Sustainable Growth In Agricultural Production: Into the 21st Century

— by Vernon W. Ruttan —

➢ **A number of agricultural resource, environmental and health concerns will condition the capacity of the agricultural sector in both developed and developing countries to increase production in the coming century. These concerns give rise to four generic issues: (a) Many of the issues are international in scope. In turn, the responses will also have to be international or at least multinational. (b) The capacity to design and build the institutions necessary to achieve increases in agricultural production is limited. (c) Much more attention needs to be given to designing technologies and institutions that increase the number of alternative actions that can be taken in the future, and (d) National and international capacities to monitor changes in the sources of and changes in productivity, environmental amenities and health conditions are severely limited.**

For the third time since World War II, we are in the midst of a wave of social concern about the availability of our natural resources and the quality of our environment.

The first wave of concern, in the late 1940s and early 1950s, focused primarily on how the scarcity of resources would limit economic growth.

The second wave came in the late 1960s. With this second wave the focus of the first wave was augmented with concern about the pollution generated by growth associated with technologies such as pesticides and fertilizers.

Now we are in the midst of a third wave of concerns focused on environmental changes that are occurring on a transnational scale—issues such as global warming, ozone depletion, and acid rain—and their effects on environmental quality, food production, and human health.

With each new wave of concern, the issues dominating the earlier wave were not abandoned but continued. Although intensity of earlier concerns about limits to growth and pollution associated with growth have ceded somewhat in part due to society's technical and institutional responses, these concerns continue to be part of the environmental agenda.

The Agricultural Transformation

Now in the closing years of the 20th century we are completing one of the most remarkable transitions in the history of agriculture. Prior to this century almost all of the increase in food production was obtained by bringing new land into production. There were only a few exceptions—in limited areas of East Asia, the Middle East, and Western Europe.

Yet in the next century, almost all increases in world food production must come from higher yields—from increased output per hectare. This shift from expanding crop area to increasing land yields has been underway in most of the developed world since the turn of the last century. In contrast, this kind of shift in the developing world has been occurring only since mid-1900. Among developing countries those countries of East, Southeast, and South Asia have proceeded further in this transition than most countries in Latin America or Africa.

Recent historical trends in production and consumption of the major food grains could easily be taken as evidence that concern about the capacity of the world's farmers to meet future food demands is misplaced. World wheat prices, adjusted for inflation, have declined at least since the middle of the last century. And, rice prices have declined since the middle of this century. These trends suggest that productivity growth has been able to more than compensate for the rapid growth in demand, particularly during the decades since World War II.

As we look toward the future, however, we know that the demand increases will be large. The demands related to population growth and improved incomes in the developing economies will be exceedingly high. During the next several decades growth in food and feed demand rising from growth in population and income will run upwards of 4.0 percent per year in many developing countries. Many will experience more than a doubling of food demand before the end of the second decade of the next century.

Biological and Technical Constraints on Crop and Animal Production

Several developments suggest that gains in agricultural production required over the next quarter century will be achieved with much greater difficulty than in the immediate past. Difficulty is currently being experienced in raising yield ceilings for the cereal crops which have experienced rapid yield gains in the recent past. The incremental response to increases in fertilizer use has declined. Expansion of

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irrigated area has become more costly. Maintenance research, the research required to prevent yields from declining, is rising as a share of total research effort.

Further, the institutional capacity to respond effectively to these developments is limited, even in the countries with the most effective national research and extension systems. Indeed, during the 1980s, many countries have had difficulties maintaining their agricultural research capacity at levels achieved in the 1970s.

It is possible that within another decade, advances in basic knowledge in molecular biology and genetic engineering will create new opportunities to advance agricultural technology sufficiently to relieve these concerns. But the expected date when these promising advances will be translated into productive technologies seems to be receding.

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Courtesy of USDA Soil Conservation Service

Among conclusions of the first consultation were:

• *Advances in conventional technology will remain the primary source of growth in crop and animal production over the next quarter century.* Almost all increases in agricultural production over the next several decades must continue to come from more intensive use of land currently in use. Improved crop and animal productivity will come from better plant and animal breeding, more effective animal nutrition, and more efficient use of technical inputs including chemical fertilizers and pest control chemicals.

Even so, the productivity gains from conventional sources are likely to come in smaller increments than in the past. Further, the sources of yield gains, such as advances in soil and water management, will be extremely knowledge and information intensive.

• *Agricultural research must be reorganized to take advantage of advances in microbiology and biochemistry.* The future holds a wide range of possibilities for molecular biology and biochemistry to supplement traditional agricultural research. These possibilities range from the transfer of growth hormones into fish to conversion of lignocellulose into edible plant and animal products. But realization of these possibilities will require a reorganization of agricultural research systems so that substantially more private sector resources are devoted to agricultural research. Public sector research organizations will have to increasingly embrace "big science" modes of organization similar to the Rockefeller Foundation sponsored collaborative research program on the biotechnology of rice and the University of Minnesota program on the biotechnology of maize.

• *Efforts to institutionalize agricultural research capacity in developing countries must be intensified.* As with developed countries, the only way for developing countries to obtain and develop advanced production technologies is to have a cadre of scientists. In a large number of developing countries this capacity is just beginning to be put in place. Even a relatively small country, producing a limited range of commodities under a limited range of agro-climatic conditions, will require a cadre of agricultural scientists in the 250-300 range. Unfortunately the research capabilities in a number of countries, that experienced substantial improvements in their research capabilities during the 1960s and 1970s, have eroded.

• *A substantial basic biological research and training capacity must be established in the tropical developing countries.* The tropics require agricultural research specifically tailored to their conditions, areas of research that do not receive adequate attention in developed countries. There also needs to be a closer link between training in applied science/technology and training in basic biology. And there will be need for close linkages among tropical agricultural research centers as they are being established and once they become fully staffed throughout the world.

This paper draws on a series of three consultations on (1) Biological and Technical Constraints on Crop and Animal Productivity, (2) Resource and Environmental Constraints on Sustainable Growth in Agricultural Production, and (3) Health Constraints on Agricultural Development. The consultations were held in response to a concern with the implications of global change for agricultural, environmental and health research agendas. Participants included leading agricultural, environmental, and health scientists, economists and policy specialists from around the world. Support for the series of consultations was provided by the Rockefeller Foundation, the University of Minnesota Agricultural Experiment Station and the University of Minnesota Center for Food and Agricultural Policy. A book based on the three consultations and a subsequent conference held at the Rockefeller Foundation Conference and Study Center in Bellagio, Italy, *Agriculture, Environment and Health: Toward Sustainable Development Into the 21st Century*, will be published by the University of Minnesota Press in early 1993.

Resource and Environmental Constraints

A second round of consultations brought scientists studying changes in climate together with agricultural scientists and economists. They focused on two sets of concerns:

(1) The impact of intensive agricultural production practices including soil erosion, water-logging and salinization, groundwater contamination, and growing resistance of insects, weeds and pathogens to present methods of control, and, (2) The impact of industrialization on global climate and other environmental changes. There can no longer be much doubt that there will be a rise in global

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average surface temperatures over the next 30-60 years. And there continues to be great uncertainty about the climate changes that can be expected to occur at any particular date or location in the future.

Four major conclusions emerged from this consultation.

• *Seriously examine alternative ways in which land now used in farming can contribute to energy and environmental demands as well as food and fiber demands.* The world's demand for food and fiber over the coming decades will increase dramatically in response to population and income changes especially in developing countries. However, there will also be increased demands for alternative ways in which land now in agriculture is used. For example, past advances in biological and chemical technology, have been driven by increasingly favorable access to low priced energy. These conditions are likely to change. By the early decades of the next century there will be strong incentives to improve energy efficiency throughout our society.

Particular attention should be given to alternative and competing uses of land. Land use transformation, from forest to agriculture, is presently contributing to radiative forcing through release of CO_2 and methane into the atmosphere.

An example is the proposal to convert low intensity agricultural systems to forest as a method of absorbing CO_2. There will also be increasing demands on land use for watershed protection, and biomass energy production.

• *More closely monitor the interaction between agriculture and the environment.* Only in the last 15 years has it been possible to estimate the magnitude and productivity effects of soil loss in the United States. Even rudimentary data on productivity effects of soil loss is virtually unavailable in most developing countries. The same point holds, with even greater force, for groundwater pollution, salinization, species loss and others. It is time to design the elements of a comprehensive, agriculturally related, resource monitoring system. Data on the effects of environmental change on the health of individuals and communities is even less adequate and monitoring should include a major focus on the effects of environmental change on humans.

• *Design technologies and institutions to achieve more efficient management of surface and ground water resources.* During the next century water resources will become an increasingly serious constraint on agricultural production. Agricultural production has adversely affected the quality of both ground and surface water. Limited access to clean and uncontaminated water supply is a major source of disease and poor health in many parts of the developing world and in the former centrally planned economies. Further, global climate change can be expected to have a major differential impact on the water availability, water demand, erosion, salinization, and flooding. Thus, technologies and management systems that enhance water use efficiency are a high priority both because of short and intermediate run constraints on water availability and the longer run possibility of seasonal and geographical shifts in water availability.

• *Develop incentives for behavior compatible with social objectives for management of resources.* The first research priority is to initiate a large-scale program of research on the design of institutions capable of implementing incentive compatible resource management policies and programs. By incentive compatible institutions I mean institutions capable of achieving compatibility between individual, organizational, and social objectives in resource management. We have global warming and environmental pollution problems to a large extent simply because individuals and public and private institutions have incentives to take actions incompatible with society's overall goal. The challenge is to design institutions whereby people and organizations find it advantageous to act in ways that help achieve overall goals of society including the quality and quantity of food, quality of the environment, and health.

Health Constraints on Agricultural Development

A third consultation focused on the interaction between health and agriculture. One might very well ask why this topic was included in a series of consultations on agricultural research. The emergence of AIDs, combined with other health threats, could emerge as a major threat to economic viability in both developed and developing countries.

Also the environmental impacts of agricultural and industrial intensification may already be imposing significant health burdens in some countries, particularly in parts of the USSR and Eastern Europe, and they may become more burdensome in the future.

If one visualizes a number of these health threats emerging simultaneously in a number of countries it is not too difficult to construct a scenario in which there are large numbers of sick people in many villages around the world. The numbers could become large enough to be a serious constraint on food production. It was this set of concerns that guided the dialogue in the third consultation.

Four priority issues were identified.

• *Health delivery systems capable of reducing the incidence of illness have not been developed in either developed or developing countries.* Health systems in place in most countries are more accurately described as sickness recovery systems rather than health systems. They are health care rather than health maintenance systems. A major deficiency is their failure to provide families and individuals with the knowledge needed to achieve better health and to rely less on the health care system.

Many countries have been able to design reasonably effective agricultural extension systems that help farm people achieve higher levels of productivity. But we have yet to design an effective system that helps families and individuals lead more healthy lives.

• *Residual by-products of industrial and agricultural production are an increasingly important source of illness in a number of countries and regions.* The most serious impacts are occurring in the centrally planned economies of Eastern Europe, the USSR and China.

Levels of atmospheric, water and soil pollution have caused higher mortality rates and reductions in life expectancy. The effects are evident in the form of congenital malformation, pulmonary malfunction and excessive heavy metals in soils and in crops grown on contaminated soils. Many of the health effects of agricultural and industrial intensification are due to inadequate investment in the technology needed to control or manage contaminants. Rapid industrial growth in poor countries, in which investment resources are severely limited, will continue to be accompanied by underinvestment in the technology needed to limit the release of contaminants. The situation that exists in Eastern Europe presents a vision of the future for many newly industrializing countries unless better technology can be made available and more effective management of environmental spillover effects can be implemented.

• *Location and site-specific research capacity is lacking in most developing countries.* It is no longer possible to maintain the position that health related research results can simply be transferred from developed country research laboratories or pharmaceutical companies to developing countries. Local capacity is needed for the identification and analyses of the sources of health problems. Local talent and institutions are also needed to design and test health delivery systems and conduct needed analyses.

The support of the international donor community to the development of health research systems in the tropics has lagged relative to the support for agricultural research systems. For example, there is now in place a network of more than a dozen international agricultural research centers (IARC's), sponsored by the Consultative Group on International Agricultural Research. They play an important role in backstopping national agricultural research efforts.

In contrast, the capacity to conduct research on tropical infectious and parasite diseases that was supported by the former colonial countries—United Kingdom, France, Netherlands and Belgium—has been allowed to atrophy. And, today, the only comparable internationally supported center in the field of health is the Diarrheal Research Center in Bangladesh.

• *More effective bridges are needed between the agricultural and health communities with respect to both research and practice.* At present these two "tribes", along with veterinary medicine and public health, occupy separate and often mutually hostile "island empires". But solutions to the problem of sustainable growth in agricultural production and improvement in the health of rural people and the consumers of agricultural commodities would be facilitated if there were serious collaboration among these empires. For example, multi-purpose water resource development projects have contributed to the spread of onchocerciasis. Successful efforts to control the black fly have reopened productive lands to agricultural cultivation. The introduction of improved cultivars and fertilization practices have helped make the productivity growth sustainable. But examples of effective collaboration either in research, or in project development are few in number.

Perspective

My own perspective on the world's balance between food demands and food production is cautiously optimistic. Admittedly, resources for expanded production, like crop area and water for irrigation, increased non-farm demands for environmental amenities, and greater insistence that the health of producers and consumers is protected will constrain increases in production in response to increased demands for food and fiber.

However, the global agricultural research system, the technology supply industry, and farmers are much better equipped to confront the challenges of the future than they were when confronted with food crises in years past such as in the mid-1960s. This is partially because of the challenges themselves, but also due to the foresight of public and private research institutions, as well as the signals generated in markets throughout the world. It cannot be emphasized too strongly, however, that the challenges are both technical and institutional. The great institutional innovation of the 19th century was "the invention of the method of invention." The modern industrial research laboratory and today's agricultural experiment stations, and research universities are products of this institutional innovation. It was not until well after mid-century that national and international agricultural research institutions became firmly established in most developing countries. The challenge for the coming century is to design institutions focused on the adverse environmental affects of the intensification of agricultural and industrial production—the negative spillovers that pollute our soil, water, and atmosphere.

Several developments suggest that gains in agricultural production required over the next quarter century will be achieved with much greater difficulty than in the immediate past.

The world's capacity to increase incomes and to increase agricultural production while contributing to an improved environment is also related to overall economic conditions in lower income countries. Slow population growth and rapid growth of employment and incomes will have positive effects on increased crop and animal production and sustainable adaptation to resource and environmental constraints. If the non-farm sector in developing countries does not grow rapidly, the long-term trend of lower world food prices may be reversed simply because investments in resource and technology development are inadequate.

Growth in the non-farm economy is particularly important for the landless and near landless workers in the rain-fed upland areas of developing countries. They have been left behind by the advances of seed-fertilizer-water technology in these countries in the last quarter century. Higher incomes, rather than rapid population growth, will generate demand for high value crop (fruits and nuts) and animal products. Such demands will permit farmers in these areas to diversify out of staple cereal production and into higher value crop and animal products. It will also provide opportunities to shift fragile lands from crop production to less intensive land use.

For More Information

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