7. Challenges for Research and Policy

This report describes how new data and analyses have been used to re-examine an old question: how differences and changes in land quality affect agricultural productivity and food security. As rising populations and incomes increase pressure on land and other resources worldwide, agricultural productivity becomes increasingly important for continued improvement in food supplies and food security. Agronomic studies and conventional wisdom have long recognized that land quality affects agricultural productivity, but it has been difficult to disentangle land quality's effects from those of other factors, such as changes in input use. Advances in spatially referenced data and GIS techniques offer progress in understanding land quality's role in shaping patterns of agricultural productivity.

First, econometric analysis using new data on soils and climate, and controlling for the affects of agricultural inputs and other measures of resource quality, confirms that differences in land quality contribute to significant differences in agricultural productivity between countries. Some of these differences can be mitigated (e.g., by increasing fertilizer use to reduce or reverse soil nutrient depletion in Sub-Saharan Africa), but others may not be reversible at reasonable economic or environmental cost.

Second, land degradation appears to generate productivity losses that are relatively small on a global scale (although their relative importance may increase if productivity growth continues to slow). New estimates of productivity losses are consistent with the lower range of previous estimates. For example, potential yield losses to erosion estimated in the soil science literature average 0.3 percent per year across regions and crops. These estimates focus on biophysical relationships in the absence of behavioral response; actual yield losses will be lower to the extent that farmers act to avoid or reduce these losses.

Third, farmers' responses to land degradation affect how potential impacts on yields may translate into actual impacts on agricultural productivity. Econometric and simulation analyses show how differences in land tenure and other factors that affect farmers' planning horizons combine with differences in land quality to influence decisions about practices that reduce erosion and nutrient depletion. Results indicate that actual yield losses under optimal practices will typically be lower than potential losses estimated in agronomic studies (and are generally less than 0.1 percent per year in the north-central United States).

These findings do not imply that degradation-induced yield losses are unimportant—just that they have historically been masked by growth in yields (which has averaged over 2 percent per year in recent decades for the world as a whole) due to improvements in technology and increases in input use. Degradation-induced yield losses may become more significant in relation to yield growth in the future, as yield growth rates are projected to fall below 1 percent per year over the next few decades. Land degradation's effects on productivity are also likely to be more severe in some regions and local areas, due to a combination of resource factors (terrain, soils, and precipitation) and economic factors (poverty, tenure insecurity, and lack of infrastructure).

Finally, land degradation's impacts on productivity may affect food security in some areas both through losses in aggregate production (and thus higher food prices for all consumers) and through losses in income for those who derive their livelihoods from agricultural land or agricultural labor. Model results suggest that the number of people with nutritionally inadequate diets in low-income developing countries would decline 5 percent if average annual yield losses to land degradation in those countries were reduced from 0.2 percent to 0.1 percent over the next decade. Such improvements would contribute to meeting the 1996 World Food Summit objective of halving the number of undernourished people in the developing world by 2015 but would not be sufficient to meet this objective.

These results suggest that when markets function well, private incentives to reduce land degradation are generally sufficient to address onfarm productivity losses. When markets function poorly (e.g., when property rights are insecure or credit is expensive or unavailable), private incentives to address productivity losses are diminished. In either case, private actions are unlikely to adequately address land degradation's other, and perhaps more significant, effects: offsite impacts on both economic performance and environmental quality. Priorities for further progress in understanding and addressing the links between resource quality, agricultural productivity, and food security include targeted improvements in data, analysis, technology development, and policy.

Improving spatially referenced data on resources and farm practices

Recent years have seen dramatic improvements in the availability of spatially referenced, high-resolution data on natural resources—particularly on land cover, weather, and other variables suited to remote sensing. Nevertheless, important gaps remain. With respect to land cover, for example, consistent classification with fine resolution at the global scale is currently available only for a single composite time period (1992-93) from the AVHRR data set. Considerable effort and judgment are required to transform raw data into classification schemes that strike a useful balance between specificity and generality. The costs associated with this process inhibit the development of usable time series on land cover at high spatial and temporal resolution, even though relevant raw data (e.g., LANDSAT and MODIS) are being collected.

Data also remain scarce on actual (not just characteristic) land quality and land degradation. Improved data on land cover, precipitation, and slope, combined with data on inherent soil properties, offer the prospect of improvements in estimation of some land degradation processes (such as soil erosion). Efforts to allocate production spatially represent significant progress toward accounting for differences in data on inputs and outputs and allow improved estimates of nutrient depletion. But critical data on management practices remain scarce at fine spatial and temporal scales, limiting the precision of such estimates.

Spatially referenced data are even harder to find on property rights, institutions, infrastructure, and other less-tangible variables that nevertheless exert potentially significant influence on agricultural productivity. The complexity and context specificity of such variables pose considerable obstacles to improvement in data collection.

Despite these limitations, there remains considerable potential for improvements in coordination of and access to existing data on land cover and land quality characteristics, including nondigitized subnational data available in some countries, through collaboration with IFPRI, FAO, and other interested parties.

Incorporating simultaneity in analysis of resources and farm practices

In addition to new data and improvements in access to existing data, there remains considerable scope for improvements in analysis of existing data. One key area that deserves closer attention is empirical incorporation of the relationships between inputs, outputs, and land quality in a fully simultaneous system. While the simplest production function historically represented output as a function of conventional inputs (i.e., quantities of land, labor, and capital inputs), in fact the production function is only one component of a complex system in which output, inputs, and land quality are simultaneously determined.

Progress has been made in extending the simplest production functions to include land quality characteristics. Initial efforts (e.g., Masters and Wiebe, 2000) have estimated extended production functions in a simultaneous system with equations expressing inputs as functions of outputs and land quality, but further work is needed in this area. Lindert (2000) has estimated extended production functions simultaneously with land quality characteristics as functions of outputs and inputs using existing data at the subnational level in China and Indonesia. Hopkins et al. (2001) combine all three relationships in their simulation analysis of the north-central United States. Nevertheless, data requirements for a fully simultaneous econometric analysis (including the need for time-series data on soil erosion, salinization, nutrient balances, and farmers' practices) remain prohibitive at larger scales.

Improving R&D to address the needs of resource-constrained farmers and areas

Resource quality differences generate significant differences in productivity between regions/countries. Resource degradation generates productivity losses over time that are relatively small at a global scale but potentially much larger in some areas. Given that two-thirds of the rural population in developing countries live in "marginal areas" (Scherr, forthcoming) and that resource degradation also generates significant offsite effects in terms of both environmental quality and food security, there is a role for public policy to support agricultural R&D directed at areas with high potential impacts (particularly relative to trends in productivity, and particularly in areas with already-poor and/or degrading lands).

Heisey and Renkow (forthcoming) note that areas that are less favored in agro-ecological terms have also been less favored historically in terms of R&D investment. Whether such areas should receive greater priority, however, remains the subject of debate. Some argue that R&D for less favored areas should be increased to reduce widening geographic disparities in incomes, while others argue that scarce R&D funds should be focused on favored areas where returns are highest. Fan and Hazell (1999) estimate returns to research in some less favored areas that may actually exceed returns in relatively favored areas, but Heisey and Renkow argue that this conclusion is diminished by the significant spillovers to less favored areas from R&D targeted at relatively favored environments. Such spillovers, which may reduce income disparities, occur both through the gradual adoption of new technologies (e.g., seed varieties developed for favored areas) in less favored areas and also through indirect effects via commodity markets (e.g., production increases in favored areas reducing food prices in less favored areas) and/or labor markets (e.g., via increased wages in favored areas spilling over to, and drawing labor from, less favored areas).

Heisey and Renkow also note the growing share of agricultural R&D expenditures directed at resource/environmental concerns rather than (or in addition to) traditional productivity-oriented objectives. Such a shift would seem to indicate an increasing emphasis on less favored areas. Given that such concerns are generally of less interest to private sources of R&D funding, this implies an increased role for public support of agricultural R&D.

Improving policy and institutions to do likewise

To the extent that land degradation generates adverse effects (whether economic or environmental) on individuals who are not parties to the decisions that result in land degradation in the first place, policy has a role to play in modifying incentives and decisions to mitigate adverse impacts. Examples of policy roles include removing distortions produced by inappropriate or ineffective tenure systems—keeping in mind that formal systems based on individual private property rights are neither necessary nor sufficient in this regard. Other examples of policy roles include improving physical and institutional infrastructure and/or offering reasonably priced credit to reduce excessive discount rates and encourage investment.

In addition to efforts to improve market performance in general, it may also be necessary in some circumstances to offer direct payments over time to enhance farmers' incentives to adopt conservation practices that provide social/offsite as well as private/onsite benefits. Such payments are well established in conservation programs (such as the Conservation Reserve Program) in the United States and in many other countries but require careful attention to the timing and magnitude of incentive payments to sustain incentives for conservation over time. Such approaches may also be warranted to achieve the broader agricultural, environmental, and food security-related objectives of the 1994 UN Convention to Combat Desertification, the 1996 World Food Summit, the 2002 World Summit on Sustainable Development, and other multilateral initiatives.