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Does Land Degradation Threaten Global Agricultural Productivity & Food Security?

Photo courtesy of USDA NRCS

Increased resource use and improvements in technology and efficiency have raised global food production more rapidly than population in recent decades, but 800 million people remain food insecure. Meanwhile growth in agricultural productivity appears to be slowing, and land degradation has been blamed as a contributing factor.

Estimates of land degradation's impact on productivity vary widely. Productivity losses have been estimated as high as 8 percent per year due to soil erosion alone (in the U.S.), and as low as 0.1 percent per year due to all forms of soil degradation (on a global scale). These differences make it difficult to assess potential impacts on food security or the environment, and thus the appropriate nature and magnitude of policy response.

Recent improvements in economic analysis of geographic data offer new insights. Research by USDA's Economic Research Service (ERS) indicates that land degradation does not threaten productivity growth and food security at the global level. Nevertheless, problems do exist in some areas, especially where fragile resources are found along with poverty and poorly functioning markets and institutions.

Growth in Population & Income Has Increased Demand for Agricultural Commodities

Global demand for agricultural commodities has increased rapidly since the mid-20th century as a result of growth in population, income, and other factors. The world's population nearly doubled over the past four decades, to 6 billion in 1999. World population growth has slowed in recent years, but is projected to reach 9 billion by about 2050. Per capita income is projected to grow by an average of about 2 percent per year over the next decade, continuing recent trends.

Based on these factors, the Food and Agriculture Organization (FAO) of the United Nations and the International Food Policy Research Institute (IFPRI) project that global demand for cereals will increase by 1.2-1.3 percent per year over the next several decades, while demand for meat will increase slightly faster. Most of the increased demand is projected to come from developing countries, especially in Asia.

Although demand growth is slowing and remains within the range of crop production growth rates achieved over the past several decades, demand growth will continue to put pressure on land and other natural resources for the foreseeable future.

Cropland Expansion Has Slowed & Land Quality Varies Widely

FAO reports that the total area devoted to crops worldwide has increased by about 0.3 percent per year since 1961, to 3.7 billion acres in 1998. Growth has slowed markedly in the past decade, to about 0.1 percent per year, as a result of weak grain prices,

Land degradation refers to changes in the quality of soil and water that reduce the ability of land to produce goods and services that people value. Some forms of land degradation, such as nutrient depletion, can be halted and even reversed relatively easily, for example by appropriate application of fertilizers. Other forms of land degradation, such as erosion or salinization, can be slowed or halted through appropriate management practices, but are generally very costly or time-consuming to reverse.

Agricultural productivity is a measure of the amount of agricultural output that can be produced with a given level of inputs. Agricultural productivity can be defined and measured in a variety of ways, including the amount of a single output per unit of a single input (e.g., tons of wheat per acre of land or per worker), or in terms of an index of multiple outputs divided by an index of multiple inputs (e.g., the value of all farm outputs divided by the value of all farm inputs).

Food security is generally defined in terms of access by all people at all times to sufficient food for active, healthy lives. As such, food security depends not only on how much food is available, but also on the access that people have to food—whether by purchasing it or by producing it themselves. Access depends in turn on economic variables such as food prices and household incomes, as well as on agricultural technology and the quantity and quality of natural resources.

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deliberate policy reforms (in North America and Europe), and institutional change (in the former Soviet Union). FAO estimates that an additional 6.7 billion acres currently in other uses are suitable for crop production, but this land is unevenly distributed, and includes land with relatively low yield potential and significant environmental value.

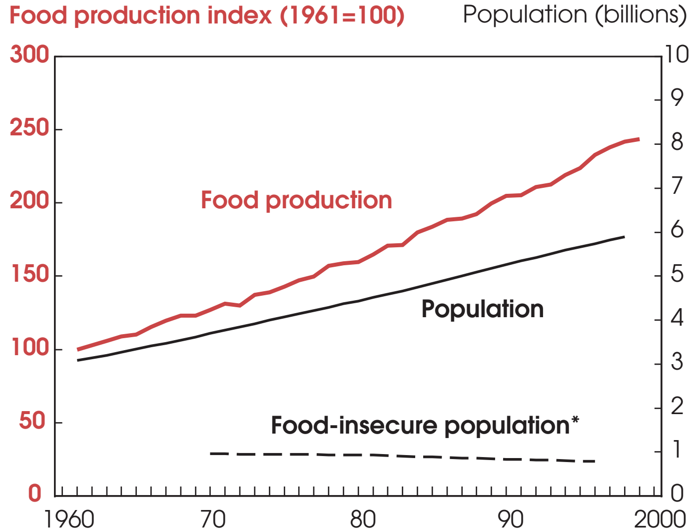
Given economic and environmental constraints on cropland expansion, the bulk of increased crop production in the future will need to come from increased yields on existing cropland. FAO data indicate that world cereal yields rose by about 2.5 percent per year from 1961 to 1990, but growth slowed to 1.1 percent per year in the 1990s. As a result of changes in input use (reflecting low cereal prices), market and infrastructure constraints, and low levels of investment in agricultural research and technology, IFPRI and FAO project that yield growth will slow further to about 0.8 percent per year over the next several decades.

ERS recently examined regional differences in cropland quality using geographic data on land cover, soil, and climate. Among the countries of sub-Saharan Africa, a median of 6 percent of cropland has soils and climate that are of high quality for agricultural production. The median proportion of high-quality cropland was higher in other regions, ranging from 20 percent among Asian countries to 29 percent among high-income countries (mainly countries in North America and Europe, plus Australia and Japan), and 30 percent among the countries of Latin America and the Caribbean.

Land quality changes over time as a result of natural and human-induced processes, but data on these changes are extremely limited. Only one global assessment has been done to date: the Global Land Assessment of Degradation (GLASOD) in 1991, which was coordinated by the International Soil Reference Information Centre for the United Nations Environment Programme. Based on the judgment of over 250 experts around the world, GLASOD estimated that 38 percent of the world's cropland had been degraded to some extent as a result of human activity since World War II (including 65 percent of cropland in Africa, 51 percent in Latin America, 38 percent in Asia, and 25 percent in North America, Europe, and Oceania). GLASOD identified erosion as the principal cause of degradation, affecting 4 billion acres (mostly in Asia and Africa). Loss of soil nutrients was the primary cause of degradation on 336 million acres (mostly in South America and Africa), while salinization affected 190 million acres (mostly in Asia) and 272 million acres were degraded as a result of other processes.

GLASOD did not estimate productivity losses associated with land degradation, but about 37 percent of the total degraded area was estimated to have been lightly degraded, indicating that productivity had been reduced somewhat but could be restored through modifications in farm management. Another 46 percent had been moderately degraded, indicating greater losses in productivity that would require costlier improvements to reverse. The remainder were identified as strongly or extremely degraded, implying losses in productivity that are virtually irreversible.

World Food Production Has Been Increasing Faster Than Population



*Note: Data are available only for 1970-96.
Source: Food and Agriculture Organization.

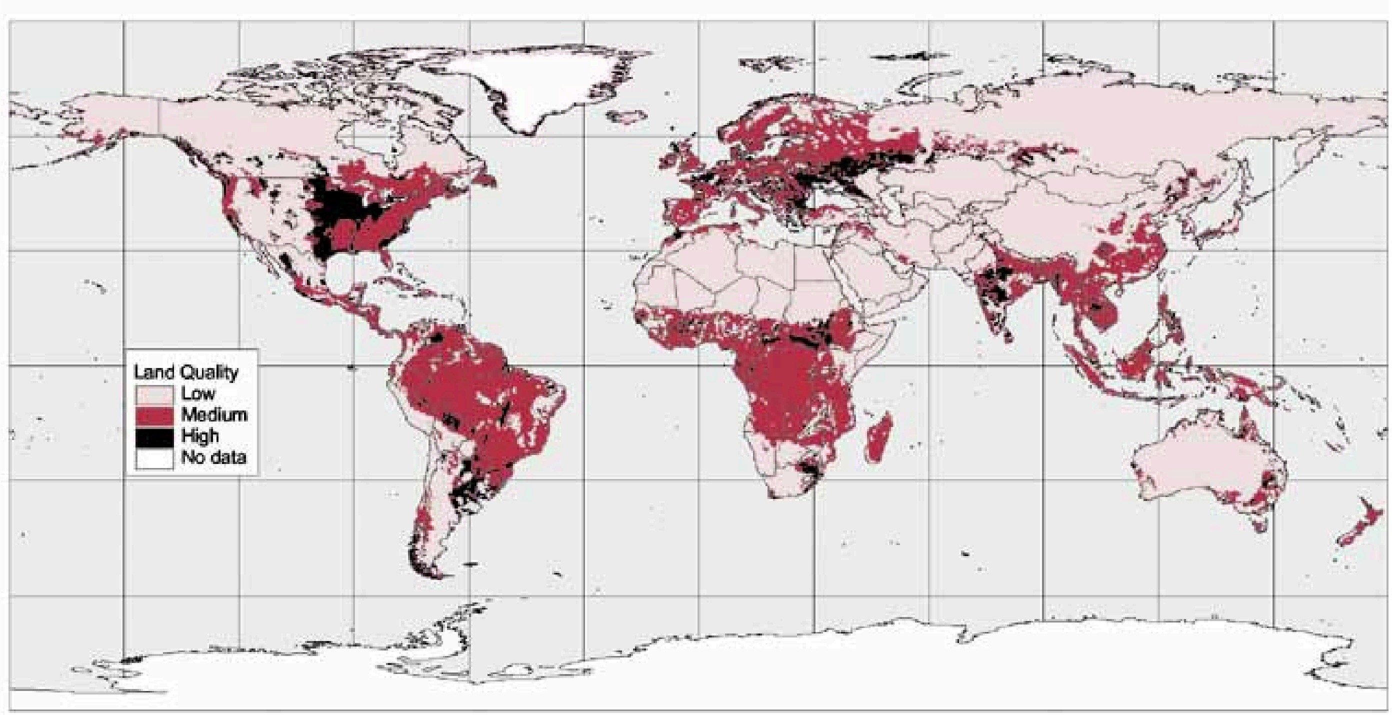
Economic Research Service, USDA

Land Quality Affects Agricultural Productivity

Previous studies have sought to measure land quality's role in explaining differences in agricultural productivity between countries, but have considered only factors such as climate and irrigation because of data constraints. Recent ERS analysis incorporates the role of soil characteristics as well. Holding other factors constant, this analysis finds that the productivity of agricultural labor is generally 20-30 percent higher in countries with good soils and climate than it is in countries with poor soils and climate. The quality of labor (measured by literacy and life expectancy), institutions (measured by the absence of armed conflict), and infrastructure (measured by the extent of roads and agricultural research expenditures) also affected agricultural productivity.

Better indicators of land quality also improve our understanding of the effects of other factors on productivity. In countries with poor soils and climate, basic inputs like fertilizer, water, and institutional stability are more important than they are in countries that are better endowed. Factors such as labor quality, road density, and mechanization appear less constraining for poorly endowed countries than they are for those with better soils and climate. These results are particularly clear in sub-Saharan Africa, but hold true in other regions as well.

Most High-Quality Land is Found in the Northern Hemisphere



Note: Land quality classes are based on the suitability of all soils and climate for agricultural production.
Source: USDA Natural Resources Conservation Service, World Soil Resources Office.

Economic Research Service, USDA

Land Degradation Reduces Crop Yields…

Based on climate and inherent soil properties, scientists from USDA's Natural Resources Conservation Service have estimated water-induced erosion rates that vary widely by crop production area, soil, and region, but range in most cases between 5 and 7 tons per acre per year. Researchers at ERS and Ohio State University reviewed over 300 plot-level experiments on yield losses due to soil erosion from around the world and found that for most crops, soils, and regions, yields declined by 0.01-0.04 percent per ton of soil loss. Combining these erosion rates and yield impacts allows estimates of potential annual yield losses to erosion in the absence of changes in farming practices.

These estimates vary widely by crop and region. Corn yield losses to soil erosion range from an average of 0.2 percent per year in North America to 0.9 percent per year in Latin America. Yield losses are generally lower for sorghum and millet, ranging from 0.1 percent for sorghum in North America to 0.5 percent for millet in Asia. Annual wheat yield losses are below 0.3 percent in all regions except Australia, where they average 0.7 percent. Differences in crop coverage limit comparison of regional totals, but aggregating across regions and crops (using current commodity prices and total production levels as weights) generates an estimated potential erosion-induced loss of 0.3 percent per year in the value of global crop production.

…and Raises Food Security Concerns

Land degradation may affect food security through its impacts on food production as well as on incomes and food prices. Land degradation's impact is difficult to quantify on a global scale, given limited data and complex interlinkages, but preliminary findings are provided by recent ERS analyses of agricultural production and trade.

ERS' food security assessment model projects future food production, trade, and consumption in 67 developing countries. In the baseline analysis (assuming that recent conditions, trends, and policies continue), the model projects that an additional 13 million tons of food will be needed in 2010 to maintain per capita consumption at 1997-99 levels in the 67 countries. (An additional 22 million tons would be needed to raise per capita consumption to the minimum caloric intake requirements estimated by FAO.)

To assess the potential impacts of land degradation on food security, two alternative scenarios were used. The first assumed that cropland area expanded more slowly than in the baseline scenario due to irreversible degradation, while the second assumed that yield growth was reduced by an average of 0.3 percent per year due to erosion. The amount of additional food required to maintain per capita consumption at 1997-99 levels in 2010

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increased by 69 percent in the reduced-area-growth scenario and by 85 percent in the reduced-yield-growth scenario. (The amount of additional food needed to raise consumption to minimum caloric requirements increased by 30 percent in the first scenario and by 34 percent in the second.) In each case, the food gaps increased most sharply in sub-Saharan Africa.

These estimates indicate the potential for increased food security concerns as a result of land degradation. Actual impacts will be moderated by the actions farmers take to avoid, reduce, or reverse land degradation and its impacts.

Farmers Have Incentives To Address Land Degradation

In addressing land degradation, as in all choices they make, farmers have incentives to consider costs and benefits that affect them directly. Careful understanding of these costs and benefits is thus critical if we are to better understand the likelihood that resource degradation will occur, the likely economic and environmental consequences if degradation does occur, and the various ways in which these consequences can be mitigated or avoided.

Farming practices that degrade the land may generate declining net returns over time, while practices that conserve the land and sustain net returns may require costly initial investments. A comparison of alternatives is complicated by the fact that returns received in the future are generally worth less than the same nominal amount received today, and must thus be appropriately discounted.

Such a tradeoff between short-term and long-term net returns introduces several critical factors into farmers' choices. Perhaps most basically, in order to benefit from a conservation practice, farmers must expect to farm a particular plot of land long enough to recover their costs. Farmers who rent are thus less likely than owner-operators to adopt conservation practices that require a substantial initial investment, while renters and owner-operators are equally likely to adopt conservation practices that cover investment costs quickly.

Farmers might also be unable to adopt a beneficial conservation practice if they are unable to afford the initial investment. This might be the case because of poverty, for example, or credit constraints. Even with sufficient cash reserves or credit, farmers might lack the information needed to compare practices, particularly when market or environmental conditions are highly uncertain.

Data remain inadequate to measure the effect of these factors on a global or regional scale, but ERS analysis of evidence from the U.S. confirms that optimal conservation strategies are sensitive to resource conditions and farmers' planning horizons. When farmers choose practices to maximize net returns over the long term, yield losses to land degradation will typically be lower than those estimated in agronomic studies, which hold farmers' choices fixed. On selected soils in the North Central U.S., for example, yield losses under practices that maximize longrun net returns are generally less than 0.1 percent per year.

These losses are consistent with the lower range of previous estimates. This does not mean that degradation-induced yield losses are unimportant—just that they have historically been masked by increases in input use and improvements in technology and efficiency. Problems do exist in some areas, especially where resources are fragile and markets function poorly. Given projections that yield growth is slowing, yield losses to land degradation are likely to become more of a concern in the future.

Policy measures to reduce land degradation include strengthening tenure systems, investing in infrastructure, and improving access to credit. In addition to efforts to improve market performance in general, it may also be necessary in some circumstances to offer direct payments to enhance farmers' incentives to adopt conservation practices. Such payments are well established in conservation programs in the U.S. and in many other countries, but require careful attention to the timing and magnitude of payments in order to sustain incentives over time. Such approaches may also help achieve the broader agricultural, environmental, and food security objectives of the World Food Summit, the United Nations Convention to Combat Desertification, and other multilateral initiatives. AO

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For further information:

"Resource Quality, Agricultural Productivity, and Food Security in Developing Countries," by Keith Wiebe and Abebayehu Tegene, in *Food Security Assessment*, GFA-12, USDA Economic Research Service, December 2000, www.ers.usda.gov/publications/gfa12/

"World Soil Resources," Online Soil Education Series, USDA, Natural Resources Conservation Service, www.nrcs.usda.gov/technical/worldsoils/

Who Will Be Fed in the 21st Century? Challenges for Science and Policy, edited by Keith Wiebe, Nicole Ballenger, and Per Pinstrup-Andersen, Washington, DC: International Food Policy Research Institute, Economic Research Service, and American Agricultural Economics Association, 2001, www.ifpri.org/pubs/jhu/fed21century.htm

"The State of Food Insecurity in the World 2001," Food and Agriculture Organization of the United Nations, Rome, 2001, www.fao.org/docrep/003/y1500e/y1500e00.htm

Analysis Comparison 2002 Farm Bill

No time to read the Farm Bill cover to cover?

A side-by-side comparison of old and new farm legislation is available on USDA's Economic Research Service web site.

On the special ERS farm bill web page:

- Side-by-side comparison of the 2002 Farm Bill with 1996-2001 farm legislation, title by title
- Economic implications of selected Farm Bill provisions
- Glossary of farm policy terms
- Links to ERS background research
- Updating of the site as new analysis proceeds

A summarized, substantive resource on the Farm Security and Rural Investment Act of 2002

Access this time-saving reference at:
www.ers.usda.gov/features/farmbill

Visit the USDA web site for a gateway to further information on the Farm Bill and on implementation across USDA agencies, including a summary of the bill's highlights.
www.usda.gov/farmbill