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Challenges to World Agriculture in the 21st Century

by Alex F. McCalla

World agriculture in the 21st century will face three major challenges: how to feed a growing world population, how to contribute to reducing the still–high prevalence of rural poverty in the world, and how to respond to increased concerns about managing the natural resource base.

Challenge I: Global Food Security

The first and continuing challenge facing world agriculture is to produce enough food to feed the growing world population. World population could reach eight billion people by 2025. Nearly all of the increase of two billion people in the next 25 years will be in developing countries.

The urban population in developing countries will rise by a like number. The implications of urbanization are significant for the food system. It is estimated that people living in rural areas depend on their own production for more than 60 percent of their food supply (only 40 percent is purchased in the market). People living in urban areas, however, depend on the market for close to 90 percent of their food supply. So every time one person moves from a rural to an urban setting, needed market supplies must increase by a factor of two.

Where will this food come from? If trends of the last 50 years continue, expanded trade will not be the answer. Since 1960 world grain production has more than doubled, and world grain trade also doubled. Thus the share of world grain consumption that is traded remained constant at about ten percent. This says that on average, 90 percent of the world food production is consumed in the country where it is produced. If this trend continues, then it is clear that most of the increase in the food production must come from production systems in the countries where the additional people will live.

And where will they live? Most of the population growth between 2000 and 2030 will occur between the Tropic of Capricorn and the Tropic of Cancer, in countries that are still experiencing rapid population growth.

Putting these two "facts" together suggests that most of the food needed to meet increased needs in the next 25 years must be produced in tropical and subtropical farming systems. We know that these systems are complex, highly heterogeneous, fragile, generally low in productivity, and dominated by small-scale, poor farmers. And to make

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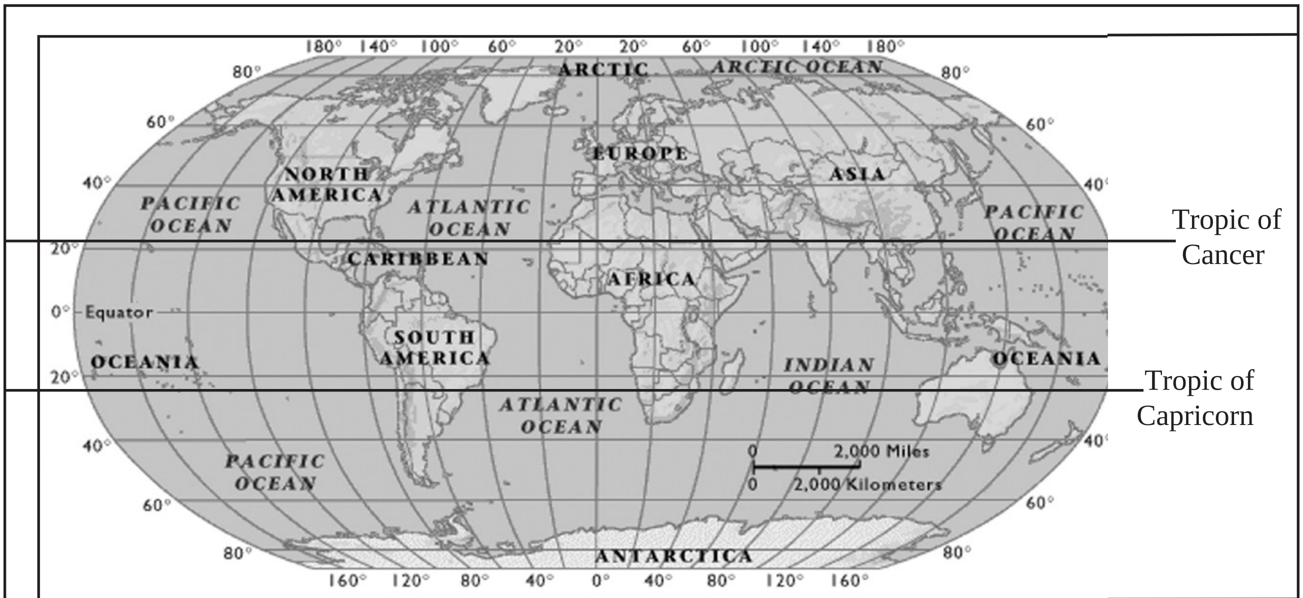

On average, 90 percent of the world food production is consumed in the country where it is produced. Most of the population growth between 2000 and 2030 will occur between the Tropic of Capricorn and the Tropic of Cancer. Map by MapQuest

things more complicated, we know much less about farming systems in these regions than we do about systems in temperate regions.

So the food production challenge ahead is not small or easy. It requires increasing the productivity of complex, low–yielding farming systems in ways that do not damage natural resources or the environment.

Challenge II: Poverty Reduction

Despite the rapid urbanization projected to occur in the coming decades, it will be 2015 before as many people live in urban areas as in rural areas. As of today, some 70 percent of the poor are still rural dwellers, the majority of whom draw some or all of their income from agricultural activities. Literally billions of small and generally poor farmers live in poverty or near the poverty line.

Therefore the second challenge facing global agriculture is to develop technologies, policies and institutions that contribute to unleashing agriculture's full potential as an engine of growth. Meeting this challenge will require farmers to have access to both domestic and international markets.

Challenge III: Sustainable Natural Resource Management

The third challenge to agriculture in this new century is to create a set of technologies, incentives and policies that encourage small–scale farmers to want to pay attention to the long-run stewardship of the natural resources they manage. This is critical because farmers use most of the world's arable land and are involved in managing much of the world's forest and range land. Agriculture uses more than 70 percent of the world's fresh water, and much biodiversity is contained in agricultural systems. Agricultural activities influence the boundaries of forests and deserts. Therefore, the question of improving the management of our natural resources is intimately tied to improving the productivity and profitability of small-scale farmers in the developing world.

How Did World Agriculture Meet Past Challenges?

The performance of agriculture over the last 200 years has been phenomenal. World population has increased six-fold, and global agricultural production has more than kept pace. Falling real grain prices for most of the 20th century are evidence of that success. The sources of increased food production, however, have changed. For example, for most of the 19th century, increased output came from expanding the land area in production, and that expanded area was primarily located in "newly settled areas"—the Americas, Southern Africa and Australia. Science–based agriculture is really a product of the 20th century. The new technology—mechanical, biological, and chemical—came in different forms and was adopted in different sequences in different parts of the world. It led to phenomenal increases in yields in some parts of the world.

Land area expansion as a contributor to increased

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output declined in importance throughout most of the 20th century. Developments to increase the intensity of land use through, for example, greatly expanded areas of irrigated agriculture, played a significant role in increasing agricultural output over much of that period. But in general, over the last 200 years, science and technology have played an increasingly important role in meeting world food needs.

The results of these technological developments have been really quite substantial. The 1960s was a period in which there were dire predictions of famine, yet the world did remarkably well in providing adequate global supplies of cereals. From 1960 to 1990, global cereal production doubled, per capita food availability increased 37 percent, per capita calories available per day increased 35 percent and real food prices declined 50 percent.

Even with these good indicators of overall global performance, significant regional differences remained. For instance, in sub-Saharan Africa, per capita food availability decreased between 1960 and 1990.

The global gains over the 1960–90 period came from the Green Revolution and from rapidly expanding production in developed countries based on conventional genetic crop improvement and intensified monocultures using high levels of fertilizers and pesticides. The policy environment in most countries was protective and inward looking. Farmers in rich countries were subsidized, receiving high guaranteed prices that further encouraged intensification. Farmers in poor countries, on the other hand, were taxed. The international trading system under GATT allowed agriculture to remain highly protected.

But despite all these gains, more than 840 million people remain undernourished, mostly in Africa and South Asia. Worldwide, 1.3 billion people live on less than U.S. $1 per day, and the majority of them are in agriculture. Rates of natural resource degradation are judged to be increasing.

Can Agriculture Meet the Three Challenges?

Meeting the Supply Challenge There are widely differing views on the difficulties of meeting food needs in the 21st century. Those using economic projection or simulation models, based significantly on history, tend to project sufficient global supplies until at least 2010. The International Food Policy Research Institute (IFPRI) reaches similar projections to 2020. Those projecting on the basis of resource availability and environmental constraints (perhaps these should be called ecological modelers) are generally much more pessimistic. The most extreme view combines resource constraints with biological yield.

How can these economic optimists on the one hand and the ecological pessimists on the other hand reach such different conclusions in projecting food supply potential? Their differences come from how they deal with four critical projection variables.

1) *Assumptions about the rate of increase in biological yields.* Economic modelers are projecting production growth of 1.5-1.7 percent per year, less than in earlier periods, but it still results in adequate supplies, as population growth rates are projected to fall even more rapidly. Ecological modelers point to yield increases in the 1990s of less than 1 percent, yield stagnation in intensive irrigated systems – e.g., triple–cropped rice in the Philippines and a decline in yields in rice–wheat systems in South Asia. These modelers are very skeptical about biotechnology being a savior.

2) *Assumptions about how much land will be added to or lost from agricultural production over the next 30 years.* Economic modelers continue to assume some increase in land area under agricultural production but less than in the previous period. Ecologists

Most of the food needed to meet increased needs in the next 25 years must be produced in tropical and subtropical farming systems. We know that these systems are complex, highly heterogeneous, fragile, generally low in productivity, and dominated by small-scale, poor farmers. Photo by The World Bank argue that land lost to urban and industrial use, plus degradation of existing land, means that *less* land will be available in the future.

3) *Assumptions about how much land can be subjected to increased intensification through irrigation and/or changed cropping patterns.* Intensification had a big impact over the past 40 years as irrigated area in developing countries doubled and cropping intensity increased. Economic modelers project that this trend will continue, though at lower levels. Ecologists argue that there will be no more new irrigation but rather increased competition for water and significant land degradation.

4) *Assumptions about the impact of environmental degradation on food production capacity.* Economic modelers tend to ignore natural resource constraints. Ecologists see them as big issues. Land erosion and water pollution will reduce yields. Rangelands are overgrazed and fisheries depleted.

In my judgment, the optimists are too optimistic and the pessimists are too pessimistic. Reality suggests that feeding two billion more people will be an enormous challenge. The bottom line is that virtually all of the increase in production globally will have to come from knowledge–based agricultural intensification, using modern science and biological technology, accompanied by improved capacity to deal with biotic and abiotic stresses. Land expansion and intensification through capital intensive irrigation simply will not make significant contributions to output. In fact, we may have to raise output with *less* land and *less* water and do it in a resource–friendly way.

Can these challenges be met? On the production side, there are four "big ifs" or uncertainties:

1) ***If** we can develop sustainable production systems capable of doubling output. This is an unprecedented challenge for agriculture and biological science.*

2) ***If** we have in place domestic and international policies and institutions that do not discriminate against agriculture and that provide appropriate incentives to hundreds of millions of farmers around the world.*

3) ***If** we continue to invest in public agricultural research—for example, through the Consultative Group on International Agricultural Research (CGIAR)—and build stronger partnerships with the private sector to tap the enormous potential of molecular biology.*

4) ***If** we stay the course with removing distortions to freer agricultural trade.*

These will all help to meet the food supply challenge.

Meeting the Poverty and Natural Resource Challenge

In the developing world, poverty remains a predominantly rural challenge. To meet these challenges, we must improve the productivity and profitability of millions upon millions of small farmers and promote employment–intensive rural growth.

For this to occur, farmers will need new, appropriate technology. Here the role of biotechnology should be critical if it can be applied to the crops of complex farming systems in the tropics and subtropics.

Profitability will come from increased market orientation as farmers produce food and fiber for domestic and international markets. Here the critical issues are appropriate policies and incentives.

If we can help improve farmers' wellbeing, we will also have the additional benefit of encouraging farmers to be more effective stewards of the world's natural resources. Therefore the issue of improving the welfare of rural communities, by improving the profitability of agriculture, is a **triple-win situation**. *It contributes to poverty reduction, it contributes to food security and it contributes to improved natural resource management.*

Implications for California and U.S. Agriculture

The consequences for the United States and California of meeting these challenges are substantial and positive. International trade is accounting for a steadily increasing share of U.S. and California agricultural sales. Markets grow when countries grow and incomes rise. Thus, reducing rural poverty in developing countries ultimately benefits us. Forty years ago Taiwan and South Korea were concessional markets for food give–aways. Today they are important markets. Likewise India, China and other developing countries will become better markets when their economies perform better. Even better news for California is that as incomes rise further, the composition of imports shifts from basic grains and bulk products toward fruits, vegetables, processed foods, specialty products and other higher value imports.

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