Mali.” Agricultural Economics, 19,1: 53-62.
Mead, D.C. and C. Liedholm, C. 1998. “The dynamics of micro and small enterprises in developing countries.” World Development 26, 1: 61-74.
Lev L. and D. Campbell. 1987. "The temporal dimension in Farming Systems Research: the importance of maintaining flexibility under conditions of uncertainty." Journal of Rural Studies, 3,2: 123-32.
Lilja, N and J.H. Sanders 1998. “Welfare impacts of technological change on women in southern Mali.” Agricultural Economics, 19, 1: 73-79.
McDonald, M. & Brown, K. 2000. Soil and Water Projects and Rural Livelihood. Land Degradation and Development, 14: 343-361
Mortimore, M. 2000. “The ecology of practice: studies of food crop production in Sub-Saharan West Africa.” Journal of Modern African Studies, 38, 3: 545-547.
Olson, J.M. Intensification processes and political bounds: a framework of land use change in the East African Highlands. Paper presented at Earth's Changing Land: Joint Global Change and Terrestrial Ecosystems and Land Use and Land Cover Change Open Science Conference on Global Change; March 1998; Barcelona, Spain.
Ostrom, E., L. Schroeder, and S. Wynne. 1993. Institutional Incentives and Sustainable Development : Infrastructure Policies in Perspective. Boulder : Westview Press.
Pagliola, S. 1999. “The global environmental benefits of land degradation control on agricultural land.” World Bank Environment Paper, 16. Washington: The World Bank.
Peet, R. and M. Watts (eds.) 1996. *Liberation Ecologies: Environment, Development, Social Movements*. New York: Routledge.
Pretty, J. 1999. Capital Assets and Natural Resource Improvement: linkages and new challenges in McDonald and Brown, 2000 op cit.
Reij, C. & Steeds, D. 2003. Success Stories in Africa’s Drylands. Supporting Advocates and Answering Skeptics. Paper for G.M., March 2003.
Repetto, Robert. 1986. Soil Loss and Population Pressure on Java. *Ambio* 15 (1):14-18.
Ruben, R and A. van Ruijven. 2001. “Technical coefficients for bio-economic farm household models: a meta-modelling approach with applications for Southern Mali.” Ecological Economics, 36, 3: 427-441.
Scherr, S. 1999. “Soil degradation; A threat to developing-country food security by 2020?” IFFPRI, Washington: Food, Agriculture, and the Environment, Discussion paper, 27.
Scoones, I.1998. Sustainable rural livelihoods: A framework for analysis. Institute of Development Studies, Working paper, 72. University of Sussex.
Serageldin, 1996. Sustainabiloity and the wealth of nations: first steps in an ongoing journey. Environment and Development Studies Monograph Series, 5. Washington: The World Bank.

Serageldin, I. and A. Sfeir-Younis 1996. “Effective financing of emviromrentally sustainable development.” Washington: The World bank. Environmentally Sustainable Development proceedings Series, 10.
Tiffen , M, M. Mortimore, F. Gichuki. 1994. More People, Less Erosion: Environmental Recovery in Kenya. London: Wiley.
Tiffen, M. 2003. Intensification in an Urbanising Context: The Case of Dryland Sub-Saharan Africa. Paper presented at “Reconciling Rural Poverty Reduction and Resource Conservation: Identifying Relationships and Remedies,” Cornell University, May 2-3, 2003. UNEP 1997
Warren, A. 2002. “Land degradation is contextual.” Land Degradation & Development, 13: 449-459.
Watts, M. 1987. "Drought, environment and food security: some reflections on peasants, pastoralists and commoditization in dryland West Africa." in M.H. Glantz (ed.) Drought and Hunger in Africa Denying Famine a Future, Cambridge: Cambridge University Press. pp. 171-211.
World Bank. 2002. Linking Poverty Reduction and Environmental Management: Policy Challenges and Opportunities. Washington: The World Bank. July 2002.
Zimmerer, K. S. . 1994. Human Geography and the ‘New Ecology’: the prospect and promise of integration. Annals of the Association of American Geographers 84 (1): 108-125.
Zimmerer, K. S. 2000. “The reworking of conservation geographies: Nonequilibrium landscapes and nature-society hybrids.” *Annals of the Association of American Geographers*, 90,2:356-369.

LAND DEGRADATION IN CHINA: ITS EXTENT AND IMPACT

L. Berry

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TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN CHINA: IT'S EXTENT AND IMPACT

Preface

This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established and the cost of current remedial programs can be identified.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

CHINA


Heilongjiang
Jilin
Liaoning
BEIJING
Tianjin
Xinjiang
Gansu
Inner Mongolia
Hebei
Ningxia
Qinghai
Shanxi
Shandong
Henan
Jiangsu
Shaanxi
Tibet
Sichuan
Hubei
Anhui
Shanghai
Zhejiang
Chongqing
Jiangxi
Hunan
Guizhou
Fujian
Yunnan
Guangxi
Taiwan
Guangdong
Hong Kong
Islands of
South China Sea
Hainan
Islands of South China Sea

LAND DEGRADATION IN CHINA: IT'S EXTENT AND IMPACT

Executive Summary

China, with 22% of the world's population has only 6.4% of the global land area, and 7.2% of the world's farmland; hence sustainable productive land management is critical for the country's long-term agricultural economy. However, while some parts of the country have enjoyed continued high levels of productivity, others are experiencing moderate to severe degradation. Over 40% of the country is adversely affected.

China has made a number of regional and national assessments of the cost and other impacts of land degradation. In 1999 total direct costs were estimated at $7.7 billion about 4% of the GDP while indirect costs were $31 billion. Regional impacts are greatest in the Loess Plateau area and in the extensive Western Region. Poverty and land degradation are closely correlated.

The direct causes include ongoing deforestation of steep slopes, over intensive use of grasslands, neglect of community conservation practices under the new rural system, and use of biomass for energy in rural areas.

The root causes relate to decreasing land per capita, poverty in fragile environments, top down application of policies without local participation and sector driven management initiatives.

As the problem has become severe responses have also grown, but while the minimum cost to the country is over 4.0% of GDP, investment is around 0.08%. Regional assessments show that while the return to farmer investment in soil conservation in the Yangtse valley is high; in the Yellow River and the Loess Region this was not so and external investment was needed. Over $13 billion of investment is projected over ten years in the Western Provinces.

In these and other investments; policy and process issues, as well as pricing, marketing and economic infrastructure will need to be addressed.

LAND DEGRADATION IN CHINA: ITS EXTENT AND IMPACT

INTRODUCTION

Scope of Land Degradation in China

China is among the most affected countries in the world in terms of the extent, intensity and economic impact of land degradation. Current estimates suggest that over 40% of the land area (3-4 million km^2) is adversely affected by wind and water erosion, loss of grazing, deforestation and salinization.

As the Peoples Republic of China (PRC) economy has expanded rapidly over the past decade land degradation has intensified with direct and indirect impacts. With arable land per capita at 0.11 ha, the impact of land degradation especially in poor rural areas is considerable. Annual soil loss is around 5 billion tons and 90% of grassland suffers degradation in the face of rising demand for meat and livestock products.

The basic problem is that PRC has to feed 22 per cent of world's population on 6.4% of global land area, 7.2% of the world's farmland and 5.8% of the world's annual water resources.

Basic Land Use and Ecological Setting

China is a large country but with the world's largest population of about 1.3 billion. Only 1.3 million Km^2 is suitable for cultivation, i.e. about 14 per cent of the total land area. Of the remainder 28% is grassland, 24% woodland and forest and the rest unproductive or urban area. About 500 million Chinese live and work in rural areas, 300 million as rural laborers. Population growth is now a low 1.1% year but urban growth continues to be rapid. Land resources available per capita is about 1.3 ha per rural worker but a high percentage of this is grassland. Because China is so diverse the PRC government has divided the country into seven broad regions for the purpose of land and water conservation programs (Table 1).

Table 1. Main Soil Conservation Planning Areas

- The Loess Plateau Region – North/Central China
- The Black Soil Region of Northeast China
- The Red Soils Region of Southern China
  - The Red Soils Hill and Mountain sub-region of Southern China
  - The Red Soils Coastal Plain sub-region of Southern China
- The Northern Mountain Region
- The South West Mountain Region
- The North West Region
  - The Mountain sub-region of North West China
  - The Grassland Plains sub-region of North West China
- The Tibetan High Plateau and Mountain Region

Source: People's Republic of China National Strategies for Soil and Water Conservation. 2002. Final Report (Draft).

The Loess Plateau is a unique region of up to 200 m deep fine sediment, which is dissected by deep gullies and yields high sediment loads to the rivers. The Black Soil region has high potential for grain production, but susceptible to accelerated erosion if not well managed. The Red Soil region of the South is relatively infertile and susceptible to water erosion. The mountain regions, which make up 66 per cent of China are not agriculturally productive except in the valleys and in the northwest grassland areas, while the Tibetan Plateau is high and cold and has a low potential for crop production. These constraining environmental factors have concentrated highly productive agriculture in the river valleys and alluvial plains, but have also led to intensive unwise use of hill slopes and marginal land, together with the intensive livestock occupation of the grasslands.

Water is also a constraint to sustainable land use, and high sediment loads in rivers provides additional problems. Potential for flooding and drought, both natural phenomena, have been increased by inappropriate land use practices.

EXTENT OF LAND DEGRADATION IN CHINA

Changes in Land Cover

Changes in vegetation status in China are well documented. Forest removal has been an historic process in China and the 20th C. saw a partial reversal of that process so that from 1934-1993 forest cover almost doubled, but most of this was in the form of plantations. Natural forest continues to be depleted and biodiversity has significantly decreased. Grasslands in contrast have suffered significant degradation (Table 2) and 34% of grasslands are moderately to severely degraded, while 90% is degraded to some degree. This has resulted in a reduction in production potential. Regional data for Inner Mongolia show that in the 1950's there was 3.3 ha per sheep while in 2000 this had reduced to 0.42 ha per unit.

One consequence of this degradation appears to be in the increase in frequency of severe dust storms in Beijing from 0.5 a year in the 1950's to 2.3 per year in the 1990's. In two storms in March 2002, 56,000 tons of sand and dust were deposited in the capital. (China Daily. 23 March. 2002).

Table 2 – Extent of Grassland Degradation in China 1998

Province	**Grassland Area** (Million ha)	**Grassland Area Moderately to Severely Degraded** (Million ha)	%
Tibet	82.4	21.4	26
Inner Mongolia	79.1	45.9	58
Xinjiang	56.4	26.0	46
Qinghai	36.0	10.8	30
Sichuan	21.1	6.1	29
Gansu	17.6	8.4	48
Yunnan	15.2	0.5	3
Other Provinces	117.8	17.7	15
Total	393.6	136.7	34

Source: Ministry of Agriculture. 1999. cited in World Bank. 2001.

Impacts on Cultivated Land

Some indication of the impacts on cultivated land is that while chemical fertilizers have doubled in use, the application of organic matter has decreased by 70% (Wang, Z. et al 1999). This is because crops residues are increasingly being used for fuel because of the lack of other local energy resources. Surveys yield inconclusive data on the status of soils but organic matter is below 0.6% on 20% of cultivated land, while the northeast shows a decline for all indicators. There is data on salinity constraints on cultivated land indicating 7-8 million ha (8%) are moderately-severely affected. The available data for salinization in general shows no strong trend but monitoring is not precise (Huang J. 2001).

Trends

An important negative trend for cultivated land is the increasing conversion of land to urban uses. This was a major problem in the 1960's-1980's when 538,000 ha/year was converted. More recent regulation has reduced this rate but between 1986-95 an additional 680,000 ha was converted equivalent to 3 million tons of grain production. This significant allocation puts additional stress of the remaining cultivated land (World Bank 2001).

The available data suggests that the most important negative trends in land degradation are in the north and west, i.e. the arid and semi-arid parts of the nation. This pattern of change is dramatized by the increase in number of intensity of dust storms in Beijing quoted above, though cause and effect are not scientifically documented.

Table 3 illustrates some of the identified trends for the arid and semi-arid areas where data is more clearly available.

Table 3. a. Annual expansion of degraded land in arid and semiarid regions

1980's	Mid 1990's	Late 1990's
1800 Km^2	2460 Km^2	3436 Km^2

b. Land degradation due to wind erosion and salinization

1970's	1990's
1500 Km^2 year	3500 Km^2 year

Source: State Forestry Administration 2002 and ADB/GEF Project document (2002)

NATIONAL AND REGIONAL ECONOMIC IMPACTS OF LAND DEGRADATION

The impact of land degradation has national and regional dimensions, which relate not only to the magnitude of the physical losses but also to the nature of the regional economy and livelihood. Annex 1 outlines some of the basic data for China at the conservation region level. (Modified from ADB final draft report National Strategies for Soil and Water Conservation 2002).

National Impacts

A number of assessments of the cost of land degradation at the national level have been made. Total direct costs are estimated at $7.7 billion per year in 1999, 4% of GPD, while indirect costs are thought to be around $31 billion a year (Tables 4 and 5).

Table 4. Economic Costs of Land Degradation

Direct	$ 7.738 billion
Indirect	$ 30.952 billion

Breakdown

Water Erosion	$ 4.8 billion
Wind	$ 0.43 billion
Salinization	$ 2.24 billion
Sand Storms	$0.16 billion

Source: Chinese Journal of Population and Resources (2002)

Reduced grain yield alone due to nutrient loss was estimated at 5% per annum for the period 1976-89. This is equivalent to 6 million tons of grain with a value of $700 million and representing an equivalent of 30% of the imports of grain for those years (Huang & Roselle 1995).

Table 5 illustrates an alternative set of estimates prepared for the National Strategies report (Ning, 2002). These figures suggest an annual cost of $11 billion with an additional cost of replacing lost nutrients of $6.4 billion. Offsite costs total approximately $12 billion for a total cost of $28.4 billion. The bottom line on both calculations is similar and huge.

Table 5. Estimates from Ning et al

On Site	
	Billion
Desertification	$ 3.4
Soil Erosion	6.4
Salinization	0.05
Soil Pollution	0.18
TOTAL	**$11.03**
Replacement of lost nutrients	6.4 a year
Off Site	
Loss of Reservoir Function	$11.57
Loss of Navigation due to Silting	0.42
TOTAL	**$11.99**

Regional Impacts

There is data from a wide range of provinces to give an indication of regional impact.
Some examples are:

- Inner Mongolia: wheat yields decreased from 1875-2250 kg/ha to 525-750 kg/ha over 30 years (Zhang, J. 1998)
- SW China paddy yields decreased by 50 per cent in degraded areas (Zhang, J. 1998)

- Returns to farmers in Guizhon province declined by 50% between 1983 and 1999 mainly because of land degradation. resulting in an increase in relative poverty in this area.

However, the greatest impact of land degradation is felt in the poorest areas and there is data to show a strong positive correlation between poverty and ecologically sensitive environments. In these areas, poverty and land degradation feed off each other in a downward spiral.

Additionally poor degraded areas are also characterized by severe health impacts in terms of malnutrition, disease resulting from poor water quality and respiratory diseases from dust and other contaminants.

Regional Impact in Western Region

The vast western region of China is the area most intensely affected by land degradation.[*] The combination of the arid/semi-arid environment relative isolation and generally low productivity has resulted in a combination of land degradation and poverty. Data for the region suggests that moderate-severe land degradation affects almost half the area, a region of 350 to 400 million people with 27% of the area experiencing wind erosion, 16% water erosion and 10% with advanced desertification (SEPA 2001).

Absolute poverty in this western region affects over 30 million people. This is by the PRC definition of $0.75 million a day in 2001 values. If the world bank $1 a day was used, the total would rise to 100 million. This is a predominantly rural area with low population densities, a general subsistence base of grazing and small farms. There are long distances between population centers, poorly organized local markets and a generally poor economic, institutional and social structures (Cua et al 2002). Poverty and land degradation are closely linked.

APPARENT ROOT AND PROXIMATE CAUSES

Land degradation is a result of environmental conditions and inappropriate human management. In China particular circumstances include:

- High rain intensities in south china often associated with typhoons, especially impacting steeply sloping areas.
- Strong spring winds in North China affecting dry loose loess soils and degraded grasslands.
- Generally mountainous relief adjoining alluvial plains, with flood prone, sediment-laden rivers.

Direct (proximate) human activities include:

- Deforestation of hill slopes and inappropriate cultivation of steep slopes.
- Over intense use of grasslands for livestock production.
- Grain production in dryland areas without soil conservation
- Poor management of ground water resources.
- Improper management of soil and water on irrigated lands.
- Neglect of communal conservation practices under new rural system.

[*] The western region includes six provinces: Sichuan, Guizhou, Yunnan, Sha'anxi, Gansu and Qinghai and five autonomous regions, Tibet, Ningxia Hui, Xinjiang Nygur, Inner Mongolia and Guangxi Zhuang.

- Loss of agricultural land through urban and industrial expansion.
- Use of biomass for rural energy needs. Over 70% of rural energy is natural or cultivated biomass (ADB.TA 2002; ADB/GEF, 2002;.UNDP 1998; World Bank 2001).

Root causes include:

- Low loads of land resources per rural worker (under 0.5 ha cultivated).
- Poverty in the most vulnerable ecological zones (90% of poor live in areas of moderate – severe land degradation).
- Increasing urban demand. As living standards, especially in urban areas, rise rapidly there is increasing demand for meat and livestock products encouraging overuse of grasslands.
- Change in farming and land use systems from traditional to intensive modern with the growing use of chemical fertilization.
- Top down application of policies without respect to provincial conditions.
- Sector driven management and lack of coordination between ministries and between national, regional and local administrations. Even within one sector such as water or soil different agencies are responsible for different uses so there is a compelling need for within sector and cross sector cooperation.
- Inadequate regulatory environment for dealing with land degradation.
- Poor financial incentives for conservation.
- Under pricing or regressive pricing for natural products especially for irrigation water and land rents (Li Zhou, 2002; Wang, Z, 199; ADB.TA 2002).

PAST INVESTMENT IN SUSTAINABLE LAND MANAGEMENT AND IMPACTS OF THIS INVESTMENT

China has a long history of investment in soil and water management, with terracing for rice documented for over 3,000 years and water management on a large scale for an even longer period. This section deals with the PRC government response in the past few decades. A major effort over the past several decades has been efforts to overcome desertification in the arid and semi-arid areas and most national plans included specific environmental goals and objectives. The typical approach is engineering based combined with revegetation and farm based conservation. One government project in the Upper Yangtze basin represented an investment of over \$120 million, which produced 4,330 Km^2 of terraces, 15,000 Km^2 of forest production, 5,760 Km^2 of orchards and provided protection to 56,000 Km^2 or 16% of the eroded area (ADB.TA 2002 Ch 4).

As the perception of land degradation has grown and as public concern has become more articulate, investment in sustainable land management has grown. In the 1990's total investment grew from \$2.2 billion to \$6.5 billion. The largest increase has been in forestry, a sector that has traditionally not contributed significantly to the Chinese economy. Investment in soil conservation has also grown at 10% a year (Table 6), but even so investment is equivalent to 0.08% of the GDP while the minimum cost to the country is over 4.0% of GDP.

Table 6. Five-Year Average Public Investment in Key Land Degradation Control Programmes(U.S. $ million)

Sector		Forestry	Water and Soil Conservation	Total
1991-1995	Total	122	358	480
	Central government	38	31	69
1996-2000	Total	710	705	1415
	Central government	553	102	655

(ADB.TA 2002)

Assessments have been made on a regional basis to value the on-site benefits of soil conservation. Evaluation was attempted for China as a whole, the Yangtse Valley, the Yellow River Valley, and the Loess Plateau (ADB.TA 2002 Annex IV).

Nationally soil erosion was valued at a loss of 4-6% of the value of annual agricultural products. As only on-site losses and benefits were taken into account, this suggests a significant additional investment could be economically profitable. In the regional analysis it was found that in the Yangtse Valley the returns to farmers from conservation measures were so great that there was an internal on farm incentive to invest in conservation. Markets are available for produce and benefits to increased yield are clear.

In the Yellow River and Loess area there are different situations. In these areas the fertile soil is so deep that off-site costs are greater than the perceived loss to the farmer. Therefore, the study suggested more government investment may be a priority. However, in cooperation with Donors, the PRC has a strong commitment to address root and proximate causes in the Western Region over the next decade, though this is being funded through the "line" ministries.

In the western provinces government investment in 2002 was planned at $1 billion and a total of $13 billion is projected over the next ten years with a possible increase to $32 billion . (ADB/GEF2002).

Table 7 illustrates current or recent World Bank and Asian Development Bank projects related to sustainable land management. The Loess plateau project, the Heilongjang agricultural Development project and the West Henon agricultural Development project are noteworthy in that they appear to incorporate a range of policy, conservation and economic issues in a pro-active way.

Annex 2 summarizes some of the most recent specific studies in the literature. The papers on local policy and local government role seen particularly important in future policy and project design.

A current article (Hai & Shaolin 2003) describes the history and practice of ecological restoration in China and suggests that over 200,000 ha have been restored in China with a value of more than $1 billion U.S., but also notes the many millions of hectares that need restoration.

Table 7. Current/recent World Bank and Asian Development Bank projects related to sustainable land management

Agency	Project Title	Duration of Project	Total Cost
World Bank	Loess Plateau Watershed Rehabilitation Project (02)	1999 - 2004	$150 m
World Bank	Heilongjiang Agricultural Development Project	1997 - 2003	$240 m
World Bank	Heilongjiang Land Reclamation Project	1983 - 1989	$80 m
World Bank	Jiangxi Agricultural Development Project	1990 - 1995	$60 m
World Bank	Sustainable Forestry Development Project	2002 - 2009	$215 m
Asian Development Bank	Yellow River Flood Management Sector Project	1999 - 2002	$412 m
Asian Development Bank	Songhua River Flood Management Sector Project	1999 - 2002	$358 m
Asian Development Bank	West Henan Agricultural Development Project	1993 - 2000	$151 m
Asian Development Bank	Sanjiang Plains Wetland Protection (earlier listed as Integrated Natural Resources Management for Sanjiang Plains)	2002	$600,000*
Asian Development Bank	Dryland Farming Project in the Northern Region	2001 - 2002	$450,000*
Asian Development Bank	Fujian Soil Conservation and Rural Development II	1999 - 2001	$650,000*
Asian Development Bank	Yunnan Comprehensive Agricultural DevelopmentI	1998 - 2000	$1,332,000*
Asian Development Bank	Songhua River Flood Wetland and Biodiversity Management Project (formerly "Songhua river Flood and Wetland Management Project")	1999 - 2000	$1,545,000*

*Prepartory Costs only

INDICATORS TO MONITOR TO IDENTIFY TRENDS

Very significant investment is being planned in the most affected provinces both by PRC and the donor community. It is recognized by both groups that the problem of land degradation can only be efficiently addressed by a combined approach addressing root and proximate causes. Indicators to identify progress in this arena must therefore combine these.

Suggested indicators to identify economic returns from this investment include;

- Land use change – particularly on degraded hill slopes.

- As alternative land use patterns develop the economic benefit of improved productivity in terms of biomass and carbon sequestration can be identified.
- The off-site reduced sediment yield.
- Community participation in land degradation responses (Index of social capital).
- Realization of policy reforms and coordination between institutions(Index of institutional capital).
- Value of production from degraded region (Index of economic capital).
- Reduction in dust storms and improvement in patterns of water flow (Index of natural capital).

CONCLUSIONS

In a potential great step forward the PRC has recognized in principle that rapid economic growth has to become sustainable economic growth in terms of agriculture and natural resources.

However, the "root cause" driving forces still exist and may in some cases be increasing in intensity. While allocation of more financial resources is important, the list of critical root causes includes several which identify policy, style and process issues. These need to be addressed and it appears this is recognized in current national plans.

Any evaluation of progress towards combating land degradation will need to involve:

- Much better integration of administrative mechanisms.
- Devolution of responsibility and implementation to provincial and local levels.
- Participatory involvement in on-site conservation measures.
- Attention to pricing, marketing and economic infrastructure issues.

These are all addressed in plans and proposals. Monitoring and evaluation of these factors will be important in assessing progress towards sustainable land and water management.

REFERENCES

ADB/GEF. 2002 Project. Document: PRC-GEF Partnerships on Land Degradation in Dryland Systems.

ADB TA 3548. 2002. PRC National Strategies for Soil and Water Conservation. Final Report (Draft).

Anonymous. 2002. Chinese Journal of Population, Resources and Environment. Vol 12. No. 2.

Bi Yuyun, (ed). 1995. Cultivation Land of China. Chinese Agriculture. Science and Technology Publishing House. Beijing.

Can, E. A. and Lan Wang. 2002. Notes on the Western Development Strategy. Manila. Asian Development Bank.

Feng, Q., Endo, K. N., Cheng, G. D., 2001. Towards sustainable development of the environmentally degraded arid rivers of China – a case study from Tarim River. Environmental Geology. Vol. 41, pp 229 – 238

Hai, R. and P. Shaolin, 2003. The Practice of Ecological Restoration in China. A brief history and conference report. In Ecological Restoration. Vol. 21 No. 2. June 2003. pp. 122-125.

Huang, J., 2000. Erosion and Salinization. Chinese Center for Agricultural Policy. Chinese Academy of Science. Beijing.

Huang, J. & Roselle, 1995. Environment Stress and Grain Yields in China. American Journal of Agriculture Economics. Vol. 77.

Liu Xiaoying, 2002. Past and Ongoing National, Provencial and Local Level Projects and Programs for Managing and Controlling Land Degradation by Using Participatory Approaches. Report for Asian Development Bank. 3544, People's Republic of China.

Li Zhou, 2002 Survey of the Linkage Between Land Degradation and Poverty. ADB TA 3548 PRC Paper.

Lindert, P. H., 1999. The Bad Earth? China's Soils and Agricultural Development Since the 1930's. Economic Development Culture Change. 47(4): 701-736.

Muldavin, J. S. S., 1997. Environmental Degradation in Heilongiiang: Policy Reform and Agrarian Dynamics in China's New Hybrid Economy; Annuals Association American Geography. Vol 87. p 579-613.

Ning, D. and Chang, Y., 2002. An Assessment of Economic Loss Resulting from Degradation of Agricultural Land in China. ADB TA 3548 PRC special paper.

Rozelle S. Huang, J. K., Zhang, L. X. 1997. Poverty, population and environmental degradation in China. Food Policy. Vol. 22, pp 229 - 251

Scherr, S.J. and S. Yadav. 1996. Land degradation in the developing world: Implications for food, agriculture and the environment to 2020. Food, Agriculture and the Environment Discussion paper 14. Washington, DC: international Food Policy Research Institute.

Skinner M.W. Kuhn R.G. Joseph, A.E. 2001. Agricultural land protection in China: a case study of local governance in Zhejiang Province. Land Use Policy. Vol. 18, pp 329 – 340.

State Environmental Protection Agency (SEPA). 2001. Investigation on Eco-environment in Western China. Beijing. SEPA.

UNDP, FAO and UNEP. 1993. Land degradation in South Asia: Its security, causes, and effects upon the people. Final report prepared for submission to the Economic and Social Council of the United nations (ECOSOC). Rome: Food and Agriculture Organization.

UNDP. 2002. China Human Development Report. Making Green Development a Choice. OUP.

Veeck, G. & Wang Shaohua. 2000. Challenges to Family Farms in China. The Geographic Review. Vol 90. p 57-82.

Verburg, P.H. Veldkamp, A. 2001. The role of spatially explicit models in land-use change research: a case study for cropping patterns in China. Agriculture Ecosystems & Environment. Vol. 85, pp 177-190

Voegele, J. 2001. Combating Desertification in West China: a Policy Perspective. Washington, DC. World Bank.

Wang, G.X. Cheng, G.D. 1999. Water resources development and its influence on the environment in arid areas of China – the case of the Hei River basin. Journal of Arid Environments. Vol. 43, pp 121 – 131

Wang, Z. Ye, X. and Li, G. (eds). 1999. Chinese Ecological Agriculture and Intensive Farming Systems. China Environmental Science Press. Bejing.

World Bank. 2001. China: Air, Land & Water – Environmental Priorities for a New Millennium. Washington, DC.

Zhao, J. Z. Wu, G. Shao, G.F. Kong, H.M. Lu, Q. 2002. Strategies to combat desertification for the twenty-first century in China. International Journal of Sustainable Development and World Ecology. Vol. 9, pp 292-297.

Zhang J. 1998. Research on the Characteristics of the Different types of Degradated Land in SW China. Ph.D. diss.

ANNEX 1. Basic Data by Conservation Regions

1. The Loess Plateau Region

Land area	640,000 Km^2 - 6.73% of total area of PRC
Rural population	Total rural population: 48,000,000 Rural population density: 50-100 per square kilometer
Land use characteristics	Arable land: 150,000 Km^2 or 23.4% Pasture land: 256,000 Km^2 or 40% Forest & woodland: 38,400 Km^2 or 6%
Land degradation types	Dominant degradation type(s): Water erosion, wind erosion Other key degradation type(s): Soil fertility decline associated with soil chemical, physical and biological (organic matter) degradation.
Land degradation severity and extent	a) Water Erosion None: 288,764 Km^2 45% Slight: 114,197 Km^2 18% Moderate: 115,826 Km^2 18% Severe: 63,478 Km^2 10% Very severe: 57,735 Km^2 9%
	b) Wind Erosion Slight: 11,989 Km^2 2% Moderate: 35,952 Km^2 6% Severe: 39,140 Km^2 6% Very severe: 81,539 Km^2 13%
	c) Soil Fertility Decline Anecdotal evidence suggests a severe loss of soil fertility but no quantitative studies were cited.
	c) Other land degradation types Some areas of landslides, water logging and salinity
Other comments	Region with the most serious erosion in the PRC. Rates of soil loss may be as high as 50-100 tonnes/ha/yr. Over large parts of the Loess Plateau the surface soil has been completely eroded, leaving only skeletal and immature soils. Much soil is lost through mass wasting in the form of landslides and mud flows.

2. The Black Soil Region of Northeast China

Land area	1,096,609 Km^2 - 11.54% of total area of PRC
Rural population	Total rural population: 45,000,000 Rural population density: 10-50 per square kilometer
Land use characteristics	Arable land: 550,000 Km^2 50.2% Pasture land: 200,000 Km^2 18.2% Forest & woodland: 228,983 Km^2 25.1%
Land degradation types	Dominant degradation type(s): Wind erosion , water erosion Other key degradation type(s): Soil fertility decline, salinity, waterlogging.
Land degradation severity and extent	a) Water Erosion None: 942,553 Km^2 85.95% Slight: 102,601 Km^2 9.36% Moderate: 43,108 Km^2 3.93% Severe: 8,085 Km^2 0.74% Very severe: 262 Km^2 0.024%
	b) Wind Erosion Slight: 13,279 Km^2 1.21% Moderate: 8,777 Km^2 0.80% Severe: 3,462 Km^2 0.32%
	c) Soil Fertility Decline Organic matter, K, N, Ph, pH all declining. Because of surface soil erosion, in the Keshan area soil organic matter content decreased from 8-10% in 1950s to 0.15-5.0% at present, correspondingly, contents of N and P lowered from 0.35-0.40% to 0.18-0.20%, and from 0.15-0.20% to 0.1-0.12%, respectively. Crop yield reduced 1-1.25 billion tons each year.
	c) Other land degradation types Areas of alkaline soils, waterlogging and salinity.
Other comments	Region is the largest corn supply base of China, so the safety of soil productivity is very important. Major soil type is “Black soil” (phaeozem) whose top layer is fertile but can be easily eroded.

3. The Red Soils Region of Southern China

Land area	1,163,549 Km^2 - 12.24% of total area of PRC
Rural population	Total rural population: 203,500,000 Rural population density: 100-200 per square kilometer
Land use characteristics	Arable land: 350,250 Km^2 30.1% Pasture land: 100,000 Km^2 8.6% Forest & woodland: 360,700 Km^2 31.0%
Land degradation types	Dominant degradation type(s): Water erosion Other key degradation type(s): Soil fertility decline associated with soil chemical, physical and biological (organic matter) degradation.
Land degradation severity and extent	a) Water Erosion None: 910,000 Km^2 78.2% Slight: 96,446 Km^2 8.29% Moderate: 71,775 Km^2 6.17% Severe: 25,065 Km^2 2.15% Very severe: 5,605 Km^2 0.5%
	b) Wind Erosion Slight: 379 Km^2 0.03% Moderate: 50 Km^2 0.004%
	c) Soil Fertility Decline Assumed to be declining. Soils have poor physical structure.
	c) Other land degradation types Waterlogging, naturally acidic soils.
Other comments	Although the vegetative cover here is the best in China, the high precipitation is able to cause serious erosion. But the ecological restoration is easier than that in the other regions.

4. The Northern Mountain Region

Land area	717,771 Km^2 - 7.6% of total area of PRC
Rural population	Total rural population: 179,442,750 Rural population density: 200-300 per square kilometre
Land use characteristics	Arable land: 448,607 Km^2 62.5% Pasture land: 150,000 Km^2 20.9% Forest & woodland: 71,777 Km^2 10.0%
Land degradation types	Dominant degradation type(s): Water erosion and wind erosion Other key degradation type(s): Salinity, soil pollution, fertility decline.
Land degradation severity and extent	a) Water Erosion None: 494,768 Km^2 68.93% Slight: 156,220 Km^2 21.76% Moderate: 52,152 Km^2 7.27% Severe: 11,979 Km^2 1.67% Very severe: 2,652 Km^2 0.37%
	b) Wind Erosion Slight: 6,837 Km^2 0.95% Moderate: 3,885 Km^2 0.54% Severe: 1,128 Km^2 0.16%
	c) Soil Fertility Decline Conflicting evidence! K and pH declining. Some evidence to suggest N, Ph and organic matter are improving. Soil is poor and rocky in mountainous areas.
	c) Other land degradation types Chemical pollution from overuse of fertilizers and pesticides, areas of secondary salinity, some desertification on Alluvial fans
Other comments	Land use characteristics in this region corresponds to its landscape structure stony mountain slopes, earth covered mountain slopes, alluvial fan, or plain. In much of North China, annual double cropping or biannual triple cropping is common.

5. The South West Mountain Region

Land area	1,196,613 Km^2 - 12.6% of total area of PRC
Rural population	Total rural population: 89,745,975 Rural population density: 50-100 per square kilometre
Land use characteristics	Arable land: 264,619 Km^2 2.11% Pasture land: 550,000 Km^2 45.96% Forest & woodland: 216,586 Km^2 18.10%
Land degradation types	Dominant degradation type(s): Water erosion Other key degradation type(s): Soil fertility decline associated with soil chemical, physical and biological (organic matter) degradation.
Land degradation severity and extent	a) Water Erosion None: 778,432 Km^2 65.05% Slight: 182,839 Km^2 15.28% Moderate: 171,429 Km^2 14.33% Severe: 52,192 Km^2 4.36% Very severe: 11,721 Km^2 0.98%
	b) Wind Erosion Slight: 2,556 Km^2 0.21% Moderate: 3,565 Km^2 0.30%
	c) Soil Fertility Decline No empirical data, but appears to be declining rapidly, especially organic matter.
	c) Other land degradation types Some waterlogging, rockification.
Other comments	Thin soils on steep slopes mean that even small amounts of soil erosion is a major problem. Three types of karst landform are recognized in these regions. The latest survey shows that there are about 50,000 km^2 of rockification in Guizhou province at this moment. In recent 20 years, area of rockification in Guizhou province has been expended by 1800 km^2 each year. In Guizhou province about 91333 ha land is changing to bare mountain/hills each year.

6. The North West Region

Land area	2,072,992Km^2 - 21.81% of total area of PRC
Rural population	Total rural population: 29,000,000 Rural population density: 10-15 per square kilometer
Land use characteristics	Arable land: 290,000 Km^2 13.99% Pasture land: 1,000,000 Km^2 48.24% Forest & woodland: 124,379 Km^2 6.00%
Land degradation types	Dominant degradation type(s): Wind erosion and water erosion Other key degradation type(s): Soil fertility decline associated with soil chemical, physical and biological (organic matter) degradation.
Land degradation severity and extent	a) Water Erosion None: 1,807 648 Km^2 87.20% Slight: 169,225 Km^2 8.18% Moderate: 81,664 Km^2 3.94% Severe: 10,400 Km^2 0.50% Very severe: 4,055 Km^2 0.20%
	b) Wind Erosion Slight: 701,603 Km^2 33.84% Moderate: 166,065 Km^2 8.01% Severe: 154,298 Km^2 7.44% Very severe: 493,367 Km^2 23.80%
	c) Soil Fertility Decline Assumed extensive, but no firm figures.
	c) Other land degradation types Overgrazing
Other comments	A very dry, windy, remote region with a fragile environment. Chinese Government has extensive and aggressive plans to develop this region. Extreme care must be used to ensure development is environmentally sustainable.

7. Tibetan High Plateau and Mountain Region

Land area	2,615,179Km^2 - 27.52% of total area of PRC
Rural population	Total rural population: 5,000,000 Rural population density: 1-2 per square kilometre
Land use characteristics	Arable land: 250,000 Km^2 9.56% Pasture land: 1,000,000 Km^2 38.24% Forest & woodland: 130,758 Km^2 5.00%
Land degradation types	Dominant degradation type(s): Water erosion , Wind erosion, freeze-thaw erosion. Other key degradation type(s): Thin soils, suffering decline in fertility.
Land degradation severity and extent	a) Water Erosion Slight: 86,834 Km^2 3.3% Moderate: 18,958 Km^2 0.7% Severe: 7,075 Km^2 0.3% Very severe: 3,014 Km^2 0.1%
	b) Wind Erosion Slight: 51,610 Km^2 2.0% Moderate: 32,904 Km^2 1.3% Severe: 49,962 Km^2 1.9% Very severe: 44, 389 Km^2 1.7 %
	c) Soil Fertility Decline Assumed to be decreasing, but no quantitative research.
	c) Other land degradation types Freeze-thaw erosion – difficult to control. Patches of saline and alkaline soils.
Other comments	Low population density, with large areas of land unsuitable for agriculture. Considerable government investment in this region and tourism is viable option to agriculture.

ANNEX 2. Recent Research Assessments of Land Degradation and Responses to Investment

STRATEGIES

During the past half century, China has experienced increasingly severe land degradation, soil erosion, and desert expansion. Desertification is affecting one third of China's total territory and the annual accelerating rate of desertification spread is as high as 2460 km(2) in China. In 1996, China developed a National Action Programme to Combat Desertification (NAP), which is aimed to apply new legal measures and technical approaches to slow down desertification processes and achieve a long-term goal control desertification and alleviation of poverty through continuous efforts to fight against desertification, stabilize mobile dunes, revegetate degraded rangeland and control soil erosion in arid, semi-arid, and dry sub-humid areas. The long-term and integrated strategies of China's NAP result in encouragement of social participation, legal institutional guarantees, policy making, and establishment of demonstrations/pilot projects to combat desertification at both national and provincial level.

Source: Zhao JZ; Wu G; Zhao YM; Shao GF; Kong HM; Lu Q. INTERNATIONAL JOURNAL OF SUSTAINABLE DEVELOPMENT AND WORLD ECOLOGY 2002, Vol 9, Iss 3, pp 292-297.

LINKS BETWEEN LAND DEGRADATION AND POVERTY

This paper studies the relationship among population, poverty, and environmental factors, and the impact they have had on China's land, water, forests and pastures, It does so by examining the extent of environmental degradation and China's success in controlling its environmental problems is reviewed; by investigating how the leadership has tried to develop a legal framework and series of institutions to carry out environmental policy; and by providing empirical evidence demonstrating the determinants of the successes that China has achieved in surmounting (or slowing) some of its environmental problems, Five of China's rural resource concerns are surveyed in this paper: water pollution, deforestation, destruction of the grasslands, soil erosion, and salinization, The paper finds that government policy has not been effective in controlling rural resource degradation primarily because it has limited fiscal resources and poorly trained personnel, and under these constraints the government has delegated responsibility for environmental and resource protection to the ministries of agriculture and forestry, two institutions that have an incentive to favor pro-production policies, Instead, China's efforts to alleviate policy, integrate markets, and control population appear to have helped mitigate a number of adverse environmental consequences of China's development effort of the last 40 years.

Source: Rozelle S; Huang JK; Zhang LX . Poverty, Population and Environmental Degradation in China. FOOD POLICY 1997, Vol 22, Iss 3, pp 229-251.

EFFECTS ON POVERTY

The Loess plateau is one of the regions of greatest soil erosion in China, with 80% of its total area (69,000 Km^2) affected. It is also one of the poorest regions of the country. Methods to attempt to control land degradation include biological (afforestation and planting of grasslands), engineering (level ditches, level terraces and reverse slope terraces), and farming methods (contour cropping, deep ploughing, raised edges, etc.).

The study examines the effects of various forms of soil conservation on social and economic life of the people. Villages with and without conservation were compared; and whole watersheds were also analyzed. In each case the presence of soil conservation increased production in both wet and dry years. This increased production translated into increased income and to a more sustained income across wet and dry years in areas with effective soil conservation measures. The three main crises that soil conservation addresses are food, fuel and fodder. The social and economic benefits, present one of the most compelling arguments for investment in soil conservation.

Source: L. McLaughlin. A Case Study in Dingii County, Gansu Province, China. World Soil Erosion and Conservation 1993. D. Pementel (ed). C.U.P. p87-107

SALINIZATION AND LAND DEGRADATION

Increases in water resources development and utilization over the last 30 years have led to significant environmental and hydrological degradation of the Tarim River basin. Water discharge in the lower reaches has been seriously compromised. A total of 300 km of the lower reach has been drained between the 1950s and 1970s. The water table fell from 2-3 to 4-10 m between the years 1960 and 1980, and the annual rate of fall of the water table was 20 cm from 1980 to the present. The area populated by *Populus euphtatica* has declined by two thirds and the biomass has decreased by half between the years 1958 and 1978 in the Tarim River basin. From the 1950s to the 1990s, the area of *P. euphratical/E. angustifolia* forest, the main tree species of the region, declined by 3,820 km^2 in the lower reaches of the Tarim River basin, while the shrub and meadow area declined by 200 km^2. Such hydrological changes have resulted in a marked degradation of aquatic habitats and have caused substantial land desertification. A total of 12,300 km^2 of desertified lands formed between the 1960s and 1990s. During the past 30 years, the salt content of the Tarim River has increased gradually. The maximum salt content in 1981-1984 reached 4.0 $gL^{-1,}$ and in 1998 was 7.8^{-1}. Among factors contributing to these problems, human activities are foremost. Solving these problems will require raising the level of scientific and technological expertise in the monitoring, conservation, protection, and rehabilitation of water resources and associated habitats. Presently the greatest priority is to expand and improve water conservation studies.

Source: Feng, Q. Endo, K.D., Cheng, G.D. Towards Sustainable Development of the Environmentally degraded arid rivers of China – A Case Study fromTarim River. Environmental Geology. 2001. 41:229-238.

LOCAL POLICY FACTORS

This paper analyzes environmental degradation in rural China as structurally embedded in China's rapid economic growth in the post-Mao era. The theoretical discussion focuses on changes in the organization of production, resource use, and regional development. A critical assessment of the Chinese hybrid economy challenges standard views of the reforms. The overall environmental problems of state socialist agriculture in China have been aggravated following the agrarian reforms of the current regime, Rather than mitigating negative trends, marketization and privatization have brought new, qualitatively different, environmental problems. Resource decline and its attendant social problems are not limited to aspects of transitional economy but are a fundamental part of the new hybrid system. It offers an alternative explanation for interpreting increases in rural productivity as an appropriation and use of collective assets, suggesting that the mining of communal capital is hidden behind the economic growth of the rural economy. Case studies in Heilongjiang Province based on long-term field data provide a profile of three aspects: intensification of land use, agroindustrial pollution, and declining social/communal capital. Further, the political legitimacy of the state is gradually eroded by mutually exclusive fiscal constraints on expenditure and political commitments to peasant producers. Recent repression of political dissent by peasants in hinterland regions forces indirect forms of resistance to state policy. Opportunities for sustainable development are nonetheless present within China, providing that policy makers attempt to address the structural conditions of the rural sector.

Source Muldavin JSS. Environmental degradation in heilongjiang: Policy reform and agrarian dynamics in China's new hybrid economy. ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS 1997, Vol 87, Iss 4, pp 579-613

LOCAL GOVERNMENT ROLE

China's rapid economic development following the 1978 reforms has resulted in significant economic, social and environmental change. One consequence of this change has been the accentuation of an existing trend of agricultural land loss and degradation. Although the 1978 reforms and their impacts have been subjected to considerable scrutiny, relatively little research has been directed towards the relationship between the evolution of local government structures and practices and the implementation of agricultural land protection policies. This paper presents an analysis of this relationship in Huzhou Municipality, Zhejiang Province. Zhejiang Province is situated on the eastern seaboard and exhibited the highest average annual per capita growth in China between 1978 and 1995. Huzhou Municipality is a growth centre in the northern part of the province. A synthesis of the factual knowledge and perceptions of 40 key-informants suggests that despite the development of a comprehensive legal framework for agricultural land protection, the interpretation of policy at local levels continues to permit the loss of agricultural land (and attendant environmental costs) to be traded-off against increased economic growth. This suggests a need to re-evaluate the role of local levels of government in China with respect to agricultural land protection issues; to look as much at the ways policies are implemented as at policies themselves. The devolution of administrative responsibility in China and the increasing influence of powerful local economic interests will provide an impetus for such a re-focusing of research at local levels.

Source Skinner MW; Kuhn RG; Joseph AE. Agricultural land protection in China: a case study of local governance in Zhejiang Province. LAND USE POLICY 2001, Vol 18, Iss 4, pp 329-340

LAND DEGRADATION
IN
ETHIOPIA:
ITS EXTENT AND IMPACT

L. Berry

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TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN ETHIOPIA: ITS EXTENT AND IMPACT

Preface

This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established and current remedial programs can be identified.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

ETHIOPIA

YEMEN
0 100 Miles
0 100 Kilometers
Dinder National Park
Blue Nile
White Nile
Axum
Humera
Adigrat
Mekele
Ras Dashen 15,158 ft. (4,620 m)
Tekeze
Danakil Depression
Maychew
Gonder
Bab el Mandeb
Gulf of Aden
12° N
Lake Tana
Bahir Dar
Debre Tabor
Weldiya
Asaita
DJIBOUTI
Guba
Dese
Ethiopian Highlands
Asosa
Debre Markos
Debre Birhan
Awash
Dire Dawa
Jijiga
SOMALIA
SUDAN
Gimbi
Nekemte
Harer
Awash National Park
Dembidolo
Addis Ababa
Nazret
Gambela
Gore
Asela
Degeh Bur
Jima
Shashemene
Ahmar Range
Ogaden
Mountain Nile
Sodo
Awasa
Goba
Wabe Gestro
Kebri Dehar
Warder
Omo
Great Rift Valley
Imi
Maji
Arba Minch
Kibre Mengist
6° N
Gode
Wabe Shebele
Kelafo
Negele
Dawa
Yabelo
Provisional Administrative Line
Lake Turkana (Lake Rudolf)
DEM. REP. OF THE CONGO
UGANDA
36° E
KENYA
Moyale
42° E
48°

LAND DEGRADATION IN ETHIOPIA: ITS EXTENT AND IMPACT

Executive Summary

In Ethiopia 85% of the population are directly supported by the agricultural economy. However, the productivity of that economy is being seriously eroded by unsustainable land management practices both in areas of food crops and in grazing lands.

The direct costs of loss of soil and essential nutrients due to unsustainable land management is estimated to be about three percent of agricultural GDP or $106 million (1994 $). Other modeling work suggests that the loss of agricultural value between 2000-2010 will be a huge $7 billion. None of these estimates takes account of the indirect impacts of land degradation in Ethiopia.

A number of factors contribute to unsustainable land management in Ethiopia. With steady growth in population, clearing of woodland for agriculture has been a continuous process at an estimated rate of 62,000 ha a year; methods of cereal production are conducive to soil loss and dung and crop residues are needed for fuel, reducing their use as fertilizers.

Root causes of these problems include historical and changing patterns of land ownership and government control, low levels of investment in agriculture and animal husbandry, poor rural infrastructure and markets and low levels of technology.

Remedial measurers have in the past focused on physical structures including terracing and bunding. Donor support has provided new levels of fertilizer input, but the difficulties of transportation and marketing has reduced the impact of improved productivity in the areas affected.

Policy, institutional and participation issues are not usually highlighted in remedial measures and these directed to the regional issues and needs within Ethiopia could be an important component of future actions.

LAND DEGRADATION IN ETHIOPIA: ITS EXTENT AND IMPACT

The Scope And Impact Of Land Degradation In Ethiopia

Ethiopia is among the poorest of countries and poverty and land and resource degradation appear to feed off each other. The irony is that Ethiopia is a country with high biodiversity and distinctive ecosystems and the natural resource base is critical to the economy and the livelihood of a high percentage of the population. Agriculture accounts for 50 percent of GDP, 85 per cent of foreign exchange earnings and supports, albeit insufficiently, 85 percent of the workforce. Estimates vary considerably but direct losses of productivity from land degradation are minimally 3 percent of agriculture GDP. With a population growth rate of 2.3 percent this is a critically important figure (Annex 1).

All physical and economic evidence shows that loss of land resource productivity is an important problem in Ethiopia and that with continued population growth the problem is likely to be even more important in the future. There are several studies that deal with land degradation at the national level in Ethiopia. These include the Highlands Reclamation Study: Ethiopia (EHRS-FAO 1986); studies by the National Conservation Strategy Secretariat (Sutcliffe 1993), the Ethiopian Forestry Action Plan (1993), and Keyser and Sonneveld (2001); Effect of Soil Degradation on Agricultural Productivity in Ethiopia.

Conclusions from these studies vary in detail. The EHRS concluded that water erosion (sheet and rill) was the most important process and that in mid 1980's 27 million ha or almost 50% of the highland area was significantly eroded, 14 million ha seriously eroded and over 2 million ha beyond reclamation. Erosion rates were estimated at 130 tons/ha/yr for cropland and 35 tons/ha/yr average for all land in the highlands, but even at the time these were regarded as high estimates. Sutcliffe produced new lower estimates for soil erosion, but emphasized the much greater importance of nutrient loss.

Map 1 illustrates the regional extent and intensity of soil degradation.

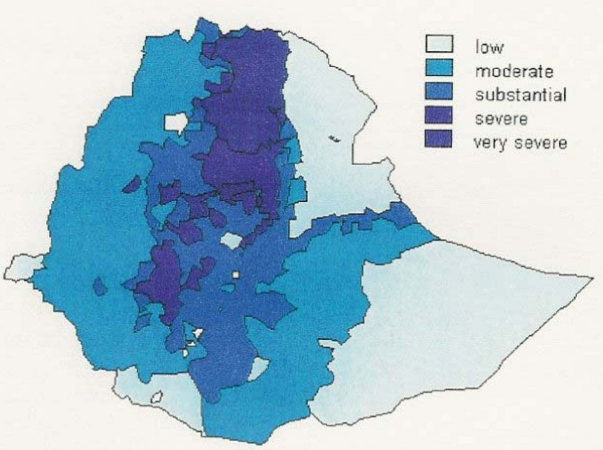

Figure 1. Soil degradation in Ethiopia (Source: Hakkeling, 1989).

The Ethiopian Forestry Action Plan outlines the pattern of deforestation. The current rate of deforestation is estimated at 150,000 ha per year (Ethiopian Forestry Action Plan) or 62,000 ha/yr (World Bank 2001). Forests in general have shrunk from covering 65% of the country and 90% of the highlands to 2.2% and 5.6% respectively (Table 1).

Table 1. Forest Reduction

	Original Extent of Forest	1950's	1990	2000
Ethiopia	65%	16%	2.7%	2.2%
Highlands	90%	20%	?%	5.6%

Keyzer and Sonneveld (2001) attempted a detailed national assessment of soil degradation on the basis of UNEP/grid DATA. The inventory was detailed, but the assessment was qualitatively carried out by experts on the region and physiographic zone.

These authors also attempted a regional analysis of the extent and impact of land degradation. The modeling compared yields in relation to soil degradation and soil fertility. The analysis identified the following:

- Soil degradation has its major impact on soils of lower fertility and where population density is low.
- On fertile soils, soil degradation tends to be compensated by fertilizer application
- Many areas, populated by a large percentage of the people are in a critical state, where fertility loss needs urgently to be compensated by new external impacts and/or soil conservation measures need to be implemented. The most vulnerable areas are in North Ethiopia

In addition to these general assessments, current reports on specific issues show:

- A loss of 30,000 ha annually due to water erosion, with over 2 million ha already severely damaged (National Review Report 2002)
- A total loss of 4,000 ha of state farms due to severe salinization
- An estimate of 1 billion tons of top soil lost per year (Tefetro 1999)
- Nutrient depletion of 30 kg/ha of nitrogen and 15-20 kg/ha of phosphorous (UNDP 2002)
- Loss of 62,000 ha of forest and woodland annually (World Bank 2001)

In the highlands of Ethiopia, the area of most intense population density, the area of greatest livestock density and the area of greatest land degradation, recorded measurements of soil loss by water erosion range from 3.4 to 84.5 tons per ha per year with a mean of 32.0 tons/ha/year. While losses are uneven this represents a loss of 4 mm of soil a year, twenty or more times replacement rates. Some of these measurements do not allow for the benefits of redeposition of eroded material. Some redeposition is far away in Sudan and Egypt but some is more local partly reducing these losses. However, the effects of physical soil loss is accompanied by the impacts of nutrients lost by erosion especially nitrogen and phosphorus. Estimates of losses from soil and nutrient loss are considerable (Bojo & Cassells 1995, Sutcliffe 1993).

The Cost Of Land Degradation In Ethiopia

The costs of land degradation in Ethiopia include:
Direct Costs -

- Costs of nutrients lost with top soil erosion (or the replacement costs of these nutrients)
- Lost production due to nutrient and soil loss
- Costs of forest removal
- Loss of livestock carrying capacity

Indirect Costs –

- Loss of environmental services
- Silting of dams and river beds
- Increasing irregularity of stream and rivers and reduced groundwater capacity

Other indirect costs relate to social and community losses due to malnutrition, poverty and migration, while poverty is compounded by the lack of economic marketing structure.
Some of these costs can and have been quantified, others are more difficult (Bojo and Cassells. 1995).

As estimates of the severity of land degradation in Ethiopia vary so do cost estimates. Almost all estimates of cost relate to the loss of soil and of nutrients from agricultural or grazing lands. They do not take into account the impact of soil redeposition which may be harmful such as the cost of silting of lakes, reservoirs and rivers, or may sometimes add productivity to depositional areas. Bojo and Cossells (1995) modified earlier estimates by Sutcliffe and the EHRS to reduce estimates of the cost of soil erosion, but to greatly increase the estimates of losses due to nutrient removal from agricultural areas. In 1994 they estimated a loss of $106 million a year or about three percent of agricultural GDP from a combination of soil and nutrient loss. The gross discounted cumulative loss was calculated at $1.948 billion U.S. The estimated other losses on an annual basis include $23 million a year on forest losses due to deforestation and $10 million a year due to loss of livestock capacity the equivalent of almost 1 million livestock units. This total loss of $139 million annually is almost 4% of agricultural GDP.

None of these cost estimates takes consideration of a whole range of costs which cannot at present be quantified. These include the human capital costs of drought and malnutrition, the costs and benefits of migration streams within and outside Ethiopia partly driven by rural poverty and the environmental services costs due to the impact of heavy sediment streams on the rivers of Ethiopia and on other countries such as Sudan, Somalia and Egypt.

The estimated range of losses through soil degradation for two important crops is shown in Table 2a. The data in the table are derived from nutrients studies in areas of high and low nutrient loss. Table 2b shows the losses in those two situations. The total loss per hectare of wheat is about 400 birr ($46) per hectare in areas of low loss and 4736 birr ($544) per hectare in areas of high soil loss. The comparable data for maize is $31 and $379. If we applied the lowest level of loss ($31 ha to the 54 million hectares of cropland in the highlands, we have a total of $1.674 billion.

Table 2a. Calculated Loss In Grain Yield Due To Losses In Nitrogen Through Erosion

Crop	Yield lost (kg) per kg N lost	Range of nutrient loss N (kg/ha)		Range of nutrient loss N (kg/ha)	
	(Crop response ratio)	Low	High	Low	High
Maize	9.6	36	429	0.345	4.12
Wheat	6.9	36	429	0.248	2.96

Source: Sertsu 1999. Integrated soil management for sustainable agriculture and food security in Southern and East Africa

Table 2b. Monetary Values Of Crop Yield Losses As A Result Of Soil Degradation

Crop	Yield lost (Mg/ha)	Grain Price (Birr/kg)		Total loss (Birr)	
		Low	High	Low	High
Wheat	0.248	2.960	1.60	396.8	4,736
Maize	0.345	4.118	0.80	276.0	3,294

Source: Sertsu 1999. Integrated soil management for sustainable agriculture and food security in Southern and East Africa

Sonneveld (2002) developed a complex model for the assessment of current and future impact of water erosion on food production in Ethiopia. The model developed several scenarios for the potential production from agricultural land in Ethiopia (Table 3).

In Scenario 1 no additional land and water conservation measures are adopted. Under this scenario total national agriculture remains stagnant. Water erosion reduces potential production by 10% by 2010 and 30% by 2030, but during this time period additional labor from rural population growth more or less compensates for the decline. Obviously agricultural value per capita drops from $372 U.S. in 2000 to $162 in 2030, while food availability per capita drops from 1971 Kcal per day in 2000 to 685 Kcal per day in 2003. This is a disaster scenario.

Other scenarios all assume greater flexibility for migration and for technology impact. Each scenario points to the need for a sustained focus on rural production together with conservation of natural resources. However, a vital agricultural sector will also depend on "the accelerated growth of non-agricultural activities" in rural areas. This study emphasizes the need for a combined conservation investment and infrastructural approach.

Sonneveld estimates that the loss of agricultural value due to land degradation between 2000 and 2010 would be $US 7 billion; a huge sum in relation to current investments in sustainable land management.

These varied estimates reflect the uncertainty of the data but all illustrate the magnitude of the problem. Whether direct losses are in the lower end of the range at $139 million a year or at the upper end at over $1 billion a year, the costs of unsustainable land management are an important element in recurring food shortages and famine in Ethiopia.

Table 3. Summary of Scenario Results

Scenario		Soil Conser-vation	Net Food production (in billion USD; PPP)		Food per Capita (in Kcal)		Value added per capita: rural population (in USD; PPP)		Value added per capita: total population (in USD; PPP)	
			2010	2030	2010	2030	2010	2030	2010	2030
1. Stationary		No	12.4	12.0	1083	685	218	162	627	1267
2. Control		Yes	17.8	18.7	1611	1085	324	260	709	1330
3. Migration	Restricted	No	15.9	16.1	1242	786	263	198	662	1290
		Yes	23.2	25.0	1801	1213	383	307	754	1360
	Free	No	16.9	17.1	1317	833	279	210	674	1298
		Yes	24.2	26.0	1878	1264	399	320	767	1368
4. Technology	Stationary /UN	No	43.5	42.9	3978	2681	706	519	1004	1497
		Yes	65.4	42.1	6228	5852	1060	1038	1277	1833
	Stationary /AccUrb	No	43.5	46.4	3968	2605	705	508	1021	1661
		Yes	65.3	84.4	6212	5682	1058	1021	1366	1992

Source: Sonneveld 2002 p 192.

Stationary: No soil conservation – current technology – continued in-situ population growth
Control: Investment in soil conservation halting/reducing decline–continuing in-situ population growth
Migration: Restricted – indicates movement within orbit of traditional ethnic groups
Free – indicates movement within and across ethnic boundaries
Technology: Assume better quality produce and higher potential levels of production

Apparent Root And Proximate Causes Of Land Degradation

There are multiple interacting forces, which have caused and are causing land degradation in Ethiopia. The proximate causes include clearing of woodlands and forests, unsustainable arable farming techniques, the use of dung and crop residues for fuel and overstocking of grazing lands.

PROXIMATE CAUSES

Woodland Clearing

The clearing of forests has been a long historical process in Ethiopia and it continues at a conservatively estimated rate of 62,000 ha per year. This is mostly converted into cropland with a greatly reduced vegetative cover and accelerated soil erosion. Also importantly the change in land use can change the hydrological pattern of run off, reducing infiltration and increasing stream flow during and after rain.

Arable Land Management

Most arable land (70%) in the highland is in cereals, with wheat and barley in the higher ground and teff, sorghum and maize in the lower elevations. All these crops leave bare areas of soil during some or all of the growing season exposing soil to erosion. Twenty percent of the cultivated area is in perennial crops including coffee, enset (similar to banana), oil seeds, fruit trees and cotton. Pulses occupy the remaining ten percent. Enset (found only in Ethiopia) in particular provides good ground cover, needs manure, and is a good crop to maintain fertility.

The annual crops are mainly planted after the rains begin, allowing early rains to directly impact the soil contributing to high erosion levels. Additionally, as a population grows more fragile marginal lands are used. A further result of population growth is the reduction in fallow periods in some areas from a five-year rotation to a two-year or even shorter rotation.

Dung And Crop Residues

As rural populations have grown and woodland is converted to cultivation, the use of dung and crop residues for fuel has become much more important. A 1989-90 study suggests that nationwide 18 percent of energy in rural areas is supplied by dung and crop residues and this percentage has probably grown since then (Table 4).

Table 4. Estimates Of Consumption Of Household Energy (percent)

	EEA 1989-90	
Fuel	**Urban**	**Rural**
Wood/Charcoal	75	82
Dung	8	10
Crop residues	6	8
Kerosene, gas	8	0
Electricity	3	0
Total	**100**	**100**

Source: Ethiopia 1993, annex 6.2, p. 3

Specific studies in two upland villages showed maize and sorghum stalks providing 69 percent of total fuel and use in one, and dung providing 50 percent of energy use in the other. With fuel wood increasing in scarcity these numbers can only have increased.

The situation with energy use is one of the most critical land degradation issues in Ethiopia. Estimates of current demand for fuel wood approach 55 million cubic meters per year with an estimated sustainable production of 13 million cubic meters per year. While per capita use may be reduced and tree-planting programs may meet some of the gap the pressure on the growing use of crop residues and dung for fuel will continue and the pressure on soil productivity will increase.

Overgrazing Of Pasturelands

It has been estimated (Melese 1992) that 20 percent of total soil erosion is from pasturelands and livestock density data show that current stocking rates are well above optimum rates though in some areas for example Tigray improvements have occurred (see page 8). The data in Table 5 is from 1993 and some densities may have increased since then.

Table 5. Current And Optimum Livestock Stocking Densities (hectares/TLU)

Zone	Stocking Rates	
	Current	Optimum
HPP (Highlands)	1.49	1.45
HPC (Highlands)	1.28	1.51
LPC (Highlands)	1.51	3.21
Lowlands	5.44	4.07

Source: Adapted from the EFAP (Ethiopia 1993, p. 49).

Root Causes Of Land Degradation

Among the interacting root causes of land degradation in Ethiopia are:

- The impact of natural conditions especially periodic drought, inaccessibility of rural areas due to topographic constraints
- Steady growth of population and livestock totals without changes in agricultural and other economic systems
- Historical patterns of feudal ownership of land followed by government ownership and despite policy changes uncertain status of land ownership
- Institutional overlap, duplication of effort and shortage of financial resources
- Lack of rural infrastructure and markets
- Lack of participation of stakeholders in management decisions especially at the local level
- Weak extension services
- Low technology agriculture, leading to risk aversion and reliance on cattle as wealth

Natural Conditions
Basic physical conditions in Ethiopia, which impact land degradation, include rainfall variability from year to year and place to place, particularly in the drier parts of the highlands. The sequence of drier years with reduced vegetation cover followed by wetter years with heavy rainfall is conducive to high levels of soil loss. Additionally, the physical make up of the Ethiopian Highlands with gorges and other topographic barriers restricts the development of effective internal marketing systems in some areas.

Population Growth
With increasing numbers of people there has not been a related change in the pattern of agriculture, which is still essentially small holder relying on expanding the cultivated area, often into marginal land, rather than adopting intensification techniques. There is still a strong tendency to hold wealth as livestock, often cattle, further impacting grazing resources.

Land Ownership
Ethiopia has seen a number of changes in land ownership, which continue to provide uncertainty to the farmer and to rural communities. The traditional feudal system was followed by a communal form of government ownership and while policies now have changed, there is still confusion at the regional and local level about security of tenure and land and resource rights.

Institutional Issues
While a number of institutions are charged with responsibility for dealing with land degradation (Ethiopian Agricultural Research Organization, Regional Agricultural Bureaus, the Environment Authority, etc.) budgets for these organizations are inadequate and with the decentralization programme to zonal and woreda levels institutional capacity has been further stressed. Institutional responsibilities are not always well defined and donor programmes are not always well integrated into national efforts.

Rural Markets
An important part of moving to sustainable land management is the development of an appropriate rural infrastructure to encourage alternative livelihoods and to develop local and regional markets. This infrastructure is lacking in Ethiopia greatly restricting the economic movement of produce from areas of surplus to areas of need.

Participation and Extension
Because of the weak infrastructure and the shortage of funding extention services are weak and serve only a small part of rural areas. Allied with this problem is the poor historical record of local participation in finding approaches to dealing with the particular local problems of unsustainable land management. As some of the specific studies cited below show understanding local and regional issues on the basis of indigenous knowledge is a key component of successful programmes.

Low Technology Agriculture
As illustrated above most of agriculture in Ethiopia is still low technology and is inadequately equipped to deal with drought and famine. Fertilizers because of cost or availability factors are not in general use and traditional organic fertilizer is increasingly being used as fuel. A modest transformation in technology is likely to be an important component of successful sustainable agriculture.

Economic Returns From Land Degradation Investments

Root Causes

Land degradation has been long recognized as a major impediment to economic growth and famine preparedness in Ethiopia, and efforts have been made to address the problem especially in the last quarter of the 20th century. Since 1999 when the TGE obtained power, the national policy has been "Agricultural Development Led Industrialization". This policy included improvements in agriculture sector technology and management, investment in infrastructure and other impacts to agriculture, and increasing farm size with a reduction of the population depending directly on agriculture.

Conservation and sustainable land management was not a highlight of the original policy, but has received more attention recently (Benin et. al. 2002). Specific programs usually sponsored by bilateral or multilateral donors have been initiated. Many of these have dealt with the physical infrastructure. For example between 1976 and 1985, 600,000 km of soil and stone bunds were constructed on arable land, 500,000 km of hillside terraces were constructed, 500 million tree

seedlings were planted and 80,000 ha set aside for natural regeneration. However, by the mid 80's conservation activity had impacted only 1 percent of the highlands only 15-20 percent of seedlings had taken root and much of the physical infrastructure was imposed without much input from stakeholders and in some cases involved coercion. Consequently, these structures were not well maintained.
Some insights of the impacts of measures to combat land degradation may be gained from specific studies (See Annex 2).

Ethiopia continues to rely heavily on donor support for sustainable land management activities and that support has varied considerably from year to year. Ongoing and recent projects in 2002 are listed in Annex 3 (Tables 6, 7 and 8). Project assessments and outcomes are not generally available, but an analysis of the types of projects provides some insight into the approaches taken. Of the projects in Table 6, \$275m of the total is devoted to the Southeast Rangelands project, \$11m is for forest inventory and conservation, \$14m in environmental support and the rest are relatively small scale. The regional assistance projects in Table 7 are more directed to agricultural and environmental management support with a prime focus on Amhara (\$94.7m) with Oromiya (\$32.8m) and Tigray (\$10.5m), accounting for the rest. Table 8 lists the most important World Bank agriculture and natural resource management projects. Livestock and range management was a major focus from 1973-1985 with investments of over \$71m. Peasant agricultural development mostly focused on fertilizer provision together with some investment in small-scale irrigation and water management. Ongoing projects address food security and agricultural research and training. While few projects address land degradation issues directly, this is a component of several.

FAO (FAO/AGL – MADS – SEA) 2003 additionally lists the following: Soil Conservation Research Project (Swiss and Dutch ALD), National Soil Service Project (FAO/UNDP), Land Use Project (FAO/UNDP), Vertisol Management Project (Dutch), and Management of Degraded Soils in the Rift Valley (AUCC-CIDA).

If we examine the root causes of land degradation as identified in this document relatively few have been directly addressed by the current range of projects or by government action. A World Bank project is addressing decentralized agricultural research and restoration, and food security issues are the focus of a number of donors. However, at his opening address to a recent conference Vice Minister Belay Ejigu (Minister of Agriculture, Ethiopia) reported on the findings of a research project "Policies for Sustainable Land Management in the Highlands of Ethiopia". He said,

> "Results of the study indicate that population pressure has a negative impact on the natural resource conditions in the highlands. Better market access, credit services, and technical assistance programs can have positive impacts on land improvements and resource and welfare conditions, indicating that 'win-win' development strategies can reduce land degradation and poverty, and increase agricultural productivity.
>
> However, the strategies need to be tailored to local conditions. In low rainfall environments such as much of Tigray, responsiveness to fertilizer and improved seeds has been found to be less than in high rainfall areas. Other strategies, such as promoting development have been found to yield substantial returns. Population policy/programs have been identified as one of the priority intervention areas, and efforts made so far in

this regard, together with provision of improved market access, have resulted in encouraging outcomes. Involving local communities in natural resource management has been found to be more sustainable and beneficial in areas with intermediate population that are far away from towns. Literacy will no doubt contribute towards more sustainable development in the highlands.

Although these findings are very useful, it will be important to develop some pilot policy experiments to test 'on the ground' some of the findings before we scale up to many regions in the country."

Annex 4 (from McKonen 2002) outlines the main priority issues from an Ethiopian perspective and links to a substantial degree with the root causes listed above. While sectoral issues are being addressed to some extent the policy, institutional and participation issues are not highlighted. Yet the studies quoted in Annex 2 indicate that these, especially farmers and herders perceptions, are key components of successful approaches. In addition, it seems important that regional approaches, which include policy, land tenure, market development and farmer support might be effective ways to move forward.

Conclusions

While the focus of most activities to arrest land degradation and improve productivity have been on the physical parameters of the problem and these are important, the priority issues appear to be the following:

- Developing a long term locally acceptable set of land management rights and responsibilities
- Improving marketing infrastructure both physical (roads) and pricing (Shiferaw & Holden 1997)
- Give high priority to fuel provision on a regional basis through conservation, woodlands, use of conservation technologies
- Improve extension capacity especially with respect to sustainable land management
- Develop diversified rural enterprises in the context of an enhanced pattern of local and regional markets

In addition continued approaches to deal with the proximate causes of land degradation should include:

- Woodland protection
- Improved productivity of the livestock sector.
- Greater participation of local farmers and herders in the identification of local land degradation issues and their remediation.

It could be that the next important step for Government and donors it to take Minister Belay Ejigu's advice (page 12) and develop projects which will move effective research findings into on the ground projects, but at the same time addressing the key policy issues.

REFERENCES

Amede, Tilahun, Takele Belackew and Endrias Geta. 2001, Reversing the Degradation of Arable Land in the Ethiopian Highlands. Managing Africa Soils. No. 23. iied.

Asefa, D.T., Oba, G., Weladj, R. B. & J.E. Coleman. 2003. Policies for Sustainable Land Management in the East African Highlands. An Assessment of Restoration of Biodiversity in Degraded High Mountain Grazing Lands in North Ethiopia. Land Degradation and Development. 14. 25-38.

Benin, S., Pender J. an Ehui, S. 2002. Policies for Sustainable Land Management in the East African Highlands. IFPRI & ILRI. Summary of Papers and Proceedings Conference. Addis Ababa. April 24-26, 2002.

Bojo, J. & D. Cassells. 1995. Land Degradation & Rehabilitation in Ethiopia. A Reassessment. World Bank.

Daba, S. 2003. An Investigation of the Physical and Socioeconomic Determinants of Soil Erosion in the Hararghe Highlands East Ethiopia. Land Degradation and Development 14. 69-81. 2003.

Ethiopia, Ministry of Natural Resources Development and Environmental Protection, 1993. Ethiopia Forestry Action Program. Vol. II.

Ethiopia, United Nations Development Programme. 2002. Technical Note on the Environment. DCGE. Addis Ababa.

Ersado, L., Amacher, G., & Alwany, J. 2003. Productivity and Land Enhancing Technologies in N. Ethiopia: Health, Public Investments and Sequential Adoption. EPTD Discussion, paper 102 IFRH: Washington, D.C.

FAO 1986. Highlands Reclamation Study Ethiopia Final Report. Vol. I & II. Rome, Italy

FAO 1998a. The Soil and Terrain Data Base for north-eastern Africa. Land and Water Digital Media Series 2. FAO, Rome, Italy

FAO 1998b. Cropping Production Systems Zones of the IGAD. Land and Water Digital Media Series 2. FAO, Rome, Italy

FAO 2003. FAO/AGL – MADS – SEA website

Hakkeling, R.T.A. Global Assessment of Soil Degradation Eastern and Southern Africa. Vol. 1. Main report. Vol.2 Matrix Netherlands Soil Survey Institute. Wageningen, The Netherlands.

Herweg, K. and Stillhart, B. 1999. The Variability of Soil Erosion in the Highlands of Ethiopia and Eritra. Research Report 42 Centre for Development and Environment. University of Berne.

Hurni, H. 1993. Land Degradation, Famines and Resources Scenarios. In D. Pimental. World Soil Erosion and Conservation. Cambridge University Press. Cambridge pp 27-62.

Jabbar, M.A., M. Ahmed, S. Benin, Berhana Gebremedhin and S. Ehiu. 2002. Livestock, Livelihood and Land Management Issues in the Highlands of Ethiopia, International Land & Resource Inst. Ethiopia. Policies for Sustainable Land Management in the East African Highlands. IFPRI & ILRI. Summary of Papers and Proceedings Conference. Addis Ababa. April 24-27, 2002.

Keyzer, M.A. & B. G. J. S. Sonneveld. 2001 The Effect of Soil Degradation on Agricultural Productivity in Ethiopia: a Non-Paramatic Regional Analysis In Economic Policy Reforms & Sustainable Land Use in LDC's. (Heerink, H. Van Keuken & M. Kurpios - Eds.) Physica Verlag pp 269-292.

MeKonen, G. 2002. Country Partnership Framework to Combat Land Degradation & Poverty. Ethiopia. Global Mechanism.

Melese, B. 1992. Integrated Planning and Rehabilitation of Arable Lands. The Case of Sirinka Catchment, Ethiopia Proceedings of the 2nd International Symposium on Integrated Land Use Management for Tropical Agriculture. Brisbane, Australia.

Oba, G. and D. G. Kotile. 2001. Assessments of Landscape Level Degradation in Southern Ethiopia. International Conference on Policy & Institutional Options for the Management of Rangelands in Dry Areas. Tunisia. May 7-11, 2001.

Pender, John. Berhanu Gebremedhim and Mitiku Haile. 2002. Livelihood Strategies and Land Management Practices in the Highlands of Tigray. Policies for Sustainable Land Management in the East African Highlands. IFPRI & ILRI. Summary of Papers and Proceedings Conference. Addis Ababa. April 24-27, 2002.

Sanders, D.W. 1987. Food and Agriculture Organization activities in soil conservation. In: Conservation Farming on Steep Lands. Ed. Moldenhauer and Hudson. Soil and Water Conservation Society and the World Association of Soil and Water Conservation, Ankeny, Iowa

Scoones, I. & C. Toulmin. 1999. Policies for Soil Fertility Management in Africa. Case Study of South Ethiopia. IDS AND IIED U.K. p 104.

Sertsu, Sahlemedhin. 1999. Integrated Soil Management for Sustainable Agriculture and Food Security in Southern and Eastern Africa. Ethiopia

Shiferaw, B. & S. T. Holden. 1998. Resource Degradation & Adoption of Land Conservation Technologies in the Ethiopian Highlands. Agricultural Economics. 18. pp 233-247.

Sonneveld, B. G. J. S. 2002. Land Under pressure: The Impact of Water Erosion on Food Production in Ethiopia. Shaker Publishing. Netherlands.

Sonneveld, B. G. J. S. & M. A. Keyzer. 2002. Land Under Pressure; Soil Conservation Concerns and Opportunities for Ethiopia in Land Degradation & Development. Wiley InterScience. www.interscience.wiley.com.

Sutcliffe, J.P. 1993. Economic Assessment of Land Degradation in the Ethiopia Highlands. Addis Ababa, Natural Conservation Strategy Secretariat Ministry of Planning and Economic Development.

United Nations Development Programme. 2002 World Development Report. Oxford University Press.

World Bank. 2001. African Development Indicators. Washington.

Annex 1. Background

Arable land occupies about 10 percent of the total land area but permanent cropland only 0.7 percent. The remaining area is pastureland or infertile and/or severely degraded. Current (2002) population of Ethiopia is estimated at 67 million almost doubling since 1975. Urban population is around 11 million and most of the remaining rural population is represented by over 7 million small farmer-household, which produce 95% of agricultural output on 0.5 – 1.5 ha plots with additional grazing lands. Food crops including 6.8 m ha under cereal production together with oil seeds and pulses are the mainstream of this production sector. Cotton and sugar are produced on state-owned large-scale enterprises. Ethiopia also has large livestock resources including cattle, sheep, goats and camels as well as small stock totaling 32 million TLU's or 78 million animals. Significantly, the average annual growth rate of major food grains production is 0.6% while the population growth rate is over 2 percent (National Review Report 2002).

Most of the agricultural production system is located on the Ethiopian Highlands where 88 percent of the total population lives at an average density of 144 per Km^2. Most analyses of the impact of land degradation in Ethiopia are thus focused on the highland zone of the country.

Nationally forest reserves have been heavily depleted sequentially over much of the 20 century from over 40 percent to 2.2 percent in 2000. The annual deforestation rate is 0.8 percent in this greatly reduced forest area.

Ethiopia is noteworthy as the country of famine. Food shortages are endemic and since 1970 severe famine has occurred almost once a decade (1973; 1982 – 1984 early and late 1990's and 2002 – 2003). Although there are many contributing factors, land degradation is an important underlying cause, periodically highlighted by low and uncertain rainfall.

Annex 2. Findings of Local Studies on Land Degradation

Highlands Cultivation

This study analyzed the impact of soil erosion in the region and differential farmer's perceptions of and responses to the problem. Gully erosion and the removal of fertile topsoil are the major forms of land degradation, resulting in reductions in land productivity and also significant sedimentation in local lakes. This sedimentation reduces water availability, particularly for irrigation of the critical intercropping of sorghum, maize and chat, the later a popular stimulant. In the area provision of incentives are important components of local farmers willing to undertake SWC measures, with fertilizer provision a key incentive.

The more general message is that SWC and sustainable land management is most effective when specific farmer perceptions and priorities are taken into account. In this case water scarcity is a prime problem affecting farm productivity and a comprehensive rather than sector approach to land use planning is critical.

Source: S. Daba. An Investigation of the Physical and Socioeconomic Detriments of Soil Erosion in the Hararghe Highlands East Ethiopia. (Land Degradation and Development 14. 69-81. 2003).

Tigray Cultivation

In Tigray the rate of return on investment in stone terraces was about 25% and terraces were correlated with increased use of fertilizer. Reduced burning, reduced tillage and application of manure and compost had even more positive results. "Promotion of such conservation practices and exploitation of complementary livestock production show more promise to boost crop production than large applications of modern inputs.

Source: John Pender, Berhanu Gebremedhim and Mitiku Haile. 2002. Livelihood Strategies and Land Management Practices in the Highlands of Tigray.

High Mountain Grazing Lands

In North Ethiopia land degradation is centuries old due to cultivation on steep slopes and intensive grazing. As a result the area is characterized by shallow soils, diminished water-holding capacity and greatly reduced herbaceous and woody vegetation cover. In Eastern Tigray, North Ethiopia 65% of the open grazing lands are severely degraded and in Northwest Ethiopia forest cover reduced from 27% to 0.3% between 1957 and 1995 (Tekh 1999).

In response to these severe levels of degradation land rehabilitation funded mainly by food for work program in Hauzien Wereda allowed some 143,000 ha to be restored by adopting area enclosures and stone terracing. The enclosed areas were protected from grazing and interference for three years, during which period grass and herbaceous plants covered 60 – 80% of the area. After three years grass harvesting took place yielding 2 – 3.5 times as much dry matter as in the continuously grazed areas. An additional benefit in the older protected areas was the production of harvestable woody vegetation.

Source: Asefa, D.T., Oba, G., Weladj: RB & J.E. Coleman. An assessment of restoration of Biodiversity in Degraded High Mountain Grazing Lands in North Ethiopia. Land Degradation and Development. 14. 25-38. 2003.

Livestock, Livelihood and Land Management

Population growth has led to deforestation and the conversion of pastureland to crops leading to overstocking and further degradation. Crop residues are increasingly used for fuel rather than mulch. Dung is used as fuel rather than manure. All these factors lead to nutrient loss and increased erosion. Studies of Amhara, Tigray and Oromiya regions, show decline in livestock population for different reasons between regions. Pastureland decreased in quality over the past ten years except in Tigray where common grazing land management improved quality slightly. While in general the traditional nutrient cycling has been broken, this is not so in Oromiya. Use of dung and crop residues for energy are common in the High and Low potential cereal zones not in intermediate perennial zone.

Soil erosion and fertility problems are more serious in the HPC and LPC zones Semi-subsistence smallholder crops – livestock system facing problems; – 49% of population below the absolute poverty line so the cereal crop is the major priority.

Source: Jabbar, M.A., M. Ahmed, S. Benin, Berhana Gebremedhin and S. Ehiu. 2002. Livestock, Livelihood and Land Management Issues in the Highlands of Ethiopia, International Land & Resource Inst. Ethiopia.

Policy Issues

"To the extent that investments in land improvement are necessary for conservation purposes, it appears that ending future land distributions alone will not have much impact on reducing land degradation. However, ending redistribution in addition to allowing the current rental market to operate freely and encouraging longer leases may have more impact on the land degradation problem." pp 94

Source: Benin, S. Policies Affecting Land Management, Impact Use and Productivity: Land Distribution and Tenure in the Highlands of Amhara region. (ILRI paper. 2002)

Southern Highlands

A case study on responses to land degradation provides data and insight from the Southern Highlands. As elsewhere yields and farm incomes have declined, while the poorer farmers particularly have fewer resources to invest in soil conservation and/or fertilizers. The decline in fertility and responses to potential responses varied across the five socio-economic groups, but with fertility in remote fields declining more rapidly than the more nurtured close fields.

Source: Amede, Tilahan, Takele Belacheu and Endrias Geta. 2001. Reversing the Degradation of Arable Land in the Ethiopian Highlands. Managing Africa's Soils. No. 23. iied U.K.

Health and Sustainable Land Management

The adoption of more efficient farming practices and technologies that enhance agricultural productivity and improve environmental sustainability is instrumental for achieving economic growth, food security and poverty alleviation in sub-Saharan Africa. Our research examines the interaction between public investments, community health, and adoption of productivity and land enhancing technologies by households in the northern Ethiopian state of Tigray. Agricultural technology adoption decisions are modeled as a sequential process where the timing of choices can matter. We find that time spent sick and opportunity costs of caring for sick family members are significant factors in adoption. Sickness, through its impact on household income and labor allocation decisions for healthcare and other activities, significantly reduces the likelihood of technology adoption. Our findings suggest that agencies working to improve agricultural productivity and land resource conservation should consider not only the financial status of potential adopters, but also their related health situation.

From: Ersado, et.al., 2003 IFPRI

Annex 3. On-going Land Degradation Related Projects in Ethiopia

Table 6. Multilateral and Bilateral Assistance for Sectoral Projects/Programmes in Agriculture and Natural Resources

No.	Sectoral Project	Implementing Agency	Funding Agency	Project Budget (in millions US$)	Duration
1	Environmental Support Project	MoWR	Netherlands Gov't	14	-
2	The Woody Biomass Inventory and Development Project – WB.II	MoA	Netherlands Gov't	9.35	4 years
3	Ethiopian Forest Conservation in High Priority Areas	MoA	WWF	1.74	4 years
4	Strengthening Forest Fire Management in Ethiopia	MoA/FAO	FAO	0.35	2 years
5	South – East Rangelands Project Phase II	MoA	ADB	275	5 years
6	National Fertilizer Development Study Project	MoA	ADB	1.8	3 years
7	Rehabilitation 15 Small Scale Irrigation in Four Regions of Ethiopia	MoA	-	4	3 years
8	Honey and Beeswax Production and Market improvement Project	MoA	FAO	0.31	2 years
9	Accelerating the Impact of Agro-forestry Research and Development in East and Central Africa	EARO	EU	2.8	5 years
10	Research and Transfer of Technology for Sustainable Barley Production in Ethiopia (Phase II Project)	EARO	Netherlands Gov't	2.7	3 years
11	Southern Wello Agricultural, Productive and Water Resources Activities	EARO	Italian Gov't.	2.0	18 months
12	Tigray RSA, Productive and Water Activities	Lrc-Italian Agency	Italian Gov't.	-	18 months
13	Farmers Utilization of Biodiversity in Agro-Ecosystems in Ethiopia	Mekele University	Netherlands Gov't	1.1	5 years
	TOTAL			**317.98**	

Source: Modified from MeKonen, G. 2002. Annex I

Table 7. Regional Assistance For Agricultural And Natural Resources Programmes/Projects

No.	Sectoral Project	Implementing Agency	Funding Agency	Project Budget (in millions US$)	Duration
1	Southern Region Agricultural Support Service Project	SNNPR	ODA/UK	4.8	5 years
2	IFAD Special Country Programme	Oromia	IFAD	32.8	6 years
3	Sida Support to Natural Resources Management and Environmental Protection	Amhara	SIDA	2.3	5 years
4	Sustainable Agricultural and Environmental Rehabilitation of Drought Prone Ethiopian Highland	Tigray	SIDA	2.3	-
5	Integrated Watershed Management in the Amhara Regional State	Amhara	Netherlands Gov't	3.4	4 years
6	Sustainable Development Project Adi-Arkay	Amhara	UNCDF	9	5 years
7	Agricultural Research Intervention for Food Insecured Woredas	Amhara	USAID	5	5 years
8	Water Harvesting and Institutional Strengthening	Tigray	CIDA	6	6 years
9	Agricultural Extension and Training Project	Amhara	USAID	70	5/7 years
10	An Integrated Participatory Watershed Management and Sustainable Water Resource Development Erosion Prone Areas	Amhara	Netherlands Gov't	2.8	4 years
11	Low-Pressure Drip Irrigation in Arbaminch Water Technology	SNNPR	Governments of Israel	-	5 years
12	Improving Nutrition and Household Food Security	Tigray and Amhara FAO	Belgium Survival Fund	4.4	4 years
13	Biodiversity of Lake Tana and its Watershed Project	Amhara	GEF	0.036	1/2 years
	TOTAL			**145.8**	

Source: Modified from MeKonen, G. 2002. Annex II

Table 8. World Bank Projects: IBRD/IDA Projects Related to Natural Resource Management

TITLE	$ MILLIONS	PERIOD	PURPOSE
Peasant Agricultural Development Program	85	1988 –1997	70% for fertilizer, the rest for inst support for peasant sectors
Livestock Project	5	1973-1979	Stock Routes & Marketing
Livestock Project	39	1987-1994	Animal Health & Production
Rangelands Development Project	27	1975-1985	Land Planning & Range Management for Gradual Control of Numbers, Boreholes, Marketing Infrastructure
Forestry	45	1986-1994	Forest Plantations for Woodland, Self Help Community Forestry & ?
Small Scale Irrigation & Conservation	7	1987-1996	Combat Drought & Desertification Arsi, Bale, North Sidano & Hararghe Small Scale Irrigation, Land Conservation, Improved Production
Water Supply Development & Rehabilitation	35.7	1996-2003	Urban & Rural Water Supply Infrastructure
Agricultural Research & Training	60	1998-2005	Building an Effective Agricultural Research System on a Decentralized Basis
Biodiversity	1.8	2001-2006	Medicinal Plants & Health Care
Conservation & Sustainable use of Medicinal Plants	2.6	2001-2005	Medicinal Plants & Health Care
Food Security	85	2002-2009	Build Resource Base of Poorer Rural Households

Annex 4.

Major Issues And Priority Areas In Combating Land Degradation And Poverty

Important Issues	Main Problems; why it is an issue?	Desired Situation (Objective, aim)	Measures to be taken (Strategy)	Responsible Body
Participation	- Lack of an enabling environment - Lack of awareness - Misconception of partnership	- Enhancing enabling environment - Enhancing partnership - Devolution of power	- Awareness creation - Clear definition of partnership - Empower local governance	GOs, NGOs, International partners
Land tenure	- Insecurity of tenure	-Ensure long term use through issuing a sort of title deed	- Proper land use policy and legislation - Promote proper indigenous practices	Federal and Regional Governments
Inappropriate land use system	- Steep slope farming - Deforestation - No or short fallowing period - Lack of modern technologies - Lack of know-how - Overgrazing - Population pressure	- In place land use and ownership policy - Forest policy - Availability of modern know-how and technology - Grazing management policy and legislation - Population policy (in place)	- Issues appropriate policies and legislation on land use, forest, SWC and grazing management - Educate the public - Implement population policy - Make available modern technology through research	- Federal and Regional Governments - NGOs/CBOs - Development Partners
Livestock population	- Overgrazing /uncontrolled grazing - Quantity valued than quality	- Livestock number balanced to the available feed resources	- Increase off-take rate - Change the mgt system from open to zero grazing	Govt's, NGOs/CBOs, communities
Population pressure	- Man to land ratio incompatible - Uncontrolled growth - Women not educated and empowered to control their own fertility	- Population growth balanced to economic growth - Family planning exercised - Women empowered	- Proper implementation of the population policy (family planning) - Alternative employment opportunity created - Resettlement - Educate and empower women	- Governments - NGOs/CBOs - Development partners

Important Issues	Main Problems; why it is an issue?	Desired Situation (Objective, aim)	Measures to be taken (Strategy)	Responsible Body
Poverty	- Unbalanced population growth vis-à-vis economic growth - High unemployment rate - Low productivity (Land/man) - Lack of poverty reduction strategy - Inequitable share and distribution of resources and services - Hunger, illiteracy, etc. - Deprivation of basic needs (food, shelter, cloth)	- Economic growth balanced to population growth - Access to basic needs - Access to social services - Equitable sharing and distribution to resources and services	- Integrate economic development with population controlled strategy - Encourage labor intensive investment - Improve the quality of the population through education, knowledge and skill - Promote equitable share and distribution of resources and services	- Governments - NGOs/CBOs - Development partners - Population
Important Issues	**Main Problems; why it is an issue?**	**Desired Situation (Objective, aim)**	**Measures to be taken (Strategy)**	**Responsible Body**
Institutional failures	- Institutional instability - Overlapping of mandates - Shortage resources - Integration and coordination problem - Lack of a common forum	- Stable with clear mandates institutions - Adequate resources - Clear mechanism of integration and coordination - Established M&E	- Establish institution with clear mandate and empowerment - Secure appropriate resources - Create a mechanism where institutions integrate and coordinate their activities - Established M&E	- Federal Govt's - Regional States - NGOs - Development partners
Investment	- Conflict with NR conservation measures - Low investment on off-farm activities	- Proper EIA - Labor intensive investment promoted	- EPA should be empowered - Labor intensive investments should be encouraged	- Governments - Private investors - Development partners
Infrastructure and market failures	- Lack of access to market - Lack of access to services (school, light, clinic, water grinding mill, communication, extension and family planning services	- Access to services - Access to markets	- Improve rural infrastructure and services - Promote appropriate energy saving technology - Develop alternative renewable energy system.	- Federal and Regional Governments - NGOs/CBOs - Development partners

Source: MeKonen, G. 2002

LAND DEGRADATION

IN

MEXICO:

ITS EXTENT AND IMPACT

D. Campbell, L. Berry

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TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN MEXICO: ITS EXTENT AND IMPACT

Preface

This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established and the cost of current remedial programs can be identified.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

MEXICO


Baja California Norte
Sonora
Chihuahua
Coahuila
Nuevo Leon
Baja California Sur
Durango
Sinaloa
Zacatecas
Tamaulipas
San Luis Potosi
Nayarit
Yucatan
Quintana Roo
Jalisco
Veracruz
Campeche
Puebla
Tabasco
Michoacan
Guerrero
Oaxaca
Chiapas
1 Aguascalientes
2 Guanajuato
3 Queretaro
4 Hidalgo
5 Tlaxcala
6 Federal District
7 Mexico State
8 Morelos
9 Colima


Tropical Hot & Humid
Tropical Hot & Subhumid
Temperate
Arid and Semiarid
Sea-Land Transition
500 km
Ecological Zones in Mexico

LAND DEGRADATION IN MEXICO: ITS EXTENT AND IMPACT

Executive Summary

In Mexico land degradation is an important factor in Mexico's national economy impacting 65% of the national land area. While data is not precise, it is estimated that losses of nutrients and productivity in agricultural and grazing areas costs over $2 billion a year, losses due to salinization approach $1 billion and the costs of deforestation are up to $0.5 billion making a total impact 6%-5% of NDP. Land degradation differentially affects poor regions, where it has impacts a dimension higher than national averages. It has also been shown that land degradation is an important contributing factor to rural-urban migration in Mexico and to Mexico-U.S. migration streams. 700,000 – 900,000 people migrate from Mexico's drylands annually. There is a strong correlation between environmental stress and poverty and migration.

Mexico illustrates the importance of government policy in dealing with land degradation. There was a period when with land reform and the development of the ejido system, there was a focus on rural development and while land degradation occurred it was not catastrophic. This can be partly attributed to government investment in rural services, including agricultural extension, with accompanying subsidies of farm inputs.

Policy changes associated with Structural Adjustment Programs (SAP) and NAFTA changed this picture. SAP reduced government investment in rural areas and cut subsidies of inputs to smallholder agriculture. NAFTA treaty agreements undercut produce prices and led to increasing competition of imports of foodstuffs from the USA. This contributed to rural decline, and increased land degradation. Another result has been rural to rural migration to frontier areas, and encroachment on forestlands with the double burden of increased land degradation in both abandoned areas and in areas of new settlement.

Responses to land degradation have increased in the last decade, but are still far short of the magnitude of the problem. Policy changes have allowed an ecosystem approach and have resulted in an increased attention to the immediate causes of land degradation, i.e. deforestation, soil erosion, nutrient loss and salinization.

Future approaches should continue to address these issues while creating a better information flow on the true costs of land degradation and in addition approaches which address root causes in order to create a national and local policy environment which encourages investment in productive sustainable land management practices.

LAND DEGRADATION IN MEXICO: ITS EXTENT AND IMPACT

INTRODUCTION

Several studies of the costs of environmental degradation have been conducted for Mexico, at local, regional and national levels. These have recognized a variety of components of land degradation including deforestation, soil erosion, contamination of air and water, and the implications for economic activity and human health. A number of different approaches to measurement have been employed. All recognize that the complexity of components of land degradation, their in-situ costs and externalities, together with paucity of data, make estimation of the costs of land degradation difficult.

EXTENT AND DISTRIBUTION OF LAND DEGRADATION

A number of studies have provided estimates of the extent of land degradation in Mexico and have identified the principal causes.

The Mexican Ministry of Environment, Natural Resources and Fisheries (SEMARNAP) has estimated the impact of different biophysical process upon soil degradation (Table 1), while the FAO has examined the human impact in terms of extent, cause, and severity (Table 2).

Table 1. Mexico: Total Area Experiencing Soil Degradation by Principal Process

Principal Processes		Area Affected Km^2	Percent of Total Land Area
Water Erosion	Total	724651	37
	Loss of topsoil	495669	25
	Structural Deformation of soil	227760	12
	Sedimentation	1222	0
			0
Wind Erosion	Total	291711	15
	Loss of topsoil	285856	15
	Removal of vegetation	5855	0
			0
Chemical Degradation	Total	132550	7
	Nutrient Loss	31172	2
	Gleying	12989	1
	Salinization	62421	3
	Contamination	25967	1
			0
Physical Degradation	Total	34878	2
	Urbanization	7469	0
	Dryness	10790	1
	Compaction	5473	0
	Floods	11146	1
			0
Biological Degradation		70817	4
	Totals	1,254,607	65

Source: SEMARNAP, Subsecretaría de Recursos Naturales, 1999.

According to these Government of Mexico figures some 65% of the land area is impacted, while using the FAO data (Table 2) 45% of the country (874,000 km²) is severely or very severely degraded.

Table 2. Mexico: Estimate of Human-Induced Land Degradation

SEVERITY OF HUMAN-INDUCED LAND DEGRADATION													
	Total Area	**None**		**Light**		**Moderate**		**Severe**		**Very Severe**			
	'000 km²	**'000 km²**	**%**	**'000 km²**	**%**	**'000 km²**	**%**	**'000 km²**	**%**	**'000 km²**	**%**	**Cause**	**Type**
Mexico	1966	710	36	201	10	181	9	525	27	349	18	A,O	W

Legend: *Cause*: A = agriculture; O = overgrazing. *Type*: W = water erosion.
Source: TERRASTAT - Land resource potential and constraints statistics at country and regional level. FAO, Rome 2000 – (*http://www.fao.org/ag/agl/agll/terrastat/*)

Other studies have examined the national extent of degradation of land or vegetation. According to Dregne and Chou (1992) a significant proportion of Mexico's dry lands are subject to desertification, defined as "a human-induced process of land degradation that can range in severity from slight to very severe and in cause from erosion to salinization to toxic chemical accumulation to vegetation degradation, irrespective of climate." (1992: 1) (Table 3).

"Sixty-four percent of agricultural lands and forests have been damaged by erosion, with more than 20 million hectares having lost between 40 and 60 percent of their capacity to retain water."

Table 3. Mexico: Total Area of Drylands and Percent Desertified

	Irrigated	Rainfed	Rangeland	Hyperarid	Total Drylands
Land Class (Hectares)	4,890	10,005	133,142	1,738	149,775
Percent Desertified	36	54			

(after Dregne and Chou. 1992)

Land degradation occurs throughout the country and different causes exist from one region to another. The Mexican Government (Commision Nacional 1994) has identified this variation (cited in Schwartz and Notini 1994: 8-9). According to this investigation, the Mexican states with the greatest rates of land degradation are:

Water erosion Aguascalientes, Guanajuato, Coahuila, Michoacan, Zacatecas, Jalisco, Nuevo Leon and San Luis Potosi, with more than 45 percent of the surface severely affected;
Wind Erosion San Luis Potosi, Morelos, Hidalgo, Nuevo Leon, Baja California, Queretaro, and Zacatecas, with more than 80 percent of their surface affected;
Salinization Tamaulipas, Sonora, Baja California, Chihuahua, Coa-huila, and Colima, with more than 2 percent of their surface affected;
Sodification Campeche, Sonora, Quintana Roo, Morelos, Yucatan, Tabasco, and Mexico, with 13-40 percent of their surface affected;
Physical Degradation Hidalgo and Veracruz, with 40-90 percent of their surface affected;
Biological Degradation Colima, Morelos, Tabasco, Chiapas, Veracruz, Jalisco, Michoacan, Nayarit, Yucatan, and Sinaloa, with more than 90 percent of their surface affected;
Chemical Degradation Tabasco, Campeche, Veracruz, Nayarit, and Oaxaca, with 20-67 percent of their surface affected;

While this variation in processes has been identified across the nation, studies of degradation have been stymied by lack of reliable data. One study (McIntire, J. 1994) has estimated the regional variability in the severity of soil erosion (Table 4). The most affected ecological zones are the irrigated arid states and the rain fed arid states. Annex 1 provides a detailed analysis of the distribution and intensity of soil erosion by state.

Table 4. Severity of Soil Erosion in Mexico, by State and Climatic Region, 1982

State and climatic region	No manifest	Light	Moderate	Rapid	Severe	Total Area
Productivity loss compared with situation without erosion (%)	17	22	37	38	75	35
State and climatic region						
Tropical States						
Campeche	1,630	2,038	917	306	214	5,095
Colima	125	21	88	234	62	521
Chiapas	4,557	2,123	477	64	-	7,442
Quintana Roo	1,611	1,915	504	252	756	5,035
Tabasco	760	887	380	127	380	2,534
Oaxaca	1,413	1,413	1,894	1,884	2,826	9,421
Veracruz	3,604	3,462	96	2	1	7,190
Yucatán	578	193	1,194	193	1,694	3,851
Central temperate highlands						
Distrito Federal (Mexico City)	23	62	12	1	-	148
Tiaxcala	17	71	209	77	10	403
Guanajuato	1,026	506	874	383	218	3,059
Guerrero	2,449	127	1,676	1,354	839	6,446
Hidalgo	501	63	397	522	605	2,087
Jalisco	1,864	81	1,459	4,134	467	8,106
México	516	919	611	28	7	2,146
Michoacán	961	120	1,382	3,245	300	6,009
Aguascalientes	27	82	192	110	137	549
Irrigated arid states						
Morelos	9	293	170	13	-	494
Nayarit	818	1,219	607	76	7	2,705
Puebla	102	1,923	815	357	131	3,392
Querétaro	138	23	367	207	413	1,148
Sinaloa	1,170	1,170	1,111	1,228	1,170	5,849
Sonora	3,286	2,373	4,016	3,103	5,477	18,225
Baja California Norte	1,003	1,146	2,364	1,791	860	7,163
Baja California Sur	870	1,015	2,174	2,029	1,159	7,247
Tamaulipas	2,229	796	2,388	1,353	1,194	7,960
Rainfed arid states						
San Luis Protosí	1,145	1,666	2,811	575	32	6,324
Chihuahua	4,427	4,250	13,188	2,109	681	24,561
Durango	3,459	247	4,817	1,235	2,594	12,532
Coahuila	301	1,654	4,662	6,911	1,504	15,040
Zacatecas	367	2,057	367	3,085	1,469	7,345
Nuevo León	260	1,693	1,497	2,731	826	6,510

Deforestation

Deforestation is an important factor in land degradation in Mexico both in forested and in woodland areas. The original forest and woodland cover in Mexico was 55% to 57% of the country, of which about 60% remains. However, the rate of deforestation has increased in recent years. Government of Mexico data show that from 1976 to 1993 forest and woodland cover decreased from 55,262,000 ha to 42,566,000 ha, a loss of 747,000 ha per year or 1.36%. Table 5 shows that this loss was greater in the humid and sub-humid forest areas where rates averaged around 2%.

The dry tropical forests of the country have also been severely depleted, with only 27 percent of their area remaining intact in 1990 (Trejo and Dirzo 2000). The impact of the loss of these and other forests is discussed by Whiteford and Melville (2002: 4): "Deforestation, which is now progressing at a rate of 600,000 hectares a year, is creating severe soil erosion in many areas (see Annex 2 for regional details).

Table 5. Deforestation in Mexico 1976- 1993

	Total % Loss	Annual % Loss
Temperate Woodlands	15.6	0.92
Humid Forests	36.6	2.15
Sub-humid forests	31.5	1.85

Source: LA Gestion Ambiental En Mexico Semarnap. 2000.

The main causes of deforestation were burning, logging for wood and fuel and expansion of agriculture. Recent data (WRI 2002) estimates that nationally deforestation continues at a rate of 0.9-1.3% annually with estimates varying by source.

The costs of the deforestation loss are hard to quantify because in some cases there are offsetting benefits through alternative uses of the land, but in most areas forest removal has resulted in a deterioration of the land and other resource base. A current annual rate of loss of forests of 600,000 ha may be equivalent to a loss of $75m a year to $500m a year (based on loss of woodland resource and estimated return to agriculture).

ESTIMATES OF COSTS OF LAND DEGRADATION

Estimates of the cost of land degradation in Mexico have focused on the impacts of soil erosion by wind and water and of salinization.

- SEMARNAP estimates for production losses in only the arid and semiarid zones are $1.49 billion annually (SEMARNAP 2000). This can be estimated at 65% of total losses which would then be in the order of $2.1 billion.
- Salinization of irrigated land can be estimated to reduce production by $624 million to $1 billion annually (Calculated from production losses and degree of salinization).
- Costs of land degradation due to deforestation estimated in the range of $75 million - $500 million per year.

Earlier estimates were:

- Total annual costs to the economy of soil erosion are estimated at $1 billion (Margulis 1992);
- Annual costs of particulates in the air are estimated at $850 million, and the related additional health costs at $1.1 billion (Margulis 1992).
- Annual estimated losses to crop production are $50 million per annum, of which $38 million is accounted for by losses in maize production (Margulis 1992).
- Deforestation and land use change and depletion of environmental resources accounted for a reduction in NDP of 6% and land degradation accounted an additional loss of 7% of NDP in 1985 (van Tongeren et al. 1991).
- Environmental degradation accounted for about 6 per cent of NDP in 1992, and when the cost of degradation in the form of air pollution, soil erosion and deforestation was included the total cost of degradation was estimated at 13percent of NDP (UNEP 1992).

The current best estimates of the direct costs of land degradation in Mexico is as follows:

Agricultural production soil & nutrient losses	$2.1 billion
Salinization	.75 billion (average)
Deforestation	.35 billion
Total	$3.20 billion

Other measurements of the costs of land degradation are valued differently. For example studies show that an important factor in the annual migration of the 700,000-900,000 people who migrate from Mexico's drylands is related to the degradation of the rural economy and the rural environment. Although there are return economic benefits in the form of remittances in some cases there are also the major costs of this social and economic upheaval. "There is a strong correlation between environmental stress, poverty and population pressure which can lead to migration"(NHI 1997). (See also Annex 2)

ROOT AND PROXIMATE CAUSES OF LAND DEGRADATION

A common theme of scientific articles and reports from the Government of Mexico and NGOs, is that environmental degradation is a consequence of complex interactions between societal and environmental processes, and that these processes are both local and national/international in scope.

At the local level decisions by land managers determine land use practices that may ameliorate or exacerbate land degradation. These decisions are influenced by the experience of the land manager, her/his economic status, linkages to local and external institutions, and by the external macro-economic and policy context.

The Government of Mexico explicitly recognizes that environmental degradation is not a simple process but is one that is an outcome of interactions between social, political, demographic, economic and environmental processes (OECD 1998; JICA 1999). Recent studies have identified an intensification of the complex process that affect environmental degradation, particularly as a consequence of NAFTA and SAPs (Barbier 2000), and while there has been little updating of the economic impact of these trends, it is fair to state that the estimates from the 1980s and 1990s represent an underestimate of contemporary costs to the national economy, and of the extent of poverty among rural producers.

Examination of regional patterns indicate that complex society-environmental issues are implicated in rural poverty for example in La Montaña (Landa et al. 1997), San Andrés Lagunas (García-Barrios and García-Barrios 1990), Sinaloa (Cruz-Torres 2001), and Michoacan (World Rainforest Movement 1998), and the poverty and violence in Chiapas (Howard and Homer-Dixon 1995; Richter 2000; Ochoa-Gaona 2001), in increased desertification (Gonzales-Barrios et al.2002), in degradation of water resources (see case studies in Whiteford and Melville 2002), and in issues of establishing effected protected areas (Steadman 1987).

Proximate Causes

In rural areas population growth in the context of a lack of non-land-based economic opportunities results in a continuing increase in clearance of land for agriculture. This results in a loss of forest and of the habitat for forest species of flora and fauna. Proximate causes of rural land degradation include:

- Biophysical factors such as poor soils, steep slopes, and uncertainty in the amount and distribution of rainfall.
- Lands that are ecologically marginal are often the focus of rural-rural migration placing pressure on marginal land resources.
- Reduction in length of the fallow period in slash-and-burn shifting agriculture.
- Overgrazing.
- Exploitation of forest resources for fuel, timber, and sale of forest products.
- Poor management of water sources for domestic use and for irrigation.
- Population growth and extensification of agriculture.
- Rural-rural migration to the forest frontier and subsequent forest clearance for agriculture.

Root Causes

The proximate causes identified above represent specific conditions that require attention to reduce land degradation. Many of these are, however, outcomes of complex processes, both local and external, and as such are symptoms rather than root causes. Policies that address these symptoms but fail to target root causes may provide short-term remediation but over the long term it is the root causes that will need to be the focus of remedial policies. Root causes include:

- Poor ecological conditions for agriculture, including soil conditions, slopes, and climatic variability.
- Poverty and Income Inequality. The OECD (1998: 40) states that income inequality is among the highest in OECD countries and that 17 million are estimated to be living in poverty, about 6.4 million of whom in the early 1990s lived in rural areas.
- Rural decline consequent upon redirection of government services and incentives to commercial agriculture.
- The lack of real economic alternatives to slash-and-burn subsistence agriculture.
- Land abandonment in established areas where soil productivity cannot be maintained, and rapid migration to and land clearance expanding the agricultural frontier.
- Growing population on stagnant or declining land base.
- Government policy, SAP and NAFTA regulations have resulted in "conflicting pressures for development of rural areas and for protection of biodiversity have created a mesh of incompatible programs and policies that promote land clearing and forest degradation." (Steadman 1987).
- Geographical redistribution of economic opportunity under recent policy reforms, including SAP and NAFTA, with consequent migration patterns and implications for environmental degradation.

There has been considerable examination by the scientific and the NGO communities of the impact on land use and management of the interacting processes set in motion in the 1980s and 1990s by SAP, NAFTA, and related changes in government policies towards agriculture (The Agrarian Reform Law 1992), and land tenure that altered the *ejido* system from one of usufruct rights to land title which led to a land market, and forest management (The 1992 revisions to the Forestry Laws). These have generally favored commercial producers and the majority of rural farmers have been negatively affected. These impacts include:

- **Structural Adjustment Policies** (SAP). These are seen to have led to inflation. There were wage increases but these were less than the rate of inflation resulting in a decline in purchasing power. SAP also resulted in a reduction in the availability of government services such as health, credit, extension etc. and where the private sector has replaced these it has invested in more productive areas and in commercial enterprises more than in the activities of the majority of rural farmers and in marginal lands.

- **NAFTA** (Natural Heritage Institute 1997; U.S.-Mexico Chamber of Commerce 1998; Barbier 2000, 2002) The Government of Mexico did not implement the full range of policies that were designed to accompany the economic policies consequent upon the signing of NAFTA, and provide a 15-year period of adaptation to NAFTA policies. For example less Government investment in social services and services in support of production (credit, extension). This has an impact on human capital – education may be more costly, as is health care – leading to less knowledgeable and productive workers. Such policies might have offset the impacts of NAFTA by providing a safety net to ease the transition from the pre-NAFTA era when government services supported rural producers, to the free market policies of NAFTA.

- Further the legal frameworks for agriculture, land tenure, and forestry introduced alongside the SAP and NAFTA initiatives have often been contradictory as different government bureaucracies were responsible, each with different mandates. NAFTA is seen to have resulted in a drop in the price of maize (the major crop of a rural agriculture) as a consequence of the removal of tariffs that allowed for the importation of cheaper maize from the USA. Economic incentives were also put in place that promoted cash crop production (horticulture) and cattle raising. Among the consequences are:

  *The import of GM maize from the USA is seen as a potential threat to the genetic diversity of Mexico's indigenous maize stock. This is an issue that has been debated since the 1940s when Green Revolution technology was first being developed in Mexico.

  *The incentives for commercial agriculture led to an extension of the area under horticultural crops, and to land clearance for cattle raising. Deforestation was an outcome in some areas.

  *The incentives to commercial production led to laborsaving investments in technology that reduced the demand for rural labor. This has reduced the income to many rural households whose options have included migration to towns and to the US, and into forested areas resulting in deforestation.

  *Removal of price supports for maize farming led to a reduction in production for the market and a concentration on subsistence production; the loss of commercial income led to increased rural poverty, and migration – including that to the forest frontier resulting in deforestation.

*the decline in income from maize, and reduction in income opportunities in the commercial sector, led to rural-urban/US migration involving close to a million migrants annually (Leighton-Schwarz and Notini 1994; Natural Heritage Institute 1997). Poverty also led to an abandonment of farms where farmers could no longer afford farm inputs (e.g. fertilizer) and a migration to the frontier resulting in deforestation.

*loss of labor in rural areas to rural-rural, rural-urban, and rural-US migration streams disrupted labor-intensive land management practices that depended upon social capital – social norms that provided for sharing of community labor. This decline in labor availability for land management led to a reduction in new investment in landesque capital (Blaikie and Brookfield 1987) and in a decline in upkeep of existing investments.

*urban expansion, mining, and public works.

Government Policy
The Government of Mexico has since the 1930s promulgated laws and regulation to address environmental issues (Whiteford and Melville 2002). The contemporary situation is illustrated in OECD 1998 and JICA 1999. These reports emphasize the government's view of the environment as an issue that integrates a variety of sectoral ministries. JICA (1999: 5) Annex 3 lists the ministries involved.

- **Land Reform**. There is a complex history of government policy affecting land management through agrarian policy, land tenure regulation, and regulations pertaining to water rights and forests. In 1934 the government initiated land reform that resulted in land redistribution as the hacienda system was transformed to promote greater equality in land ownership through the creation of elides. Subsequent government regulation regarding water rights and water development were implemented to support rural communities.

  Beginning in the 1960s government support began to wane and by the 1980s corrupt political practices accumulated to facilitate the wealthier landowners and impoverish rural communities. According to Barkin (2002: 258) the impact on many rural communities was that:

  > Without access to new technologies and with declining real prices, falling purchasing power, and declining fertility as a result of external pressures, they lacked the resources to purchase appropriate quantities and types of fertilizers ……Environmental damage accelerated with soil compaction, erosion and deforestation.

  The agrarian reforms and development of a land market under recent land tenure regulations has favored commercial enterprises over more subsistence-oriented producers. This has exacerbated rural poverty (OECD: 101ff) and led to migration, including that to the agricultural frontier with consequent forest clearance. This might have been controlled had the forestry laws been enforced and rules of tenure in forest lands clarified.

- **Demography**. Population Growth Rates (current estimate 1.5%) has led to a demand for land – this led to out-migration (estimated at about 1 million per year) from rural areas both to cities and the USA and to the agricultural frontier where it contributed to deforestation.

  According to OECD (1998: 39-40) the population of Mexico grew by 36 percent between 1980 and 1995, exceeding the growth of GDP at 29.1 percent during the same period. This relative growth in population and GDP, in the context of high-income inequality, has led to significant poverty that is associated with environmental degradation.

- **Local Conditions**. There is significant historical evidence that indigenous land management practices had included assessments of and responses to land degradation (e.g. Zinck and Barrera-Bassols 2002). However in contemporary Mexico, agricultural practices in areas where environmental degradation is most active are often dependent upon inputs of fertilizers or slash-and-burn agriculture dominates. With economic liberalization the ability of rural farmers to afford inputs has declined, many have abandoned their farms and moved to the forest frontier. The consequent increase in population engaged in slash-and-burn agriculture has led to reduced fallow and thus both to forest clearance and decline in soil quality.

  These processes are exacerbated by changes in land tenure regulations, by a favoring of commercial over more subsistence agriculture in the context of SAP and NAFTA and few opportunities for rural producers to diversify their income sources through crop sales or local off-farm employment, leading to a greater dependence on distant employment and remittances.

- **Environmental Conditions**. There are important ecological resources in Mexico – soils, forests, flora and fauna. These are being degraded as a consequence of processes outlined above. Alongside these Socio-economic-political processes are biophysical ones. These include: soil erosion (water and wind)- particularly on steep slopes; impact of hurricanes; etc

RESPONSES TO LAND DEGRADATION

After a period of time when the issues of land degradation and deforestation were not high on the Mexican government's agenda specific action and programs were initiated. In 1995, SEMARNAP established the Directorate of Restoration and Soil Conservation in order to face the problem of the deterioration of resources, to reduce the processes of degradation and to gradually reverse them. In general terms, the program tries to alleviate the causes of forest fires, deforestation, the land use change, erosion and the degradation of the forest ecosystems.

The program for sustainable land management (PMT) takes an ecological approach: This instrument allows planning and programming actions of sustainable management of significant land parcels. It was necessary to reorient institutional support to support producers that apply Best Management Practices (BMP's) previously validated in 21 pilot centers and nine micro-basins. It attempts to increase agricultural productivity, to reverse land degradation, and to promote a more appropriate land use. Up until June 2000 this program restored over 65,000 ha. In addition a number of steps have been taken to combat deforestation, including setting up additional sustainable management and replanting. Table 6 shows an estimation of the relative costs of the corresponding protection to the diverse programs of the SEMARNAP. It is clearly more expensive to replant areas already deforested or degraded, than the programs of conservation, sustainable management and prevention of deforestation by means of productive restructuring. "The UMA constitute the most economic form of protection, although the effectiveness of the latter completely depends on the performance of the owners of the land. Reforestation is the most expensive activity per hectare; nevertheless, it is essential to recover forest resources." It is clear from this data that this program is just beginning to tackle the problem.

Table 6. Battle Against Deforestation: Economic Aspects

	Program	Accumulated surface – by end of 1999 (Millions of ha.)	Assigned budget year 2000 (Millions Pesos)	Feasible expansion[1] (Millions of ha/year)	Cost per hectare (Pesos)
Conservation	ANP	11.54*	148.3	0.63	235.4
	UMA	12.70	23.3	2.00	11.7
Sustainable Management	Forest sustainable Management[2]	7.50	135.3	0.75	180.4
Replanting	PRONARE	1.22	327.7	0.16	2,048.1
	Commercial plantations[3]	0.035	(60.0)[4]	0.035	**
Prevention	Reconversion	0.1640	23.9[5]	0.07	341.4

Source: SEMARNAP 2000.

Table 7. Selected Projects Addressing Land Degradation

Project Title	Date/Cost	Objectives
Integrated Ecosystem Management in 3 Priority Regions (GEF GOM)	$77m 2000-2008	Support Sustainable Regional Development Program (PRODEPS), improved biodiversity & combat land degradation
Environmental Structural Adjustment Loan	$202m 2000-2008	Environmental Policy & Law, national & sub national, agriculture, insure environmental sustainability
Land Conservation Mechanisms Project	$0.75m GEF	Natural Resource Management
Mesoamerica Biological Corridor Project	$15m GEF	Biodiversity & restore degraded ecosystems
Rural Development in Marginal areas	$63m 1998-2003	Sustainable agriculture in poor rural areas, including institutional strengthening
Environmental project	$57.6m 1992-1997	Strengthening government's ability to carry out environmental protection & resource management functions

Table 7 lists a number of recent World Bank projects on environment and land degradation. These support an emphasis on policy change within Mexico and more recently an ecosystem approach to dealing with Natural Resource issues. The revised policies of the GOM in the 1990's appear to be one outcome of these initiatives.

In addition, Mexico has been a partner in a GEF project with the Natural Heritage Institution in an effort to develop indicators of environmental change as a tool for assessment and remediation of land degradation.

REMEDIAL STRATEGIES

While the GOM strategies above have addressed proximate causes through forestry, soil conservation and policy initiatives, there is a need to also deal with root causes. Among strategies to address root causes are the following:

- Assess the consequences for land degradation of altered linkages between rural areas and the national economic and policy context. Explore continued role for the government alongside the private sector to facilitate the transition to decentralization and market liberalization.
- Migration – address root causes of migration to frontier areas that stem from reduced productivity of areas of subsistence agriculture consequent upon SAP, NAFTA etc.
- Examine consequences of land tenure reforms for impact upon commercial and subsistence agriculture and implications for driving forces of land degradation.
- Diversify rural economic opportunities (see for example Buechler 2002). Redistribute income-generating activities to reduce population engaged in primary activities – develop secondary and tertiary opportunities. This will provide local demand for agricultural products from those engaged in non-farm activity; expands wealth of agricultural and non-agricultural sectors in rural economy. Reduces out-migration.
- Availability of labor and increased farm income will allow for landesque capital investments
- Improved productivity in areas of existing production reduces forest clearance at the frontier.

REFERENCES:

Barbier, E. B. 2000. “Links between economic liberalization and rural resource degradation in the developing regions.” Agricultural Economics, 23: 299-310.

Barbier, E. B. 2002. “Institutional constraints and deforestation: an application to Mexico.” Economic Inqury, 40, 3: 508-519.

Barkin, D. 2002. “The production of water for Mexican development.” Chapter 14 in Whiteford, S. and R. Melville (eds.) Protecting a Sacred Gift: Water and Social Change in Mexico.La Jolla: Center for Mexican-U.S. Studies, University of California, San Diego.

Blaikie, P. M. and Brookfield, H. (1987). Land Degradation and Society. Methuen, London.

Buechler, S. 2002. “Irrigated agriculture on ejidos: complementatrities with off-farm economic strategies.” Chapter 7 in Whiteford, S. and R. Melville (eds.) Protecting a Sacred Gift: Water and Social Change in Mexico. La Jolla: Center for Mexican-U.S. Studies, University of California, San Diego.

Comision Nacional de las Zonas Aridas. 1994. Plan de Accion para Combatir la Desertificacion en Mexico. San Luis Potosi.

Cruz-Torres, M.L. 2001. “Local-level responses to environmental degradation in northwestern Mexico.” Journal of Anthropological Research, 57 (2): 111-136.

Dregne, H. E., and N-T. Chou. 1992. Global desertification dimensions and costs. In Degradation and restoration of arid lands. Lubbock: Texas Tech. University

Garcia-Barrios, R., and L. Garcia-Barrios. 1990. Environmental and technological degradation in peasant agriculture: A consequence of development in Mexico. World Development, 18 (11): 1569-1585.

Gonzales-Barrios, J.L., L. Descroix, D. Viramontes, and E. Anaya. 2002. “Soil degradation and desertification in the Western Sierra Madre of Mexico. “17th WCSS, 14-21 August 2002, Thailand.

Howard, P. and T. Homer-Dixon. 1995, "Environmental Scarcity and Violent Conflict: The Case of Chiapas, Mexico", University of Toronto: Occasional Paper for the Project on Environment, Population, and Security.

JICA, Japan International Cooperation Agency. 1999. Country Profile on Environment: Mexico.

Landa R, J. Meave, J Carabias. 1997. “Environmental deterioration in rural Mexico: An examination of the concept.” Ecological Applications, 7 (1): 316-329.

Leighton Schwartz, M. and J. Notini. 1994. “Desertification and Migration: Mexico and the United States.” San Francisco: Natural Heritage Institute.

Margulis, S. Back-of the envelope estimates of environmental damage costs in Mexico. *Policy* Research Working Papers, WPS 824, The World Bank, January 1992.

McIntire, J. 1994. A review of the soil conservation sector in Mexico. Chapter 11 in E. Lutz, S. Pagiola, and C. Reiche (eds.), Economic and Institutional Analyses of Soil Conservation Projects in Central America and the Caribbean. World Bank Environment Paper, 8.

Natural Heritage Institute. 1997. "Breaking the cycle: Desertification and Migration on the U.S. – Mexican border."

Ochoa-Gaona, S. 2001. "Traditional land-use systems and patterns of forest fragmentation in the highlands of Chiapas, Mexico." Environmental Management, 27 (4): 571-586.

OECD.1998. Environmental Performance Reviews: Mexico. Paris: OECD.

Richter, M. 2000. "The ecological crisis in Chiapas: A case study from Central America." Mountain Research and Development, 20 (4): 332-339.

SEMARNAP. La Gestion Amiental En Mexico. Government Of Mexico 2000.

Schwartz, M.L. and J.Notini. 1994. Desertification and Migration: Mexico and the United States. *Research Paper*, US Commission on Immigration Reform.

Steadman, . 1997. *Socioeco*nomic Root Causes of Biodiversity Loss: The Case of Calakmul, Mexico. WWF.

Trejo, I. And R. Dirzo. 2000. "Deforestation of seasonally dry tropical forest: a national and local analysis in Mexico." Biological Conservation, 94: 133-142.

UNEP, 1992. Committee of International Development Institutions on the Environment (CIDIE): Workshop on Environmental and Natural Resource Accounting, Summary Record, Nairobi, 24-26 February 1992. Environmental Economics Series, Paper No. 3. United Nations Environment Programme (UNEP)

U.S.-Mexico Chamber of Commerce. 1998. "Environmental issues in Mexico under NAFTA." Washington, D.C.: U.S.-Mexico Chamber of Commerce.

Van Tongeren, J., S. Schweinfest, E. Lutz, M.G. Luna, and F.G. Martin. 1991. Integrated Environmental and Economic Accounting: A case study for Mexico. *Environment Working Paper*, 50. The World Bank, Environment Department, December 1991.

Whiteford, S. and R. Melville (eds.) 2002. Protecting a Sacred Gift: Water and Social Change in Mexico.La Jolla: Center for Mexican-U.S. Studies, University of California, San Diego.

World Rainforest Movement. 1998**.** "Purepecha Plateau" Case Study Michoacan, Mexico. September, 1998

Zinck, A. and N. Barrera-Bassols. 2002. "Land moves and behaves: indigenous discourse on sustainable land management in Mexico.". 17th WCSS, 14-21 August 2002, Thailand.

ANNEX 1. Regional Intensity of Soil Erosion

Table 4 and its derivatives (Tables 8 and 9) provide an indication of the distribution of intensity of soil erosion among the states of Mexico. Two summary measures can be calculated from the data provided in Table 4. The erosion index (Table 8) was lowest in the tropical states (average value of 1.15), while the central temperate highlands averaged 1.3, the arid irrigated states averaged 1.4, and the arid rainfed states 1.5. However these averages for the climatic regions conceal differences among the states in each zone. The following states have an “erosion index” equal to or greater than 1 standard deviation above the overall mean: Oaxaca, Yucatán, Hidalgo, Aguascalientes, Querétaro, Sonora, Coahuila, Zacatecas, and Nuevo León.

Table 9 shows the percent of land in each state subject to rapid or severe erosion. One state, Zacatecas has a value over 60%, and eight states (Colima, Oaxaca, Hidalgo, Jalisco, Michoacán, Querétaro, Coahuila, Nuevo León) have a value between 50% and 59%.

The two indices derived from Table 4 provide information on which states are the most vulnerable to soil erosion and might therefore be the initial focus of research to value its impact, and on remediation strategies.

Table 8. Severity Index by State and Ecological Zone (Based on Table 4)

State and Climatic Region	Calculated Degradation Score (DS) [1]	Total Area (TA)	Degradation Severity Index (DS/TA) [2]
Tropical States			Regional Mean 1.15
Campeche	3,557	5,095	0.7
Colima	932	521	1.8
Chiapas	1,699	7,442	0.2
Quintana Roo	5,116	5,035	1.0
Tabasco	2,661	2,534	1.1
Oaxaca	18,615	9,421	2.0
Veracruz	1,836	7,190	0.3
Yucatán	8,549	3,851	2.2
Central temperate highlands			Regional Mean 1.30
Distrito Federal (Mexico City)	46	148	0.3
Tiaxcala	477	403	1.2
Guanajuato	2,957	3,059	1.0
Guerrero	8,481	6,446	1.3
Hidalgo	4,154	2,087	2.0
Jalisco	13,703	8,106	1.7
México	1,169	2,146	0.5
Michoacán	10,755	6,009	1.8
Aguascalientes	1,056	549	1.9
Irrigated arid states			Regional Mean 1.39
Morelos	349	494	0.7
Nayarit	1,435	2,705	0.5
Puebla	3,193	3,392	0.9
Querétaro	2,548	1,148	2.2
Sinaloa	9,446	5,849	1.6
Sonora	34,868	18,225	1.9
Baja California Norte	10,855	7,163	1.5
Baja California Sur	12,390	7,247	1.7
Tamaulipas	10,945	7,960	1.4
Rainfed arid states			Regional Mean 1.52
San Luis Protosí	5,210	6,324	0.8
Chihuahua	23,310	24,561	0.9
Durango	18,404	12,532	1.5
Coahuila	28,783	15,040	1.9
Zacatecas	14,984	7,345	2.0
Nuevo León	12,475	6,510	1.9
		Overall Mean = 1.3; sd = 0.6	

[1] Calculated Degradation Score (DS) calculated using the following weightings for the area under different degrees of stress: 0 for no manifest erosion; 0.5 for light; 1 for moderate; 2.5 for rapid; and 4 for severe.
[2]Degradation Severity Index calculated by dividing the Calculated Degradation Score (DS) by the Total Area (TA).

Table 9. Percent of Area with Rapid or Severe Soil Erosion by State and Ecological Zone (Based on Table 4)

State and Climatic Region	Total Area (TA)	Area with Rapid or Severe Erosion	Percent Area with Rapid or Severe Erosion
Tropical States			
Campeche	5,095	520	10.2
Colima	521	296	56.8
Chiapas	7,442	64	0.9
Quintana Roo	5,035	1008	20.0
Tabasco	2,534	507	20.0
Oaxaca	9,421	4710	50.0
Veracruz	7,190	3	0.0
Yucatán	3,851	1887	49.0
Central temperate highlands			
Distrito Federal (Mexico City)	148	1	0.7
Tiaxcala	403	87	21.6
Guanajuato	3,059	601	19.6
Guerrero	6,446	2193	34.0
Hidalgo	2,087	1127	54.0
Jalisco	8,106	4601	56.8
México	2,146	35	1.6
Michoacán	6,009	3545	59.0
Aguascalientes	549	247	45.0
Irrigated arid states			
Morelos	494	13	2.6
Nayarit	2,705	83	3.1
Puebla	3,392	488	14.4
Querétaro	1,148	620	54.0
Sinaloa	5,849	2398	41.0
Sonora	18,225	8580	47.1
Baja California Norte	7,163	2651	37.0
Baja California Sur	7,247	3188	44.0
Tamaulipas	7,960	2547	32.0
Rainfed arid states			
San Luis Protosí	6,324	607	9.6
Chihuahua	24,561	2790	11.4
Durango	12,532	3829	30.6
Coahuila	15,040	8415	56.0
Zacatecas	7,345	4554	62.0
Nuevo León	6,510	3557	54.6

ANNEX 2. Supporting Documents

The Role of Agricultural Land Degradation in Migration

Our research shows, however, that the degradation of agricultural lands in Mexico can contribute directly to cross-border migration via its impacts on household incomes in the agricultural sector. Data demonstrate that high levels of environmental stress and high population pressures at the municipal level are associated with poverty. As poverty is a major determinant of migration, environmental degradation may be seen to influence migration through its impacts on poverty in the agricultural sector.

Indeed, three-quarters of all lands affected by soil erosion and other forms of desertification in Mexico are agricultural. The most critically affected states are Oaxaca, Tamaulipas, Yucatan, Veracruz, and Chiapas. The environmental factors responsible for this degradation are myriad. Erosion-causing deforestation is a primary contributor, and indeed today Mexico has only about 130,000 square kilometers of forests remaining. Data indicate deforestation rates of 24% to 34% per year in ejido communities. Climate change at both the global and local levels is also a major factor, and there is evidence suggesting that land degradation and climate change are reciprocal contributory factors. Yet poor land and water management practices remain the most significant -- and preventable -- contributors. Increasing degradation and scarcity of Mexico's agricultural water supplies is combining to aggravate the already serious problems stemming from overgrazing, over harvesting, and other unsustainable practices. The resulting land degradation dramatically impacts agricultural productivity. Migration can become the only means to avoid economic ruin, as declines in land quality in dryland areas lead to cessation of cultivation and abandonment of lands. In other words, higher environmental degradation increases the level of poverty, which in turn increases the expected income gains from migration. Under the "new" migration economic theory, migration may also be a temporary or seasonal avenue to generate income to compensate for market failures, i.e., remittances from migration are used to invest in capital or land at home as a means of increasing agricultural productivity and income.

This intuitive link between land degradation and migration is borne out by our research. Two environmental stress indicators, municipal-level deforestation rates from 1980-1990 and municipal population pressure (measured as the product of average farm size and average rainfed corn yield in the municipality) were analyzed with the results of the 1994 ejido survey. Although no nationwide soil erosion data were available, these two indicators serve as adequate proxies, since 75% of Mexico's remaining forests are located in ejido areas, and corn yield is an excellent indicator of agricultural land productivity.

Our analysis of the 1994 ejido survey data with other economic and environmental variables substantiates the correlations between environmental stress, poverty, and migration. As this report describes, the results of the analysis show a systematic inverse relation between environmental stress variables and income levels. At the municipal level, high levels of environmental stress are highly associated with poverty, which in turn, is highly correlative with migration the ejido survey also makes clear. Since much of the land degradation in Mexico is the result of human factors, particularly unsustainable land management practices, it follows that programs to improve these practices will likely have a positive impact on stabilizing agricultural incomes, reducing the acceleration of poverty rates, and, by extension, reducing the incidence of cross- border migration.

(Source: Breaking the Cycle: Desertification and Migration on the U.S. - Mexico Border. Natural Heritage Institute. Dec 1997)

Deforestation – Humid Areas

Deforestation rates and land-use changes related to environmental factors (slope angle and soil type), in addition to some local population and economic attributes, were estimated from Landsat MSS satellite images of two municipalities of different sizes and for a greater portion of the highlands of Chiapas, Mexico. Annual deforestation rates for 1974–84 and 1984–90 were 1.58 and 2.13%, respectively, in the central highlands of Chiapas; 1.84 and 1.10% in the highly populated Huistán; and 0.46 and 3.42% in the relatively unpopulated Chanal. Changes in the proportion of habitat types differed between the two municipalities between 1974 and 1990 ($p<0.001$). Dense forests decreased irrespective of slope angle, while increases were observed in open forested habitats and developed areas. Soil properties also determined the locale and rate of deforestation. In addition to permanent deforestation, a highly dynamic pattern of land-use change was found, and a gradient of degradation of forest structure and floristic composition. These processes appeared to be related to land-use history, as well as to environmental and socioeconomic attributes in each municipality. The current situation in the study region suggests the maintenance and even increasing impact of these processes, complicating the development of solutions to the generalized trend of impoverishment and resource depletion. The results encourage caution in the interpretation, use and analysis of data on the causes and consequences of deforestation, which frequently may not take into consideration the many aspects and scales of this process within a given region.

Keywords: Forest degradation; Human disturbance; Landscape ecology; Remote sensing; Rural development; Shifting cultivation; Tropical highlands

Divisio´n de Conservacio´n de la Biodiversidad, El Colegio de la Frontera Sur (ECOSUR), Apartado Postal 63, 29200 San Cristo´bal de Las Casas, Chiapas, Mexico
Received 8 April 1998; accepted 12 July 1999

(Source: Land use and deforestation in the highlands of Chiapas, Mexico. Susana Ochoa-Gaona *, Mario Gonza´lez-Espinosa)

Deforestation - Drylands

Seasonally dry tropical forests in the neotropics reach their northernmost distribution in Mexico. This vegetation type has both a high diversity and endemism, yet information about its conservation situation is scarce. This study analyzes the loss of this forest at the national level, comparing its potential coverage with that of the early 1990s; and at the local, using a time-series of the potential vegetation and coverage in 1973 and 1989 in the state of Morelos (central Mexico). At the national level we found that only 27% of the original cover remained as intact forest by 1990. At the local level, close to 60% of the original vegetation has been lost, and only 19% remains in a forested condition. These remnant forests are restricted to areas with steep slopes. An annual deforestation rate of 1.4% was calculated and remaining areas are heavily fragmented and somewhat disturbed. If the trends detected continue, these remaining forests will be heavily reduced and degraded in the near future. Urgent measures to promote their conservation are required.

Keywords: Seasonally dry tropical forest; Mexico; Deforestation; State of Morelos; Land use patterns
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Deforestation of seasonally dry tropical forest: a national and local analysis in Mexico. Irma Trejo [a,*], Rodolfo Dirzo [b,1]

ANNEX 3. Ministries Involved in Environmental Issues

Ministry of Environment, Natural Resources and Fishery is composed of the following agencies and covers all aspects of the environmental management:

INE National Institute of Ecology
PROFEPA Federal Attorney's Office for Environmental Protection
CNA National Water Commission
IMTA Mexican Institute of Water Technology
INP National Institute of Fishery
INIFAP National Institute for Forest, Agriculture and Livestock Research, under the Ministry of Agriculture, Livestock and Rural Development
CONBIO National Commission for the Knowledge and Use of Biodiversity
CECADESU Center for Education and Training for Sustainable Development

National Institute of Ecology formulates a national environmental policy and legislation of Mexico as its duty including air, water, solid waste, water supply, sewerage system planning, forest resource management, biodiversity protection and natural resource management. INE also is in charge of promotion of NGO's activities on environmental protection as well as listing of NGOs.

Federal Attorney's Office for Environmental Protection is responsible for environmental audit on air, water and solid waste management.

National Water Commission and Mexican Institute of Water Technology monitor and explore water resources of both surface and groundwater as well as develop the sewerage system.

National Institute for Forest, Agriculture and Livestock Research also investigates the forest and make a research on the forest resources management.

Ministry of Health, Ministry of Agriculture, Livestock and Rural Development, Ministry of Energy, Ministry of Commerce and Industrial Development, and Ministry of Interior that includes National Earthquake Disaster Prevention Center, National Earthquake Service, National Meteorological Service.

LAND DEGRADATION
IN
UGANDA:
ITS EXTENT AND IMPACT

J. Olson, L. Berry

Commissioned by Global Mechanism
with support from the World Bank

TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN UGANDA: ITS EXTENT AND IMPACT

Preface

This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established and the cost of current remedial programs can be identified.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

UGANDA

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34°
Sudan
N
Bahr-al Jabal R.
(White Nile)
Kenya
0 75 km
0 50 mi
Moyo
Kaabong
Pager R.
Atiak
Kitgum
Arua
Albert
Nile R.
Gulu
Achwa
R.
Kilbali
R.
Ora R.
Moroto
Victoria
Nile R.
Pakwach
Uganda
Okere
R.
Zaire
Kafu
R.
Lake
Kwania
Okok
R.
Lake
Bisina
Lake
Albert
Butiaba
Masindi
Lake
Kyoga
Soroti
Hoima
Kapchorwa
Ituri
R.
Lugogo
R.
Su
R.
Nkusi R.
Namasagali
Victoria
Nile R.
Mbale
Mbulamuti
Busembatia
Tororo
Kyenjojo
Fort
Portal
Mubende
Bombo
Jinja
Iganga
Nzoia
R.
Mityana
Kampala
Kasese
Entebbe
Lake
George
Ntusi
Lake
Edward
Masaka
Sese Islands
Lyantonde
Mbarara
Gucha R.
Ntungamo
Lake Victoria
Kenya
Kabale
Kagera R.
Lac
Muhazi
Rwanda
Tanzania
Tanzania

LAND DEGRADATION IN UGANDA: ITS EXTENT AND IMPACT

Executive Summary

Despite the fact that Uganda has a large percentage of arable land, soil degradation is a substantial problem in the country. Generally it is estimated that 4% - 12% of GNP is lost from environmental degradation 85% of this from soil erosion, nutrient loss and changes in crops. The worst affected areas include highland areas in the southwest and some dryland districts. There has been relatively little national scale analysis of the cost of land degradation to the national economy, but the extent of the problem is documented in detailed studies of land use change, which show declining fertility, particularly on fields away from the homestead. Percentages of land affected by land degradation range from 90% in Kabale to 20% in Masindi.

There are good national environmental plans in Uganda, but at present poorly developed institutional structures to implement those plans in the most affected areas.

LAND DEGRADATION IN UGANDA: ITS EXTENT AND IMPACT

INTRODUCTION

Uganda is in the comparatively enviable position of having a large percentage of its land arable, and much of that not yet under cultivation. Approximately 75 percent of the country's land is relatively fertile and receives sufficient rainfall for rainfed cropping or pasture. Only around 30 percent of the arable land is currently under cultivation (Zake et al. 1999). The agricultural population is concentrated in Eastern, Southern and Western Uganda, and zones within those areas have very high population densities. In several regions, important signs of soil degradation trends are apparent including declining yields and a switch to crops that demand fewer nutrients. Indeed, food production has not kept up with the country's population growth despite an expansion of the area under crops. Per capita food production hit a low in 1980, and even with recent increases it has not reached the levels of the 1970's (NEMA 2001).

The expansion of area under cultivation has been primarily due to short and medium-distance migration and conversion of wetlands, grasslands and forests to crops. This has come at the price of some environmental problems. With peace and security, new longer distance migration can be expected with an increase in land under crops. Arable land per capita is expected to decline from 1.1 ha in 1991 to 0.6 ha in 2015 (NEMA 2001). Meanwhile, it is critical to both reduce land degradation in areas already under cultivation, and to ensure sustainable land management practices to prevent degradation in the areas that will be placed under cultivation in the near future. Uganda's comparative advantage in climate and soils means that it has the potential to become an important producer of agricultural products if sustainable systems of production are implemented.

THE ECONOMIC IMPACT OF LAND DEGRADATION

The only available estimate of the economic impact of land degradation is a 1991 thesis and this continues to be cited in governmental reports (Slade and Weitz 1991; NEMA 2001). In the thesis, Slade and Weitz estimated that 4% to 12% of the national GNP was lost due to environmental degradation. Soil erosion contributed 85% and water contamination 9% of the loss, with biodiversity loss, water hyacinth and deforestation contributing the remainder. The value of the total in 1991 was in the range of $170-460 million per annum (Kazoora 2002). Current values (2003) are in the range of $230-$600 million. The lack of economic estimates of degradation is attributed to the deficiencies in the collection or dissemination of natural resources information by the relevant research institutions (Zake et al. 1999).

THE EXTENT AND IMPACT OF LAND DEGRADATION

The State of the Environment reports (1999, 2000, 2001) and other literature describes the causes and severity of land degradation in the country based on the best available knowledge but without the benefit of a national level study. The most common physical component of land degradation is soil erosion. The NEAP of 1995 and subsequent reports have stated that most of the country has been affected by erosion. Even the relatively flat areas have experienced severe sheet and rill erosion, and the nutrient loss associated with soil erosion is identified as the cause of steady losses in soil productivity (NEAP 1995). Table 1 at the end of this report includes estimates of the percent of land area affected by erosion in selected districts. Those worst affected include the highland areas in the Southwest, Kabale and Kisoro (85%-90% affected), but also badly affected (75% - 80%) include Mbale, Rakai and Kotido cattle grazing districts. Some dryland districts (Moroto and Nakasongola, and Kakuuto county in Rakai) are said to be facing desertification (NEMA 2001). A summary of research on erosion and other agronomic research can be found in Nakileza and Nsubuga (1999).

In addition to the loss of land productivity, the siltation of lakes and rivers associated with erosion is leading to problems of eutrophication and reductions of fish populations. This problem is severe where former wetlands adjacent to lakes and rivers have been converted to cropping. Severely affected areas include Manafa, Kafu, Nyamwamba and the Nile River (NEAP 1995). Lake Victoria is also experiencing heavy sedimentation along its shores.

Agricultural productivity is low in Uganda in general, with wide gaps between output per hectare produced on experimental plots and what the average Ugandan farmers harvests. Bashaasha *et al*. cite a report from Ohio State University that actual yields as a percentage of potential levels are 51% for maize, 68% for soybeans, and 55% for sunflowers. The low yields are attributed to a lack of yield-enhancing investments from improved science and technology that would come from agricultural research (Bashaasha et al. 2001). Other factors that have delayed intensification include the under-development of regional markets that would permit trade of commodities between regions, a labor constraint on many farms being exasperated by the HIV-AIDS crisis and other illnesses, and inadequate government services including health care and agricultural extension (NEMA 2001).

The importance of land degradation against this backdrop of relatively low yields can be illustrated by examining banana production. Together, cooking, fruit and beer banana varieties are the most important food crop in Uganda, and occupy the largest area under food crops. Most farmers in Central, Southern and Southwest Uganda produce bananas. Indeed, Uganda is the world's largest producer and consumer of bananas. Banana production, however, has been stagnating over the past two to three decades with declines in outputs and yields. Any increases in production have come due to an expansion of area under production. The traditional center of banana production, Mpigi and Mukono districts in Central Uganda, has been experiencing declining yields and farmers are switching to cassava and sweet potatoes. Meanwhile, banana production is moving towards new land opening up in the West (Zake et al. 1999).

PROXIMATE AND ROOT CAUSES OF LAND DEGRADATION

The socioeconomic reasons for land degradation and low productivity on small-scale farms nationally have been summarized as:

1. Poverty and land fragmentation leading to over-exploitation of the land with inadequate soil and water conservation practices,
2. Increasing rural population densities with few non-farm income opportunities,
3. Low levels of commodity trade and the production of lower value commodities, reducing incentives to invest in the soil,
4. Little farmer knowledge of improved agricultural technologies, insufficient agricultural research that takes into account the needs and resource constraints of farmers, and a lack of effective agricultural extension,

5. Inappropriate farming practices/ systems including deforestation, bush burning and overgrazing (Olson 1998; Zake et al. 1999; NEMA 2001; Kazoora 2002).

The land under crops in Uganda is being cultivated primarily by small-scale farmers, with an average farm size of 2.5 ha (Zake et al. 1999). Approximately 80 percent of the country's population lives in rural areas and depends on agro-pastoralism for its food and income (NEMA 2001). The farms and often the individual fields are commonly divided amongst the sons as land is inherited, leading to increasing fragmentation of land holdings. The farmers are mostly poor, with few resources and numerous production constraints leading to low yields. Women and children conduct most of the agricultural labor by using simple hand tools.

Labor and capital resources available at the household level to invest in soil maintenance and management remain limiting. The middle income and poorer farmers in particular cannot afford to hire agricultural labor, and inputs such as manure and fertilizers are usually not available or not cost effective in the short term. Indeed, chemical fertilizer use declined ten fold between 1962 and 1980 to almost zero except in large estates. Between 1990 and 1995, only 6,000 tons of fertilizers were imported into the country (none are produced locally) and most of that was used on the estates (Zake et al. 1999). Even in projects providing micro-finance for agriculture, small-scale farmers have not used the credit to purchase fertilizer (Akello 2002).

Agricultural commercialization has grown rapidly from a very small base since the 1980's as the national economy has grown and as the market was liberalized. As commercialization increases in importance, the value of productive land and incentives to increase yields will eventually increase. Up to now, however, areas with higher market access have been associated with higher agricultural intensification but declining yields, suggesting nutrient depletion (Nkonya et al. 2002). An analysis of regional market integration of maize (Rashid 2002), a food crop increasing in relative importance in Uganda, concluded that since the recent liberalization of the market, market integration has generally improved especially in Masaka and Mbarara. The prime markets are Kamapala and Jinja. The Northern districts, in comparison, did not experience increasing integration and even suffered a decline, reflecting a worsening of the poverty situation linked to insecurities and/or perhaps trade across the border. Other studies concluded that elsewhere in the country, greater market access was associated with more income from bananas, higher manure application on bananas, more bean production, more use of fertilizer and improved fallow, and more investment in woodlots. In general, access to roads was associated with production of higher value commodities and fewer cattle, but with declining yields (Nkonya et al. 2002; Pender 2002).

Programs providing information on land management technologies have not necessarily lead to their adoption, probably due to the their limited profitability in the present economic situation, but in general extension was associated with higher use of soil inputs and other technologies (Jagger and Pender 2002). Most farmers, however, do not have contact with extension agents or other technical assistance programs (Pender 2002).

Insecure or counter-productive land tenure systems have also been blamed for poor land management and land degradation (NEAP 1995). Reforms to land management policies to address those and other issues include major national land tenure policy changes in 1975 and 1998, the implementation of the NEAP, and the recent decentralization of governmental authority. Boundaries of protected areas, for example, have regularly been changed, and former communal grazing land has been modified to more restricted access (Bashaasha 1998; Mugisha

2002; Tukahirwa 2002). Some studies have found, however, that the impact of tenure systems on land management has mixed or limited results (Nkonya et al. 2002). The implementation on the ground of many of the recent regulations concerning soil and water conservation and other land degradation mitigation practices is not yet fully in place.

The two most fragile ecosystems in the country are the highlands and the drylands. The problems of these two ecosystems will therefore be examined in more detail in this report. Other regions, with very different agro-ecologies and land management systems, are also experiencing various degrees of land degradation processes (see Table 2).

Highland Areas

The highlands occupy around 25 percent of the country's land area and contain 40 percent of the country's population. They are found in the Southwestern, Eastern, Western and Northeastern regions. Those with steep slopes, such as Kabale, Kisoro, Bundibugyo, Mbale and Kapchorwa, are the most seriously affected by erosion. Population densities are, in general, high in these areas and most land, including marginal lands, are under cultivation. There is as yet little evidence that the increases in population densities have led to sufficient adoption of land management practices to offset worsening erosion and nutrient depletion (Nkonya et al. 2002).

Kabale

Many aspects of the Kabale agro-ecosystem are similar to other highlands in Uganda. Kabale is a highland area in the Southwest with steep slopes, intensely cropped hillsides and high population densities. Erosion and consequent soil degradation have been assumed to be a major problem since before independence (Carswell 2002), and that assumption continues today (NEIC 1994; Kazoora 2002). The region has experienced out-migration for many years due to the scarcity of land. Several researchers have examined the extent and impact of erosion in the district (Bagoora 1988; Tukahirwa 1995). The erosion measurement results vary greatly, but it appears that the soils of Kabale are stable and have high infiltration rates, leading to less than expected but still significant soil loss.

The economic impact of the erosion and land degradation have not been estimated, but model results based on measurements and farmer perceptions of productivity decline by Ellis-Jones and Tengberg (2002) indicated that the relationship of soil loss and yield decline for Acrisols has a negative exponential form, though results varied by soils and management types. On Ferralsols and Acrisols, cultivation without soil and water conservation can lead to critical losses of production even on moderate slopes after one to four years. The model results also indicated that good soil cover was the most important factor reducing yield loss. Farmers traditionally have used trash lines (lines of crop residues and weeds placed along the contour), and these are indeed beneficial. However, when labor costs are taken into account it becomes uneconomical to cultivate a field after 4-5 years of cropping with trash lines, and 3-4 years without trash lines. Their study concludes that the traditionally used techniques are very important, but have inherent weaknesses and limitations that will become increasingly apparent (Ellis-Jones and Tengberg 2000).

A study of the evolution of land use, the agricultural system and soil degradation was conducted in Kabale using remote sensing, household and field surveys, and transects (Olson 1995, 1996; Breyer et al. 1997; Olson 1998). The study found that since the 1950's, almost all land that had been pasture or wetlands has been converted to cultivation, and most fields are being managed with only short (one rainy season long) fallows. The only exception is land owned by a few wealthy farmers near Kabale town who graze dairy cows on their pastured valley fields, and who leave much of their hillside land fallow. In other farms, however, fields are intensely cultivated (see Figure 1). Characteristic land management technologies employed include crop rotation, trash lines, and use of mulch on bananas.

Fragmentation of land holdings is severe. On average, 16 fields are cultivated per household, and the average household farm is 2.25 ha. Fragmentation diversifies the micro- ecologies that farmers exploit, from the hilltop to the valley, reducing their risk throughout the year and in seasons of variable rainfall. Having so many fields, however, reduces the labor and other resources farmers invest particularly in their distant hillside fields. Available organic materials, such as manure and crop residues, are placed only on fields nearest the homestead. The fields farther from the home receive no inputs but are left fallow more often. Besides being difficult to reach (many fields are over 30 minutes walking from the home), the far fields are difficult to guard against incursion by grazing cattle.

Declining fertility is worst on fields far from the homesteads, where over half of the fields are suffering from declining fertility. Another study by Briggs and Twomlow that measured the impact of biomass transfer from the far to the nearby fields also found significant yield declines in the far fields (Briggs and Twomlow 2002). In comparison, only 27 percent of fields near the homestead have declining fertility. Certain crops are being particularly affected by soil degradation. Peas are no longer producing well and are being planted less. Irish potatoes and beans are also affected, with beans now very susceptible to diseases.

Responses To Land Degradation In The Highlands

Erosion control bunds had been installed by the colonial administration in Kabale and are still being maintained by farmers, but as field boundary markers rather than as structures to prevent erosion. Farmers perceive their lack of ability to fallow to be a more important reason for declining fertility than erosion, though they do regret the loss of good topsoil from their fields being deposited onto the fields below owned by other farmers. The owners of the above and below fields share the topsoil collected behind the bunds when the bunds are cut down. This regular practice reduces the attraction of placing more long-term erosion control devices such as grass lines or hedgerows of agroforestry species. As the system intensifies, however, the fodder production and soil fertility benefits of such practices should increase relative to their labor costs.

Production constraints are important for all but the wealthiest of households. The use of soil inputs, such as chemical fertilizers and manure, was at a very low level in the mid-1990's. Indeed, no farmer reported using chemical fertilizers and only half applied manure to any field. This low level of input use may be due to low levels of agricultural intensification related to slowly emerging crop commercialization and agricultural extension. The labor and cash costs of inputs were not yet remunerative. Fallowing was practiced especially by the wealthiest group of farmers, with others able to leave a field fallow for at most 6 months. Declining soil fertility is a problem experienced on the fields of the poor and medium sized farms. Despite the high population densities, labor is an important constraint to further agricultural intensification especially in the poor households where the husbands are usually absent. There is, generally, a high level of dependence on women and children for agricultural labor.

Dryland Areas

The second most fragile ecosystem in Uganda, after the highlands, is the dryland areas of livestock production. The "Cattle Corridor," the rangelands from Moroto and Kotido in the Northeast though Luwero and south to Masaka and Mbarara, covers a large extent of the country. The drylands are a fragile resource, with low and unreliable rainfall and sparse vegetation.

Except in the North, much of the Corridor is considered over-stocked and seriously degraded, with problems of de-vegetation and compaction leading to erosion. Gully erosion is especially visible. Desertification is already pronounced in Karamoja and Nakasongola districts, and Kakuto County in Rakai district (NEMA 2001). Bush burning during the dry season also leads to important wind erosion, especially in the eastern districts of Kumi, Soroti, Katakwi, Moroto and Kotido. In general, the extent and frequency of xerophytic species has expanded due to the soil degradation, leading to a decline in forage quality (Zake et al. 1999). The semi-arid areas considered severely affected by both water and wind erosion include Karamoja, Soroti, Katakwi, Mbarara, Rakai and North Luwero.

The land tenure of most of the rangelands is communal, with communal grazing on natural pasture. Major socioeconomic changes are occurring in the drylands to affect this system, however, including increasing human population density and in-migration by agricultural settlers. While the human population has been increasing at a rapid rate, doubling from the 1930's to 1960's, the cattle population has increased at a slower rate. The increase in both populations is placing pressure on the land with intensive degradation occurring especially at watering points, along livestock paths and on hilltops. Areas particularly affected by over utilization include counties in Mbarara and Rakai districts (NEMA 2001).

While small-scale herders own most of the country's livestock, private or government large-scale commercial ranches own approximately 30%. Many ranches are currently being either reduced in size or privatized.

Other changes include the fencing of newly privated, formally communal grazing lands, such as in Rakai district. This is causing a concentration of livestock that had previously grazed on those lands, and severe sheet erosion on hillsides. Similarly, a large land area in Kotido and Moroto districts where the Karimojong graze their huge herds of cattle is being stressed due to the reduction of mobility of the formerly nomadic pastoralists following the imposition of administrative boundaries, security problems and increasingly frequent droughts. The area is experiencing concentration of cattle and severe degradation including invasion of unpalatable forage species and soil erosion (NEMA 2001).

Summary studies have been recently conducted of changing land management and perceptions of land degradation in agricultural zones in semi-arid Uganda (Nakileza and Nsuguga 1999; Okubal and Makumbi 2000). The authors conclude that farmers are aware of the degradation, especially that caused by erosion and declining soil fertility, but that tackling the problem would require both additional technological or agronomic research, and a multi-sectoral and interdisciplinary approach. Research in Mbarara by Tumuhairwe and others, for example, has taken a participatory approach to developing improved soil and water conservation practices in cultivated areas. Research in Toroma in the Northeast (Okubal and Makumbi 2000) concluded that the broader socioeconomic context, including the recent history of social and economic upheaval, and current livelihood insecurity, strongly affects farmers' ability and interest in investing in their land. Farmers perceive flooding and drought to be the major environmental problems they face, with only 10% of farmers mentioned erosion as being a problem. The decline of cotton growing has meant that most crop production is destined for household consumption or local trading at relatively low prices, reducing incentives to invest in soil and water conservation. Cattle production, which had started to replace cotton as the major income source, declined with insurgencies and cattle raids. New laws and regulations on land management are not yet having much effect, partly due to a weak local government.

LAND DEGRADATION MITIGATION

Ugandan, regional (AFRENA) and international institutions such as ICRAF and TSBF have found that the most promising and profitable technological option for improving soil productivity is using a combination of organic and inorganic fertilizers, with erosion control measures where necessary. Sources for organic materials include manure, coffee husks and other crop residues. Improved management of existing organic sources, such as methods integrating manure and composting, may significantly increase soil organic matter and reduce nutrient loss (Briggs and Twomlow 2002). Other sources of organic materials include legume cover crops, useful especially where population densities are intermediate and fallow is still practiced. They can produce high quality fodder as well as green manure and other soil enhancing properties. A rotation with *mucuna* (velvet bean) earned higher returns than with fertilizer for some areas in Eastern Uganda (Pender 2002). Ground cover has been found to be critical to reduce erosion and fertility losses associated with erosion.

The soils of Uganda are generally deficient in phosphorus, and increasing this mineral through biomass transfer or applying rock phosphate improves productivity. Some biomass, such as *Tithonia diversifolia*, has been found to be of very high quality, and it increases P and soil productivity after being transferred directly onto fields or incorporated into compost (Delve and Ramisch 2002). Combing *T. diversifolia* with rock phosphate produced the highest yields, though *T. diversifolia* use alone was most profitable (Pender 2002). Phosphorus rock is available in Tororo near Sukulu rock and Mbale near Busumbu rock. Use of the rock in nearby areas, especially combined with nitrogen fixating legumes, has shown promising results (Zake et al. 1999).

Analyses of the costs and benefits of various technologies to farmers, especially in land and/or labor constrained regions, are important in developing the technologies. In Eastern Uganda, it was found that investment in some technologies was only profitable after the soil had been depleted of nutrients, but that for maize they were profitable only in areas of higher rainfall and better soils (Pender 2002). Farmers in areas where *T. diversifolia* was tested innovated and adapted the technology to their own requirements, but the higher labor costs in particular would probably need to be met by returns from high value crops (Delve and Ramisch 2002). As market integration improves, the economics of investing in these technologies will change. Improving the farmer-researcher-extension-farmer linkages through participatory research is critical. The variability between farmers and households that affect resource constraints and influence adoption of technologies, including wealth and gender, also need to be considered.

Semi-arid areas have received much less attention by researchers and have additional research needs including water harvesting, storage and use methods, and improved integration of crop and livestock production. The processing and marketing of commodities produced in semi-arid areas, and infrastructure development, would also benefit from additional research.

Table 1. Estimates of the Proportion of Land Area Affected by Soil Erosion in Selected Districts (cited in NEMA 2001)

	District	Total Land Area (ha)	Estimated Area Affected by Soil Erosion		Population Density (Pple/Sq km)	Main Causes of Soil Erosion
			(Ha)	(%)		
1.	Kabale	165,300	148,770	90	250	Slopes, population pressure, deforestation, poor farming, vulnerable soil
2.	Kisoro	66,200	56,270	85	279	Slopes, population pressure, deforestation, poor farming, vulnerable soil
3.	Mbale	250,400	200,320	80	282	Slopes, population pressure, deforestation, poor farming, vulnerable soil
4.	Rakai	388,900	311,120	80	98	Vulnerable soils, poor farming, overgrazing
5.	Kotido	1,320,800	990,600	75	14	Overgrazing, bush burning, vulnerable soils
6.	Kasese	272,400	163,440	60	126	Slopes, vulnerable soils population pressure, overgrazing, poor farming
7.	Nebbi	278,100	166,860	60	114	Slopes, vulnerable soils, deforestation, population pressure
8.	Moroto	1,411,300	846,780	60	12	Overgrazing, bush burning, vulnerable soils
9.	Masaka	551,800	275,900	50	151	Slopes, population pressure, vulnerable soils, poor farming
10.	Mbarara	1,058,700	529,350	50	88	Deforestation, bush burning, overgrazing, poor farming, vulnerable soils
11.	Bundibugyo	209,700	83,880	40	55	Slopes, population pressure, deforestation, poor farming, vulnerable soils
12.	Luwero	853,900	341,560	40	53	Overgrazing, bush burning, vulnerable soils
13.	Rukungiri	258,400	77,520	30	150	Slopes, population pressure, deforestation, vulnerable soils
14.	Kapchorwa	173,800	52,140	30	67	Slopes, deforestation, poor farming
15.	Mpigi	448,600	112,150	25	204	Overgrazing, bush burning, vulnerable soils
16.	Arua	759,500	151,900	20	82	Slopes, vulnerable soils, population pressure, overgrazing, poor farming
17.	Bushenyi	490,600	981,200	20	149	Slopes, vulnerable soils, deforestation, population pressure, overgrazing
18.	Kabarole	810,900	162,180	20	91	Overgrazing, vulnerable soils, poor farming, deforestation
19.	Masindi (Rift Valley)	845,200	169,090	20	33	Vulnerable soils, bush burning, vulnerable soils

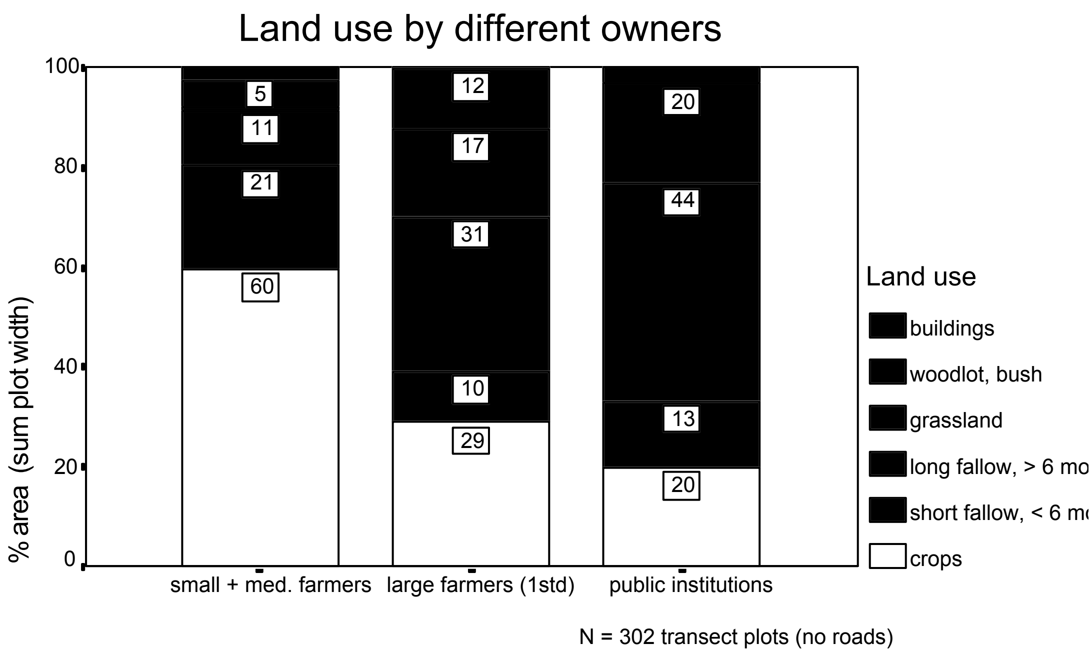
Source MAAIF

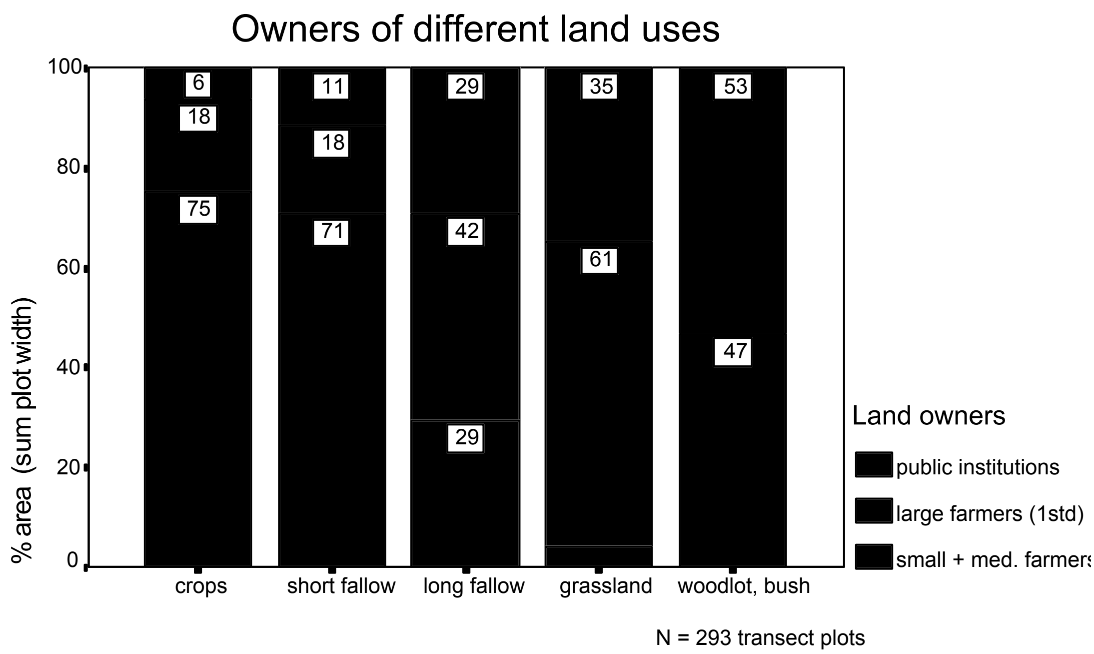
Table 2. Land Degradation Challenges by Farming System (cited in Akello 2002)

Farming system	Area	Land degradation challenges
Intensive-banana coffee system	Shores north of Lake Victoria, Mukono, south-east Mubende, southern Luwero, Ssese Islands, Kampala and Entebbe, Jinja, Iganga, Mpigi, south Kamuli and eastern Masaka and Rakai	Perennial crops and intercropping though advantageous has not stopped soil degradation due to continuous use of small plots that do not benefit from restorative measures; *mailo* land tenure system
Western banana-coffee-cattle	Bushenyi, Kabale, Rukungiri and parts of Mbarara	Highly fragmented land holdings due to population pressure; alarming deforestation, poor farming practices and steep slopes resulting in soil erosion; customary land tenure
Kigezi Afro-montane (Southwest highlands)	High altitude areas in Kabale and Kisoro as well as the northern slopes of the Muhavura Mts.	Soil fertility is dwindling fast; land fragmentation increasing due to population pressure; contour bunding increasingly eroded for more farmland therefore increased soil erosion leading to land slides
Northern and eastern cereal-cotton-cattle	Apac, Gulu, Kumi, Tororo, Soroti and some parts of Mbale	High wind and water erosion; bunding and fallowing virtually abandoned
West Nile cereal-cassava-tobacco	Arua, Nebbi, Moyo, Adjumani, Yumbe	Declining soil fertility; increased soil erosion

Source: http://easd.org.za/Soe/Uganda/CHAP3.htm

Figure 1. Land Use of Fields by Farm Size in Kabale District (source: Olson 1996).





REFERENCES

Akello, Grace. 2002. The Role of Micro-Credit in Addressing Land Degradation in Uganda. In Policies for Sustainable Land Management in the East African Highlands, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Bagoora, D.F.K. 1988. Soil Erosion and Mass Wasting Risk in the Highland Area of Uganda. Mountain Research and Development 8 (2/3):173-182.

Bashaasha, Bernard. 1998. Public Policy and Rural Land Use in Uganda. Ph.D., Department of Agricultural, Environmental and Development Economics, Ohio State University, Columbus, OH.

Bashaasha, Bernard, David S. Kraybill, and Douglas D. Southgate. 2001. Land Use Impacts of Agricultural Intensification and Fuelwood Taxation in Uganda. Land Economics 77 (2):241-249.

Breyer, Jutta, Dorthe Larsen, and Joyce Acen. 1997. Land Use Cover Change in South West Uganda: International Centre for Research in Agroforestry.

Briggs, L., and S.J. Twomlow. 2002. Organic Material Flows within a Small Holder Highland Farming System in South West Uganda. Agriculture, Ecosystems and Environment 89:191-212.

Carswell, Grace. 2002. Farmers and Fallowing: Agricultural Change in Kigezi District, Uganda. Geographical Journal 168 (2):130-140.

Delve, R.J., and J.J. Ramisch. 2002. Impacts of Land Management Options in Western Kenya and Eastern Uganda. In Policies for Sustainable Land Management in the East African Highlands, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Ellis-Jones, J., and A. Tengberg. 2000. The Impact of Indigenous Soil and Water Conservation Practices on Soil Productivity: Examples from Kenya, Tanzania and Uganda. Land Degradation and Development 11:19-36.

Jagger, Pamela, and John Pender. 2002. Motivating Smallholder Investment in Sustainable Land Management: Emerging Roles for NGOs and CBOs in Uganda. In Policies for Sustainable Land Management in the East African Highlands, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Kazoora, Cornelius. 2002. Road Map for Resource Mobilisation for the Implementation of National Action Program to Combat Desertification and Land Degradation in Uganda. Kampala, Uganda: Ministry of Agriculture, Animal Industry and Fisheries, and Ministry of Finance, Planning and Economic Development.

Mugisha, Samuel. 2002. Root Causes of Land Cover/Use Change in Uganda: An Account of the Past 100 Years. Kampala, Uganda: LUCID.

Nakileza, Bob, and Edward N.B. Nsuguga. 1999. Rethinking Natural Resource Degradation in Semi-Arid Sub-Saharan Africa: A review of soil and water conservation research and practice in Uganda, with particular emphasis on the semi-arid areas. Kampala, Uganda: Overseas Development Institute.

NEAP. 1995. The Nation Environmental Action Plan for Uganda. Kampala, Uganda: Ministry of Natural Resources.

NEIC. 1994. State of Environment Report for Uganda. Kampala, Uganda: National Environment Information Center (NEIC), Ministry of Natural Resources.

NEMA. 2001. Uganda State of the Environment Report 2000 Version 2. Kampala, Uganda: National Environment Management Authority, Ministry of Natural Resources, Government of Uganda.

Nkonya, Eparaim, John Pender, Dick Sserunkuuma, and Pamela Jagger. 2002. Development Pathways and Land Management in Uganda. In Policies for Sustainable Land Management in the East African Highlands, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Okubal, Peter, and Med Makumbi. 2000. Rethinking Natural Resource Degradation in Semi-Arid Africa -- Implications for Policy: Toroma Uganda Case Study. Kampala, Uganda: Overseas Development Institute.

Olson, Jennifer M. 1995. Natural Resource Management by Farmers in Kabale District, Uganda. Nairobi: International Centre for Research in Agroforestry.

———. 1996. Initial Results Concerning the Use of Fallow in Kabale District, Uganda. Nairobi: International Centre for Research in Agroforestry.

———. 1998. A Conceptual Framework of Land Use Change in the East African Highlands. Paper read at Earth's Changing Land: Joint Global Change and Terrestrial Ecosystems and Land Use and Land Cover Change. Open Science Conference on Global Change, at Barcelona, Spain.

Pender, John. 2002. Overview of Findings and Implications. In Policies for Sustainable Land Management in the East African Highlands, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Rashid, Shahidur. 2002. Dynamics of Maize Market Integration in Post-Liberalized Uganda. In Policies for Sustainable Land Management in the East African Highlands, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Slade, Gordon, and K. Weitz. 1991. Uganda Environmental Issues and Options. Unpublished Masters Thesis, Duke University, Durham, North Carolina, USA.

Tukahirwa, J.M. 1995. Measurement, Prediction and Socio-Ecology of Accelerated Soil Erosion in Kabale District. Ph.D., Geography, Makerere University, Kampala, Uganda.

———. 2002. Policies, People and Land Use Change in Uganda: A Case Study in Ntungamo, Lake Mburo and Sango Bay Sites. Kampala, Uganda: LUCID.

Zake, Julius S., Charles Nkwijn, and M.K. Magunda. 1999. Uganda. In Integrated Soil Management for Sustainable Agriculture and Food Security in Southern and East Africa: Proceedings of the Expert Consultation, edited by H. Nabhan, A. M. Mashali and A. R. Mermut. Harare, Zimbabwe: Food And Agriculture Organization of the United Nations.

ANNEX 1. Excerpts/abstracts from recent documents on sustainable land management in Uganda.

1. Nutrient Losses

It is now recognized that nutrient losses from the steeply sloping hillsides of the tropics subtropics occur not only through soil erosion, but through the net transfer of annual crop residues to more profitable parts of the farming system. Studies of soil nutrient balances across Africa are showing evidence of widespread mining of the soil resource within the smallholder farming sector, as the organic matter and nutrient source is not replenished in annually cropped hillside fields. This paper presents information that is central to the understanding of the farming systems employed by smallholder farmers within the highlands of South West Uganda. A time static model of organic resource flows was developed with a smallholder farming community, using visible flow data from farm surveys and semi-structured interviews, to describe this situation. The model explores the sources, whereabouts and current management strategies of organic resources and defines their flow around the farming system. Results confirm a net transfer of 24Mg$ha^{-1}yr^{-1}$ ($P<0.01$) of organic material, mainly crop yields and residues, from the annually cropped hillsides (covering an area of 0.6ha per farm ($P<0.001$)) to other parts of the farming system. The stover from the annual crop is used almost exclusively as mulch in banana (Musa sp.) plantations. As a consequence, the soils on the hillsides are gradually becoming depleted of nutrients, as farmers' place little value on improving the nutrient status of hillside fields distant from homesteads. Households, as is the case with most African subsistence farmers, would rather concentrate their limited labour and organic residue resources in maintaining the fertility/productivity of the more profitable parts of the farming system, in this instance banana plantations and annual fields close to homesteads. Consequently, in the short term the perennial banana system maintains a balanced flux of organic resources at the expense of hillside soil fertility. Unfortunately, over the longer term the current system will inevitably lead to a severe reduction in mulch availability, which will mean perennial crop yields will eventually decline, leading potentially, towards an unsustainable farming system. Fortunately, however, there are under-exploited organic resources within the existing farming system, that if fully utilised and could help sustain and even improve the yields of both annual and perennial crops. The whereabouts, management and value of these organic resources need to be highlighted to farmers so that alternative management strategies for organic residues can be developed, that are both economically appropriate to the farmer and the resources available, at farm level.

Source: Briggs L.; Twomlow S.J.[1]. Organic material flows within a smallholder highland farming system of South West Uganda. Agriculture, Ecosystems and Environment, May 2002, vol. 89, no. 3, pp. 191-212(22)
[1]Silsoe Research Institute, International Development Group, Wrest Park, Silsoe, MK454HS, Beds., UK

2. Land Tenure and Land Degradation

This article provides an empirical analysis of the impact of different tenure systems (mailo, customary, and public land) on agricultural investment and productivity in central Uguanda. A major hypothesis tested is that land investments and practices may have both economic and tenure security implications. The results indicate that coffee planting is used by farmers to enhance tenure security, while fallowing is practised to a greater extent by farmers on more secure holdings. This supports the notion that farmers consider tenure implications when making investments and that different tenure systems do not inhibit the promotion of tree-planting investment. Tenure had no impact on the productivity of crop farming.

Source: Place F.; Otsuka K.. Land Tenure Systems and Their Impacts on Agricultural Investments and Productivity in Uganda. Journal of Development Studies, August 2002, vol. 38, no. 6, pp. 105-128(24)

3. Soil Organic Matter

Under continuous cultivation, nutrients in the topsoil are decreasing and soils are becoming more acidic. Under prolonged continuous cultivation conditions, total SOM level may not be enough to indicate soil fertility status, hence there is a need to identify a better indicator. To arrest the land degradation process, appropriate soil and water conservation methods to reduce nutrient losses and acidification through reduced erosion and increased use of inputs will be required. Where nutrients are leached, rotating shallow-rooted crops and deep-rooted crops/grasses or agroforestry species should be encouraged to increase recycling of leached nutrients and reverse acidification trends. For continuously cultivated soils, inputs are necessary to reduce degradation and nutrient imbalances due to losses through erosion and nutrient exports. Although the fertilizer market in Uganda is liberalized and there is no tax on fertilizers, the fertilizer market is not developed and there is a need for financing, training and information provided to dealers, stockists, farmers, extension agents, and policy makers.

This paper gives a good insight into the trend of soil fertility in selected sites in Uganda. An important finding is that soil organic carbon alone is not anymore a good indicator for soil fertility and that investments are needed in order to restore the fertility of the soils. This result will have consequences for fertilizer recommendations in Uganda.

Source: Ssali, H. Soil Organic Matter And Its Relationship To Soil Fertility Changes In Uganda, National Agricultural Research Organisation, Uganda. In Policies for Sustainable Land Management in the East African Highlands. IFPRI – ILRI. September 2002

4. Impact Of Technical Assistance Projects

We find that technical assistance programs are having substantial impact on increasing adoption of improved land management practices, yields and income of some crops (e.g. bananas), livestock incomes, incomes from other farm and non-farm activities, and reducing soil erosion. This broad set of positive outcomes suggests that "win-win-win" strategies contributing to increased agricultural productivity, reduced poverty and sustainable use of natural resources are possible. Still, the coverage of these programs is very limited, and the vast majority of farmers have not been involved in extension or training programs, especially in remote areas such as much of the eastern highlands.

This study observed that the poorest regions are the north and east, pointing to the need to target programs in these areas to address poverty problems. Specifically, our observation that areas with high market access were associated with higher agricultural intensification but declining yields of several crops suggests that nutrient depletion in such areas is a major concern. Although improved market access may increase efficiency of agricultural marketing, low profitability of outputs may limit farmers' ability to apply adequate inputs to stop the nutrient depletion. Therefore, large use of external inputs may not be a feasible option for addressing land degradation.

One of the solutions often suggested for this problem is integrated soil fertility management, which includes use of a variety of sources of nutrients and cultural practices that conserve, add or increase availability of naturally occurring nutrients. However, we observe that organic fertility sources did not show significant increases in most crop yields. This calls for increased research and extension efforts to generate and disseminate organic fertility management technologies that are acceptable to and profitable for smallholder farmers.

Education may be one of the approaches of relieving land pressure as we find that education increases the probability of farmers getting engaged in off-farm activities. However, education is associated with less adoption of labor-intensive land management practices. There is a need to include practical training in agriculture and land management in educational curricula to minimize negative impacts of education on land management.

Source: Nkonya E., Pender, J., Sserunkuuma, D., and Jaggera, P. Development Pathways and Land Management in Uganda. International Food Policy Research Institute, USA & Makerere University, Uganda. In Policies for Sustainable Land Management in the East African Highlands. IFPRI-ILRI. September 2002.

5. Importance Of Markets

Some important general themes/lessons emerge from these papers. One is the primary importance of improving markets and identifying profitable opportunities if significant progress is to occur. As argued by Woelcke et al., soil nutrient depletion is likely to continue to be a major problem in Uganda unless the profitability of agriculture substantially improves. Adoption of inorganic fertilizers and other soil fertility-enhancing technologies is predicted by Woelcke et al. to be inadequate to halt declining fertility, unless there are major increases in output prices and/or major reduction in input prices. It is not clear whether the extent of improvement in price ratios considered by Woelcke et al. is feasible, though he provides some information on marketing margins in Uganda suggesting that significant improvement should be possible.

Source: Woelcke, J., Berger, T., & Park, S. Land Improvement And Technology Diffusion In Uganda: A Bioeconomic Multi-Agent Approach. Center for Development Research, University of Bonn, Germany. In Policies for Sustainable Land Management in the East African Highlands. IFPRI – ILRI. September 2002.

6. Biological Responses

This paper examines the potential of using the velvet bean (*Mucuna pruriens*) as a way of enhancing soil fertility in Uganda. This approach for soil fertility restoration is very interesting because inorganic fertilizers are costly and not available everywhere.

The results showed that *mucuca* can fix large amounts of nitrogen and contribute to increase the productivity of the soil. The best economic return is found on the most productive soils.

Source: Kaizzi, C.K., Ssali, H., Nansamba, A., and Paul, L.G. Vlek. The Potential Benefit Of Velvet Bean (*Mucuna Pruriens*) And N-Fertilizers In Maize Production On Contrasting Soils In Uganda. National Agricultural Research Organisation, Uganda & University of Bonn, Germany. In Policies for Sustainable Land Management in the East African Highlands. IFPRI – ILRI. September 2002.

7. Summary Statement

In summary, there are many opportunities to promote improved livelihoods and land management in the East African highlands. The prospects for breaking out of the downward spiral of land degradation, low productivity and poverty are good, but the task is not simple or easy. Changes in policies, programs and institutions will be needed that are well suited to the comparative advantages of different locations, taking into account the diversity of circumstances in the East African highlands, and recognizing that the same intervention can have different impacts in different circumstances, that complementary interventions need to be bundled together to be most successful, and that trade-offs among desirable outcomes are often likely to occur. By recognizing and taking into account such realities, policy makers and development agencies will be better able to achieve results that are in line with the potential of the region and its peoples.

Source: Benin, S., Ehui, S., & Pender, J. (September 2002). Policies for Sustainable Land Management in the East African Highlands. IFPRI – ILRI. In . In Policies for Sustainable Land Management in the East African Highlands. IFPRI – ILRI. September 2002.

ANNEX 2. Land Degradation Projects - World Bank 2001

1. Environmental management and Capacity Building Project

The Second Environmental Management and Capacity Building Project will sustain environmental management at the national, district, and community levels, and assist the Government of Uganda (GOU) in the implementation of the National Environmental Action Plan, related National Environment Statute, and the Local Government Act. Project components are as follows. 1) The local government, and communities environmental capacity building component, will provide support to enable the fulfillment of statutory roles in decentralized environmental management. Logistical support will be provided, to build, and strengthen capacities in environmental planning, and, redress key environmental issues. The component will complement the GOU efforts to eradicate poverty, and improve living standards within the country. 2) The capacity building component will strengthen partnerships with lead agencies, within sectoral mandates as required by the National Environment Statute (1995). Critical actions, and policies by lead agencies will be identified, and, logistical support, skills development, knowledge support will be provided to enable integrated environmental policies, plans, and programs. 3) The component will consolidate the institutional structure of the National Environmental Management Authority (NEMA), ensure that capacities in regulation, and compliance are built, and promote sustainable development through awareness campaigns.

World Bank - Working Paper (2001)

2. Nile River Basin: Transboundary Environmental Analysis

This trans-boundary environmental analysis is a catalyst, a valuable resource to the riparian countries, that provide a description of the range of ecosystems within its basin rivals, and, presents and examines the required development challenges, and efforts to promote the Nile ' s sustainability. The report identifies trans-boundary environmental issues, namely, deforestation and soil erosion that can increase vulnerability to drought, leading to sedimentation and flood risks; loss, and degradation of wetlands and lakes; need for cooperative protection of key habitats; spread of invasive water weeds; and, water borne diseases - malaria, diarrhea, and bilharzia (Schistosomiasis). A program of complementary preventive, and curative actions is recommended, to address current and emerging issues, that emphasizes on stakeholder awareness, and involvement on water and environmental management, on training and education, capacity building, information sharing, and institutional development. It also reviews opportunities for mobilization of resources, to support the recommended program.

LAND DEGRADATION

IN

RWANDA:

ITS EXTENT AND IMPACT

J. Olson, L. Berry

Commissioned by Global Mechanism
with support from the World Bank

TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN RWANDA: ITS EXTENT AND IMPACT

Preface

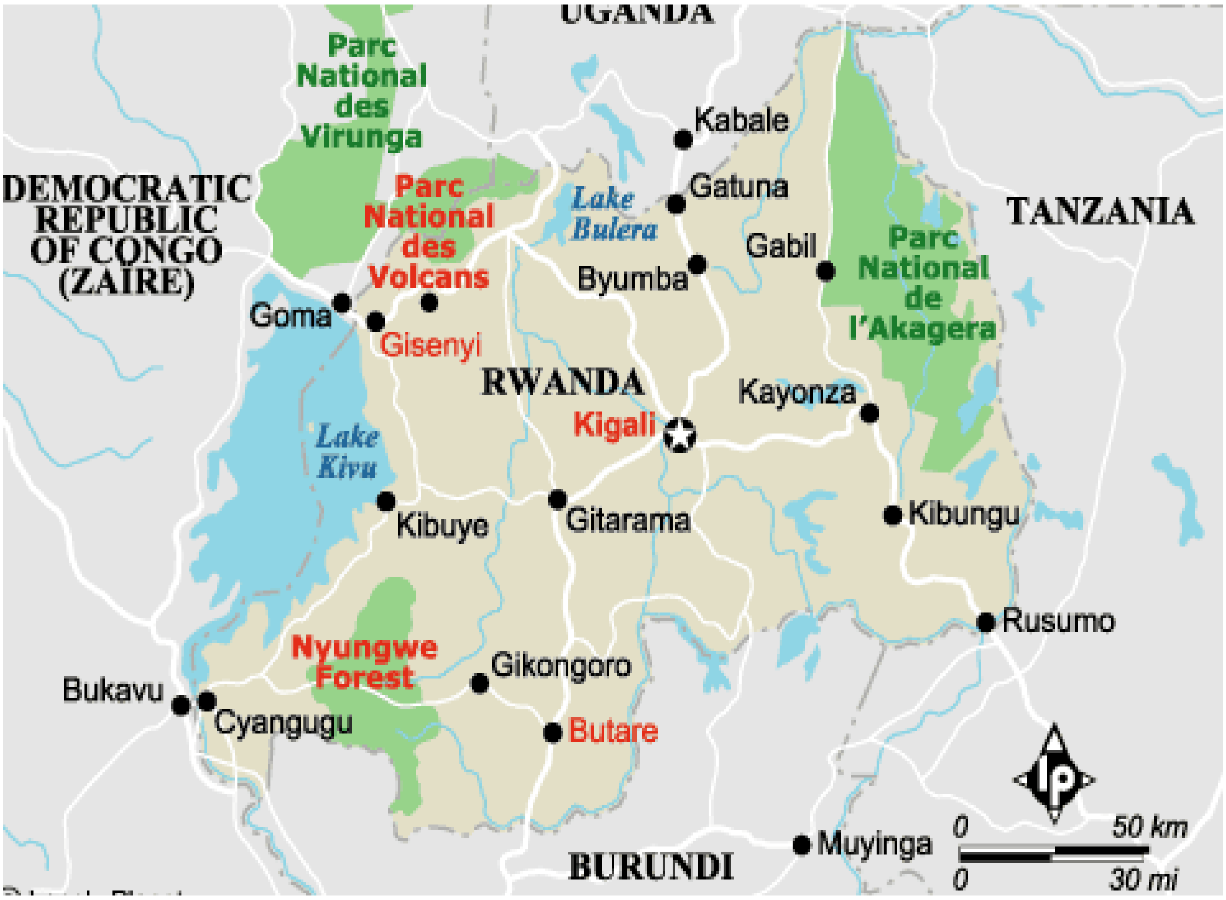
This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established and the cost of current remedial programs can be identified.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

RWANDA


UGANDA
Parc National des Virunga
DEMOCRATIC REPUBLIC OF CONGO (ZAIRE)
Parc National des Volcans
Kabale
Gatuna
Lake Bulera
Gabil
Byumba
TANZANIA
Parc National de l'Akagera
Goma
Gisenyi
RWANDA
Kayonza
Lake Kivu
Kigali
Kibuye
Gitarama
Kibungu
Rusumo
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Gikongoro
Bukavu
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LAND DEGRADATION IN RWANDA: ITS EXTENT AND IMPACT

Executive Summary

Land degradation has long been recognized as a major problem in Rwanda, especially impacting the Southwest of the country, but important everywhere. Field research stations report soil losses 35 to 246 tons ha/yr, and farmers report declining productivity of their fields. An important root cause is the pressure on farm households as a result of a steadily increasing rural population and dramatic changes in farm size to average less than one hectare.

While government measures emphasized terracing and other measures to reduce soil loss, farmers see the problem more as the reduction of available manure to fertilize the fields. A widespread response to declining fertility is to change crops, reducing cereal production and increasing less nutrient tubers. Yet per ha yields of tubers also show steep declines.

Costs of land degradation are hard to measure, but estimates of the impact of declines in productivity suggest a loss of at least 3.5% of agricultural GDP. Changes in crops are resulting in declining nutrients available to rural families and an underlying factor contributing to the social unrest and civil war in the regions.

The Executive Directors of the World Bank in commenting on the Country Assistance Strategy (CAS) noted “that a comprehensive rural development strategy, that addressed land reform and gender issues, would be critical” and also noted “the week institutional capacity and obvious environmental degradation in the country.”

Mitigation responses in the past have focused on physical or biological approaches to reduce soil loss from the often steep hillsides. As these approaches have been imposed on farmers there is a legacy of resistance to soil conservation measures.

In most parts of the country improved markets are an important component of mitigation efforts. Current donor efforts have the potential to break the degradation/poverty cycle by addressing agricultural and non-agricultural sectors on a regional basis.

LAND DEGRADATION IN RWANDA: ITS EXTENT AND IMPACT

THE EXTENT AND IMPORTANCE OF LAND DEGRADATION

Rwanda is often characterized as having very high rural population densities, lush vegetation due to high rainfall, and steeply sloping highlands. Erosion and land degradation have long been assumed to be severe and a major reason for the poverty and food insecurity in the country. The colonial administration and the post-independent government responses included large, countrywide programs to dig erosion prevention ditches on the hillslopes using mandatory, communal labor. Nevertheless, researchers and farmers perceived soil fertility to be declining rapidly in the 1980's and 1990's throughout the country but especially in the Southwest, and the low productivity undoubtedly contributes to the country's poverty.

Early agricultural research focused on types and severity of erosion, and mechanical and biological methods to reduce erosion. The results of the research, conducted by the national agricultural research institute (ISAR) and by other scientists indicate that loss of soil due to erosion is severe, ranging from 35 to 246 tons/ha/year with most stations measuring over 100 tons/ha/year. On five of the seven research stations where erosion was measured, erosion would remove the fertile topsoil within 30 years if no anti-erosion techniques were used (König 1994). One estimate was that in 1990, erosion caused the loss of productivity equivalent to 8,000 hectares per year, enough to feed 40,000 people (Gasana 2002). The agronomic research did not attempt to estimate the monetary impact of erosion or loss of soil fertility, so these statistics are not available. Results of agronomic or economic research on the status of degradation since the 1994 civil war are not yet available. Authorities agree that land degradation in Rwanda is a major problem, but quantitative assessments of its true cost are not available.

Rwandan farmers depend primarily on seasonal crops, such as maize, sorghum, beans and tubers, and hand hoe their soil at least twice yearly exposing the soil to erosion and rapid decomposition of organic matter. The dominance of seasonal crops increased following the decline of international coffee prices starting in the early 1990s. Coffee, which had been grown in a government-mandated practice that included mulching and terracing, had been relatively common on small-scale farms but is now rare. A large increase in tree planting around homes and on field boundaries reduced the fuelwood shortage, but governmental and NGO efforts to introduce agroforestry and other forms of biological erosion control have not been widely adopted, partly because of the perception that they occupy much space on the fields and compete with crops for nutrients.

DISTRIBUTION OF LAND DEGRADATION

In a nation wide survey taken in the early 1990's it was found that soil fertility was declining in all parts of the country with only one prefecture, Gisenyi, showing a lower degree of impact (Annex 1). It was found that the area of the country that was experiencing the worst poverty and social problems was also the region experiencing the worst land degradation: the Southwestern prefectures of Gikongoro and Kibuye. Marginal environmental conditions combined with relative isolation and a low degree of non-farm economic activity are reflected in poverty and the large percentage of fields with declining soil fertility. Farmers reported that 56 percent of the fields in Kibuye and 49% of the fields in Gikongoro had declined in fertility since the farmers had started cultivating their land. Although worst in the highlands, farmers even in the newly settled eastern savanna lands in Kigali and Kibungo reported declining soil fertility on over one third of their land. Only farmers in Gisenyi, an area of volcanic soils, were not experiencing declines despite living in the region with the highest population densities. The national message was farmers were experiencing declines in productivity of their land. Women headed households experienced the worst declines, probably due to their land tenure insecurity, loss of animals to the husband's family when the marriage ended, and their general poverty and inability to invest in soil management. Because the history of land use and population change is so important to understanding the nature and importance of land degradation, these issues are included in the regional analysis.

Conditions in Rwanda vary widely both within the western highlands and between the west and the flatter Savannah land of the east. The following sections outline the nature and extent of land degradation on a regional basis.

THE SOUTHWEST

Status

Land degradation is most severe in the Southwest of the country, especially Gikongoro, Kibuye, and the higher zones of Cyangugu, Butare and Gitarama. In these areas, the soil is ferrallitic and the slopes of the hillsides are often very steep. After many years of intensive seasonal cropping, the soils have become highly acidic (less than 4.5), are deficient in P and N, and suffer from aluminum toxicity (König 1994; Roose and Barthès 2001).

Causes

Land use change over the past four decades is an important component of land degradation. Following independence, the large amount of land that had been reserved for grazing, primarily in the valleys and steep hillsides, was distributed to farm families. Currently almost no communal or private grazing land remains and only a small percentage of farmers own a cow. As the population grew in the 1980's, young families moved to marginal lands such as steep slopes and the edge of what is now protected forest, a cold area with very poor soil, and many moved East to settle former grazing land there. Nevertheless, the population densities increased and, with a system of equal inheritance among sons, the farms because extremely small (an average of around 0.7 ha). Landlessness and near-landlessness, especially by women-headed households, is increasingly common.

Government Responses

As the land degradation problem intensified, government policy following colonial tradition was to develop physical responses to the problem. Erosion ditches and grass lines, installed with enforced communal labor, covered almost all the hillsides by the early 1990's. Erosion probably was, however, still an important cause of soil degradation. The erosion control program was extremely disliked by the farmers, and they often insisted that it was not erosion but the lack of manure and other sources of soil organic matter (SOM) that caused the declining productivity. When the government lost its will or ability to continue the heavy-handed enforcement approach (e.g., following independence and in the early 1990's), farmers destroyed the erosion ditches as symbols of repression. Meanwhile, soil organic matter content on farmer fields is very low and farmers have been unable to increase SOM due to their inability to fallow on their tiny farms, almost continuous cropping including hoeing the soil twice yearly, and the lack of manure due to the shortage of grazing land for cattle and other animals.

Farmers Response

A common response to land degradation has been crop substitution from grains and pulses, which no longer produce well and are increasingly subject to diseases, to tubers, especially sweet potatoes. This indicates an important loss of agricultural productivity as measured by economic or nutritive value. Very small amounts of chemical fertilizers were being used, despite the need. Government and NGO efforts to promote the use of green manure and biological erosion control through agroforestry or other means were not very successful because farmers felt that those plants occupied too much space on their fields.

The Southwest has been subject to periodic famines following relatively small climatic or other perturbations for many years because of the low food production per capita, and the lack of alternative income sources beyond farming (Nsengimana and Gascon 1991; Gascon 1992).

Summary

This region, therefore, is an example of an area where land degradation is already severe and the soil has probably reached a plateau of very low productivity. Efforts to improve productivity through a combination of mineral fertilizers and increasing SOM would probably provide an immediate and vitally beneficial impact on food security and poverty reduction. Improving returns to farming in the region, through the promotion and marketing of higher value crops or stall-fed dairy cattle, for example, could make these investments in mitigating land degradation more economical for both the farmer and the government or donor. Stall-fed cows would also provide the highly valued manure to improve the soil.

THE NORTHWEST

The Northwest of the country (Ruhengeri, Byumba, Gisenyi) experiences some land degradation and about one third of farmers identify declining productivity but this area has not experienced as severe land degradation, despite even higher population densities, because of its volcanic soil, a more economically productive farming system and critically the availability of non-farm income sources. Indeed, it has been a large supplier of Irish potatoes, beans and other crops that were traded nationally and across the Uganda border. Coffee and tea also produce well. The former government invested in this region providing a good transportation infrastructure, agricultural development projects for Irish potatoes and other crops that provided inputs and marketing, and in non-farm economic opportunities in the small towns and villages. Outcomes of the highly fertile soil and economic opportunities included lower rates of out-migration, higher rural incomes and less malnutrition (Habimfura and Fabiola 1993; Olson 1994a).

Nevertheless, the region's steep slopes and continuous cultivation threaten greater erosion levels and loss of productivity if erosion control measures are not maintained and if SOM declines. Farm sizes are extremely small and returns to labor in the current system are probably much less than one. The region, however, has important potential to produce high value export crops because of its cool and moist climate, fertile soils, and large and skilled agricultural workforce.

THE EAST

The East of the country (Kibungo, Umutara, Kigali-rural), which is relatively dry and covered with gently rolling hills, came under widespread cultivation only since the 1970's, yet over a third of farmers complain of visibly declining fertility. Indeed, land that had been cattle ranches, wetlands and a national park has come under cultivation since the resettlement program following the 1994 civil war. Population densities are lower than in the West, but the warmer temperatures and lower rainfall preclude the West's extremely intense farming system.

Although the farms are larger than in the West, they are still small at approximately 1.4 hectares. This area, which had been a large producer of bananas and still has high agricultural potential, is the region of the country with the most agricultural income to lose from current and future degradation. In general, the soil in the East is not badly eroded and still relatively fertile compared to the West, because it has been cultivated for less time and the gentle slopes do not lead to the same degree of erosion.

Land degradation threats include:

- In recently drained swamps and lowlands, salinization and soil compaction may become a problem if drainage and other land and water management practices are not well planned and executed.
- The soils of the semi-humid savanna areas being put under crops are vulnerable to rapid decomposition of SOM, increased water and wind erosion, and loss of nutrients due to twice yearly plowing of the soil to produce seasonal crops.
- Herds of cattle and other animals concentrated in relatively small areas lead to erosion around their paths, and to compaction and other forms of soil degradation in the grazing areas.

CAUSES OF LAND DEGRADATION[1]

Research in the 1990's on the socioeconomic factors that led to the severe soil degradation in the South identified the factors influencing farmers to change their soil management, and how they were adapting to the degradation (Olson 1994b, 1994c). Although degradation is most severe in the South, the socioeconomic causes of degradation are similar throughout the country.

Halt In Manuring And Fallow

The findings pointed to the almost complete halt to the application of animal manure and the practice of fallowing starting in the late 1970's, which caused a rapid decline in soil organic matter and loss of soil nutrients. Farmers blame the declining productivity especially on the lack of manure; cattle

[1] Much of this report on Rwanda is based on the Ph.D. dissertation research of the author (see Olson 1994b) except where specific citation is provided.

and cattle manure are highly valued in Rwandan culture (Sirven, Gotanegre, and Prioul 1974; Newbury 1988). Survey results showed that the fields nearest the homestead, where manure and other organic inputs were applied, were the least degraded but even these fields were experiencing declining fertility. The lack of manure and ability to fallow was due to the loss of communal pasture land to raise animals and the small farm sizes, land issues that stemmed from land tenure changes related to political events, rural population increases and a poor and stagnant agricultural economy. Non-agricultural sources of income in the country were very limited and after the 1980's new land to clear was no longer available, so rural households had few alternatives to farming their old land. Governmental programs to replace coffee or provide other economic options were not successful in raising incomes. Meanwhile, government and donor investment in health, education and other services declined during the same period.

Decline In Farm Size

The crops produced especially in the Southwest were of low economic value with returns to agricultural labor being less than one. The small farms, in a country where the average farm size is less than one hectare, are in the worst situation. In analyses of national survey data, a strong inverse relationship was found between farm size and land productivity, and the opposite for labor productivity. Returns to land were the greatest, and to labor the least, on the smallest farms. The smallest farms used the most intensive erosion control measures but their erosion losses were approximately the same as on other farms (Byiringiro and Reardon 1996). Returns to investing in soil erosion control or other practices to reduce soil degradation were not profitable especially where soil was already severely degraded. Farmers termed the inability of the poorest to manure and otherwise care for their soil "social fertility," in which their low soil fertility mirrors their own social status (Olson 1994b).

Crop Changes

Nevertheless, farmers were found to be adapting to the degradation by switching to crops more tolerant of poor soils such as tubers and certain trees, reserving tiny patches of fodder grasses and trees to raise at least one small animal for its manure, and "deep hoeing" to replace the topsoil lost from erosion. Non-agricultural responses included searching for short-term agricultural labor, delaying marriages and reducing the number of children born to the family (den Biggelaar 1994; Olson 1994b, 1994a). These responses did not compensate for the losses due to degradation; for example tubers are much less nutritious than cereals or legumes.

Despite the wide variability throughout the country, nation-wide statistics of agricultural production reflect an evolution of productivity associated with:

1. New land being put under production due to clearance of new lands in the East, cropping land considered previously to be too marginal, and a growing agricultural population, and

2. The impact of soil degradation and decreasing farm sizes on the amount being produced per capita and a switch in the type of crop produced. Table 1 below reflects the large increase in tuber production (mostly sweet potatoes and cassava, which are less nutritious than legumes or cereals) compared to other crops, and the decline in per capita production of cereals and legumes (beans and peas) (König 1994).

Table 1. Agricultural Production in Rwanda 1966-1986. (König, 1994)

	1966	*1976*	*1986*	*1966-1986*
Total Production (1000 tons)				
Bananas	1452	1820	2266	+56.1%
Legumes (beans, peas)	195	237	314	+61.0%
Cereals	194	234	297	+53.1%
Tubers	513	1301	1679	+227.3%
Total	2354	3592	4556	+93.5%
Production per capita				
Legumes	736	798	701	-4.8%
Cereals *what are units?*	61	53	48	-21.3%
Tubers	61	52	46	-24.7%

Since the 1994 civil war, the government and NGO's have implemented a major resettlement and land re-distribution program throughout much of the country. This has consisted of moving families to live in houses within villages so they are no longer living on their farms, redistributing farmland among households, and, in some areas, distributing former ranching and protected area land among farming and pastoralist households. Possible consequences may include longer distances farmers need to walk to reach their fields and a feeling of tenure insecurity, both of which may result in reduced ability to or interest in investing their labor and capital in soil management. (See Annex 2 for some recent studies of Rwanda land degradation).

COST OF LAND DEGRADATION

As noted earlier there are few numerical estimates of the costs of land degradation in Rwanda, though a case could be made that the real costs are a component of the civil strife that has beset this country especially since 1994.
Among the costs that can be identified are:

- The costs of loss in productivity through soil and nutrient loss
- The costs of crop change in value and also in nutrient level
- The costs of social upheaval due to land pressures

Loss of Productivity

National statistics illustrate the general problem in Rwanda. In the period 1982 to 1994, while the index of agricultural production rose a little from 107 to 110, per capita agricultural production fell from 97 to 75 and the food production index fell by a similar amount. Even more significantly yield per hectare dropped by 2 per cent for cereals and by 20 percent for tubers. The latter represents a loss of over 1200 Kg/ha on tubers.

Losses of cereal production and tuber production can be roughly quantified as $20 per ha and with 1,160,000 ha in cultivation this translates into $23,200,000 a year. With agricultural GDP at $650 m, the drop in value is 3.5% of agricultural GDP. While these are generalizations from specific data in a poverty stricken country hopes of economic growth in the agricultural sector will depend on reversing the productivity decline including dealing with the land degradation problem.

Costs of Social Upheaval

The civil war and massacres of 1994 and subsequent years had many causes. But one clear contributing factor was the pressure brought about by the difficulties of adjustment to rapidly declining rural productivity in many areas and the lack of alternative livelihood systems. An agriculturally based country of 2.1 million people in 1950 became a country of almost 8 million in 1995 without the general emergence of a rural infrastructure and with dramatically declining farm size and per capita productivity. The costs in human life and social disruption were enormous.

MEASURES TO PREVENT AND MITIGATE LAND DEGRADATION

It has been indicated earlier that while official attention has been directed to issues of soil and nutrient loss, farmers have been more concerned with the reduction in the amount of manure available as fertilizers. Research also has focused on soil conservation technologies.

In the past, the government focused almost exclusively on controlling erosion to the exclusion of other soil management or improved agronomic practices. An approach that had been promoted by the government, "radical" terraces (bench terraces) would be more effective in reducing erosion compared to the erosion ditches and grass lines established in the 1980's. The construction of such terraces, however, would require a significant amount of labor and probably an intensive community-based program with technicians and extension agents.

Technical Approaches

Much research has been conducted in Rwanda testing various techniques to reduce erosion (Moeyersons 1994). A replicated finding is that biological controls, such as lines of agro-forestry trees or grasses planted along the contour, eventually forming "micro-terraces," reduce the loss of soil more effectively than the type of ditch terraces installed by the government in the 1980's. The relative costs of biological measures in terms of labor and land, and the effects of competition with the crop for light, water and nutrients, would need to be considered before specific techniques could be promoted. Farmers have been already using various forms of biological control to reduce erosion, including leaving crop residues on the fields, planting trees and bushes around the fields and multi-cropping to cover the soil during the rainy season.

The biological erosion control methods also produce fodder or green manure that increase soil organic matter and nitrogen. On-station research indicates, however, that controlling erosion and increasing organic matter using animal or green manure is insufficient to increase productivity on the acidic, ferrallitic soils of Rwanda due to P-deficiency. Applications of mineral fertilizers and dolomite, in addition to erosion control, produced a reasonable yield (Roose and Barthès 2001).

Additional improved techniques, such as careful composting of animal manure to reduce the loss of N and K, economically viable opportunities to increase the number of animals raised, and increasing vegetative cover with perennial crops or by using mulch, would also improve soil productivity.

Economic Considerations

The approaches described above all require varying amount of land, capital and especially labor. Soil erosion control, mineral inputs and other soil management practices compete for the extremely scare resources of the Rwandan farmers. Erosion control through forced labor, the former approach, has perhaps been proven to be effective in establishing the infrastructure, but when the threat of enforcement is gone, the farmers have shown that they will let the terraces crumble or actively destroy them.

The resources farmers invest are highly dependant on the potential increase in agricultural production, as well as what resources are available for the farmer to invest. The amount of investment made at the farm level is closely tied to the potential increased productivity to be gained. The value and marketability of the crops produced are therefore critical factors in the decision to invest in the soil. Farm level investments in coffee, for example, included mulching and mineral fertilizers that were done without the heavy enforcement required for building terraces. Once the coffee market collapsed, however, the use of mulches and fertilizers declined and were rarely used on lower value crops.

In comparing the Southwest with the Northwest, it is clear that the Southwest's lower value crops, the lower inherent soil fertility, and the lack of non-farm income sources led to a spiral of low productivity/ low investments/ increased soil degradation. Farmers do not have the resources themselves to break this cycle without economic assistance and an improved market for their crops and animal products.

Programs to prevent and mitigate land degradation will therefore need to be conducted within a broad economic development plan that includes the agricultural and non-agricultural sectors.

Social Factors

In Rwanda, farmers have shown themselves to respond quickly to new or to declining economic opportunities. Nevertheless, certain aspects of the society affect the willingness and ability of households to implement soil management practices. For example, the percentage of households headed by women is very large, especially following the civil war, and the needs of these women farmers must be considered. Traditionally, women were not permitted to own land or graze animals, and they frequently became landless and extremely poor after the break up of their marriage following death or separation. Considering the importance of women headed households, their tenure security will need to be ensured before they are willing to invest in the land. Agricultural extension and economic program staff will need to consciously cater to women farmers to ensure the relevance and appropriateness of the programs.

Land Use and Tenure Requirements

Land tenure security is a pre-condition in Rwanda before farmers can be expected to invest long-term in their soil. Before the 1994 civil war, the main land related problem felt by farmers was the extremely small farm sizes, the scarcity of additional land, and land degradation. Since the war, additional problems the country is facing include the return of numerous recent and older refugees (800,000 to 1 million), many asking for land (Van Hoyweghen 1999). In response, the government carried out a policy throughout most of the country of villagization (regrouping of families into villages, or *imidungudu*) and redistribution of farmland among families. The government implemented it rather forcefully in some areas (HRW 2001). Although the goals for the policy were ambitious and positive, consequences that are being experienced include a sense of land tenure insecurity, a new group of near-landless, and long distances some farmers must walk to reach their fields. They also fear theft of their production from fields that they cannot monitor. These consequences may further impede farmers' willingness or ability to invest in erosion control or conduct other soil management practices.

Donor Programs

As security issues become resolved to some extent donors begin to work with the GOR to provide support for rehabilitation. The World Bank Poverty Reduction Strategy Paper (PRSP) presents a broad strategy for poverty reduction, addressing among other issues rural development and agriculture transformation and economic infrastructure. A 48 million dollar loan from the World Bank is targeting the whole issue of agricultural productivity and maturity. Phase 1 will focus on building the institutional and technical capacities needed to support the generation and adoption of efficient cropping and post-harvest technologies and hence launch the intensification process. Phase 1 includes seven components: The first component will empower beneficiary farmers to efficiently manage marshland/hill-side cropping and livestock activities and promote the adoption of improved soil, water and, fertility conservation techniques; and private operators to intervene in land and water infrastructure construction and maintenance. The integrated management of critical ecosystems component will strengthen the capacity of local communities to effectively manage critical ecosystems. The promotion of commercial and export agriculture component will develop export crop agriculture through facilitation of access to investment capital and strengthening of capacities of farmers and exporters. The fourth component will strengthen the capacities of agricultural research and extension systems. The fifth component will strengthen the capacities of local communities, private sector operators, farmers and other private sector operators, and water management infrastructure to develop small-scale infrastructure. The sixth component will lead to higher levels of off-farm employment and incomes. The last component will support project coordination.

This project approach appears to have the breadth and vision to begin to address sustainable land management issues. The active participation of local people in the implementation will be a key component of success.

CONCLUSION

The situation of high population densities and land degradation Rwanda, though extreme, is similar to regions of other countries in Africa. Several lessons can be drawn from its experience:

1. The processes that led to changing land management and severe land degradation in Rwanda are tied to economic, social and political processes that occurred during several decades. Addressing land degradation will, therefore, require not simply technical solutions but also changed and improved economic and social conditions.

2. Regional differences in land degradation are important in Rwanda. The Southwest has the worst degradation, and mitigating its effects and improving productivity will provide critical food security in an impoverished region. Degradation is not as severe in Northwest or the East but investing in degradation prevention may well provide economic returns due to the chances of high value agricultural production.

3. The level of non-farm as well as farm incomes are critical factors affecting households' ability to invest in land management, and their ability to recoup those investments by marketing higher value agricultural products.

4. Some segments of society, especially those with the smallest farms and women-headed households, are disproportionately affected by soil degradation and are the least able to address the problem. They would require particular attention, from a social/ legal (for women) as well and economic standpoint.

5. Land tenure security is a necessary condition for farmers to invest in their soil. National and local land policy and especially its implementation must do everything possible to ensure tenure security.

6. Erosion control measures are not sufficient to reduce land degradation and increase productivity. A combination of erosion control, increasing organic matter and adding mineral fertilizers is required, especially in areas where degradation is already severe.

7. Rwandans place an extremely high value on the role of animal manure to prevent degradation and improve productivity. Programs to enhance farmers' ability to raise animals on their small plots would probably be highly appreciated and successful.

REFERENCES

Byiringiro, Fidele and Thomas Reardon. 1996. Farm Productivity in Rwanda: Effects of Farm Size, Erosion and Soil Conservation Investments. Agricultural Economics 15:127-136.

den Biggelaar, Christoffel J. 1994. Farmer Knowledge and Experimentation with Trees and Tree Cultivation in Agroforestry Systems in Rwanda. Ph.D., Forestry, Michigan State University, East Lansing.

Jean-François, Gascon. 1992. Pauvreté á Gikongoro. Gikongoro, Rwanda: MINAGRI and FAO.
Gasana, James. 2002. Remember Rwanda? Washington, D.C.: WorldWatch Institute.

Habimfura, Vincent and Hyacinthe Fabiola. 1993. Statut Nutritionnel et Sécurité Alimentaire au Rwanda. Kigali, Rwanda: Division des Statistiques Agricoles, MINAGRI.

HRW (Human Rights Watch). 2001. Uprooting the Rural Poor in Rwanda. New York: Human Rights Watch.

König, Dieter. 1994. Dégradation et Erosion des Sols au Rwanda. Cahiers d'Outre-Mer 47 (185):35-48.

Moeyersons, J. 1994. Les Essais Récents de Lutte Anti-Erosive au Rwanda. Cahiers d'Outre-Mer 47 (185):65-78.

Newbury, Catherine. 1988. The Cohesion of Oppression: Clientship and Ethnicity in Rwanda: 1860-1960. New York: Columbia University Press.

Nsengimana, Cyprien and Jean-François Gascon. 1991. Resultats de l'Enquete sur les Exploitations les Plus Touchées par la Disette. Gikongoro, Rwanda: Préfecture Gikongoro.

Olson, Jennifer M. 1994a. Demographic Responses to Resource Constraints in Rwanda. East Lansing: Geography Department, Michigan State University.

———. 1994b. Farmer Responses to Land Degradation in Gikongoro, Rwanda. Ph.D., Geography Department, Michigan State University, East Lansing.

———. 1994c. Land Degradation in Gikongoro, Rwanda: Problems and Possibilities in the Integration of Household Survey Data and Environmental Data. East Lansing: Geography Department, Michigan State University.

Roose, Eric and Bernard Barthès. 2001. Organic Matter Management for Soil Conservation and Productivity Restoration in Africa: A Contribution from Francophone Research. Nutrient Cycling in Agroecosystems 61:159-170.

Sirven, P., J.F. Gotanegre and C. Prioul. 1974. Géographie du Rwanda. Brussels: Editions A. de Boeck.

Van Hoyweghen, Saskia. 1999. The Urgency of Land and Agrarian Reform in Rwanda. African Affairs 98:353-372.

World Bank. 2001. Rwanda-Rural Sector Support Project. Project ID RWPE64965, Report number PID9531

World Bank. 2002. Rwanda – Poverty Reduction Strategy Paper (PRSP) and joint assessment. Report number 24503-RW

ANNEX 1- Table 2. Farmer Perceptions of Changing Soil Fertility since Cultivating Field, by Prefecture (% of fields). Source:

	PREFECTURE				
	Gitarama	Kibungo	Kibuye	Kigali	Ruhengeri
CHANGE IN SOIL FERTILITY					
Deterioration	34%	34%	56%	37%	36%
No change	49%	50%	38%	46%	58%
Improvement	14%	17%	6%	18%	6%
TOTAL	100%	100%	100%	100%	100%
MEAN CHANGE IN FERTILITY (from –3 to +3)	-0.45	-0.34	-1.06	-0.41	-0.73

Olson 1994b.

	PREFECTURE				
	Butare	Byumba	Cyangugu	Gikongoro	Gisenyi
CHANGE IN SOIL FERTILITY					
Deterioration	32%	30%	44%	49%	26%
No change	56%	63%	48%	45%	66%
Improvement	12%	7%	8%	6%	8%
TOTAL	100%	100%	100%	100%	100%
MEAN CHANGE IN FERTILITY from –3 (worst degraded), 0 (no change) to +3 (most improvement)	-0.39	-0.58	-0.80	-1.01	-0.41
N (fields)	1121	608	383	576	503

ANNEX 2. Recent Studies of Rwanda Land Degradation

Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments

This paper examines the effects of farm size, soil erosion, and soil conservation investments on land and labor productivity and allocative efficiency in Rwanda. There were several key results. First, there is a strong inverse relationship between farm size and land productivity, and the opposite for labor productivity. For smaller farms, there is evidence of allocative inefficiency in use of land and labor, probably due to factor market access constraints. Second, farms with greater investment in soil conservation have much better land productivity than average. Those with very eroded soils do much worse than average. Smaller farms are not more eroded than larger farms, but have twice the soil conservation investments. Third, land productivity benefits substantially from perennial cash crops, and the gains to shifting to cash crops are highest for those with low erosion and high use of fertilizer and organic matter. Program and policy effort to encourage and enable farmers to make soil conservation investments, to use fertilizer and organic matter, and to participate in cash cropping of perennials will have big payoffs in productivity. Land markets that allow smaller farmers to buy land could also increase aggregate productivity.

Source: Byiringiro, Fidele & Reardon, Thomas. Agricultural Economics. Vol. 15, 2, November 1996, pp 127-136

Agroforestry, water and soil fertility management to fight erosion in tropical mountains of Rwanda

African tropical mountains are often overcrowded because the climate is healthy and favorable to intensive agriculture. Consequently the density of population in the mountains of Rwanda and Burundi has reached an exceptional level (150 to 800 inhabitants/km^2) that leads to delicate problems of soil protection against runoff and various types of erosion on steep cultivated hill slopes. Previous measurements on runoff plots have shown that sheet and rill erosion risks have reached 300 to 700 t/ha/year on 20 to 60 % slopes with regional rainfall erosivity (R_{usa} =250 to 700), very resistant ferrallitic soils (K=0.01 to 0.20) and traditional farming systems (C=0.8 to 0.3). Curiosly, the runoff rate (10 to 30 %) is relatively moderate so that it is possible to restrict erosion with a natural or leguminous fallow, a pine plantation (litter effect) or by mulching coffee, banana or cassava plantations. The problem is now to produce enough biomass to mulch the whole surface with the help of agroforestry. A new strategy (GCES = land husbandry) was suggested to meet the major farmer problems: what should be done to increase the soil productivity rapidly and protect the rural environment? A part of the answer is to be found in the efficient management of water, organic matter and soil fertility restoration (Roose et al., 1998). This strategy was first tested in 9 runoff plots (5x20 m) on a 23 % slope of a very acid ferrallitic soil (pH = 4). Three types of living hedges (leucaena, calliandra, calliandra+setaria) twice replicated, were compares with the international bare standard plot and with the regional farming system (maize+beans during the first season, and sorhum during the second season). After 2 years, living hedges reduced runoff to less than 2 % and erosion to 2 t/ha/year: they produced fire wood and high quality leguminous forage (3 to 8 kg/m) and return to the soil as much as 80 to 120 kg/ha/year of nitrogen, 3 kg/ha/year of phosphorus, 30 to 60 kg/ha/year of calcium and potassium, 10 to 20 kg/ha/year of magnesium. Thanks to agroforestry it was possible tor educe erosion hazard but not to restore the soil productivity. Without 2.5 t/ha/ 3 years of lime to increase the pH up to 5 and reduce the aluminium toxicity, without 10 t/ha/ 2 years of farm manure and mineral fertilizers to nourish the crops, the yield remains very low (800 kg/ha/season of cereals). Thanks to agroforestry and a mineral fertilizer complementation, erosion hazard was controlled and the productivity of soil and labour intensified more than 3 times.

Source: Roose, Eric & Ndayizigiye, François. Soil Technology. Vol. 11, 1, May 1997, pp 109-119.

LAND DEGRADATION
IN
COQUIMBO REGION – CHILE:

ITS EXTENT AND IMPACT

F. Santibáñez – Edited by L. Berry

Commissioned by Global Mechanism
with support from the World Bank

TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN COQUIMBO REGION - CHILE:
IT'S EXTENT AND IMPACT

Preface

This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In one region of Chile in general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

CASE STUDY OF COQUIMBO REGION – CHILE

LAND DEGRADATION IN COQUIMBO REGION, CHILE:
ITS EXTENT AND IMPACT

Executive Summary

This regional case study of a heavily degraded semi-arid region illustrates the high cost of land degradation in such regions. Losses of nearly 50 percent on wheat yields and 23 percent on goat rearing are attributed to land degradation. Land degradation also impacts tourism, a major income producer of the region and also most other environmental services.

Edited by Leonard Berry

LAND DEGRADATION IN COQUIMBO REGION, CHILE: ITS EXTENT AND IMPACT

The Coquimbo Region of Chile is an arid-semi-arid part of the country. It was the pilot area for a multi-country study of indicators of land degradation (GEF Indicator Project MONITOR, Santibáñez, 2002). That work including field analysis produced a detailed systematic set of indicators. As a follow up to this work Dr. Fernando Santibáñez was asked to produce an assessment of the cost of land degradation for that region as a part of the GM case studies. Obviously the core work was carried out in a different context than the other case studies, and the results are presented here in a somewhat different format.

Environmental Background

Region IV of Chile is an area of 40.707 sq. km with a population of 504,387. Agricultural land is held in three types of tenure; modern irrigated lands (3 % of land area), large traditional estates and communal holdings. The irrigated sector has problems with unsustainable water use and salinization, but the most serious land degradation is found both in the traditional estates and in the communal areas. The greatest pressure is on the communal lands where poverty and land degradation combine. Goat herding is the main animal raising activity. Wheat is the major grain crop.

Economic Assessment of Land Degradation

The economic assessment concentrated on three areas:

- The impact of land degradation on the production of goods and services
- The impact of land degradation on environmental services
- The impacts of land degradation on the natural heritage of the region

Wheat and goat herding, the two basic agricultural products were studied

Wheat

Alcores community was chosen as a test site; it comprises about 8 % of the total area under wheat. Using actual data for wheat yields and field observations for erosion levels it was calculated that yields were 5.6 qq/ha compared with a minimum expected yield of 10 qq/ha. This equates to a loss of $80,000 for the region almost half of the expected crop value in the absence of land degradation. (For calculations see Annex 1).

Goat Herding

The region is a major goat raising area in Chile, with over 300,000 goats, 41.5 percent of the national herd. Census data on the goat population and its specific distribution was related to potential stocking rates with the range in good condition. The economic consequences of the lower than potential stocking rates were calculated for milk/cheese production, meat, leather and manure for the whole region. Table 1 summarizes the losses for the region. Current regional income from goat rearing is $656,677. Without land degradation another $196,970 would have been added to the local economy. This represents a 23 percent loss to this sector of the economy from land degradation. (Annex 2).

Table 1 – Losses in goat production because of land degradation

Product	Present income	Variation in gross income due to degradation
Cheese	3,393,023,248	-1017,899,026
Meat	839,239,020	-251,774,950
Leather	27,337,050	-8,201,700
Manure	270,782,240	-81,220,000
Total ($)	**4,530,381,558**	**-1,359,095,676**

Total loss is 1,359 million Chilean pesos ($US 196,970)

Environmental Services

According to the study the following environmental services are provided by the ecosystems of Coquimbo Region (Table 2).

Table 2. Environmental Services provided by Ecosystems of Coquimbo Region

Environmental services	Functions
Carbon sequestration	About 50,000 hectares reforested with woody shrubs.
Climatic regulation	High Solar radiation level requires soil protection to prevent desiccation. Plant cover regulates surface temperature of soil and, consequently, air temperature.
Hydrological regulation	This arid region gets the most of its water from high Andean rangelands. Vegetation of the upper part of basins plays an important role in water retention and seasonality of water flows.
Freshwater	An important part of the population live in rural areas having small water points as unique source of water. This water is highly dependent from infiltration of precipitation in the upper slopes.
Erosion control and sediment retention.	When the first precipitation of the rainy season comes, soil surface is dry and vulnerable to erosion. At this moment, plant cover is very important to prevent removal of fertile layers of soil.

Table 2. continued	
Environmental services	**Functions**
Biological control	Considering the aridity of this region, ecological equilibrium is precarious. Populations of insect move to irrigated areas during drought periods.
Species protection	There are several ecosystems that are strategic for animal and plant species.
Biodiversity reservoir	Several plant and animal species are endemic. Important vegetation relicts remain in coastal areas.
Tourist services	This region has several tourist attractions: National Parks, Natural Monuments, Valley and mountain ecosystems, etc.
Cultural Services	Several historic sites from older cultures are spread within this region.

It is quite difficult to evaluate the cost of these services in the region, but several are negatively impacted by the severe land degradation in the region. For example:

- The removal of plant cover leads to increased dessication of the soil.
- Degradation of upper valley areas increases variability of river flows
- 150,000 rural dwellers depend on well water from stressed aquifers
- Irrigated farms are supplied from large dams (La Paloma dam stores 650 million m^3). Dam life is being shorted by sedimentation
- Tourists and cultural services are an important local source of revenue. This component was subjected to more detailed analysis

Impact of Land Degradation on Tourism

Over 208,000 tourists visited the region in 2001 and of these over 31,000 visited areas of ecological interest. Tourist expenditure is estimated at $300 per visit for a total of $62,400,000. Estimates were made of the possible reductions in tourist income, as a consequence of continued land degradation and the loss of ecosystem and natural heritage visitors. The range of losses to the tourist industry are from less than 2 percent as a result of low continued levels of degradation to over 10 percent if degradation continues at a high level. This latter implies an $8 million loss of potential revenue (Annex 3).

Summary and Conclusions

This detailed regional study is included in the cases because more than most such efforts it attempts to address impacts in detail in the field and at the level of individual crops and services. While there may be questions about individual assumptions, the finding for this region at least, is that loses from land degradation are higher the most national figures would suggest. Losses of over 40 percent on wheat yields even with current technology, 23 percent on goat rearing and up to 10 percent on tourism revenues are major economic loses to the region. The data as elsewhere indicates that these loses are borne differentially by the poor.

REFERENCES

Banco Central de Chile (Chile). “Tipo de Cambio del Dólar Observado Mensual” en http://www.odepa.gob.cl/. 2 Abril 2003.

Morales L. and F. Santibáñez, 1998. Monitoring desertification using remote sensing techniques, Chapter VII, p 101-131, In: Computer tools for sustainable management of arid and Antarctic ecosystems. University of Chile/IBM International Foundation, Santiago, Chile. 300 pp.

Oficina de Estudios y Políticas Agrarias (Chile). 18/02/2003. “Mercado del Trigo” en http://www.bcentral.cl/esp/. 24 Enero 2003.

Pérez J., F Santibáñez and L. Morales, 1998 Modeling Arid Grassland Carrying Capacity. Chapter IV, p. 63-70. In: Computer tools for sustainable management of arid and Antarctic ecosystems. University of Chile/IBM International Foundation, Santiago, Chile. 300 pp

Santibañez F , 1997 Possible impact on agriculture due to climatic change and variability in South America. In: Climate and Societies-A climatological perspective. Kluwer Academic Publishers. The Netherlands. 255-277 p

Santibáñez Q.F y A de la Fuente, 1998. Multiscale modeling of Land Use and Desertification. Chapter I, p 21-38. In: Computer tools for sustainable management of arid and Antarctic ecosystems. University of Chile/IBM International Foundation, Santiago, Chile . 300 pp

Santibáñez Q.F, 1998 Climatic Variations and productivity modeling in Arid Regions : Grassland and annual crops. Charter II p. 41-51. In: Computer tools for sustainable management of arid and Antarctic ecosystems. University of Chile/IBM International Foundation, Santiago, Chile . 300 pp

Santibáñez F., J Pérez and C. Petit, 1998. The EIMS Methodology for assessing and monitoring desertification, Chapter VIII p 137- 168, In: Computer tools for sustainable management of arid and Antarctic ecosystems. University of Chile/IBM International Foundation, Santiago, Chile . 300 pp

Santibáñez F. Q y J.M.Uribe 1999 Origin and variability of droughts in Chile. In: Drought in Chile: causes, consequences and mitigation. Universidad Católica de Chile. Capítulo 2, 23-33.

Santibáñez Q F. 2002. Monitor model: a system to assess and to monitor desertification dynamics in Latin America and the Caribbean. Working manual, University of Chile. GEF/UNEP project GF 1040/00-10 (International cooperation Chile-Brazil-Mexico-USA)

ANNEX 1 – Loss of Wheat Production due to Land Degradation in Alcones Community

	Cultivated surface (ha)	Yield	Production qq	Price (2002) ($)	Total income ($)
Wheat	69.5	5.6 qq/ha	390.6	11.700 qq	4,570,020

Source: Oficina de Estudios y Políticas Agrarias – ODEPA and Publisher information of agricultural market. One qq = 100 Kg.

Evaluation of Soil erosion.
Soil erosion was evaluated in the field by mean of expert protocols, referred to 5 degrees (states of erosion):

CONCEPT	DESCRIPTION	VALUE
Very light	Very light erosion signs, the process is incipient and not very evident, some sedimentation is observed in small places where rainwater accumulates.	1
Light	Light erosion, signs begin to be visible. Removal of fine material is visible leaving the thicker material exposed (gravel, small stones), runoff waters are not totally clear.	2
Mean	Moderate erosion, clear signs of particle removal from the surface of the ground. Erosion is evident, with the hardpan material clearly exposed on the surface. Some rill erosion is noticeable.	3
Strong	Erosion strong, strong mantle erosion leaves gravel spread on the surface, rill erosion is abundant and increasing, some gullies appear in their initial state of formation. There are very few materials left from the original superficial soil, the soil has begun to change its color.	4
Very strong	Very strong erosion, all original surface materials have been removed generating a change of color of the soil, there is a widespread change of soil texture due to the dominance of the horizon C on the surface. Active gullies are observed.	5

Establishment of erosion/productivity functions

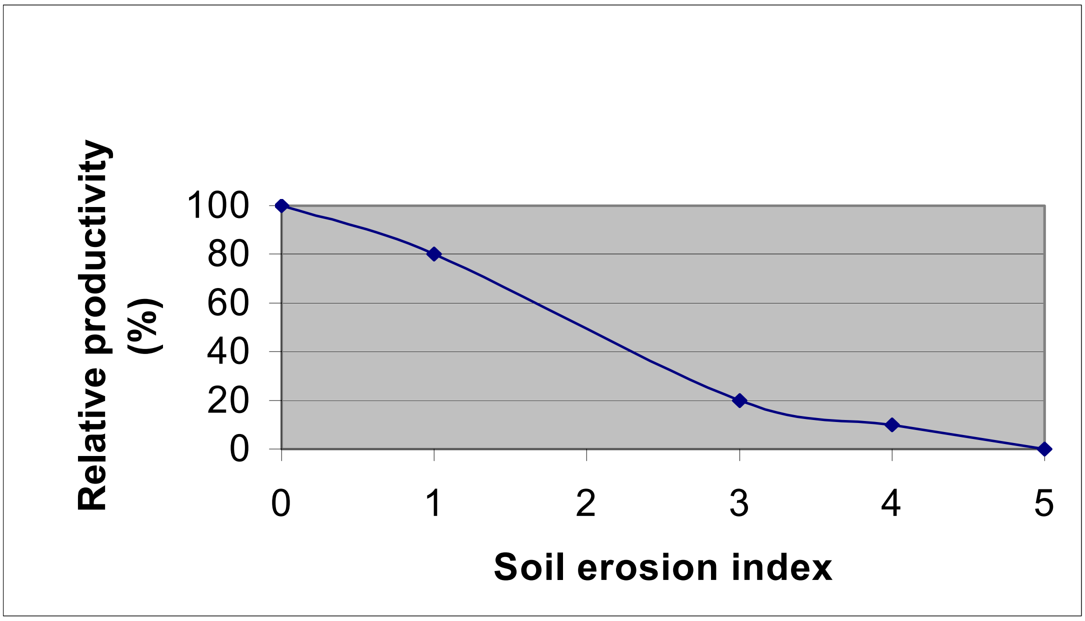
By mean of field observations, inquiries to farmers, available experimental data and numerical assumptions, we established production functions to relate soil erosion and soil productivity in arid and semiarid regions of Chile. We associated a production coefficient to each class of the scale of erosion degree:

Erosion Degree	Concept	Relative Productivity index
0	Non eroded soils	1
1	Very light	0.80
2	Light	0.56
3	Mean	0.20
4	Strong	0.10
5	Very strong	0.01

Technological coefficients were derived from field observations and inquiries. The following indices were derived:

Technological coefficients Actual yield/Potential yield	**Technological level**
Potential 1	Crop potential. Small plots in experimental conditions.
High 0.7	Farmers with good level of technology use. Yields above the national average.
Mean 0.4	Average yield. Mean level of technology use.
Low 0.2	Agriculture of low inputs, small farmers with restricted access to technology.

- Average wheat yield in the Region is 5.6 qq/ha, corresponding to 11 % of the potential productivity in rainfed cultivation.
- Most farmers use low levels of technology, so their yield should be near 20 % of the potential productivity (50 qq/ha).



Soil productivity index related with soil erosion index.

- On the basis of statistical information and empirical observations Cosio *et al* (1986), we estimated the following relation between yield and technology:

Technological level	Technological factor (Relative yield)	Absolute yield (qq/ha)
Potential	1	50
High	0.70	35
Mean	0.40	20
Low	0.20	10

- The agricultural systems in the Region are characterized by low levels of technology, so we can estimate that wheat yield has to be close to 20% of the potential (potential: 50 qq/ha, possible using low inputs: 10 qq/ha). In fact, actual yield in agricultural communities is 5.6 qq/ha, so about a half the corresponding level, considering a system of low inputs. This difference may be attributed to soil degradation, especially, soil erosion, which is the main factor of degradation in the area. About 2/3 of wheat is sown in more or less degraded soils and 1/3 in soils only recently used for agriculture.

Considering that this situation is representative of the whole region, we can extrapolate the impact of soil erosion, using the regional global figures. Combining the effect of soil erosion and technological level, we established the following table of relative productivity *(Ry)*, based on empirical data and observations. (Shaded case corresponds to present situation):

Soil erosion index		Technological level			
		Potential	**High**	**Mean**	**Low**
	0	**100**	**70**	**40**	**20**
	1	**80**	**56**	**32**	**16**
	2	**56**	**39**	**22**	**11**
	3	**20**	**14**	**8**	**4**
	4	**10**	**2.8**	**4**	**2**
	5	**1**	**0.7**	**0.4**	**0.2**

To test this matrix the following consistency has to be verified:

$$Ry_{(e,t)} * P_y \cong A_y$$

$Ry_{(e,t)}$ is the relative yield factor considering soil erosion and technological level
P_y correspond to estimated potential yield (depending on climate, specie and variety).
A_y is actual yield of this specie in the problem area.

In this case the figures are the following= 50 * 0.11 = 5.5, which corresponds with the actual yield 5.6.

About 97,5% of the wheat production is made under the rainfed system, consequently, it is very sensitive to drought. Annual rainfall varies between 150 and 250 millimeters. Despite this low amount, rainfall efficiency is very high, considering that ninety percent of this figure occurs in the milder winter when temperatures are lower, but enough for growing winter wheat. Also, the relative humidity tends to be high along the year, because the proximity of the coast. In good years, when precipitation is well distributed, potential yields, in the dry farming system, may reach 50 qq/ha. In this pilot region, total cultivated area of wheat is 873 hectares. On this basis we can make the following scenarios:

Technological level	Yield (qq/ha)	Production (qq)
Potential	50	43,650
High	35	30,555
Mean	20	17,460
Low	10	8,730

Total economic loss, T_{loss}, can be estimated as follow:

$$T_{loss} = (P_y * T_f - A_y) * C_a * P_w$$

P_y = Potential yield considering climatic situation.
T_f = Technological factor considering the level of inputs.
A_y = Actual yield
C_a = Cultivated area
P_w = Market Price of wheat.
Applying this relation to our pilot region we have:
$T_{loss} = (50 * 0.11 – 5.6) * 873 * 11{,}700 = 55{,}156{,}140$ (Chilean pesos, about US$ 80,000).

ANNEX 2 – The case of grasslands carrying capacity and goat production

We estimated the impact of land degradation on carrying capacity of the grasslands. We established the several degrees of degradation we can observe empirically, and we associated an estimation of forage productivity to each degree of degradation. This estimation was made integrating several indices describing the state of soil and plant cover:

GrasslandStateIndex = Po * I*erosion* * **I***cover* * **I***forragevalue*

Po : potential forage production, estimated by mean of a climatic model that consider precipitation regime, temperature and solar radiation (SIMPRAD Model)
I*erosion:* Relative erosion index
I*cover* **:** Soil cover (woody perennial species)
I*forragevalue:* Index of forage value of species (considering nutritional facts and fraction of consumable biomass).

To evaluate the impact of land degradation on goat production we defined minimum spatial units (polygons). The selected spatial unity was the census unit, what allow us to match environmental, agriculture and social information. We compiled information on numbers of animals, estimated carrying capacity of grasslands, composition of herds, production of meat, milk and cheese.

Basic Data – Cheese production

- Cheese represents about 73% of total income of farmers.
- Milk production per head is low as a consequence of inbreeding and the lack of genetic selection. Mean production is 150 liters per year/head.
- As consequence of low fertility, herds include 37% of females producing milk.
- They need 7 liters of milk to produce 1 kilogram of cheese.
- Mean price of cheese is 1,282 Chilean pesos per Kg. (about 2 dollars).

Basic Data – Meat, Leather, Manure

- One animal is sold for 8110 Chilean pesos (US$ 12).
- 31% of animals are sold as meat every year.
- One unit of leather (one animal) is sold for 1,170 Chilean pesos (US$ 2)
- Annual production of leather is about 7% of the number of heads.
- Price of one Ton of manure is 20,960 Chilean pesos (US$ 30).
- Annual production of manure per head is 38.7 Kg.

Assessment of stocking rate (number of heads per unit area)

The number of animal in each polygon was obtained from census data. We divided this number by total area of the polygon, to calculate present animal density. Using satellite data, we calibrated a system based on *NDVI* (normalized vegetation index) to assess biomass. This map was combined with a detailed map of vegetation, providing information on the dominant species. Each species was qualified by experts in terms of its forage value (considering nutritional facts, palatability, and consumable material). Combining both maps we distributed biomass into the dominant species, which were weighted by its forage value index. This gave us an indication of quantity and quality of forage. On this basis we calculated carrying capacity (potential heads/hectare).

It was assumed that this carrying capacity degraded proportionally to soil erosion. The "state of soil-vegetation complex" was described by a five categories system. The best condition qualified as 1, associated to the highest carrying capacity found in the region. The worst situation was 5, associated with the lowest carrying capacity (near zero for practical purposes). The following scale was then established:

Index of the sate soil-vegetation complex	Relative carrying capacity
1	1
2	0.75
3	0.50
4	0.25
5	0.05

The mean slope of relative carrying capacity is 0.25. Considering that degrading vegetation may affect more to more sensitive species, which recuperate slowly, we preferred to be pessimistic and consider a slope of 0.30 (30% of reduction on carrying capacity when the system degrades one degree.)

Assuming proportionality between degradation and production (number of animals recommended to make the system sustainable), we can express this proportionality as:

$$\frac{\mathbf{CC}_{(t)}}{\mathbf{P}_{(t)}} = \frac{\mathbf{CC}_{(t+1)}}{\mathbf{P}_{(t+1)}}$$

Where:

CC(t): Present Carrying capacity (ha/head).

P(t): Present animal stocking rate (heads/ha), as indicator of extraction pressure .

CC(t+1): Carrying capacity when the system degrade one degree (ha/head).

P(t+1): Adjusted stocking rate considering the next lower category (animal/ha).

So the new stocking rate, after degrading the system one degree is:

$$\mathbf{P}_{(t+1)} = \frac{\mathbf{CC}_{(t+1)} * \mathbf{P}_{(t)}}{\mathbf{CC}_{(t)}}$$

To assess potential impact of land degradation on this activity, we assumed a homogeneous degradation of one degree in the whole region. $P_{(t+1)}$ was calculated for the new carrying capacity and, on this basis, the carrying capacity of each polygon and the region, RCC:

$$RCC = \sum_{i=1}^{i=n} P_{i(t+1)} * Ap_{(i)}$$

RCC=regional carrying capacity
$Ap_{(i)}$= total area of the "i" polygon

To evaluate the regional impact of this situation we globalize the figures at the regional level. Summarizing the results for the whole region we have:

CC ha/head	**A Total area (ha)**	**Nh Number of heads (t)**	**P(t) heads/ha**	**P(t+1) heads/ha**	**Nh1 Number of heads (t+1)**	**Variation in number of heads**
1	2,264	219	0.0967	0.0677	153	-66
2	183,605	25,246	0.1375	0.0963	17,672	-7,574
3	312,808	36,974	0.1182	0.0827	25,882	-11,092
4	576,804	69,216	0.1200	0.0840	48,452	-20,765
5	771,632	85,805	0.1112	0.0778	60,064	-25,742
6	671,816	63,688	0.0948	0.0664	44,582	-19,106
>7	603,253	52,664	0.0873	0.0611	36,865	-15,799

CC = Carrying capacity category. Found, 1 (high) to more than 7 ha/animal head (low)
A= total area in the region having each carrying capacity category
Nh= present number of animals in each category
P(t) = present stocking rate (the highest pressure correspond to category 2 with 0.1375 heads/ha)
P(t+1)= calculated stocking rate considering one degree of degradation
Nh1= Adjusted number of heads for the new stocking rate

On the basis of variations in the stocking rate and the corresponding adjustment of the number of animal heads, we calculate economic consequences of this. We calculated the reduction in milk/cheese production, meat, leather and manure for the whole region.

Impact on Milk/cheese production

CC ha/head	Variation in number of heads	Females producing milk (37%)	Total milk production (150 lt/year)	Cheese production Kg/year	Income variation ($1282 Kg.)
1	-66	24	-3,600	-514	-658,948
2	-7,574	2,802	-420,300	-60,043	-76,975,126
3	-11,092	4,104	-615,600	-87,943	-112,742,926
4	-20,765	7,683	-1,152,450	-164,636	-211,063,352
5	-25,742	9,525	-1,428,750	-204,107	-261,665,174
6	-19,106	7,069	-1,060,350	-151,479	-194,196,078
7	-15,799	5,846	-876,900	-125,271	-160,597,422
Total ($)					**-1,017,899,026**

Impact on meat production

CC Ha/head	Variation in number of heads	Animals sent to the market (31%)	Income
1	-66	-20	-162,200
2	-7,574	-2,348	-19,042,280
3	-11,092	-3,439	-27,890,290
4	-20,765	-6,437	-52,204,070
5	-25,742	-7,980	-64,717,800
6	-19,106	-5,923	-48,035,530
7	-15,799	-4,898	-39,722,780
Total ($)			**-251,774,950**

Impact on leather and manure production

CC ha/head	Variation in number of heads	Number of leather units (7%)	Income provided by leather (1170 ChP/ unid.)	Manure production (0.0387 Ton/head)	Income provided by manure (20960 ChP/ ton)
1	-66	-5	-5,850	-3	-62,880
2	-7,574	-530	-620,100	-293	-6,141,280
3	-11,092	-776	-907,920	-429	-8,991,840
4	-20,765	-1,454	-1,701,180	-804	-16,851,840
5	-25,742	-1,802	-2,108,340	-996	-20,876,160
6	-19,106	-1,337	-1,564,290	-739	-15,489,440
7	-15,799	-1,106	-1,294,020	-611	-12,806,560
Total ($)			**-8,201,700**		**-81,220,000**

ANNEX 3 – Impact of land degradation on tourism

To evaluate the possible impact of land degradation on tourist activity, we supposed that a fraction of the tourist population is less interested in visiting the region, or the stay is shorter if landscape degrades. For that, we divided visitors in two: those who are sensitive to environmental factors and those who are indifferent. Only the first will react to land degradation. To establish the proportion of "sensitive" tourists we assumed that who visit National parks, while staying in the Region, are more sensitive.

1) Tourists visiting the Region in 2001

		IV Region 2001
Visitors	HOTEL	99,118
	HOSPICE	671
	MOTEL	64,920
	APART-HOTEL	20,733
	CAMPING	23,056
	TOTAL TOURISTS	**208,498**

Source: Instituto Nacional de Estadísticas - INE

2) Tourists visiting areas of ecological interest (National Parks, Ecological reserves, Natural monuments)

SNASPE	Number of visitors in 2001
Fray Jorge	14,241
Pingüino de Humboldt	10,069
Las Chinchillas	1,627
Pichasca	5,486
Total	**31,423**

Source: Instituto Nacional de Estadísticas - INE

- We used the following algorithm to estimate the decay in number of tourists as a consequence of land degradation

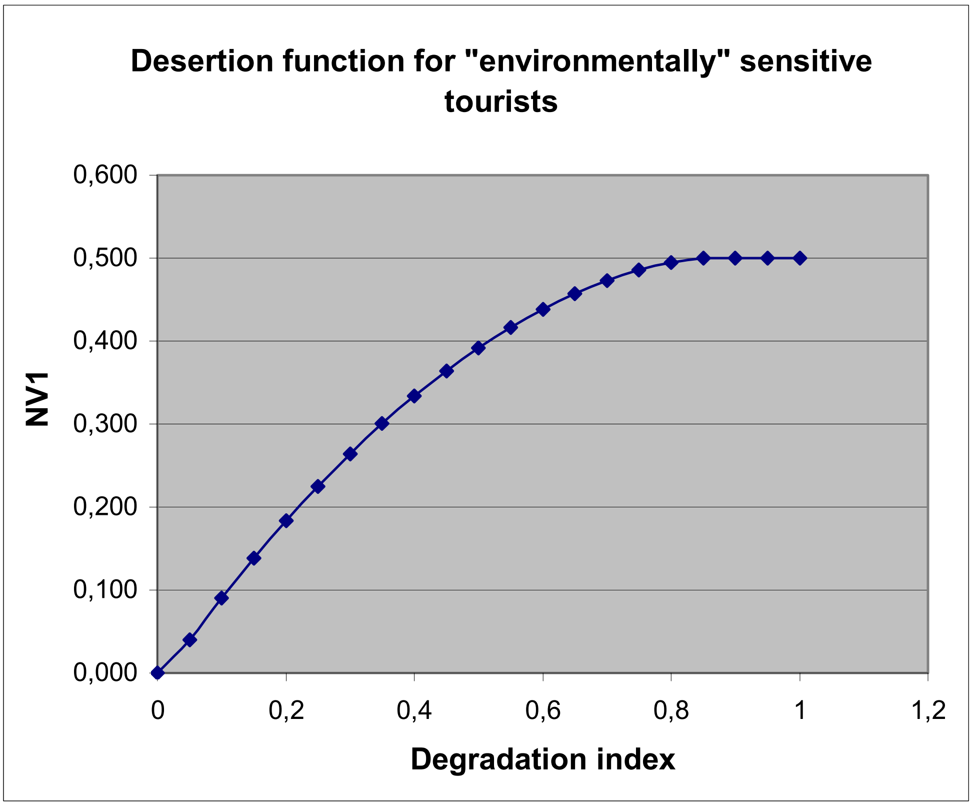
$$\Delta T = TVR\,[(VS * SD1 * NV1) + (1 - VS) * SD2 * NV2)]$$

Where:
ΔT: Decay in number of tourist
TVR: Total visitors
VS: Fraction of "environmentally sensitive" visitors (estimated from visits to ecological sites, SNASPE)
SD1: Factor of potential desertion of this type of visitors when environment degrade.
NV1: Actual desertion function of environmentally sensitive visitors when environment degrade.
SD2: Factor of potential desertion of less sensitive visitors.
NV2: Actual desertion function of less sensitive visitors when environment degrade.

- In 2001 ecological sites registered 22,832 visitors. To avoid double computation we estimated the number of visitors that visited more than one site. This figure represents 11% of total tourists visiting the region (TVR).

- The desertion function for environmentally sensitive visitors was estimated as follow. We consider that in a scenario of total degradation (supposing that all ecological interesting sites disappears), fifty per cent of these visitors do not come.

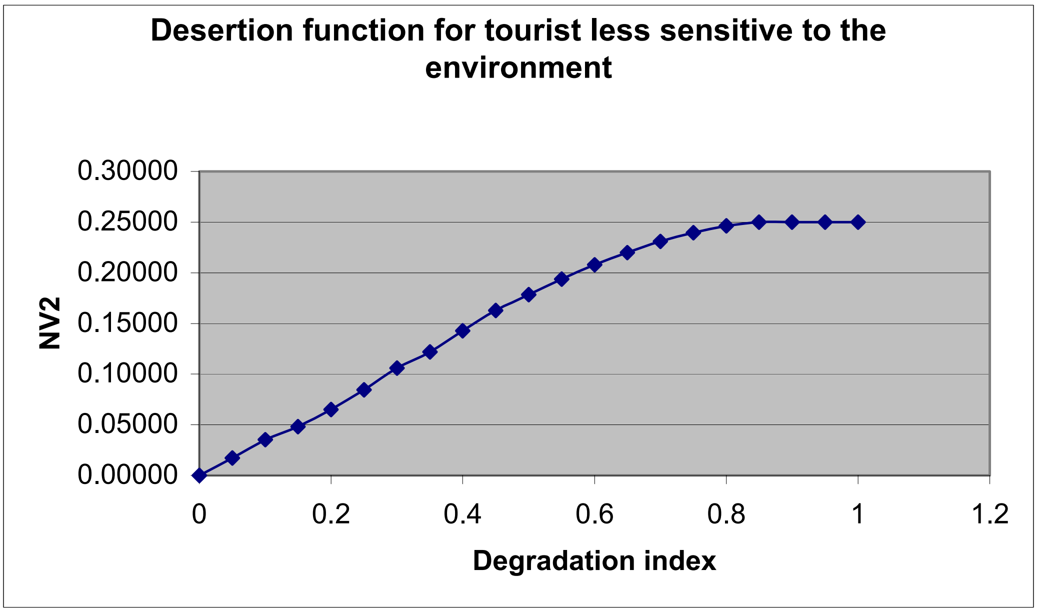
Relative degradation	**Desertion factor, NV1**
0.05	0.040
0.1	0.091
0.2	0.183
0.3	0.264
0.4	0.334
0.5	0.392
0.6	0.438
0.7	0.473
0.8	0.490
0.9	0.500
1	0.500



- In the case of less sensitive visitors we have supposed a maximum decay of 25% as reaction to an absolute desertification. That means that, despite degradation, 75% of these visitors continue choosing the Region as tourist destination.

- The desertion function for less sensitive visitors was estimated as follows:

Relative degradation	**Desertion factor, NV2**
0	0.00000
0.1	0.03529
0.2	0.06500
0.3	0.10593
0.4	0.14278
0.5	0.17847
0.6	0.20800
0.7	0.23100
0.8	0.24622
0.9	0.25000
1	0.25000



We created three scenarios:

1. Decay of tourist activity facing an extreme degradation (100% of the territory desertified)
2. Decay of tourist activity facing a moderate degradation (40% of the territory desertified)
3. Decay of tourist activity facing a light degradation (10% of the territory desertified)

Scenario 1. Decay of tourist activity facing an extreme degradation (100% of the territory desertified):

$\Delta T = TVR [(VS * SD1 * NV1) + ((1 - VS) * SD2 * NV2)]$
TVR: 208,498
VS: 0.11
SD1: 1
NV1: 0.5
SD2: 0.25
NV2: 0.25
Then:
$\Delta T = 208{,}498 * [(0.11 * 1 * 0.5) + ((1 – 0.11) * 0.25 * 0.25)]$

Scenario2. Decay of tourist activity facing a moderate degradation (40% of the territory desertified)

$\Delta T = TVR [(VS * SD1 * NV1) + ((1 - VS) * SD2 * NV2)]$
TVR: 208,498
VS: 0.11
SD1: 1

NV1: 0.334
SD2: 0.25
NV2: 0.14278
Then:
ΔT = 208,498 * [(0.11 * 1 * 0.334) + ((1 – 0.11) * 0.25 * 0.14278)] **= 14,284 tourists**

<u>Scenario 3.</u> Decay of tourist activity facing a light degradation (10% of the territory desertified)

ΔT = TVR [(VS * SD1 * NV1) + ((1 - VS) * SD2 * NV2)]
TVR: 208,498
VS: 0.11
SD1: 1
NV1: 0.091
SD2: 0.25
NV2: 0.035
Then:
ΔT = 208,498 * [(0.11 * 1 * 0.091) + ((1 – 0.11) * 0.25 * 0.035)]

Total losses due to decay in tourist attraction

Existing information suggest that each visitor spends US$ 50 per day. The mean permanence in the region is 6 days, so total expenses are 300 US dollars. Considering these figures we can estimate total economic losses o the region, due to tourist decay. The following table summarizes the resulting figures.

Degradation Index	Reduction in number of visitors (desertions)	Total losses in US$	% of reduction in tourist income
0.1	3,724	1,303,469	1.8
0.2	7,212	2,524,363	3.5
0.3	10,969	3,839,136	5.3
0.4	14,284	4,999,363	6.9
0.5	17,270	6,044,430	8.3
0.6	19,695	6,893,152	9.4
0.7	21,564	7,547,549	10.3
0.8	22,660	7,931,135	10.9
0.9	23,065	8,072,782	11.1
1	23,065	8,072,782	11.1

This calculation does not include positive externalities of tourist activity like the existence of services (public and private associated to tourist activity), providing jobs all year long, public investment, increased cultural activities, etc.
There is a global impact up to 11.1 %. However, it is likely this impact may fall mostly on the poorest sector of human communities. Jobs associated to tourism probably represent a higher part of their family incomes, and they do not have many options to mitigate this negative change. So this estimate may underestimate reduction of the quality of life and the increase in social vulnerability of some poorest groups.

LAND DEGRADATION IN JAVA, INDONESIA: ITS EXTENT AND IMPACT

J. Olson & L. Berry

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TABLE OF CONTENTS

LIST OF TABLES

LAND DEGRADATION IN INDONESIA: ITS EXTENT AND IMPACT

Preface

This paper is part of a series of case studies, which attempt on a pilot country basis to examine the costs of land degradation. This stage of the work involves a desk analysis of:

- Impacts of land degradation
- Costs of land degradation
- Costs of land improvement measures
- Costs of policy reform and institutional development.

In general there is reasonable, though not comprehensive, information on the impacts of land degradation and a good assessment base of the proximate and root causes. Linkages with poverty are well established and current remedial programs can be identified.

There is much less information on the impact on the ground of these actions. It is clear that the impact of land degradation is a drain on economic growth in rural areas and has an affect on national economic growth patterns. Investment in remedial action is hard to quantify, but appears an order of magnitude smaller than the scope of the problem. Actual in country joint assessment with national stakeholders will be necessary to provide specific analysis of the countries concerned.

INDONESIA

Manila
PACIFIC OCEAN
CAMBODIA
VIETNAM
Phnom Penh
Ho Chi Minh City (Saigon)
PHILIPPINES
THAILAND
MALAYSIA
BRUNEI
Kuala Lumpur
Nias
Singapore
Sumatra
Kalimantan
Sulawesi
Maluku
Irian Jaya
PAPUA NEW GUINEA
INDONESIA
Jakarta
Nusa Tenggara
Java
Flores
EAST TIMOR
Bali
Komodo & Rinca
Lombok
0 600 km
0 400 mi
INDIAN OCEAN
Darwin

LAND DEGRADATION IN INDONESIA: ITS EXTENT AND IMPACT

Executive Summary

Comprehensive studies of direct and indirect impacts of land degradation in Java in the 1980's suggested that 750,000 – 1,000,000 ha. or 8% of all farmland was severely degraded; but more recent studies estimate a lower level of impact. In general it seems that heavy use of fertilizers and good soil water management has maintained productivity. However, the situation in other islands, not studied in detail shows ongoing degradation.

LAND DEGRADATION IN JAVA, INDONESIA

INTRODUCTION

Unlike other countries being examined in this exercise, Indonesia has been the site of many years of intensive soil science research. This research has recently been collated to examine trends in soil characteristics and productivity over the past 50 or more years. Similarly, Indonesia has been the site of several attempts to estimate the monetary costs of soil degradation, especially in terms of lost agricultural productivity. The country has an impressive record of governmental programs to prevent and mitigate soil erosion and other forms of degradation, and to promote high productivity, especially on the island of Java.

Java has a long history of settlement, and is characterized by high population densities and an intensive, highly productive agricultural system. The rice paddy system, which has been in place for many years, is located in the high potential areas of relatively fertile soils. Erosion and associated problems of nutrient depletion are minimal due to the system of flat terracing and well-maintained irrigation schemes. Since the 1920's, the lower potential uplands have been settled as a frontier zone, and they are already densely populated. Crops such as maize and cassava are produced there on sloping hillsides, and erosion and chemical degradation problems are more prevalent.

Concerns about erosion and declining productivity have been expressed since the 1860's, with warnings of erosion being seen as a great and growing danger. These fears have continued to be expressed, with severe erosion blamed on the rapidly growing population and increasingly intensive cultivation. The World Resources Institute, for example, warned in 1989 that one-third of the cultivated mountain area of Java was eroding to such an extent that one million hectares were already useless for farming, threatening the livelihoods of 12 million poor (Repetto et al. 1989). This contrasts with governmental estimates of 8% of all agricultural farmland (757,000 ha) being degraded in Java in 1987 (Lindert 2000). Similarly, estimates of the economic effects of degradation on agricultural yields in Java vary from, for example, 4% of dryland crop value (by Repetto 1989), to no net loss (by Lindert, 2000).

Java is not indicative of Indonesia as a whole, however. Java has benefited from high levels of chemical fertilizer applications, soil and water erosion control programs, abundant labor, relatively good soil, and access to markets. On the other islands, which don't necessarily have these conditions and where marginal land is increasingly being cultivated, soil degradation is severe and has significantly affected agricultural productivity.

EXTENT AND SEVERITY OF LAND DEGRADATION

Java is often divided into two zones in agronomic research and programs—the rice paddy system (*sawah)*, and the rainfed upland agricultural system (*tegalan*). Java is, in general, agriculturally old and densely populated. The use of the land has not changed much since the 1940's, except for some variation in the proportion of land under different crops. A small amount of deforestation has occurred, but the forest was replaced by uses that are not the most depleting of soil nutrients such as tree crops. The forest is protected since it is seen as essential for maintaining the hydrologic system upon which irrigation depends.

Until recently, published analyses of soil degradation in Java were site-based and limited in time. Nevertheless, they provide an indication of the level of erosion on cultivated fields on the islands.

Van der Linden (1983) conducted detailed measurements of erosion levels on experiment plots in the Desel River watershed in central Java (Linden 1983). He found that grass-covered fields do not experience serious soil loss by surface runoff. Maize and/or cassava fields, however, are eroded at a rate of around 0.6 mm/ year, with bare soils losing soil at 8.2 mm year per ha. The total annual discharge of material estimated from the plot research from the watershed was 240 tons. This rate was less than previous measurements, perhaps because much of the highly erodable elements of the soil were already gone. He cautioned that much of the actual soil loss was due to extreme flooding events that would not be captured by the experimental plot measurements.

Diemont et a. (1991) reviewed available erosion studies and soil conservation programs on Java. He concluded that the widespread and continuous programs to reduce erosion on the hillslpes of Java through 1) slowing of deforestation rates starting in the middle of this century, and 2) widespread terracing of cultivated hillslopes and introduction of new crops and cropping systems since the 1940s. These have effectively reduced erosion levels so that surface erosion from hillslope fields is now under control (Diemont et al. 1991). The terracing and other erosion control programs were implemented by the Indonesian government and in various projects by FAO, UNDP, USAID and the Netherland's DGIS. Indeed, the National Watershed Development Program in Regreening and Reforestation channels about US$50 million annually to local governments throughout the country for watershed activities and donor countries have contributed hundreds of millions of dollars for upland agricultural projects (Huszar 1998). Their experiences on Java, however, were that although erosion declined on hillslope fields, sediment loads in rivers has remained high and often productivity has remained low. Diemont et al. (1991) maintain that morpho-erosion, such as landslides, incising rivers, roadside erosion, some irrigation drainage systems, and volcanic activity, is the main cause of high sediment loads. He suggests that low inputs, not erosion, are the source of low productivity.

Indonesia's Center for Soil and Agricultural Research recently completed a large effort to collect and harmonize historical measurements of soil nutrients, organic matter and other soil characteristics. Initial analyses of these data sets are beginning to be published (Lindert 2000). 4,562 soil profiles dating from the 1920's were collated that covered the country unevenly over time and space, but nevertheless allow examination of soil conditions in five land use categories (*sawah, tegalan*, tree crops, fallow that includes the imperata grassland, and primary forest/ waste land). These are the land use categories presented in Figure 1.

To estimate trends in soil characteristics due to human management, regression equations were conducted with numerous soil and site variables for the 1940 to 1990 period.

The major results reported by Lindert for Java include:

- Organic matter of the topsoil dropped from 1940 to 1970, and rose thereafter but has not yet reached the 1940 level. This appears to be the case for paddy and tegalan, as well as the other uses. Nitrogen probably followed the same trend.
- There was a gain of around 44% in total phosphorus over the same period, probably due to fertilizer application.
- Potassium levels may have also risen, around 28%, though the trend is less clear especially in the tegalan fields and tree crop soils. It, too, would be due to fertilizer application especially on food crops.
- The pH levels have fluctuated as Indonesia implemented liming applications and water control. Since 1970, the pH has generally risen.

Estimates of soil erosion over the same period were more difficult to generate due to the lack of direct measurements. Lindert (2000) used two approaches to examine erosion trends, one chemical and one physical. The chemical estimation is based on the assumption that erosion carries away organic matter and nutrients, so one would expect their loss with severe erosion. As the tables and figures indicate, however, this did not occur in the period since 1970 when Java was undergoing agricultural intensification associated with rapid population increases. The physical estimation of erosion is based on measurements of changes in the thickness of the topsoil layer. The manner in which topsoil depth was measured, however, varied over time. Even ignoring this, the trend was inconclusive, and apparently there was no dramatic change in topsoil depth. Lindert is unable to conclude, therefore, whether erosion has been significant.

The soil of Java, therefore, is a prime example of soil that is anthropomorphically generated. Humans have augmented the soil's endowments, especially phosphorus and potassium. The lack of clear impact of soil erosion led Lindert (2000) to conclude that future research on increasing land productivity should concentrate on other processes, such as water management, improved fertilizer application, and nutrient depletion through crop uptake.

AGRICULTURAL PRODUCTIVITY AND ECONOMIC IMPACTS OF DEGRADATION

Studies on Economic Impacts

Repetto of the World Resources Institute, Magrath and others conducted an analysis of the cost of natural resource depreciation to the Indonesian national income ("net domestic product"). The analysis has been widely cited because of its use an economic valuation approach that includes off-site costs of erosion, such as sedimentation in irrigation canals and reservoirs, and additional forms of resource depreciation such as logging (Repetto 1986; Magrath and Arens 1987; Repetto et al. 1989).

The cost of soil erosion to agriculture on Java was estimated by Repetto et al in 1989, before the studies of the extent and severity of land degradation reviewed above had been conducted. Their estimations were based on model results of potential erosion from slope, land use and other spatial (mapped) variables at a 1:1 million scale. Based on these model results, predicted soil loss on upland fields was presented by region, soil type, cropping system and crop. The resultant estimates of on-site costs due to soil erosion on upland, rainfed fields (*tegalan*) of Java ranged from 4.1 percent to 4.7 percent of production, or in economic value terms, around 0.04 percent of the value of annual agricultural output (see Tables 3 and 4). This was approximately as large as annual production increases due to irrigation, fertilizer and other improvements. For the single year of 1985, they estimated that erosion thus cost 53,956 million rupiah (approximately US$32.7 million), with a capitalized value of 539,560 rupiah (approximately US$327 million). Magrath and Arens (1987) estimated off-site sedimentation costs to be in the range of US$25 to US$90 million.

Java has also been the site of a household-level economic analysis of adoption of soil erosion control practices by Barbier (Barbier 1990, 1995; Barbier and Bishop 1995). Basically he found that the factors that influence adoption of land degradation practices include land tenure arrangements, soil characteristics, input and output prices, availability of off-farm employment, and discount rates. The relationship between erodability and profitability varies widely—many profitable perennial crops appear to have better erosion control, but high-valued crops such as vegetables cause major erosion (see Figure 4). Similarly, Huzar (1998) and Huszar and Cochrane (1990) examined soil conservation practices at the household level to identify the sustainability of SWC projects (Huszar and Cochrane 1990; Huszar 1998). They found that the sustainability of adoption of practices after the projects ended varied between households and regions, depending on income, input and output markets, and other economic and labor conditions.

Productivity Changes

At the level of Java Island, recent studies have been conducted analyzing production and productivity changes using price, production and other regional and national-level statistics.

With statistics of the Indonesia Central Bureau of Statistics, Van der Eng analyzed the evolution of aggregated production, the use of productive resources and productivity since 1880 using the growth accounting method (Eng 1996). He deducted the margins of transport, trade, storage and processing on the market price, used the rural retail price, and subtracted costs of farm-produced and purchased inputs. He did not include the costs of land degradation, but his analysis of changing land and labor productivity provide an indication of its possible effect. Because of the large difference between Java and Madura, and the other islands ("Other Islands") in terms of the agricultural and population history and farming system, he separated Java from the others in his analyses. He also separated the farm from the large-scale estate sector. His findings include:

- The growth of total production has been faster on the Other Islands compared to Java, because of the large amount of new land being put under production on the Other Islands. Nevertheless, growth in Java as been impressive, with gross value added in agriculture changing from (using 1960=100) around 45 in 1880 to 250 in 1988, and in the Other Islands from around 25 to over 300 during the same period.
- Per capita gross value added has also grown in Java and Madura, from around 4,000 rupiah in 1880 to 8,000 rupiah in 1988 (1960 rupiahs) (see Figure 2). Agricultural production per capita has, however, just matched population growth.
- 95% of the growth in Java since the 1920's can be accounted for by growing domestic demand (from population and average income growth) for crop and livestock food products.
- Although the number of people employed in agriculture continued to increase until 1990, the proportion of farmers in the population has steadily declined. The censuses underestimated the contribution of female labor force in agriculture at least until the 1970's because of counting only full-time agriculturalists; the labor share of women in rice production, for example, was more than half of the total labor input.

- Land productivity increased continuously in Java, except during the 1940's, and the rate has accelerated since 1970. Since the 1930's, this increase has been due primarily to growth in the farm sector, especially rice production.
- The ratio of irrigated land increased steadily in Java, contributing to the increase in land productivity.

Lindert (2000) estimated the effects of changes in soil nutrients on agricultural yields and the value of agricultural production by comparing site characteristics and their soil chemistry (since there was much site level data and insufficient time series data). He attempted to separate out the effects of agriculture on soil (including inputs), from the effects of soil on agriculture.

He found that for 1990, there was a high degree of variability between sites in productivity and prosperity (see maps in Figures 3a and 3b). In general, productivity per unit land was highest where population density is high, especially in Java and Bali. Unexpectedly, areas of high productivity per laborer are often the same areas as those with high land productivity.

He conducted two statistical tests to examine the soil-agricultural productivity relationship: one assumed that local markets are separated (approach A), and the other assumed that all districts share the same market, which would emphasize the effects of soil conditions (approach B) (reality would probably fall in between). The results (see Table 1) indicate the following:

- Water supply and proximity to large non-agricultural populations have important positive effects on productivity.
- Soil organic matter content and nitrogen appear to play a positive if weak role in effecting productivity in Java, but the other nutrients did not show up clearly. This probably reflects the large amount of chemical fertilizers being used. On the Other Islands, phosphorus and potassium showed a stronger effect on productivity.
- Other inputs (work animals, machinery and fertilizer) show positive productivity effects in the islands outside Java, but not for Java itself where their effect may be captured by more frequent harvests per year.

These results point to the impact of the application of chemical fertilizer on productivity. Their increasing use can be partly explained by their declining cost relative to production prices, due to many years of government subsidies (see Table 2). Fertilizers are effectively providing a substitute for high quality soil.

Lindert also examined changes in productivity due to changes in soil characteristics by comparing historical soil data between 1940 and 1990. He concluded that, in Java-Madura, topsoil chemical quality either dropped by 3% between 1940 and 1955, with partial recovery afterwards (seen in results of approach A, which emphasizes the effect of nitrogen and SOC), or it rose by almost 10% during the entire 50-year period (from approach B).

The topsoil chemical quality on the Outer Islands over the half century declined by around 12% or 18%, depending on the choice of approaches (A or B). The decline was most apparent after 1960. The loss was probably due to cultivation of increasingly marginal soils, continuing human-induced degradation, and use of younger (more recently cleared) land. He expects the rate of loss to slow down, now that the rate of clearance of new lands has slowed. The decline in the Outer Islands was enough to bring the country's overall national loss from 4.0% to 5.5% over that 50-year period.

Table 1 compares the changes in soil chemistry with that of overall changes in land and labor productivity. For the entire country between 1940 and 1970, both land and labor productivity were stagnant, but between 1970 and 1990, they jumped by two-thirds. Compared to those large gains, the estimated loss of 1.7 to 3.1 percent in production due to soil changes in those two decades appears small.

In Java-Madura, where the soil is inherently higher quality, the land productivity gains of 78 percent from 1970 to 1990 are even larger than for the country as a whole. The estimated effects of changes in soil quality on production, a gain of 2.8 to 4.5 percent, are small, and the effects of land degradation not apparent.

CONCLUSION

In short, Java has followed the path of land-scarce countries as expected by Hayami and Ruttan (1985) by adopting land-replacing technologies. This has been accompanied by increases in labor productivity, though not at the same rate. Major impacts of land degradation on production are not evident in the results. Land degradation even on the hillslopes of Java has not measurably reduced yields or productivity because of the 1. increasing and wide use of fertilizers, 2. increased application of labor to do SWC and other productivity enhancement practices, and 3. government terracing programs. Erosion on the Other Islands, however, has measurably reduced productivity.

Figure 1. Change in soil characteristics by land use type, Java and the Outer Islands, 1940 to 1990.
Source: Lindert 2000.

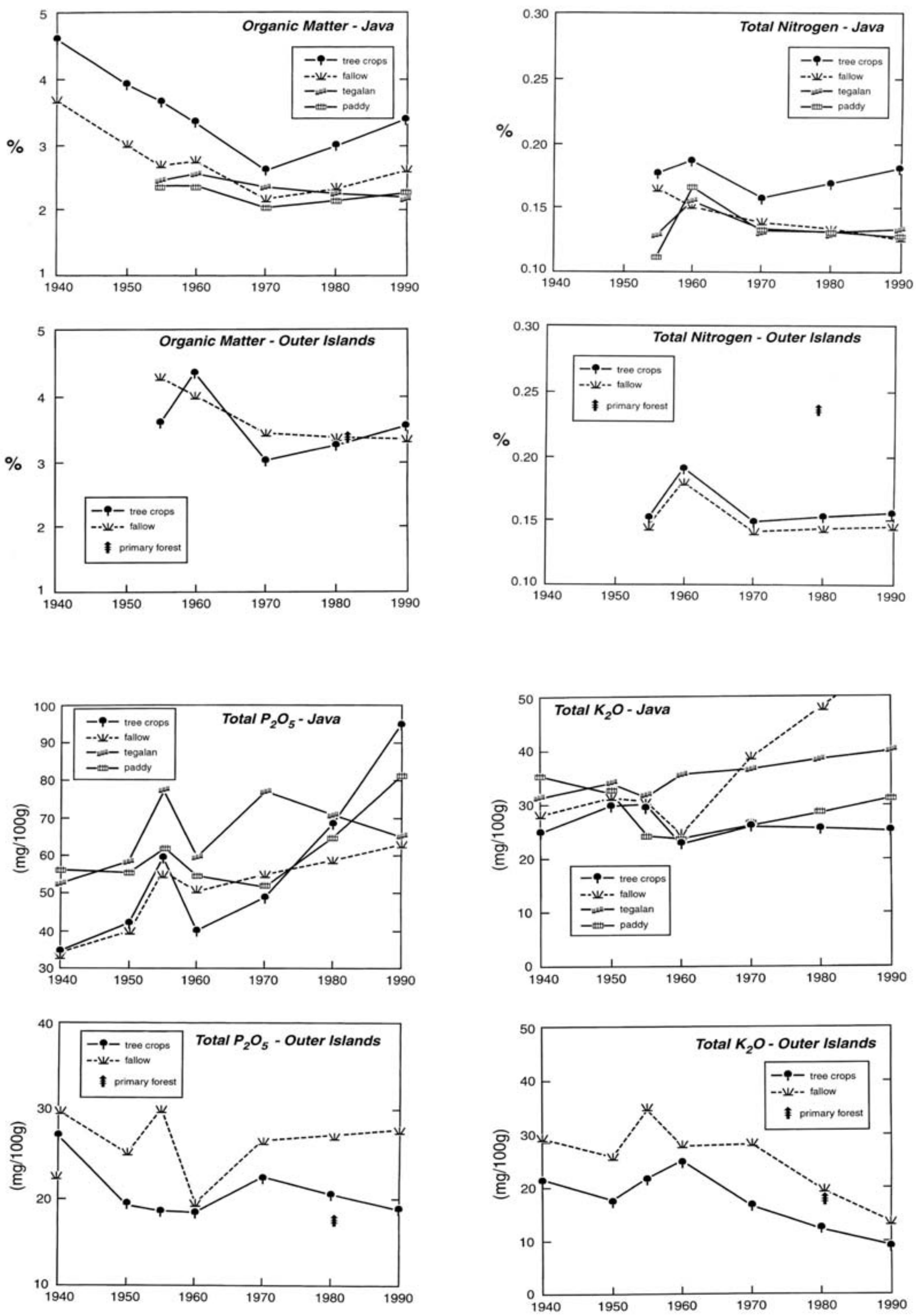


Figure 2a. Gross value of agricultural production per harvested area, 1990. Source: Lindert 2000.

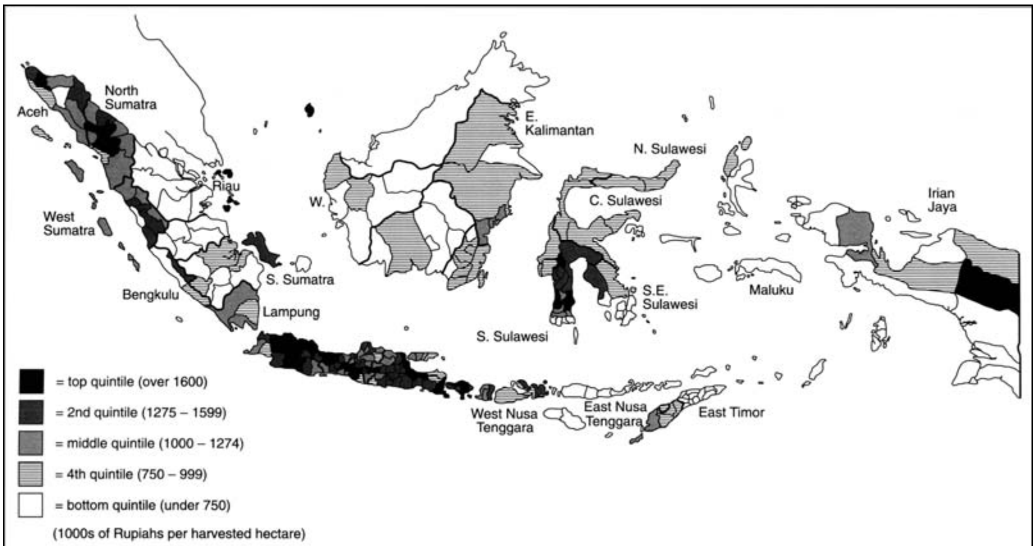


Figure 8.2
Gross value of agricultural production per harvested area, 1990

Figure 2b. Gross value of agricultural production per laborer, 1990. Source: Lindert 2000.

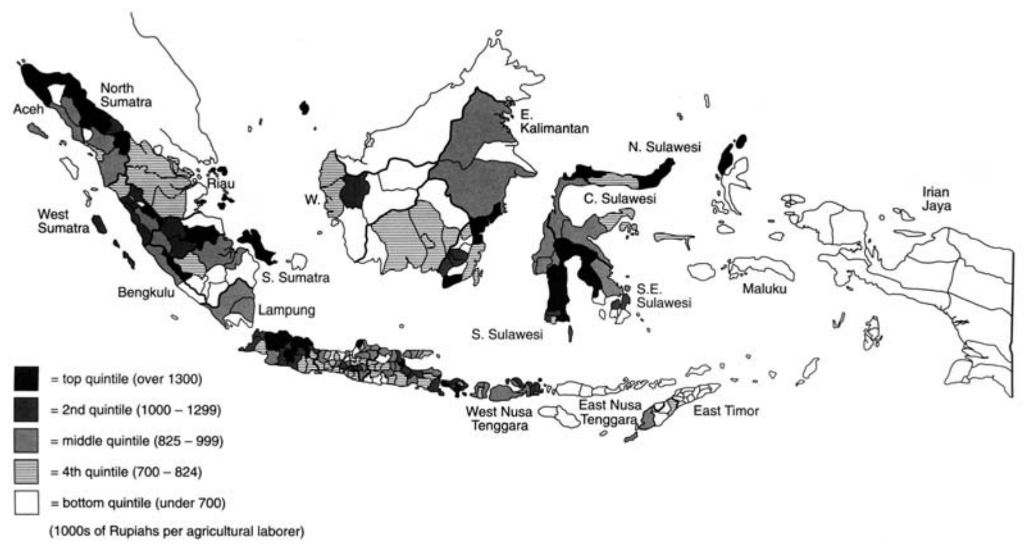
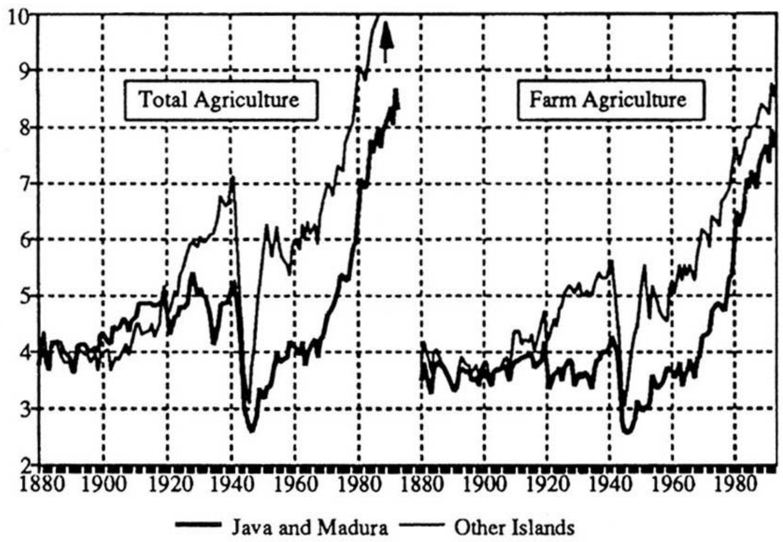


Figure 8.3
Gross value of agricultural production per laborer, 1990

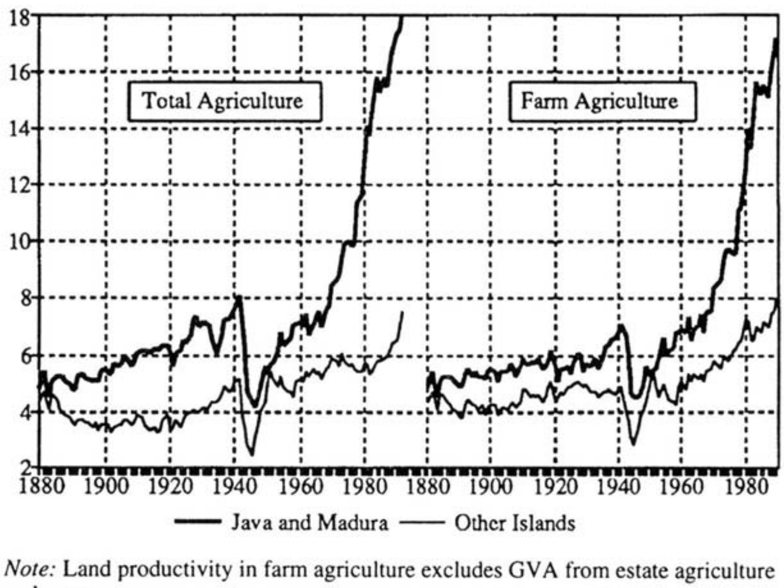
Figure 3. Evolution of Agricultural Productivity in Java and Madura, and in the Other Islands.
Source: van der Eng 1996.

Gross value added in agriculture per worker, 1880–1993
(thousand 1960 rupiahs)



Note: Labour productivity in farm agriculture excludes GVA from estate agriculture, but is calculated with total employment in agriculture.
Sources: Appendices 1 and 3, Other Islands 1.5 percent estimate.

Gross value added in agriculture per hectare, 1880–1992
(thousand 1960 rupiahs)



Note: Land productivity in farm agriculture excludes GVA from estate agriculture and estate area.
Sources: Appendices 1 and 4, Other Islands 1.5 per cent estimate.

Table 1. Role of soil chemistry in accounting for agricultural productivity differences, Java-Madura and the outer islands, 1940 to 1990. Source: Lindert 2000.

Role of soil chemistry in accounting for agricultural productivity differences, Java-Madura and the outer islands, 1940–1990

A. A half century of agricultural growth, 1940–1990

				Percentage changes		
	1940 level	1970 level	1990 level	1940–1970	1970–1990	1940–1990
All Indonesia						
Gross value of production (billions of 1990 Rupiahs)	11,712	14,431	34,444	23.2	138.7	194.1
Harvested area (thousands of hectares)	16,521	19,105	26,990	15.6	41.3	63.4
Agricultural employment (millions)	19.94	26.37	35.75	32.2	35.6	79.3
Land productivity = Production (billions of Rupiahs) per hectare	709	755	1,276	6.5	69.0	80.0
Labor productivity = Production (thousands of Rupiahs) per person	587	547	963	−6.8	76.1	64.0
Output/hectare due to soil chemistry quality (Approach A)	105.8	101.8	100.0	−3.8	−1.7	−5.5
Output/hectare due to soil chemistry quality (Approach B)	104.2	103.2	100.0	−1.0	−3.1	−4.0
Java-Madura						
Gross value of production (billions of 1990 Rupiahs)	7,437	8,294	17,107	11.5	106.3	130.0
Harvested area (thousands of hectares)	9,169	9,971	11,553	8.7	15.9	26.0
Agricultural employment (millions)	13.21	16.07	18.48	21.7	15.0	39.9
Land productivity = Production (billions of Rupiahs) per hectare	811	832	1,481	2.5	78.0	82.5
Labor productivity = Production (thousands of Rupiahs) per person	563	516	926	−8.3	79.4	64.4
Output/hectare due to soil chemistry quality (Approach A)	101.9	97.3	100.0	−4.6	2.8	−1.9
Output/hectare due to soil chemistry quality (Approach B)	90.3	95.7	100.0	6.0	4.5	10.7
Outer islands						
Gross value of production (billions of 1990 Rupiahs)	4,275	6,137	17,337	43.6	182.5	305.6
Harvested area (thousands of hectares)	7352	9134	15437	24.2	69.0	110.0
Agricultural employment (millions)	6.73	10.30	17.27	53.0	67.7	156.6
Land productivity—Production (billions of Rupiahs) per hectare	581	672	1,123	15.6	67.1	93.2
Labor productivity—Production (thousands of Rupiahs) per person	635	596	1004	−6.2	68.5	58.1
Output/hectare due to soil chemistry quality (Approach A)	111.8	106.0	100.0	−5.2	−5.7	−10.6
Output/hectare due to soil chemistry quality (Approach B)	117.7	110.6	100.0	−6.1	−9.5	−15.0

B. Java-Madura versus the outer islands in 1990

	Java-Madura	Outer islands	% difference, Java–Outer islands
Gross value of production (billions of 1990 Rupiahs)	17,107	17,337	−1.3
Harvested area (thousands of hectares)	11,553	15,437	−25.2
Agricultural employment (millions)	18.48	17.27	7.0
Land productivity—Production (billions of Rupiahs) per hectare	1,481	1,123	31.8
Labor productivity—Production (thousands of Rupiahs) per person	926	1,004	−7.8
Output/hectare due to soil chemistry quality (Approach A)	115.2	100.0	15.2
Output/hectare due to soil chemistry quality (Approach B)	146.0	100.0	46.0

Source: The Appendices in van der Eng 1996 were used for all nonsoil aggregates.
Notes: Soil measures are based on this study's soil samples and the regression results in table 8.1. Figures for gross value of production for 1940 and 1970 are based on the assumption of a constant share of real value added in the gross value of real output.

Table 2. Costs due to Soil Erosion (Indonesian rupiah 1650 = US$ 1). Source: Repetto et al 1989.

Table II.12. Costs Due to Soil Erosion for Various Cropping Systems on Java

Cropping System	Crops	Estimated Proportion of Tegal (%)	Area[a] ('000 ha)	Estimated Current Net Income (Rp/ha)[b]	Weighted Production Loss (%)[c]	Annual Cost of a One Percent Productivity Decline (Rp/ha)	Single Year Cost (million Rp)	Capitalized Cost (million Rp)
West Java								
I	Cassava, Corn							
Jogyakarta								
I	Intercropped Corn & Cassava	57	112	8,220	4.7	1,011	532	
II	Intercropped Corn, Cassava & Legumes	43	84	11,279	4.7	1,047	416	
Total Tegal		100	196	9,531	4.7	1,026	948	
East Java								
I	Intercropped Corn & Cassava Level Tegal	30	523	298,327	4.1	4,926	10,567	
II	Intercropped Corn & Cassava Terraced Hillsides	30	523	58,130	4.1	2,876	6,169	
III	Pure Stand Cassava Level Tegal	20	349	145,005	4.1	3,746	5,357	
IV	Pure Stand Cassava Terraced Hillsides	20	349	27,806	4.1	1,816	2,597	
Total Tegal		100	1,744	141,499	4.1	3,453	24,690	
TOTAL TEGAL			4,747	83,649	4.3	2,686	53,956	

a. Based on Central Bureau of Statistics. *See* Table II.6.
b. Net income equal to returns to land and management.
c. Based conservatively on rates for land cultivated in Cassava. Annual productivity loss for sensitive crops ranges from 6.8 to 7.8 percent.

Source: Adapted from Roche 1984, Central Bureau of Statistics, and data provided by the Agroeconomic Survey, Bogor. *See* Magrath, Arens, 1987.

Table 3. The Value of Crop Production Compared to the Cost of Erosion on Java (Indonesian rupiah 1650 = US $1). Source: Repetto et al. 1989

Table II.13. Comparison of the Value of Output of Six Major Rainfed Crops to the Cost of Erosion (million rupiah)

	West Java	Central Java	Jogyakarta	East Java	JAVA
Dry Rice	46,533	18,194	12,682	26,358	103,767
Maize	21,809	123,596	15,061	262,981	423,447
Cassava	81,041	109,148	22,410	134,962	347,561
Sweet Potatoes	22,191	12,131	542	15,331	50,195
Peanuts	44,916	56,475	18,340	74,615	194,346
Soybeans	17,807	45,398	37,664	124,171	225,040
Total	234,297	364,942	106,699	638,418	1,344,356
Cost of Single Year Erosion Loss	23,508	4,810	948	24,690	53,956
Capitalized Value of Erosion Losses	235,080	48,100	9,480	246,900	539,560
Single-year Erosion Cost as a Fraction of Value of Agricultural Output	0.10	0.01	0.01	0.04	0.04

Table 4. Growth in the Consumption of Fertilizer. Source: van der Eng 1996.

Table 2.8 Consumption of chemical fertiliser, 1910–90 (thousand tons)

	Food crops only			*All crops*		
	N	P_2O_5	K_2O	*N*	P_2O_5	K_2O
1910				15	± 1	0
1915				25	± 1	0
1920				21	2	0
1925				29	2	0
1930				31	3	1
1935				13	4	1
1940	4	2	0	24	12	3
1950				16	6	1
1955				25	9	2
1960	23	10	0	56	19	4
1965	69	21	2	98	32	9
1970	179	31	2	189	41	13
1975	305	102	4	336	112	19
1980	761	213	16	823	234	92
1985	1,134	477	68	1,496	550	176
1990	1,401	562	227	1,718	630	292

Note: For 1910–65 AS, urea, SP, DSP, TSP and potassium blends only. All quantities are converted to nutrient equivalents. The figures are three-year averages centred around the year shown to account for the carry-over of stocks.
Sources: Calculated from *Statistiek van den Handel* and succeeding foreign trade statistics; *Mededeelingen inzake Meststoffen* (Rotterdam: Internatio, 1940); P. Honig (1945) 'The Use of Fertilizers in the Netherlands Indies', *Empire Journal for Experimental Agriculture*, 13, p. 54; S. Affif and L.A. Mears (1968) 'A New Look at the Bimas Program and Rice Production', *Bulletin of Indonesian Economic Studies*, 4, No. 10, p. 40; *Kumpulan Data Pupuk* (1976–77); *Statistik Pertanian*; *Statistik Industri*; *Nota Keuangan 1991/92* (1991) p. 402; *Lampiran Pidato* (1994) p. vi–26.

REFERENCES

Arifin, Bustanul. 1996. Economic Analysis of Land Degradation in Indonesian Upland. Bergen, Norway: Chr. Michelsen Institute.

Barbier, Edward B. 1990. The Farm-Level Economics of Soil Conservation: The Uplands of Indonesia. *Land Economics* 66 (2):199-211.

———. 1995. The Economics of Soil Erosion: Theory, Methodololgy and Examples. Paper read at Fifth Biannual Workshop on Economy and Environment in Southeast Asia, at Singapore.

Barbier, Edward B. and Joshua T. Bishop. 1995. Economic Values and Incentives Affecting Soil and Water Conservation in Developing Countries. *Journal of Soil and Water Conservation* 50:133-137.

Diemont, W.H., A.C. Smiet and Nurdin. 1991. Re-thinking Erosion on Java. *Netherlands Journal of Agronomic Science* 39:213-224.

Eng, Pierre van der. 1996. *Agricultural Growth in Indonesia: Productivity Change and Policy Impact since 1980*. New York: St. Martins Press.

Huszar, Paul C. 1998. Including Economics in the Sustainability Equation: Upland Soil Conservation in Indonesia. *Advances in GeoEcology* 31:889-896.

Huszar, Paul C. and Harold C. Cochrane. 1990. Constraints to Conservation Farming in Java's Uplands. *Journal of Soil and Water Conservation* 45:420-423.

Lal, Rattan. 1977. A Brief Review of Erosion Research in the Humid Tropics of Southeast Asia. In *Soil Conservation and Management in the Humid Tropics*, edited by D.J. Greenland and R. Lal. New York: John Wiley & Sons.

Linden, P. van der. 1983. Soil Erosion in Central Java (Indonesia): A Comparative Study of Erosion Rates Obtained by Erosion Plots and Catchment Discharges. *CATENA Supplement* 4:141-160.

Lindert, Peter H. 2000. *Shifting Ground: The Changing Agricultural Soils of China and Indonesia*. Cambridge, MA and London, UK: Massachusetts Institute of Technology Press.

Magrath, W. and P. Arens. 1989. The Costs of Soil Erosion on Java: A Natural Resource Accounting Approach. Washington, D.C.: The World Bank.

Magrath, William B. and Peter Arens. 1987. The Costs of Soil Erosion on Java -- A Natural Resources Accounting Approach. Washington, D.C.: World Resources Institute.

Repetto, Robert. 1986. Soil Loss and Population Pressure on Java. *Ambio* 15 (1):14-18.

Repetto, Robert, William Magrath, Michael Wells, Christine Beer, and Fabrizio Rossini. 1989. *Wasting Assets: Natural Resources in the National Income Accounts*. Washington, D.C.: World Resources Institute.

Siebert, Stephen F., and Jill M. Belsky. 1990. Bench Terracing in the Kerenci Uplands of Sumatra, Indonesia. *Journal of Soil and Water Conservation* 45:559-562.

Sukmana, Soleh, and Pervaiz Amir. 1991. Technical and Economic Interventions for Soil Conservation in Java's Uplands. In *Development of Conservation Farming on Hillslopes*, edited by W.C. Moldenhauer, N.W. Hudson, T.C. Sheng and S.-W. Lee. Ankeny, Iowa: Soil and Water Conservation Society.

Suwardjo, H., Ai Dariah, and A. Barus. 1991. Rehabilitation of Degraded Land in Indonesia. In *Development of Conservation Farming on Hillslopes*, edited by W.C. Moldenhauer, N.W. Hudson, T.C. Sheng and S.-W. Lee. Ankeny, Iowa: Soil and Water Conservation Society.

USAID. 1985. Erosion in Indonesia. Washington, D.C.: U.S. Agency for International Development.