Sustainable agriculture: A global perspective

by Pierre Crosson

Most future increases in global demand for food are expected to arise by 2050. By that time, demand could increase by 2.5 to 3.0 times the present level. Given present knowledge about agricultural production, prospective global supplies of land, water, plant genetic, and climate resources will be insufficient to meet future demand at acceptable economic and environmental costs. Nor will extending natural resource supplies by increased conservation of these resources suffice. The only hope of sustainably meeting future food needs is through investment to expand knowledge of agricultural production and its environmental consequences.

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Concern about the world's ability to feed itself dates at least from the time of Thomas Malthus in the early nineteenth century. The concern waxed and waned since then, but the adequacy of global agricultural capacity still figures prominently on the policy agendas of many countries and international organizations concerned about economic development. It was featured in the deliberations of the United Nations Conference on Environment last year in Rio de Janeiro.

A sustainable agricultural system is one that can indefinitely meet demands for food and fiber at socially acceptable economic and environmental costs. There is unavoidable ambiguity in the meaning of socially acceptable costs. No consensus has emerged about what standards should be used to judge acceptability, yet concern about costs drives the current discussion about sustainability in agriculture and development generally. If we are to think fruitfully about the concept of sustainability in agriculture we cannot avoid thinking about costs.

Concern about sustainability reflects a sense of intergenerational obligation. With respect to agriculture, this means that each generation must provide subsequent generations with the opportunity to engage in agricultural production at acceptable economic and environmental costs. Sustainability cannot be discussed usefully without specifying the spatial scale of production units and the possibilities for movement of goods and people among units. In the absence of such possibilities, the agricultural system of a region may be unsustainable because it cannot meet the demands on it at costs the people of the region find acceptable.

Where trade and emigration are possible, the relevant spatial scale is greater, a region can substitute lower-cost food and fiber for its own high-cost production, and people can move from one region to other regions where costs are lower.

Thus the agricultural system for a group of regions (or countries) linked by trade and migration of people may be quite sustainable even though the systems for each separate region (or country), without the linkages, would be unsustainable. Most farmers are connected through trade to markets for their output in their immediate region and often to more distant regional, national, and international markets. Thus, the spatial scale appropriate for discussing sustainable agriculture is global.

A discussion of sustainable agriculture must specify the scale of the demands for production imposed on the system; in general, the problems of achieving sustainability become more difficult as demand for the system's output increases. The quantitative dimension of sustainability thus is crucially important.

Taken together, the above concepts create a workable meaning of sustainable agriculture. That meaning has a temporal dimension—the indefinite future; a spatial dimension—the world as a whole; a quantitative dimension—the demands placed on the system now and in the future; and a normative dimension—it must meet those demands over time at economic and environmental costs that society deems acceptable. In considering the sustainability of the present agricultural system in these respects it is useful to begin with prospective future demands on the system.

The global demand scenario

If current population projections by the United Nations are accurate, most of the future increase in global demand for food will occur by about 2050. By then, global population will be close to the expected ultimate total of 10 billion to 12 billion (the present global population is 5.2 billion).

In addition, if the global system as a whole proves to be sustainable, per capita income in the less developed countries (LDCs) will have risen to the point at which additional income would stimulate little additional spending on food because at that income level most people would be adequately nourished. In more developed countries (MDCs) per capita income already is at that point.

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Thus the critical period for the global agricultural system is roughly the next 60 years. If the system can sustainably meet the increase in demand over that period, it probably will be indefinitely sustainable.

Research at Resources for the Future (RFF) indicates that the projected increase in global population, combined with a plausible increase in per capita income in the LDCs, could increase global food demand by some 2.5 to 3.0 times the present level by the middle of the next century.

The sustainability question is whether the global agricultural system will be able to increase food production that much over that period at acceptable costs. The answer to the question will depend on the ability of the system to mobilize the resources—the social capital—necessary to sustain the production increase.

The concept of social capital

The question of sustainability can be put in terms of the kinds and amounts of social capital that intergenerational equity requires to be passed from one generation to the next. Social capital consists of all the natural and human-made resources used to produce goods and services valued by people. For agricultural sustainability, social capital includes supplies of energy, land, irrigation water, plant genetic material, climate, and knowledge embedded in people, technology, and institutions.

Energy

Over the next several decades global energy supplies are likely to be increasingly constrained by both rising real prices and concerns about the environmental costs of fossil fuels—among them the costs of the greenhouse effect on the global climate. Experience since the run-up in energy prices in the 1970s suggests that farmers should be able to adjust reasonably well to future increases in energy costs, should they occur.

There is little doubt, however, that eventually the costs of fossil fuels will rise high enough to pose a threat to sustainability, not only in agriculture but also in the economy as a whole. Avoidance of the threat will require development of renewable and other nonfossil sources of energy. When this must occur is uncertain, but that in time it must occur is not.

Land

The supply of land has both quantitative and qualitative dimensions. The United Nations Food and Agriculture Organization estimates that worldwide some 1.5 billion hectares currently are in crops of all kinds. Sketchy estimates indicate some 1.8 billion additional hectares have the soil and climate conditions suitable for crop production.

However, for several reasons this estimate surely overstates the amount of land that could be converted to crop production over coming decades at acceptable economic and environmental costs. Much of the potential cropland is of inferior quality in comparison with current cropland.

Moreover, most of it is in Africa and Latin America, but much of the future increase in demand will be in already land-scarce Asia. Asian countries will be able to draw on imports to offset some of their land constraints, but concern about food self-sufficiency probably would limit this response. Asian countries are not likely to view a hectare of potential land in Africa and Latin America as equivalent to a hectare within their own borders.

Estimates of potential cropland are also overstated because they do not take account of the opportunity costs of converting the land to agriculture.

Yet these costs could be significant. Much land around urban areas in LDCs will be priced out of the agricultural market by demands to accommodate rising urban populations. And the clearing of forests to graze animals and raise crops is already seen by many as having high opportunity costs because of losses of plant and animal genetic diversity that clearing is believed to entail. Governments in the tropics are under increasing pressure from governments of MDCs and the international environmental community to reduce these losses by curbing forest clearing, and the pressure will likely continue to grow.

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As noted, the average quality of most potential cropland is less than that of land presently in crops. In addition, the quality of agricultural land can be and is degraded by soil erosion, salinity buildup in irrigated areas, compaction from overuse of heavy tractors or trampling by animals, loss of nutrient supply through overgrazing, and other kinds of damage. Global land degradation through these various processes is widely believed to be severe.

However, work done at the World Bank and elsewhere indicates that the evidence of land degradation is too sparse to warrant firm conclusions about the extent of the problem. Research at RFF and at the U.S. Department of Agriculture indicates that soil erosion in the United States, widely believed to be a major threat to the sustainability of the nation's agriculture, is not in fact a serious problem. Comparable studies have not been made for other countries.

It is worth noting, however, that global crop yields (output per hectare) continue to increase, as they have for the last 40 years, indicating that on a global scale soil erosion has not so far seriously impaired land quality.

Water

About 17 percent of the world's cropland, producing about one-third of global crop output, is irrigated. Almost 75 percent of this land is in the less developed countries, 62 percent of it in Asia—mostly in India, China, and Pakistan. Africa has a little more than 4 percent of the global total of irrigated agricultural land, and Latin America about 6 percent.

World Bank estimates indicate that, based solely on soil and climate factors, the present area of irrigated land worldwide could be increased about 50 percent. However, these estimates, like those for potential cropland, almost surely overstate the real potential for additional irrigation. The estimates give too little weight to the economic and environmental costs of additional irrigation. World Bank studies of India's experience show that the real economic costs of recent irrigation projects were substantially higher than the costs of earlier ones, in large part because the best sites were developed first.

Nor do the estimates of potential irrigation take proper account of sharply rising demands for nonagricultural uses of water in urban areas and for instream flows to protect aquatic habitat.

Much irrigation water is inefficiently used, not only because it is typically priced well below its true social value but also because much of it is managed by large, unwieldy public bureaucracies. Even if these inefficiencies were removed—a formidable undertaking—the potential for expanding global irrigation at socially acceptable economic and environmental costs surely is well below that suggested by the World Bank estimates.

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Climate

Although there is now a strong scientific consensus that the global climate will change over the next 50 to 100 years because of the greenhouse effect, there is no consensus about the consequences of this for global agricultural capacity. Studies conducted for the Intergovernmental Panel on Climate Change and by the U.S. Department of Agriculture suggest that climate change might reduce global agricultural capacity by 15 to 25 percent.

However, these estimates make no allowance for the ability of farmers to adjust to the changed climate or for agricultural research institutions to develop new technologies better adapted to the changed climate. Research at RFF on the impacts of climate change on agriculture in the midwestern United States indicates that these various adjustment processes could virtually eliminate the negative effects of a hotter and drier climate in the Midwest.

Steps taken to limit climate change would reduce the damage to the social capital represented by the climate. In the best of circumstances, however, the climate will contribute little if anything to meeting the prospective increase in global demand for food and fiber.

Genetic materials

Crops and animals are under continuing assault from a host of pests and diseases and from climatic vicissitudes. Maintenance of present levels of crop and animal production requires a sustained effort by plant and animal breeders to develop new varieties better able to resist this assault. Expanding agricultural production on the needed scale will require an even more intensive effort by breeders.

To succeed in this, breeders must have access to a broad range of genetic material for developing more resistant and productive varieties of plants and animals. The plant and animal gene pool, therefore, is a critical resource for achievement of sustainable agriculture. Most of the research on the supply of genetic resources for agriculture has dealt with plants. "Banks" to protect plant genetic materials have been set up by private firms and governments—most prominently, by the U.S. government—and by the Consultative Group on International Agricultural Research (CGIAR). These gene banks serve not only as repositories for plant genetic materials but also as distributors of the materials to plant breeders worldwide.

A study for the World Bank of the CGIAR system criticized some details of the system's performance, but overall gave it high marks. Studies by World Bank researchers of the gene bank system as a whole pointed to some potentially serious weak spots in LDCs, particularly in Africa, but also concluded that in general the system is robust. The key question is whether the global gene bank system will continue to receive the support from national governments and international institutions it will need to maintain that state of health. If it does, the plant genetic resource should be adequately protected. However, as the resource already is reasonably well managed, improvements in its management are unlikely to add much to its supply.

Knowledge

The above discussion points to the conclusion that, within the present knowledge regime, the potential supplies of land, water, climate, and genetic resources would be quite inadequate to meet the prospective increase in global demand for food and fiber at acceptable economic and environmental costs. The implication is that most of the burden of sustainably meeting future demand must be carried by increasing the productivity of these combined resources. Achieving the necessary increases in productivity will require a substantial increase in the social capital represented by knowledge of agricultural production embodied in people, technology, and institutions.

Thus the critical question for agricultural sustainability is whether the global supply of knowledge can be expanded on the requisite scale. Although the answer must be uncertain, there are grounds for optimism. Compared with the other resources, the supply of knowledge about agricultural production is subject to few physical constraints. Knowledge accumulates; it is never used up and, in today's world, it is quickly and cheaply transmitted to the remotest regions of the globe.

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Reflecting these characteristics, agricultural knowledge has grown enormously over the last several decades relative to the supplies of natural resources employed in agriculture. In fact, the growth of the knowledge resource accounted for most of the 2.5 to 3.0-fold increase in global agricultural production since the end of World War II.

But this record of increasing agricultural knowledge, impressive though it is, provides no assurance that the required pace of advance can be maintained over the next half century. In thinking about this challenge it is useful to keep in mind the three sources of embodied knowledge: people, technology, and institutions. Substantial growth will be needed in each source of knowledge, although not necessarily in equal proportions. The difficulty of achieving the necessary increases also may differ among the three sources. The present capacity to generate new knowledge embodied in technology is impressive. The international agricultural research system and the national agricultural research systems in more developed countries appears to be up to the future task if they continue to get adequate funding.

Private firms in those countries also are promising sources of new knowledge—for example, in biotechnology. Capacity to develop new technology also is well developed in Asia, but is less satisfactory in Latin America and not at all satisfactory in Africa.

In the latter two areas, research capacity to develop new agricultural technology must be increased. In addition, agricultural research institutions must focus more on technologies and practices that are less dependent on irrigation and on fossil fuels, and more friendly to the environment than those now in common use.

The prospects for increasing agricultural knowledge embodied in people appear more problematic. Throughout the developing world, governments have consistently underinvested in the education and training of rural people. The reasons are obscure, at least to this writer; but one suspects that a deep contempt for farming and rural people among political elites may in part be responsible.

An underestimation of the contribution of agriculture to the early development of the now wealthy countries may also account for the neglect of rural people by LDC governments. Such cultural attitudes and misunderstandings are not easily overcome.

At least since Theodore Schultze's *Transforming Traditional Agriculture* there has been no serious doubt that, within their resource constraints, poor farmers in developing countries will quickly adopt new technology when it is in their interest to do so. A major resource constraint for these people may be lack of the knowledge that will be necessary for them to master the increasingly sophisticated technologies expected to be forthcoming over the next several decades. Whether the constraint can be overcome in a timely fashion is an open question.

After decades of reluctance to rely much on open markets to organize their economies, governments throughout the LDCs, Eastern Europe, and the former Soviet Union now are struggling to capture benefits of that powerful economic institution. Lack of much experience with markets in those countries makes the struggle difficult; however, those governments willing to try can tap into the accumulated knowledge of markets embodied in institutions of the capitalist countries. That kind of knowledge transfer should help to provide economic incentives for adoption of new agricultural technologies by farmers with the requisite know-how.

Comparable institutional knowledge of how to manage the environmental consequences of a 2.5 to 3.0-fold increase in global agricultural production is generally lacking—in developed as well as in developing countries. So far, countries have sought to deal with environmental consequences of economic activity by regulatory approaches—only so much effluent is permissible, and such-and-such a technology must be installed, and so on. These approaches have had significant success in some developed countries in cleaning up the environment. But much evidence now suggests that additional improvement through regulations will be increasingly costly.

In response, the United States and some other of the more developed countries are beginning to experiment with market-like approaches to achieve environmental improvement. The underlying idea is that private firms have better knowledge of what it takes to reduce their polluting effluents than government regulators, and that provision of market-like incentives to the firms will induce them to bring that knowledge to bear. So far, experience with this approach is very limited, and confined to the more developed countries. Moreover, the institutional capacity to formulate and implement the approach appears more limited in the LDCs than in the more developed countries. Lack of this institutional knowledge in the LDCs may in the end prove to be the most serious constraint to achievement of a sustainable global agricultural system. ■

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