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Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to 2020

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Foreword

Among the most problematic issues considered as part of IFPRI's 2020 Vision initiative, which seeks to develop an international consensus on how to meet future food needs while reducing poverty and protecting the environment, are the environmental questions. And the issue addressed in this discussion paper is particularly difficult. How is land degradation affecting the ability of farmers to produce adequate food supplies today, and what is the prognosis for the year 2020? As populations grow, farmers are forced to cultivate smaller and smaller plots, where the soil eventually becomes depleted, or they expand onto marginal lands—fragile hillsides, semi-arid areas, cleared forestland. Once these lands become damaged, can they be repaired?

These questions are hard to answer because little has been done to quantify and categorize the degraded lands. We need to know where degradation is occurring, what forces have caused it, and what steps must be taken to rehabilitate degraded land. More than anything we need to know what policies work to promote good land husbandry in developing countries, where farmers mostly degrade the land out of necessity, not greed.

The workshop that led to this paper is only a first step in a concerted effort to identify the regional "hot spots" where degradation is now rampant and the "bright spots" where remediation is already under way. The most important contribution of the participants of this workshop, however, is the list of 10 policy recommendations they devised to encourage better management of agricultural lands. If the 2020 Vision is to become a reality, we must begin to put their recommendations into practice.

Per Pinstrup-Andersen
Director General, IFPRI

Acknowledgments

This paper represents a synthesis of the findings of International Food Policy Research Institute (IFPRI) research, several literature reviews, and the expert judgment of the group of distinguished researchers and development leaders who participated in the workshop on land degradation in the developing world, held April 4–6, 1995, in Annapolis, Maryland, U.S.A. We would like to acknowledge the input and comments on this paper from our colleagues Bruno Barbier, Lee Ann Jackson, and Scott Templeton. They helped by synthesizing the output of the workshop as well as presenting papers there.

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1. Introduction

In 1994, the International Food Policy Research Institute (IFPRI) began an initiative for "A 2020 Vision for Food, Agriculture, and the Environment" to evaluate current conditions and trends in food production, consumption, and distribution and to facilitate an international consensus on the directions that policy should take over the next 25 years. Among the most hotly debated elements in those projections is the extent and effect of land degradation. Some perceive that land degradation poses a potential threat to global food supplies over the long term (Pimentel et al. 1995; Brown and Kane 1994), while others argue that land degradation is overestimated and, in any event, relatively unimportant to global food supplies (Crosson 1994). Many others worry about the effects of land degradation on the livelihoods of rural dwellers, particularly in the more marginal agricultural areas (IFAD 1992). Further expansion and intensification of food production could also have a potentially degrading effect on the environment (Pinstrup-Andersen and Pandya-Lorch 1994).

The technical difficulties of assessing land degradation, the weakness of existing databases, and the poorly explored linkages between land degradation and other aspects of rural development have made this a particularly difficult area to analyze for the 2020 Vision initiative. The debate about land degradation has largely been framed by soil scientists and ecologists, and has emphasized biophysical processes and land management techniques. IFPRI's 2020 project sought to place land degradation issues within the broader context of rural development policy, and to emphasize the dynamics of land management.

To evaluate and supplement the results of its own research efforts, IFPRI organized an international workshop, bringing together a group of experts to assess the current situation and look forward to the challenges of 2020. The objective of the workshop was to answer the following questions:

1. How important a threat is agricultural land degradation, now and in 2020, to global and national food supplies, rural income, and environmental stability?
2. Where are the "hot spots" of land degradation deserving particular policy attention?
3. What are the current patterns and future prospects for significant agricultural land improvement to reverse or compensate for land degradation?
4. What are the most promising avenues for policy intervention to reduce degradation and promote land improvements?

The 35 workshop participants from 14 countries were drawn from a wide range of disciplines in the social and natural sciences, from research and development backgrounds, and from public and nongovernmental organizations. The group was selected to include individuals with in-depth experience in Africa, Asia, and Latin America, and in the major tropical and subtropical ecoregions (Appendix 1).

The three-day workshop was divided into two parts (Appendix 2). The first half was used to present and discuss results from four research papers prepared by IFPRI:

1. A literature review comparing existing studies of the scale and effects of land degradation (Yadav and Scherr 1995);
2. A modeling exercise to simulate some of the effects of land degradation on global food production, trade, and consumption (Agcaoili, Perez, and Rosegrant 1995);
3. A modeling exercise to simulate the process of land use intensification in the drylands of the Sahel to 2020 (Barbier 1995); and
4. A review of ecological principles, trends in population and natural resource degradation and improvement, and microeconomic foundations for changes in land management in tropical hillsides, and their implications for policy (Scherr, Jackson, and Templeton 1995).

In the second half of the workshop, participants divided by regional expertise into working groups for four major regions: South and West Asia, East and Southeast Asia, Africa, and Latin America. The groups identified current and potential future "hot spots" of land degradation and "bright spots" of land improvement, and recommended policy action to reduce degradation and promote land improvement.

This paper synthesizes the discussions and recommendations of the workshop. Chapter 2 summarizes perspectives on the global trends and effects of land degradation. Chapter 3 describes some of the key degradation problems and potentials for land improvement specific to the different tropical regions, both currently and to the year 2020. Policy recommendations are presented in Chapter 4 and conclusions in Chapter 5.

2. *Global Trends and Effects of Land Degradation and Improvement*

Defining Land Degradation and Improvement

"Land" includes not only the soil resource, but also the water, vegetation, landscape, and microclimatic components of an ecosystem.[1] "Land degradation" refers to a temporary or permanent decline in the productive capacity of the land,[2] or its potential for environmental management.[3] "Land improvement" is an increase in this productive potential (Table 1). Net productivity change reflects both natural- and human-induced processes of degradation and improvement.

Some types of land degradation are, for all practical purposes, irreversible. Examples are severe gullying and advanced salinization. In these cases, the long-term biological and environmental potential of the land has been compromised. Displacement of soil material (erosion) is also irreversible, although its long-term effects on productive capacity depend on the depth and quality of soil remaining.

Most types of soil degradation, however, can be prevented or reversed by, for example, adding nutrients to nutrient-depleted soil, rebuilding topsoil through soil amendments, re-establishing vegetation, or buffering soil acidity. The practicality of rehabilitating degraded landscapes depends on the costs relative to the value of output or environmental benefits expected. Where farmers wish to intensify agricultural production on a sustainable basis, it may be necessary to undertake such land-enhancing or land-protecting investments even in nondegraded landscapes.

"Degradation" is, by definition, a process of change over time. From a policy perspective, it is critical to distinguish those lands that are currently undergoing degradation, in order to assess the need for action to stabilize or reverse the process. Other lands may have reached a degraded state relative to their "natural" condition many decades or centuries ago, but are currently in a stable or improving condition. The "land degradation problem" is, for practical purposes, the former areas.

Measuring Degradation and Its Effects

It can be difficult to assess the actual extent and impact of land degradation. Farmers often mask the effects of degradation by converting their land to less demanding uses or increasing levels of compensating inputs (for example, applying more fertilizer just to maintain stable yields). There is rarely a one-to-one relationship between the amount of degradation and the effect on yields. For example, on a relatively deep soil, erosion can be quite severe for long periods of time before there is any measurable effect on

[1]Note that the United Nations definition used in the International Convention to Combat Desertification also includes associated animal populations and human settlement patterns (FAO 1995). These components were addressed in the workshop only peripherally, through discussion of the effects of land degradation on habitat.

[2]In economic terms, "productive capacity" is the attainable annual output (of product yield, of natural vegetation, water flow, and so forth) at a fixed level of nonland inputs. For example, if higher and higher levels of fertilizer are needed to maintain stable crop yields, then some type of soil degradation has probably occurred. Note that it is difficult to use a simple definition, since yield response will often differ, depending upon the associated input or the type of output.

Productivity declines may be due directly to soil degradation, for example through depletion of soil nutrients, soil toxicity, or soil waterholding capacity, or indirectly, for example through infestation of degraded soils by persistent weeds that reduce yields.

[3]Environmental management includes recycling of nutrients, amelioration and filtering of pollutants, transmission and purification of water, and encouraging vegetative growth to act as sinks for greenhouse gases.

Table 1—Types of land degradation and improvement

Component	Degradation	Improvement
Physical soil management	Crusting Compaction Sealing Wind erosion Water erosion Devegetation Overtillage	Soil conservation barriers (live, inert) Terracing Revegetation of denuded lands Tree protection Soil decompaction Breaking up of pans Covercrops Windbreaks Soil deposition Improved tillage methods
Soil water management	Impeded drainage Waterlogging Reduced waterholding capacity Reduced infiltration Salinization	Irrigation Water harvesting Field drainage Draining of waterlogged areas Filter strips
Soil nutrient and organic matter management	Alkalinization Acidification Nutrient leaching Removal of organic matter Burning of vegetative residues Nutrient depletion	Fertilization Composting Green manuring Animal manuring Flushing of saline alkaline soils Liming acid soils
Soil biology management	Overapplication of agrichemicals Industrial contamination	Introduction of biotic organisms Nitrogen-fixing microorganisms
Vegetation management	Decline in vegetative cover Decline in biodiversity Decline in species composition Decline in availability of valued species	Increased vegetative cover Increased species diversity Improved species composition Improved availability of valued species

crop yields. There is limited empirical evidence of the critical thresholds at which degradation processes produce economic or environmental effects for different soil types, climates, and crops.

Most measurements have traditionally been taken at the plot level, which may not be appropriate for drawing conclusions at the farm or policy levels. Scientists increasingly agree that measurements should be sampled within a watershed framework; however, suitable methodologies to estimate the extent and magnitude of the effects are still under development. Watershed models are also being used, but these often suffer from lack of critical information about farmers' management of degradation.

In making economic assessments of the impact of degradation, various approaches are used. Degradation costs may be measured as the costs of replacing lost nutrients, as the value of the lost yield, as the value of increased farm inputs required to maintain yields, or as the cost of rehabilitating the plot to its former condition. The more aggregate estimates of the costs of degradation must be taken with caution, as such aggregates are mostly based on standard formulas relating certain levels of degradation to estimated yield losses. Based on these estimated yield losses, the market value of lost production is determined, as well as the amount of inputs needed to raise productivity to earlier levels.

The Scale of Land Degradation

Not until the past decade have scientists initiated systematic attempts to assess the nature and extent of agricultural land degradation at a regional or global scale and to explore its effects on food supply. Since this work is in its infancy and the methodologies for sensible assessment are still under development, the estimates below should be considered indicative at best.

The most important studies on land degradation designed for purposes of international comparison are the Global Land Assessment of Degradation (GLASOD) mapping exercise by Oldeman, Hakkeling, and Sombroek (1990) and the comparative study of drylands by Dregne and Chou (1992).[4] Both depend on expert judgment. The GLASOD map was developed by asking teams of experts in 21 regions to evaluate human-induced soil degradation since World War II, using systematic criteria. The GLASOD study defined degradation as a process that lowers either the current or future capacity of the soils to produce goods or services or both. Types of degradation included water and wind erosion, chemical degradation, and physical degradation. The Dregne and Chou study includes vegetation as well as soil degradation; conclusions were synthesized from a systematic evaluation of a large number of preexisting studies by different researchers. The Dregne and Chou study defined desertification as a human-induced process of land degradation that can range in severity from slight to very severe, and can cause effects including erosion, salinization, toxic chemical accumulation, or vegetation degradation, irrespective of climate. In their paper, however, desertification is confined to land degradation in the drylands of the world.

The GLASOD study estimates that of 8.7 billion hectares of agricultural land, pasture, forest and woodland, nearly 2 billion hectares (22.5 percent) have been degraded since mid-century. Some 3.5 percent of the total has been degraded so severely that it is reversible only through costly engineering measures, if at all. Just over 10 percent has been moderately degraded, and is reversible only through significant on-farm investments. Another nearly 9 percent is lightly degraded and easily reversible through good land husbandry practices.

Globally, GLASOD indicates that nearly half of this vegetated area is under forest, of which about 18 percent is degraded; 3.2 billion hectares are under pasture, of which 21 percent is degraded; and nearly 1.5 billion hectares are in cropland, of which 38 percent is degraded (Figure 1). Water erosion is the principal cause of degradation. Wind erosion is an important cause, particularly in drylands and areas with landforms conducive to high winds. Chemical degradation, such as salinization and nutrient loss, is the result of cropping practices; it accounts for a smaller overall proportion of degraded lands, but more than 40 percent of cropland degradation. Physical degradation such as compaction accounts for a smaller proportion of degraded area.

The Dregne and Chou study shows that of global drylands, 89 percent is rangelands (of which 73 percent is degraded); 8 percent is rainfed cropland (of which 47 percent is degraded); and 3 percent is irrigated cropland (of which 30 percent is degraded).

Various sources suggest that 5 to 10 million hectares are being lost annually to severe degradation. If this trend continues, 1.4 to 2.8 percent of total agricultural, pasture, and forestland will have been lost by 2020. Declining yields (or increasing input requirements to maintain yields) can be expected over a much larger area.

According to the GLASOD estimates, degradation of cropland appears to be most extensive in Africa, affecting 65 percent of cropland area, compared with 51 percent in Latin America and 38 percent in Asia (Figure 2). Degradation of pasture is also most extensive in Africa, affecting 31 percent, compared with 20 percent in Asia and 14 percent in Latin America. Forestland degradation is most extensive in Asia, affecting 27 percent of forestlands, compared with 19 percent in Africa and 14 percent in Latin America.

Effects of Land Degradation

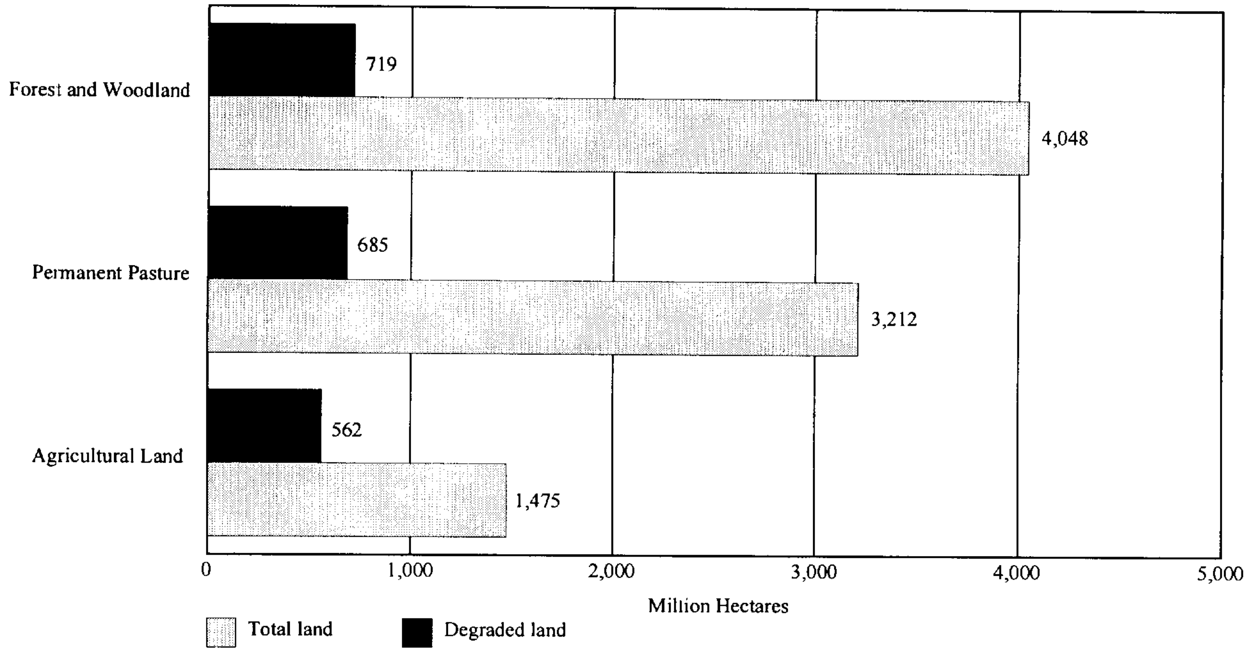
The most important on-farm effects of land degradation are declining potential yields. The threat of degradation may also be reflected in the need to use a higher level of inputs in order to maintain yields. Serious degradation sometimes leads to temporary or permanent abandonment of some plots. In other cases, degradation induces farmers to convert land to lower-value uses; for example, less-demanding cassava may be substituted for maize, fallow periods may be lengthened, cropland converted to grazing land, or grazing lands converted to shrubs or forests.

For some farmers, degradation on a particular plot causes few economic problems: they adopt a strategy of retiring that plot for a few years, or they use the soil eroded from the plot to build up topsoil

[4]The GLASOD study was designed to generate analysis at the continental scale; the sampling procedure does not permit us to draw conclusions at the national level. The Dregne and Chou study was designed for national analysis, but was limited by the availability of national studies.

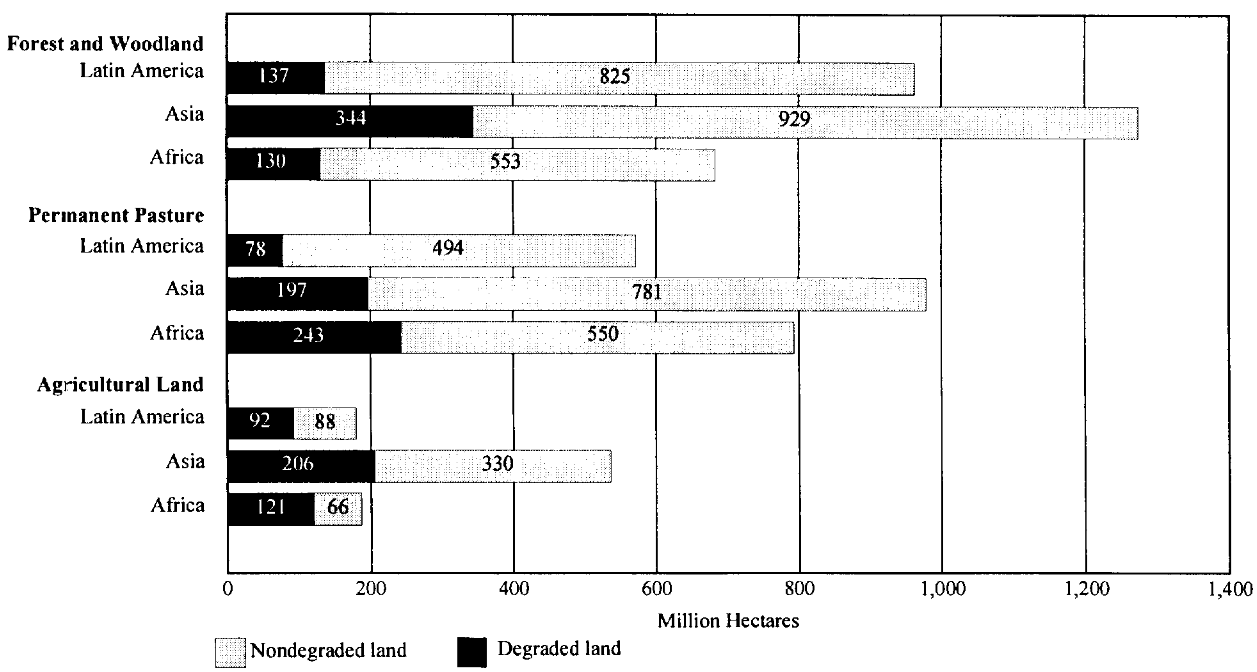
In the 1970s, the Food and Agriculture Organization (FAO) of the United Nations developed a widely used map of areas of soil erosion risk, but this does not indicate actual degradation.

Figure 1—Land degradation by type of land use: A global perspective



Source: Oldeman 1992; Oldeman, Hakkeling, and Sombroek 1990.
Note: Figures are cumulative over slightly, moderately, strongly, and extremely degraded lands.

Figure 2—Land degradation by type of land use: A regional perspective



Source: Oldeman 1992; Oldeman, Hakkeling, and Sombroek 1990.
Note: Figures are cumulative over slightly, moderately, strongly, and extremely degraded lands.

on a flatter, downslope plot. Moreover, degradation processes such as soil erosion are not necessarily associated with yield declines; the threshold of yield response to changes in land quality may occur at different points, depending on the species or variety of crop and soil type or depth.

Farmland degradation may also have important negative effects off the farm (economists refer to such effects as "externalities"). Examples include deposition of eroded soil in streams or behind dams; contamination of drinking water by agricultural chemicals; diversion of water sources from other users by irrigation; health problems or property damage caused by wind-eroded soil; or loss of habitat due to devegetation or degradation of agricultural lands.

On the other hand, nonfarm groups may also create externalities that contribute to farmland degradation through their use and management of natural resources. Examples include urban sprawl, soil pollution from industry or waste management, diversion of local water sources to distant or nonagricultural users, road and infrastructure building practices that erode farm landscapes, and rules to protect biodiversity that restrict agricultural land use and management.

Global and National Estimates of Land Degradation

Globally, there are few studies of the impact of degradation on agricultural production. Global estimates of the monetary value of productivity losses due to land degradation in drylands range from US$13 billion to $28 billion per year (Yadav and Scherr 1995).[5] A global estimate of soil erosion costs is $26 billion per year, $12 billion of which is in developing countries (UNEP 1986). All forms of land degradation in South Asia are estimated to cost $9.8 billion to $11 billion per year (UNDP, FAO, and UNEP 1993). These estimates must be judged against a total value of agricultural gross domestic product in 1985 of about $231 billion for Africa, $126 billion for Asia, and $63 billion for Latin America (WRI 1994, Table 18).[6] A recent analysis based on the GLASOD and Dregne and Chou data suggests that globally, there has been a 17 percent cumulative productivity loss over 45 years (1945–90), due to degradation (Crosson 1994). It should be noted that during this same period growth in global food production and secular declines in grain prices were unprecedented; clearly other factors dominated the effects of degradation on aggregate performance.

Agcaoili, Perez, and Rosegrant (1995), using a global food production and trade model developed at IFPRI, simulated the effects of an additional 10 percent decline in crop productivity after 25 years in developing countries, and a more severe degradation in Pakistan and China.[7] These scenarios would lead to a reversal in the otherwise projected decline in world food prices. This in turn would lead to worsening malnutrition in the developing world. They estimate that there would be 7 to 9 million additional malnourished children, above the baseline estimate of 206 million. Wheat imports would rise in developing countries, particularly in West Asia and China in the second degradation scenario. These results are due to a contraction in production and reduced consumer demand caused by higher prices.

This analysis suggests that declining food supplies from specific regions (due to degradation or any other factor) will have only a modest effect on global food supplies because of the potential for substitution from other producing areas. Other factors may affect global food supplies and nutritional status more than land degradation. In this model, for example, the simulated effects of a decline in investment in agricultural research and infrastructure produce downturns of a similar magnitude. Poverty caused by structural under- and unemployment is responsible for much of the malnutrition.

However, there could be quite dramatic effects from land degradation in those countries and subregions where the problems are most serious. The accelerated degradation scenarios for China and Pakistan in the model show significant effects on national food supply, trade, and malnutrition. For example, China's wheat import demand would rise

[5]In this paper, all dollars are U.S. dollars.

[6]These figures do not include China, Vietnam, or 8 other countries in Asia, 19 countries in Africa, or 7 countries in Latin America.

[7]This scenario assumes conditions of the first scenario but adds the following assumptions: (1) further reduction in crop yield growth in Pakistan of 50 percent; (2) imposition of a 1 percent per year decline in crop area in Pakistan (due to salinization); (3) further decline in rice yield growth in China of 5 percent, and (4) further decline in other crop yield growth in China of 21 percent.

from 26 million metric tons in the baseline to 35 million metric tons under severe degradation.[8]

Continent-wide losses in crop yields due to past erosion were estimated by Lal (1995) for Africa, based on existing quantitative data on erosion rates and productivity relationships. This analysis suggests that yield reductions due to past erosion may range from 2 percent to 40 percent, with a mean of 8.2 percent for the continent and 6.2 percent for Sub-Saharan Africa. The annual reduction in total production for Sub-Saharan Africa due to erosion in 1989 was estimated at 3.6 million tons for cereals, 6.5 million tons for roots and tubers, and 0.36 million tons for pulses. If accelerated erosion continues unabated, yield reductions by the year 2020 may be 16.5 percent for the continent and 14.5 percent for Sub-Saharan Africa.

National estimates of the crop productivity effects of land degradation are available for more than a dozen developing countries. Seven African countries with fairly comparable data show rates of 0.04 percent to 11 percent annual losses in production. Evidence from four Southeast Asian and three Middle Eastern countries indicates a decline in productivity greater than 20 percent, with declines of more than 50 percent in upland crop yields in some regions (Yadav and Scherr 1995). A comparative study by Böjo (1994) of the annual monetary effects of land degradation in nine African countries suggests that these represent less than 1 percent of agricultural gross domestic product (AGDP) in most of the countries. Exceptions include estimates from Ghana and Ethiopia of up to 5 percent of AGDP, 3 percent in Malawi, and 9 percent in Zimbabwe. The highest rates of productivity decline reported from subregional data are found in hilly areas, dryland cropping areas, irrigated lands subject to salinization, and rangelands.

Only two major studies—of salinization and waterlogging effects in irrigated croplands in India (Joshi and Jha 1991) and of soil erosion and salinization in China (Rozelle and Huang 1995)—carefully disaggregate effects of soil productivity change from changed input levels or crop value. The latter found grain yield in China reduced by 19.1 percent due to erosion, by 0.2 percent due to salinity, and by 11.1 percent due to multiple cropping intensity. In a random sample of 110 farmers from four villages in Uttar Pradesh, Joshi and Jha found a 50 percent decline in crop yields over eight years due to salinization and waterlogging in irrigation systems.

Land-Improving Investment by Farmers

Unfortunately, no data are yet available estimating the scale and effects of land improvements. Even data on changing areas under irrigation are difficult to compare across countries. Few developing countries monitor changes in areas under terracing, soil conservation practices, and so forth. A new study is under way, the World Overview of Conservation Approaches and Technologies (WOCAT), which attempts to use a decentralized, expert judgment approach to evaluate the use of a wide range of soil conservation technologies.[9]

In part due to the lack of data, no existing regional or global studies of sources of agricultural productivity change explicitly take into account such investments. Land-improving investments by farmers are usually implicitly included under "technological change," rather than as "farm investment." This confusion may cause misleading policy recommendations and certainly an underemphasis on farmland investment as a policy focus.

What is known about the process of land improvements thus comes primarily from case studies. There is a fairly rich literature documenting both intensification and extensification[10] of land use and degradation problems associated with both (see, for example, Boserup 1981; Tiffen, Mortimore, and Gichuki 1994; Ruthenberg 1980; Templeton and Scherr 1996), although comparative analysis is difficult due to noncomparable data and measurement techniques.

Where land degradation leads over time to declining production or increasing production costs,

[8]In this paper, all tons are metric tons.

[9]For information on WOCAT, contact the Group for Development and Environment (GDE), WOCAT, Institute of Geography, University of Berne, Hallerstrasse 12, 3012, Berne, Switzerland.

[10]The terms "intensification" and "extensification," in relation to land use, typically refer to a change in the total level of inputs used per unit of land per year. This may reflect a change in the frequency with which land is used (that is, the period of cropping relative to the period of fallow or the number of crops per year) or a change in the use of labor or variable inputs.

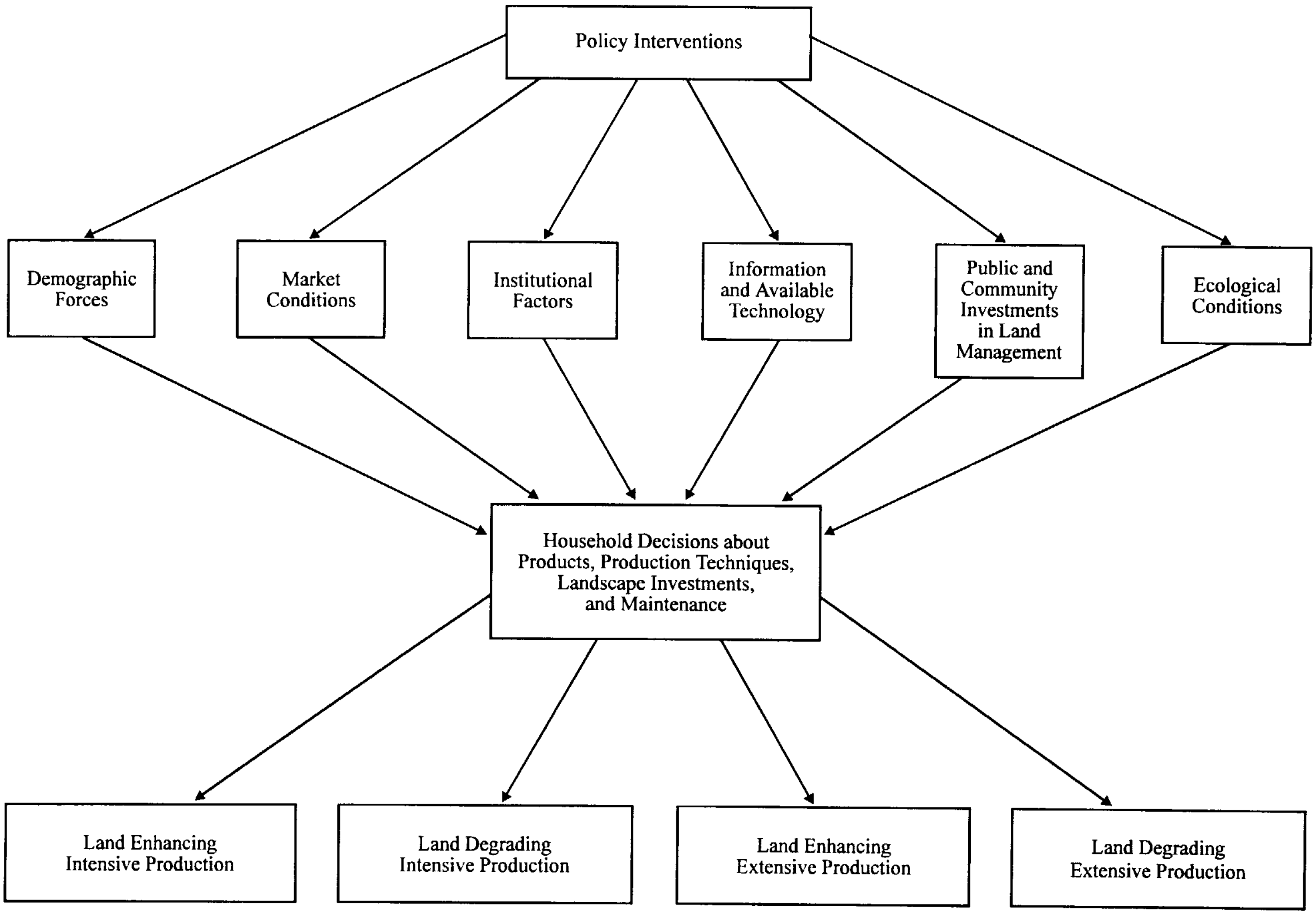
farmers are usually aware of the problem though not always the specific cause. Serious degradation is often associated with transition periods caused by major changes in population, land scarcity, or market demands.[11] If adjustment is not successful, degradation may lead to declining production or land abandonment. Historical and socioeconomic evidence suggests that farmers often respond actively to degradation by modifying their farming system or practices, either through independent innovation or by adopting practices known elsewhere. In successful adjustments, total output levels or environmental benefits may even rise. Whether farmers' welfare also improves depends on the productivity of household labor associated with technological and institutional change.

Barbier (1995) presents a multiperiod (recursive) model for 1995–2020 that simulates farmer adjustments to increased population and changing market conditions in two West African villages, one in the subhumid zone and the other in the semi-arid zone. Changing economic incentives over time lead to changes in crop choice, technology choice, land investments, and migration decisions, and consequently, changing household consumption. The study finds that population pressure would lead to land use intensification but not to higher incomes per capita. The cost of permanent agriculture, in cash and labor, would be high, particularly in the drier zone. The model also found that farmers tend to transfer nutrients, through crop residues, from marginal lands to the best lands. The model for the village in the subhumid region of Burkina Faso found that the per capita cost of land degradation by 2020 (mainly due to organic matter depletion) would be close to 30 percent of net income.

Scherr, Jackson, and Templeton (1995) note that a wide range of technically feasible, resource-protecting options are available for steeply sloping lands. Given low income levels and projected increases in the populations of hills and mountains, the question is whether farmers will choose the less degrading, more protecting options. Scherr, Jackson, and Templeton found no consistent relationship between population density or the frequency with which land is used for productive purposes and degradation of the land. Similarly, these authors found no consistent relationship between poverty and land degradation. Population growth and poverty create both incentives and disincentives for land degradation. Factors such as population density, markets and prices, information, institutional support, and intrinsic ecological conditions better explain observed patterns of intensification and natural resource outcomes (Figure 3). Public policies and research play a crucial role in supporting and accelerating transitions to land-enhancing production systems that also improve the welfare of people in these areas.

[11] Degradation commonly occurs, for example, during the conversion of forested lands to agriculture, the transition from shifting cultivation systems to permanent cropping and the shift from subsistence to commercially oriented farming systems. Each transition requires new strategies for managing soil nutrients, natural vegetation, and the landscape as a whole.

Figure 3—A conceptual framework for linking policy and land management choices



Source: Templeton and Scherr 1996.

3. *Regional "Hot Spots" and "Bright Spots"*

Continued land degradation to 2020 will present problems not so much for global supply as for development in particular subregions. In these "hot spots," land degradation poses a significant threat to food security for large numbers of poor people, to local economic activity, and to important environmental products and services. Future policy interventions should focus on such hot spots.

There are reasons to be hopeful, however. Many "bright spots" can also be identified—areas where land quality is improving or degradation has slowed down, usually in connection with improvements in rural investment incentives and supportive policies.

This section identifies some of the most important hot spots and bright spots in each major developing region. Significant differences exist in the patterns of land use among the regions, particularly where intensive agricultural systems are used. There are thus notable differences between the problems highlighted in the different regions. Priority concerns to 2020 will increasingly be related to environmental damage in Latin America (deforestation, water issues, or chemical pollution) and dryland and hillside regions where levels of poverty are high. In Africa, land degradation will continue to be linked to food security problems and to the lack of technologies for sustainable agricultural intensification in areas of rapid population increase. In South and West Asia, the principal degradation problems are those that threaten irrigated food supply (salinization) and the livelihood of the poor in dryland areas (devegetation). In the richer areas of East and Southeast Asia, environmental concerns will also come to the fore, particularly water issues. In the poorer areas of this region, threats to food supply from stagnating yields in irrigated areas, loss of land to invasive *Imperata* grass, and the challenges of managing lower-fertility and sloping lands are likely to be more important.

The information in Tables 2 and 3 is incomplete, based as it is on the experience of a small though distinguished group of experts. Most of the major problems are probably reflected in the tables, but it is clear that a more rigorous exercise of this type is needed to guide policy priorities and action.

South and West Asia

Scenarios to 2020

In looking ahead to 2020, major changes are anticipated for South and West Asia.[12] With rapid urbanization, population growth, and market integration, dependence on farming and land-based activities is likely to be reduced. Off-farm income will have to become more important in rural areas, particularly to support populations in the drylands. The development of improved livelihood systems will call for changes in social institutions and a changing role for agricultural research and development institutions.

Overview of Degradation

The GLASOD study estimates that approximately 27 percent of total agricultural land, permanent pasture, and forest and woodland areas in Asia as a whole are affected by some form of soil degradation. More than 50 percent of these degraded lands lie in dry regions. Agricultural land is most affected, followed by forests and woodlands. The major processes of soil degradation are water and wind erosion. Although areas affected by salinization and fertility decline are relatively small, the economic conse-

[12]Working groups for four regions convened at the conference. The Working Group for South and West Asia covered Syria, Jordan, Lebanon, Iran, Iraq, Saudi Arabia, United Arab Emirates, Oman, Afghanistan, Pakistan, India, Nepal, Bhutan, Bangladesh, Turkey, and Sri Lanka. Peter Oram of IFPRI provided additional information about the Middle East.

Table 2—"Hot spots" for land degradation

Nutrient Depletion	Salinization	Constraints to Yield Increases	Erosion
		South and West Asia	
Mid-altitude hills of Nepal (with decline in nutrient supplements from forests) Poor soil quality in areas of northeastern India in transition to permanent agriculture	Indus, Tigris, and Euphrates River basins	Rice-wheat region (unspecified stagnation) Lack of suitable technology for marginal arable lands in Syria, Jordan, and Iran	Foothills of the Himalayas Conversion of rangelands in West Asia to grain production, creating erosion
		East and Southeast Asia	
Nutrient mining in sandy soils of northeastern Thailand and remote upland areas in the region Poor quality soil in Myanmar, degrading in transition to permanent agriculture	Northeastern Thailand and China	Stagnant yields of intensive irrigated rice in dense areas of Java, China, the Philippines, and Vietnam (waterlogging, nutrient imbalance)[a]	Sloping areas in southern China and Southeast Asia
		Africa	
Semi-arid croplands of Burkina Faso and Senegal (leading to outmigration) Large areas under transition to short fallow or permanent cropping Reduction of silt deposits in the Nile Delta following construction of the Aswan High Dam	Nile Delta	Unsustainability of annual crops in humid lowlands of West Africa Densely populated highlands in Rwanda, Burundi, and Kenya—no obvious source of productivity increase Lack of suitable technology for crops grown in areas below 300 millimeters of rainfall in North Africa Poorly developed seed industry in North Africa	Subhumid southeastern Nigeria on sandy soils Wind erosion in Sahel Mechanization in North Africa causing water and wind erosion Mechanization with inappropriate plowing techniques, leading to devegetation and loss of topsoil (for example, transition zone in West Africa)
		Latin America	
Subhumid Central American hillsides[b] Semi-arid Andean valleys Northeastern Brazil Santa Cruz, Bolivia Caribbean Basin lowlands intensification	Northern Mexico Highland irrigation systems[a] South American irrigation zones[a]		Subhumid Central American hillsides[b] Semi-arid Andean Valley Haiti Cerrados of Brazil

Deforestation in Threatened Habitat	Vegetation Degradation	Water Scarcity or Conflict	Agrochemical Pollution
	South and West Asia		
	Rangelands, trans-Himalaya, West Asia, Pakistan, Rajasthan and Himachal Pradesh in India Grazing land in mid-altitude hills of Nepal, India, and Pakistan	Conflict in arid and semi-arid regions, especially the Euphrates River (Turkey, Syria, and Iraq) and the Jordan River (Syria, Jordan, and Israel) Depletion of the water table due to overpumping of wells (Syria)	Heavy use of pesticides on cotton in Turkey
	East and Southeast Asia		
Loss of biodiversity with forest clearing[a] Forest frontier of Indonesia, Malaysia, Vietnam, Cambodia, and Laos	Expansion of *Imperata* grasslands in Indonesia, Vietnam, and the Philippines Grazing lands in mid-altitude hills of Myanmar Devegetation of mangroves and drainage problems in coastal peats and acid sulphate soils	Conflict in high density areas[a] Urban water quality problems	Water pollution in high density areas and coastal areas Pollution from periurban agriculture Coastal and delta degradation due to sedimentation
	Africa		
Conflicts between farming and protected areas in Madagascar	Arid and semi-arid rangelands devegetation (for example, Ciskei), particularly near water sources Devegetation due to intensive collection of wood fuel Devegetation due to overstocking (for example, Morocco and Tunisia) Reduced yields due to *Imperata* and *Chromlaena* infestation in degraded soils	Water conflicts: Nile River, Niger River, Logone River, Chari River, and (pumping for irrigation) Senegal River Exhaustion of irrigation potential in North Africa by 2020 Nile and Senegal River systems' problem of allocation of water between agricultural and urban growth	
	Latin America		
Humid Amazon and Central American hillsides Lower Amazon Basin Itapua, Paraguay Pacific rainforest of Colombia and Ecuador Chaco region[a] Atlantic lowlands of Central America	Overgrazing in Haiti Northeast Brazil Lower Amazon Basin[a] Overgrazing in Caribbean Basin lowlands	Paramo water scarcity	Banana plantation pollution Santa Cruz, Bolivia, intensive agriculture Periurban agriculture in Mexico City

Source: Working Group Reports, Workshop on Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to the Year 2020, April 4–6, 1995, Annapolis, Md., U.S.A.
[a]Problems will become important by 2020.
[b]Current problem, expected to improve by 2020

Table 3—"Bright spots" for land improvement

Afforestation	Soil Conservation Practices	Water Management	Diversification to Perennial Crops
	South and West Asia		
Community forestry in India and Nepal		Multi-cropping through water harvesting in India Installation of modern watersaving irrigation technology in Jordan	Fragile lands (for example, mountains of Himachal Pradesh, India) Fruit, olive, and pistachio plantations in Jordan, Syria, and Turkey
	East and Southeast Asia		
Community forestry in Thailand, the Philippines, South China, and Indonesia, where population density is low Expansion to meet commercial demand[a]	Conservation farming in the Philippines and Thailand Other sloping areas	Aquaculture in densely populated areas of the Philippines, Malaysia, Thailand, Vietnam, and Indonesia	Multistory gardens in densely populated areas with volcanic soils in Indonesia and southern China Perennial plantations in areas of low population density with fragile soils in Malaysia, India, southern Thailand, and the Philippines
	Africa		
Active afforestation program in Morocco	Hillside conservation investment with increased population density in East Africa (Rwanda, Kenya, and Burundi) Successful conservation projects in Morocco West Cameroon, Fonta Djalon, and Guinea in West Africa	Small-scale irrigation in semi-arid region[a] Waterharvesting and gully prevention in Tunisia and Libya	Agroforestry systems for nutrient management and production[a] Olive, pistachio, and fruit plantations in Tunisia, Morocco, and Egypt
	Latin America		
Community-based forest plantations in the Andes and Guatemala Afforestation and agroforestry in Mexico and Chile Decrease in Amazon Basin deforestation rate Afforestation in Haiti and Central America[a]	Widespread adoption of conservation tillage, mulches, etc. in Mexico, Central America, Brazil, Argentina, Chile, Uruguay, and Paraguay Soil conservation, rehabilitation, and integrated pest management in Latin America	Effective control of salinization in irrigation systems (Mexico)[a] Expansion of small-scale irrigation in the Andes[a]	High-value fruit production in northern Chile and Costa Rica Conversion to coffee and other perennials on hillsides in southern Mexico and Central America Crop diversification with erosion control in Colombia

Sustainable Yield Increase	Dryland Rehabilitation	Greater Incentives for Land Investments	Habitat Conservation
		South and West Asia	
Green Revolution high-yielding variety (HYV) regions of Bangladesh, India, Nepal, Pakistan, and Sri Lanka	Shrub plantations in Syria and Jordan for livestock feed	Development of range cooperatives in Jordan	Major migratory bird reserve and wildlife breeding in Jordan
Soybeans in coastal belt and lower Ganges Plains;[a] black soils in India			
		East and Southeast Asia	
Green Revolution HYVs of irrigated rice		Favorable property rights in Vietnam, Laos, and Cambodia[a]	Increase in recreational areas[a]
Livestock production in northern Thailand, Indonesia, and the Philippines			
High-value production in Thailand, the Philippines, Malaysia, India, and China[a]			
Diversified rice-based cropping in Thailand, the Philippines, and India			
		Africa	
Maize and other grains in subhumid areas	"Holistic range management" promising for southern Africa	Favorable property rights in Ethiopia should encourage investment	
Irrigated cereals, legumes, and vegetables in the Nile Basin			
Development of phosphate fertilizer supply[a]			
Cotton in West Africa			
Semi-arid areas around Kano and Nigeria			
Periurban production of high-value crops			
		Latin America	
Green Revolution in staple foods in southern Brazil, northern Peru, Cerrao, and Mexican highlands	Revegetation of Mexican rangelands	Community-based consultation and organization of natural resource management	Biodiversity conservation schemes in southern Colombia and Costa Rica
Improved weed and pest control systems[a]	Improved pasture management in Mexico and northern Argentina	"People-centered" agricultural extension and development	More effective management of protected areas[a]
Agropastoral systems for lowland savannahs	"Holistic range management" promising in Mexico		

Source: Working Group Reports, Workshop on Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to the Year 2020, April 4–6, 1995, Annapolis, Md., U.S.A.
[a]Problems will become important by 2020.
[b]Current problem, expected to improve by 2020.

quences are high, as these problems occur in areas where population density is high and crop cultivation is intensive.

In South and West Asia particularly, degradation of soil and vegetation is widespread. Water erosion and declining soil fertility are major processes of land degradation in the humid zone, while wind erosion, waterlogging, and salinization problems are common in the dry zones. A recent study (UNDP, FAO, and UNEP 1993) estimated that about 73 percent of agricultural lands are degraded in South Asia by one or the other processes of degradation, especially deforestation, overgrazing, and improper agricultural practices.

Current and Future Hot Spots

Prime agricultural lands

- Salinization is a serious concern in the densely populated Indus River Basin and in the less populated Tigris and Euphrates basins. Without major policy shifts in water management, continued salinization in future decades could potentially threaten regional food security.
- Soil-related yield stagnation in rice-wheat production systems (still not fully understood) may become a problem by 2020.
- Heavy use of pesticides on cotton is a problem in Turkey.

Other agricultural lands

- Continued drought and water erosion in the densely populated semi-arid areas and the foothills of the Himalayan region are likely to exacerbate poverty and food insecurity.
- Soil fertility decline is occurring in the densely populated mid-altitude hills of Nepal, due to weakening of functional linkages between forestry and farming (for example, in provision of organic nutrients).
- Degradation is likely for large areas of poor quality soil across northeast India, where shifting cultivation systems are currently used, but farmers are under pressure to intensify.
- Suitable technology for marginal arable lands is lacking in Syria, Jordan, and Iran.

Rangelands

- Degradation of vegetation (cover and composition) is occurring in the rangelands of the Hindu Kush-Himalayas, West Asia, Pakistan, and Rajasthan and Himachal Pradesh states in India.
- Devegetation of grazing land in the moderately populated low and mid-altitude hills of India, Nepal, and Pakistan is occurring, due to inadequate or improper management of support lands for agriculture.
- A large extension of rangeland in the steppes of West Asia is being converted to grain production, leading to serious erosion.

Environmental issues

- Water conflicts and the possibility of climate change in arid and semi-arid regions pose the greatest threats by 2020. Of particular concern are the Euphrates River system (Turkey, Syria, Iraq) and the Jordan River system (Syria, Jordan, Israel).
- The water table is being depleted in Syria due to overpumping of wells.

Recent Bright Spots

Prime agricultural lands

- Staple food has increased production in irrigated and well-watered rainfed areas, through well-managed Green Revolution technology, in India, Nepal, Pakistan, Bangladesh, and Sri Lanka.
- Soybean production that is developing in the eastern coastal belt, the lower Gangetic plain of India, and central India is sustainable where appropriately managed.
- Modern watersaving irrigation technology has been installed widely in Jordan.

Other agricultural lands

- Fruit, olive, and pistachio plantations have been established in Jordan, Syria, and Turkey.
- Community-managed water and water-harvesting in some areas of India are producing three crops a year, where previously there was only one.
- Community forestry projects are becoming widespread in India and Nepal.
- There has been diversification into high-value perennial crops in some marginal and fragile lands (for example, the mountain zone of Himachal Pradesh State in India).

Rangelands

- Several million hectares of arid land in Iran have been rehabilitated.
- Shrub plantations have been established in Syria and Jordan.

- Range cooperatives have been developed in Jordan.

Environmental issues
- Major migratory bird and wildlife reserves have been established in Jordan.

East and Southeast Asia

Scenarios to 2020

East and Southeast Asia[13] are expected to experience continuing economic growth to 2020, which, together with rapid urbanization and industrialization, will change the focus of degradation concerns. Environmental issues will become much more important, particularly those related to water supplies and deforestation threatening important centers of biodiversity. Further intensification and product diversification will provide opportunities for high-value production in a range of land types.

It is expected that land scarcity will continue to create pressure for expansion of cultivation into marginal lands, particularly the hillside areas. The potential for sustainable, increased agricultural production in the irrigated areas will depend on successfully combating salinization, improved input use, and scientific advances to increase biological yield potentials.

Overview of Degradation

About one-fourth of total land in Southeast Asia appears to be degraded (FAO 1986). Water erosion is the major process, especially where lands have steep slopes and rainfall is high. Nutrient depletion is the other major process of degradation in the region. Wind erosion affects land along the coastal fringe. Deforestation and improper agricultural practices are major causes of degradation in the region. Urban encroachment on prime agricultural land lends greater urgency to the degradation issue.

Current and Projected Hot Spots

Prime agricultural land
- Salinization is affecting irrigated lands in moderately populated areas of northeastern Thailand and China.
- By 2020, intensive irrigated rice in densely populated regions of Java, China, the Philippines, and Vietnam could potentially suffer declining yields due to waterlogging and nutrient imbalances due to improper technology, seriously affecting food supplies.

Other agricultural land
- Erosion and decline of soil fertility (also associated with off-site damages) are affecting sloping areas in China and Southeast Asia with moderate population density and growth.
- Production potential from sparsely and moderately populated agricultural lands in Indonesia, Vietnam, and the Philippines has been lost due to infestation with *Imperata cylindrica*.
- Wind erosion affects large areas of sandy soils in northern China.
- Nutrient mining and erosion are degrading sandy soils in northeastern Thailand and remote upland areas in the region.

Environmental issues
- Biodiversity has been lost due to conversion of forest frontiers in Indonesia, Malaysia, Vietnam, Cambodia, and Laos, caused by high population growth.
- Agrochemical pollution has increased in periurban areas around Bangkok, Jakarta, and Manila.
- Devegetation of mangroves and associated problems with subsidence and drainage are reducing the productivity of peat and acid sulfate soils in coastal areas of Indonesia, Malaysia, Thailand, and Vietnam.
- Conflict over water resources is expected in all countries, in areas of high population density, with particular concerns about pollution and irregular provision.
- Coastal areas and deltas may deteriorate due to sedimentation loads and pollution.
- Degradation due to devegetation of grazing lands is now found in large areas of Myanmar under shifting cultivation, and there is pressure to intensify.

[13]The Working Group on East and Southeast Asia covered southern China, Myanmar, Southeast Asia, and west to the eastern border of western Bangladesh.

Current and Projected Bright Spots

Prime agricultural lands

- Production of irrigated rice has increased throughout the densely populated areas of Southeast Asia, due to high-yielding varieties, inputs of water and nutrients, and judicious use of chemicals.
- Sustainable intensification in densely populated areas of fertile soils in Indonesia and South China has been achieved through multistory garden systems.
- By 2020, further high-value production (for example, horticulture, animal production, and aquaculture) will develop, particularly in Thailand, the Philippines, Malaysia, Indonesia, and China, in high- to medium-density areas. This is likely to spur greater investment in land care.
- By 2020, more diversified and sustainable rice-based cropping systems will develop in Thailand, the Philippines, and Indonesia in densely populated areas.

Other agricultural lands

- In low-density areas where soils are prone to erosion with intensive tillage in Malaysia, Indonesia, southern Thailand, and the Philippines, use of perennial plantation crops has expanded.
- Aquaculture has developed in densely populated, fast-growing regions of the Philippines, Malaysia, Thailand, Vietnam, and Indonesia due to improved techniques and a growing market.
- Community forest development has spread in Thailand, the Philippines, Indonesia, and South China in areas of low population density and moderate growth.
- Livestock production has increased in northeastern Thailand, Indonesia, and the Philippines in areas of moderate population density and high growth, in response to major increases in demand for livestock products and improved technology.
- Systems of conservation farming[14] have been developed and disseminated in the Philippines and Thailand, in sloping areas of moderate and high population density and growth, due to new techniques and market opportunities.
- By 2020, there will be widespread adoption of conservation farming on sloping lands.
- By 2020, changing property rights in Vietnam, Laos, and Cambodia are likely to encourage greater investment in land improvements.
- By 2020, both community and farm forestry will expand to meet increased commercial demand for wood and nonwood forest products.

Environmental issues

- By 2020, there will be greater development of recreational areas, which will justify further conservation of habitat.

Africa

Scenarios to 2020

There was least consensus at the workshop about the current diagnosis and prognosis of land productivity change in Africa.[15] This was in part due to the great local variation in farming systems and conditions, and in part to varying degrees of pessimism and optimism about the availability of appropriate technology and the effects of the expected doubling of population.

Overview of Degradation

According to the GLASOD study, about 30 percent of total agriculture, permanent pasture, and forest and woodland areas in Africa are affected by soil degradation problems. Approximately two-thirds of agricultural lands and about one-third of permanent pastures are affected in the region. About three-fourths of these degraded lands lie in dry regions.

[14] "Conservation farming" is a generic term referring to a family of farming practices that improve land. Common components include improved land husbandry, hedges, agroforestry, or grasses and other perennials, typically planted in contour strips, alternating or intercropped with annual crops. Such systems attempt to provide integrated nutrient, soil, and water management, including practices such as residue management, minimum tillage, composting, and organic manures, with minimal use of chemical fertilizers and pesticides.

[15] Discussions of the Working Group on Africa covered Sub-Saharan Africa; additional information on North Africa was subsequently provided by Peter Oram of IFPRI.

The major processes of soil degradation are water and wind erosion, which are exacerbated by overgrazing and improper agricultural activities.

Current and Projected Hot Spots

Agricultural lands

- In most of the humid lowland area, soils are prone to nutrient depletion, acidification, and erosion. There are few sustainable intensive food crop systems available. Low prices for perennial export crops, which can be sustainable, have induced a transition to annual crops. By 2020, there may be crises in densely populated areas of humid lowlands of West Africa, where large-scale urbanization is expected.
- Severe gully erosion is found in some cropland areas of the humid region of southeastern Nigeria;
- Semi-arid cropping regions, for example, in Burkina Faso, Niger, and Senegal, are facing serious land degradation due to nutrient depletion, inadequate organic matter, and wind erosion.[16]
- Nutrient mining is occurring over significant areas of cropland under transition from long and medium fallow to short fallow or permanent cropping systems.
- Soil degradation has led to increased invasion of farmland by *Imperata*, *Chromolaena*, and other persistent weeds, resulting in declining crop yields.
- The adoption of mechanization with inappropriate plowing techniques and the removal of tree cover has led to soil degradation in many areas, particularly the transition zones of West Africa and the savannahs of southern Africa.
- Some areas in various parts of Africa have been devegetated due to overexploitation of wood for fuel.
- By 2020, there may be a crisis in densely populated highland areas in Rwanda, Burundi, and Kenya, where there are no obvious sources of further productivity increase.
- Silt deposits in the Nile Delta have been reduced since construction of the Aswan High Dam.
- The Nile Delta is becoming salinized.
- Mechanization in North Africa has caused water and wind erosion.
- Irrigation potential in North Africa will be exhausted by 2020.
- By 2020, there are likely to be major conflicts along the subhumid and semi-arid border zones, due to migrations induced by droughts and dryland degradation.

Rangelands

- Rangelands in parts of the arid and semi-arid regions are being devegetated, for example, in the Sahel, particularly near water sources.
- Devegetation is occurring due to overstocking in Morocco and Tunisia.

Environmental issues

- In Madagascar, conflict exists between protected biodiversity reserves and the deforestation and erosion caused by increasing hillside populations.
- By 2020, problems and conflicts over water access are likely to increase, particularly for key river systems such as the Nile and Senegal.
- By 2020, the increase in periurban, intensive agriculture is likely to lead to pollution problems.
- By 2020, there will be increased deforestation in Central Africa, mainly with conversion to unsustainable production systems.

Current and Projected Bright Spots

Agricultural lands

- Sustainable production of irrigated legume and vegetable crops has increased in the Nile Basin.
- Maize productivity in subhumid areas has increased, and by 2020, these areas could be a major granary for urban Africa, if problems of degradation associated with inappropriate management practices can be resolved.

[16]The effects of degradation are sometimes difficult to separate from those of poor rainfall, contributing to a continuing debate about the severity of degradation problems.

- There has been sustainable intensification of land use in the semi-arid areas around Kano, Nigeria. By 2020, there should be greater potential for periurban intensive production of high-value products.
- Active afforestation and soil conservation programs are under way in Morocco.
- Water harvesting and gully prevention have become widespread in Tunisia and Libya.
- Olive, pistachio, and fruit plantations have been established in Tunisia, Morocco, and Egypt.
- Investment has increased in hillside conservation in East Africa (Kenya, Burundi, and Rwanda) and West Africa (West Cameroon, Fouta Djalon in Guinea, Dogon in Mali), with increased population densities.
- By 2020, use of the limited area of vertisols[17] for intensive, mechanized (animal or tractor-drawn), rainfed agriculture will have increased.
- By 2020, there is likely to be greater land investment and improved technology adoption in Ethiopia, due to changes in institutional and property rights.
- By 2020, a range of agroforestry systems could contribute to soil nutrient management and production of diversified products.
- By 2020, with increasing population densities, there will be greater intensification of agriculture in some semi-arid regions, through small-scale irrigation and water harvesting.
- By 2020, extraction, stocks, and distribution of phosphate fertilizer should be developed in phosphorus-deficient areas.

Rangelands

- There have been several successful experiments to establish more sustainable management systems through communal organization in Southern Africa and West Africa. Improved pasture management under private ownership has also been achieved.

Latin America

Scenarios to 2020

The context for land productivity concerns in Latin America differs from that in the other regions. With the exception of parts of the Andes and Central America, population densities are low, relative to Asia and Africa, and rural populations are growing slowly or declining. There are still large, well-watered areas in forests or grasslands; however, much of this area constitutes important biodiversity reserves, and often it is rapidly degraded on conversion to cultivation. For these reasons, increased international resources are becoming available to support natural resource conservation.

Urbanization is leading to periurban farm conversion. Yet there is also a growing potential for increased resource transfers from rural to urban areas and associated loss of prime land for water, recreation, and other interests. Trade liberalization is increasing economic growth, although it also threatens smallholder maize production in the region. The expansion of democracy is facilitating rural organization and farmer-to-farmer information systems and reducing rural violence.

Overview of Degradation

According to GLASOD estimates, 18 percent of total agricultural land, permanent pasture, and forest and woodland areas in South and Central America are affected by soil degradation problems. Agricultural and pasture lands are affected most. Water erosion is the major process of soil degradation in the region, accounting for more than 50 percent of total degraded lands, followed by loss of nutrients. Both overgrazing and improper agricultural practices are prime causal factors accelerating degradation processes.

Current and Projected Hot Spots

Prime agricultural lands

- Salinization and some nutrient losses are affecting food supplies from irrigation systems in northern Mexico, along the coastal rivers of Peru, and in the Chaco region of Argentina and Bolivia. By 2020, salinization is expected to become a significant problem in other irrigated areas in South America.

[17]Vertisols are cracking clay soils that have high inherent fertility but are difficult to till.

- Expansion of commercial soybean production in the subhumid, subtropical Cerrados region of Brazil is leading to severe arable land erosion, some overgrazing, and nutrient loss, mainly causing environmental problems and loss of biodiversity.

Other agricultural lands

- The subhumid Mexican and Central American highlands and hillsides are experiencing severe deforestation on steep slopes, overgrazing, crop and grazing land erosion, nutrient loss, and deterioration of soil structure. These are associated with poverty, as well as environmental externalities in some regions.
- The semi-arid Andean valleys and highlands are also experiencing severe deforestation, overgrazing, crop and grazing land erosion, and nutrient loss, with consequent environmental problems.
- Salinization is a growing problem in the Andean highland irrigation systems, exacerbating poverty problems.
- The semi-arid and subhumid farming areas of Haiti are suffering from severe overgrazing, crop and pasture erosion, and nutrient loss, with associated effects on the national food supply and on rural poverty.
- In the semi-arid region of northeast Brazil, severe overgrazing and nutrient loss and some erosion and deterioration in the soil's waterholding capacity are associated with serious poverty problems.

Environmental issues

- The humid forest margins of the lower Amazon Basin and the upper Amazon hillsides are experiencing rapid deforestation, creating environmental problems and loss of biodiversity and leading to problems of overgrazing, erosion, and nutrient loss for farmers.
- By 2020, high rates of deforestation and biodiversity loss are expected in the Pacific rainforests of Colombia and Ecuador; the subhumid Chaco region of Bolivia, Argentina, and Paraguay; the subhumid/humid area of Santa Cruz, Bolivia; and the humid area of Itapua, Paraguay.
- By 2020, the banana plantations of Central America are expected to expand, causing further lowland deforestation and loss of biodiversity. Agricultural chemical pollution is expected to worsen.
- By 2020, the humid lowlands of the Caribbean Basin, where high-input diversified agriculture is developing, are likely to become a major hot spot due to overgrazing, nutrient and organic matter loss, and loss of biodiversity. Deforestation, grazing land erosion, and destruction of the coral reef will continue.
- By 2020, water supply problems are expected to become severe in the subhumid Paramo area of Ecuador.
- Periurban lands around Mexico City are likely to develop serious problems of agricultural chemical pollution, and conflicts over water supplies may arise.

Current and Projected Bright Spots

Prime agricultural lands

- High-value systems of fruit production for domestic and export markets have developed in northern Chile and Costa Rica, with increased water efficiency.
- Green Revolution-based staple food yield increases have been achieved in southern Brazil, northern Peru, the Cerrao, and the Mexican highlands. However, sustainability will depend on further increase in the use of no-tillage systems and improved management to overcome emerging problems of soil compaction, soil erosion, and pollution.
- By 2020, effective control of salinization in irrigation areas in northern and central Mexico is expected.

Other agricultural lands

- Erosion has been controlled on hillsides in parts of southern Mexico and Central America by converting annual cropland to coffee and other perennials, and in Colombia through crop diversification.
- By 2020, small-scale irrigation will have expanded in the Andean region.
- By 2020, adoption of conservation tillage, green manures, cover crops, mulches, and other practices is likely to be widespread in Central America, reducing (although not resolving) current problems.
- By 2020, there is likely to be increased use of integrated pest and weed management systems in Latin America.

- Community-based consultation and organization for natural resource management has increased in many areas. By 2020, improved systems of agricultural extension and development will be established, which will support farmer and community stages of land conservation and improvement.
- Reforestation and agroforestry establishment have been widespread in Mexico and Chile. Community-based forest plantations have been established in the Andean and Guatemalan highlands. By 2020, the trend will increase, particularly in Haiti and Central America.

Rangeland and pastures

- By 2020, pasture management in Mexico and northern Argentina will be improved.
- Revegetation of rangelands has been achieved in several areas of Mexico.

Environmental issues

- Biodiversity conservation schemes have been successfully established in Costa Rica.
- Deforestation rates have decreased since 1985 in the Amazon Basin.
- By 2020, land use systems in protected areas are likely to be more sustainable and more effective in conserving habitats.

4. *Policy Recommendations to Protect and Improve Agricultural Lands*

An effective response to land degradation calls for improving the incentives for farmers to care for their land and improving their access to the knowledge and inputs required for proper care. The 10 recommendations in this chapter are based on the workshop discussions of lessons learned from past successes and failures in managing land degradation.

The following policy recommendations aim to protect and improve agricultural lands:

1. Improve information systems for land management
2. Increase research and technology development for land improvement
3. Promote investment in land improvement
4. Modify property rights to encourage long-term land investments
5. Develop more flexible and participatory planning systems for sustainable use
6. Support local organizations to manage local resources
7. Develop marketing infrastructure
8. Correct distorted price incentives
9. Encourage rural income growth and diversification
10. Reduce discrimination against marginal regions in public investment

The first six recommend specific actions to improve land management; the final four recommend broader policies to influence the context within which farmers make short- and long-term decisions about land management.

1. Improve Information Systems for Land Management

There is a need to increase awareness of land degradation and improvement issues among political leaders and the broader society. These issues of land husbandry need to be integrated broadly into educational programs as well as in rural extension services.

Technical information about land improvement options needs to flow more quickly and widely among land users. Greater integration between rural land use sectors (such as forestry, agriculture, and agribusiness) and between disciplines (such as economics and soil science) is needed in developing extension programs. Methods developed by local farmers as well as those developed through scientific research should receive greater recognition and dissemination. Farmers' groups that work together to diagnose, design, and implement farm and community land improvements, such as the Land Clubs in Brazil and the Landcare Groups in Australia, could be central to achieving this goal.

A high priority is to develop geographically referenced, computerized information systems that can collect, store, and analyze data on natural and socioeconomic resources and that can disseminate, in "user friendly" format, information about the range of available options and techniques for different types of soils, climates, and farming systems.[18] Such information can be drawn from formal research, development project experience, or local farmer knowledge.

[18]Such information on soils and terrain is being developed through the Global and National Soil and Terrain Digital Database program called SOTER. Information about the program can be obtained from the International Soil Reference and Information Centre, P.O. Box 353, 6700 AJ, Wageningen, The Netherlands.

2. Increase Research and Technology Development for Land Improvement

High priorities are to promote public investment in research aimed at understanding land degradation and improvement and to develop resource-conserving, yield-enhancing technology. A much better diagnosis of "hot spots" and "bright spots" is needed to inform policy decisions and priority setting. The preliminary information in Tables 2 and 3 should be redone systematically at the national level to indicate approximate extent of area and population affected. Research is needed to understand the socioeconomic and policy conditions that are most conducive to investment in land management and to design specific policy instruments that promote these conditions.

Priority areas for technical research include soil fertility improvement through the use of such technologies as green manuring; use of local products as sources of macronutrients or amendments (for example, rock phosphate or lime); control of soil erosion and biological degradation; techniques for water harvesting; improved irrigation techniques, use of salt-tolerant plants to control salinization; and agroforestry systems. There is a particular need to collect more data on the yield and financial impacts of degradation and the private and public returns to investment of various types in land improvement.

Research approaches that integrate environmental and production concerns are needed (for example, agroecology). New, lower-cost strategies are required for technology development—probably with significant local experimental input—in order to address the need for technology appropriate to the wide microdiversity of conditions found in hillsides, drylands, and other heterogeneous areas. Formal scientific research should be complemented by active development and adaptation of low-cost systems incorporating local technical knowledge.

The private sector can play a significant role in some types of component and input research for more sustainable systems, particularly in Latin America and Asia. However, many types of resource management research are unlikely to offer major opportunities for private commercial gain and will have to be addressed by research in the public sector or by nongovernmental organizations (NGOs).

A greater effort is needed to survey and inventory areas of unique genetic value, and to establish international economic values for biodiversity and carbon sequestration.[19] This information is needed for effective planning and to permit development of international trade in environmental services.

3. Promote Investment in Land Improvement

Many of the more sustainable farming systems require significant investment in land improvement to support more intensive use. Examples of such investments include planting of trees and hedges, installing small-scale irrigation systems and pumps, developing windbreaks, terracing, and building up soil organic matter.

Promotion of such land improvements, particularly in the "hot spots," should be a development policy priority. Any such improvements should be designed together with farmers to meet their priority needs, using technology appropriate to local economic and social conditions. Low labor costs and the use of local materials encourage investment and maintenance. Strategies are needed to promote land improvements on both private farmland and on communal lands; experience suggests it may be easier to begin with investments on private land.

Governments, NGOs, and farmer associations can promote land investments through several mechanisms. Credit may be needed for improvements that require large initial lump sums. However, most interventions can be promoted incrementally, to reduce the need for external credit. Farm-level financial subsidies for land-improving investments are appropriate only under a limited number of circumstances. Subsidies to reduce the costs of inputs, technical information, or farmer organization may be useful to encourage farmer experimentation with new management systems or investments, but only for activities that are inherently profitable, and in circumstances where arrangements for long-term maintenance and management are in place. Extension and farmer organizations can play an important role.

[19]Scientists are concerned that release of carbon into the atmosphere from burning of fossil fuels in forest clearing and for other purposes exacerbates the problem of global warming. They currently hypothesize that some vegetative types hold or "sequester" carbon, cutting down on its release. Therefore, they recommend maintaining or expanding stands of these types of plants.

Where there are significant off-farm benefits to land improvement, cofinancing arrangements between farmers and outside beneficiaries can be explored. Direct payments to farmers for environmental services (such as reduced sedimentation or improved water quality) are an option, where the effects can be easily measured and directly attributed to farmer action.

While there is a clear role for national governments in coordination, information exchange, and research in many countries, the main role in promoting land-improving investments will fall on local governments. While ongoing efforts at government decentralization should, in the long term, enhance the level and quality of public attention to land degradation problems, in the short term there are serious shortfalls in local government capacity and funding to be overcome.

4. Modify Property Rights to Encourage Long-Term Land Investments

Secure property rights and rights of access to natural resources[20] are essential for long-term investment by farmers in land conservation and improvement, as well as to enable farmers or communities to negotiate in the development of management plans. Lack of secure tenure or rights is an important current constraint on farmer investment in land improvements.

Such security is essential, but does not necessarily require formal land titling. Insecure access and property rights for women farmers is a significant problem, particularly in areas where women are the principal land managers, either by tradition or due to labor migration by men. Protection of grazing areas for herders is a growing issue where crop production is expanding into traditional grazing areas. Rental arrangements in many regions actively discourage investment and sustainable land management. Regulations on access to public lands that define deforestation as "land improvement" may encourage farmers to deforest land they cannot manage.

In many areas, customary practice is evolving successfully to meet the new needs of intensification, investment, and access. Property rights policies must be flexible enough to accommodate and support a range of local adaptations. Where serious conflicts do emerge, property rights reforms should rely on careful prior consultation with users (including younger people who may not yet have inherited use rights), and set up mechanisms for ongoing conflict resolution, rather than fixing detailed legal rules.

A major area of concern is agricultural use rights to "public" lands, which were often established originally with forest or environmental policy objectives. With increased population and inadequate public resources to control immigration, many of these public lands have become de facto agricultural areas, yet farmers have few secure rights. A range of options is being explored to address this problem, including co-management schemes, privatization, and devolution. Agricultural, grazing or forest land rights may be vested in groups or communities, as well as individuals. The devolution of responsibilities for managing local resources to local organizations will usually mean specifying—and then enforcing—their rights. Such groups must also have access to the financial, technical, and other resources necessary for effective management.

A good land, forest, or water rights reform can bring long-term benefits after an inevitable early period of dislocation. Care must be taken, however; there is a long record of poor reforms that have created additional uncertainties and deterred, rather than encouraged, investment.

5. Develop More Flexible and Participatory Planning Systems for Sustainable Land Use

Land use planning in the past was based mainly on input from technical experts and central government policymakers; land use regulations and restrictions were the principal planning instruments. These planning models were generally not successful. They often ignored local interests (leading to noncompliance or resource expropriation), overlooked possibilities for

[20] Property and access rights to land and other natural resources take many forms and are often quite complex. The differences between private, public, and communal property may be less important than the specific "bundle" of rights to make land use decisions, to collect naturally growing products, to access water, to cultivate, to graze, to make land improvements, to plant trees, to rent, to inherit, or to sell, depending on formal and customary rights and regulations.

technical or organizational innovations to resolve conflicts between environment and production objectives, and led to plans that remained static in the face of dynamic economic and environmental change.

New paradigms emphasize participatory land use assessment and planning. These facilitate joint assessment of land degradation problems and possible solutions by different users and develop negotiated plans of action. Public agencies or an outside neutral agent may perform the role of facilitator. This approach has been successfully used in addressing problems of overgrazing and watershed management, and it could be adapted to problems of periurban land use planning, aquaculture pollution, and land management in forest margins. Appropriate tools need to be developed for this type of planning: databases, baseline surveys, training, organization, information dissemination, monitoring systems, and research. The approach can require significant organizational development and capacity building for farmers' groups and for local government.

A key responsibility of public policy is to develop mechanisms to mediate conflicts between different groups of land users created by the externalities of land degradation. Market mechanisms are typically unable to address these needs, particularly where important natural resource services or effects do not have a "market" or "price." Conflict mediation systems need to address the legitimate needs of various resource users, while protecting the resource base.

Legal limitations on the agricultural use of degradation-prone lands are not recommended, as their enforcement by outside authorities is often not feasible. In any event, technical options for non-degrading use do exist for most conditions.[21] Formal regulations on use and nonuse of particular technologies are not recommended, except perhaps in higher-income countries and regions with well-organized public institutions, and in situations where restrictions are well-grounded in research and widely seen as reasonable by the farm population.

Regulations should ideally focus on environmental outcomes (for example, defining acceptable levels of sedimentation from a critical watershed), rather than on specific farming practices. Migration into highly vulnerable areas could be slowed by restricting road construction and settlement programs.

It is important to recognize the basic conflict between land use for farming or forestry, and preservation of vigorously functioning natural habitats. Areas with habitat of great value for biodiversity should be carefully defined and protected; their number will necessarily be limited by the level of resources needed to do this well. Elsewhere, the priority objective should be sustainable farming, even while opportunities may be actively sought to maintain or protect some level of biodiversity.[22]

6. Support Local Organizations to Manage Local Resources

A more people-centered, participatory approach is likely to be more effective in addressing land degradation problems. In some cases, this may involve management of natural resources by local organizations, for example, local irrigation users' associations or range management organizations. Such control is appropriate where local people have a major stake in the resources. Public management may be more appropriate where local people's interest in the resource is peripheral.

Greater reliance on local organizations to address land management issues has several implications for public policy. First, it requires that restrictions and complicated permit systems for local organizations be lifted to reduce the costs of organization. Second, local organizations may need support to improve their management capacity. Often, local organizations and public agencies will need to work together to achieve land management goals, and institutions will have to be modified to play this role. New arrangements for collaboration between public research institutions, NGOs, and local organizations need to be developed for effective development and adaptation of resource-conserving, yield-enhancing technologies.

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[21]Conditions warranting absolute exclusion might include steeply sloping areas with soils prone to wasting or areas of highly valued natural habitat for biodiversity.

[22]Examples of integrating biodiversity concerns into sustainable farming include limited use of chemical pesticides, establishment of wildlife corridors throughout farming areas, in situ maintenance of crop biodiversity, and establishment of vegetative strips between farmlands and waterways to filter agrochemicals.

7. Develop Marketing Infrastructure

Poorly developed and distorted markets are major constraints to widespread adoption of land-improving practices. Nonexisting or poor maintenance of basic transport infrastructure, particularly roads, limits market-supported investment in land improvement, particularly in large parts of Africa and in the Andean region of Latin America. Improved infrastructure may be a necessary (though not sufficient) condition for large-scale land investment by farmers.

Input market liberalization and innovations can also help. New and more efficient systems for fertilizer delivery may be a solution to the problem of nutrient loss, especially in Africa. Fertilizer market liberalization in South Asia and purchase by local cooperatives of fertilizers in bulk are steps that could help.

Greater market liberalization for agricultural outputs is also desirable, particularly in Africa. Where food demand is strong, this will serve to increase farm-level incentives for investment. Opening up interregional trade can sometimes help to reduce the vulnerability to food shortages of populations in degraded areas.

The "infant industry" argument may be used to justify more active, interim government involvement in promoting new markets and marketing arrangements for more environmentally friendly products or inputs. Examples include alternative markets for organically grown products, tree products produced on farms, and energy sources that substitute for naturally grown wood fuel. Some of these new products may significantly alter the economic potential of marginal land (for example, ostrich farming in Zimbabwe). There may be potential in some regions for international trade in environmental services, which could create an economic alternative to farming in degradation-prone rainforest areas.

Overall, the continuing development of agricultural markets can be expected to transform patterns of production and land use throughout the developing world. Any strategy to address land degradation problems needs to be devised within a framework that anticipates and takes advantage of those changes.

8. Correct Distorted Price Incentives

Improved technical options, better information, and more secure land rights may not be sufficient to ensure widespread adoption of resource-conserving and -improving practices. Farmers will invest in land improvements and undertake resource-conserving management only if they have both the incentives and the means to do so. Unfortunately, current pricing policies for natural resources and inputs often discourage sustainable management.

Problems of salinization in irrigated regions could significantly improve if water pricing mechanisms, which now greatly undervalue water, were reformed. In Latin America and Southeast Asia, pricing of forest logging concessions should reflect their economic and other values, to reduce deforestation on lands that are difficult to manage intensively for farming. In Latin America, land tax systems, which currently encourage extensive, low-input management practices, should be improved and enforced. Governments should reconsider agricultural taxes, duties, price subsidies, exchange rate overvaluation, and other mechanisms that reduce farmers' incomes. New taxes should be considered on the "dirty dozen," the 12 most polluting and dangerous pesticides, to discourage their use and to reflect the costs of environmental and health externalities.

A careful analysis is needed of the potential value and costs of subsidies on chemical fertilizers in areas prone to nutrient depletion. In the past, subsidies have often led to diversion of supplies away from smallholders and disincentives for alternative nutrient management techniques. They may be fiscally unsustainable for the government. "Free" fertilizer donations from developed countries have discouraged development of local fertilizer industries.

However, a type of subsidy might be considered that constitutes a "co-investment" in increasing productive potential rather than simply increasing current yields. Such investments would be directed to areas where existing economic incentives do not justify farmers' purchase of fertilizer or use of other supplements, yet production without fertilizer initiates a cycle wherein inadequate vegetative matter increases erosion and long-term degradation and thus the profitability of future fertilizer application. Any fertilizer subsidies should be tied to a broader program of land improvement. For areas where fertilizer costs are unacceptably high for farmers due to infrastructure-related transport constraints, an interim subsidy on fertilizer may be justified, to be dropped once transport is improved.

9. Encourage Rural Income Growth and Diversification

General income growth and diversification can potentially help to reverse land degradation and promote land improvements through several mechanisms. Income growth can lead to growth in markets for diversified products, some more suitable to environmental conditions in marginal lands (for example, tree crops). Rising incomes create more opportunities for integrated crop-livestock systems, crop rotations, and high-value crops that help to justify land improvements. Reduction of international and regional trade barriers can provide opportunities for production of higher-value—or more environmentally suitable—products for export.

Urbanization clearly presents important opportunities for growth linkages in agriculture, with potentially positive effects for land management. However, urban-biased growth or urban growth promoted at the expense of rural producers is likely to lead to less labor and capital invested in farm improvements and may even lead to abandonment of current nondegrading practices. Evidence suggests that economic multiplier effects from increases in farm income are as large or larger than those of urban areas.

Furthermore, a reduction in rural poverty can reduce pressure for expansion of agriculture into more marginal lands, where such expansion is led by poor or landless migrants. Other strategies of rural poverty alleviation can reduce those types of land degradation that are due to inadequate investment resources or to unsustainable survival strategies of the poor during droughts or other economic downturns. Finally, rural economic diversification can provide alternative livelihood sources, reducing dependence on marginal farmlands or generating resources for investment in land improvements or both.

10. Reduce Discrimination Against Marginal Regions in Public Investment

Particularly in an era of structural adjustment and public budget cutting, but even under normal political conditions, there is a tendency to concentrate national public investment in urban areas and in the main bread baskets (or rice bowls), or centers of export agriculture. However, this strategy of discrimination against marginal agricultural regions in public investment and policy support has major short- and long-term negative consequences.

Past underinvestment in primary education, health, and family planning services in such areas has contributed to current problems of land degradation and weak efforts of land improvement. Public agricultural services can be relatively *more* important to farmers in marginal or difficult areas, which are less well-served by commercial interests. In many "hot spot" areas (such as the semi-arid/subhumid border area in Africa), such services will be crucial to prevent serious deterioration in land conditions. For example, hilly area development is a priority for the Southeast Asia region for achieving poverty alleviation, production, and environmental policy objectives. Even in areas where land use extensification is considered inevitable or desirable, the process of emigration and conversion to more extensive land uses requires critical attention to ensure that these do not accelerate land degradation.

A major challenge is to identify and build on the comparative advantages of these regions in national production and environmental services. Any such strategies must also strengthen the food security of these populations, who are exposed to conditions of greater risk and uncertainty. Land-improving investments can be instrumental in achieving both of these objectives. Public resources now used for food aid, famine relief, and aid for disasters associated with human-induced degradation can be rechanneled toward productive investment. International action to promote sustainable development in these areas, such as the Sustainable Mountain Development Initiative coordinated by the United Nations and the ecoregional initiatives of the Consultative Group on International Agricultural Research (CGIAR), such as the Desert Margins Initiative, should receive stronger support.

5. *Conclusions*

Land degradation could indeed be a potentially serious threat to food production and rural livelihoods by the year 2020, particularly in more densely populated pockets of rural poverty. Further expansion of cultivation into areas of fragile soils or critical habitats for biodiversity preservation can lead to significant environmental deterioration unless carefully managed. In areas with rapidly increasing domestic and industrial demands for water, and those where growing populations reside in water-scarce environments, poor agricultural land management in 2020 could threaten water availability, quality, and human health.

Many types of land degradation can potentially be reversed, but the process requires long-term commitment. Land-improving investments and better land management can definitely be encouraged through appropriate policies. Improved information systems and increased research and technology development are needed to develop and disseminate information on technical options. Public investment, co-financing, and training programs, together with supportive property rights, can promote farmer investment in land improvements. Institutional innovations in land use planning, particularly support for local organizations, should be explored. The broader policy context also should support rural development more generally, including developing marketing infrastructure, correcting distorted price incentives, encouraging rural income growth and diversification, and reducing discrimination against marginal regions in public investment.

It is urgent that policymakers assess the types of degradation issues that will be most critical for their countries in 2020 and begin to take action now. The international community can play a catalytic role in promoting such planning, supporting research and development of information systems, and comparing experiences of various countries with different policy strategies and policy instruments.

Appendix 1: Agenda

Workshop: Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to the Year 2020

Organized by the

International Food Policy Research Institute

AGENDA

MONDAY, APRIL 3

7:30 p.m.	Reception

TUESDAY, APRIL 4

OPENING SESSION

08:00 – 08:30	Overview of 2020 Vision Initiative Per Pinstrup-Andersen, IFPRI
08:30 – 09:00	Land Degradation Issues and Workshop Objectives Sara J. Scherr, IFPRI
09:00 – 09:30	Discussion
09:30 – 10:00	Coffee Break

SESSION 2:	**ASSESSING THE GLOBAL SCALE AND IMPACT OF LAND DEGRADATION**
10:00 – 10:30	Land Degradation in the Developing World: Is It a Threat for Food Production to the Year 2020? Part I: Scale of Degradation Satya Yadav and Sara J. Scherr, IFPRI
10:30 – 11:15	Discussion of Key Issues
11:15 – 11:45	Land Degradation in the Developing World: Is It a Threat for Food Production to the Year 2020? Part II: Productivity Impacts Satya Yadav and Sara J. Scherr, IFPRI
11:45 – 12:30	Discussion of Key Issues

12:30 – 02:00	Lunch Break
02:00 – 02:30	Impact of Resource Degradation on Global Food Balances Mercedita Agcaoili, Nicostrato Perez, and Mark Rosegrant, IFPRI
02:30 – 03:15	Discussion of Key Issues
03:15 – 03:45	Coffee Break
SESSION 3:	**PROSPECTS FOR LAND CONSERVATION AND IMPROVEMENT**
03:45 – 04:15	Policy Implications of Land Degradation in West Africa Bruno Barbier, IFPRI
04:15 – 05:30	Discussion of Key Issues
07:00	Group Dinner

WEDNESDAY, APRIL 5

08:00 – 08:30	Living on the Edge: Crafting Land Use Policies for the Tropical Hillsides in 2020 Part I: Land Use and Population Change in the Hillsides Lee Ann Jackson, IFPRI
08:30 – 09:15	Discussion of Key Issues
09:15 – 09:45	Coffee Break
09:45 – 10:15	Living on the Edge: Crafting Land Use Policies for the Tropical Hillsides in 2020 Part II: Microeconomics of Land Use Intensification in the Hillsides Scott Templeton, University of California, Berkeley
10:15 – 11:00	Discussion of Key Issues
SESSION 4:	**LAND DEGRADATION AND IMPROVEMENT: REGIONAL PERSPECTIVES**
11:00 – 12:00	Summary of Findings and Discussion of Working Group Themes 1. Current and future scenarios of land degradation and improvement to the year 2020 2. Potential impacts of land degradation on food production, poverty, and the environment to the year 2020 3. Action needed to promote critical agricultural land conservation, improvement, and increased production into the year 2020 Sara J. Scherr, IFPRI
12:00 – 12:30	Working Groups Meet (Themes 1 and 2) Group A: Latin America Group B: Africa Group C: South and West Asia Group D: East and Southeast Asia
12:30 – 01:30	Lunch Break
01:30 – 03:30	Working Group Meetings Continue
03:30 – 04:00	Coffee Break
04:00 – 05:30	Working Group Meetings Continue

THURSDAY, APRIL 6

(SESSION 4, continued): PLENARY

08:00 – 08:30	Presentation: Discussion	Group A (Latin America)
08:30 – 09:00	Presentation: Discussion	Group B (Africa)
09:00 – 09:30	Presentation: Discussion	Group C (South and West Asia)
09:30 – 10:00	Presentation: Discussion	Group D (East and Southeast Asia)
10:00 – 10:30	Coffee Break	

SESSION 5: ACTION TO PROMOTE LAND IMPROVEMENT: REGIONAL PERSPECTIVES

10:30 – 12:30	Working Groups Meet (Theme 3) Group A: Latin America Group B: Africa Group C: South and West Asia Group D: East and Southeast Asia
12:30 – 02:00	Lunch Break

(SESSION 5, continued): PLENARY

02:00 – 02:30	Presentation: Discussion	Group A (Latin America)
02:30 – 03:00	Presentation: Discussion	Group B (Africa)
03:00 – 03:30	Coffee Break	
03:30 – 04:00	Presentation: Discussion	Group C (South and West Asia)
04:00 – 04:30	Presentation: Discussion	Group D (East and Southeast Asia)
04:30 – 05:00	Synthesis of Workshop Findings	
05:00 – 05:30	Closing Remarks	

FRIDAY, APRIL 7

09:00	Walking Tour of Annapolis, Maryland Departures

Appendix 2: Participants

Workshop: Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to the Year 2020

Organized by the International Food Policy Research Institute

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1. *Alleviating Poverty, Intensifying Agriculture, and Effectively Managing Natural Resources,* by Per Pinstrup-Andersen and Rajul Pandya-Lorch, 1994

2. *Sociopolitical Effects of New Biotechnologies in Developing Countries,* by Klaus M. Leisinger, 1995

3. *Africa's Changing Agricultural Development Strategies: Past and Present Paradigms as a Guide to the Future,* by Christopher L. Delgado, 1995

4. *A 2020 Vision for Food, Agriculture, and the Environment in Sub-Saharan Africa,* edited by Ousmane Badiane and Christopher L. Delgado, 1995

5. *Global Food Projections to 2020,* by Mark Rosegrant, Mercedita Agcaoili-Sombilla, and Nicostrato Perez, 1995

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7. *Agriculture, Trade, and Regionalism in South Asia,* by Dean A. DeRosa and Kumaresan Govindan, 1995

8. *Major Natural Resource Management Concerns in South Asia,* by Gerard J. Gill, 1995

9. *Agriculture, Technological Change, and the Environment in Latin America: A 2020 Perspective,* by Eduardo J. Trigo, 1995

10. *Overcoming Malnutrition: Is There an Ecoregional Dimension?* by Manohar Sharma, Marito Garcia, Aamir Qureshi, and Lynn Brown, 1996

11. *Structural Changes in Demand for Food in Asia,* by Jikun Huang and Howard Bouis, 1996

12. *Middle East Water Conflicts and Directions for Conflict Resolution,* by Aaron T. Wolf, 1996

13. *The Transition in the Contribution of Living Aquatic Resources to Food Security,* by Meryl Williams, 1996

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