The World Food Situation: Recent Developments, Emerging Issues, and Long-Term Prospects

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THE WORLD FOOD SITUATION:
RECENT DEVELOPMENTS, EMERGING ISSUES,
AND LONG-TERM PROSPECTS

Per Pinstrup-Andersen, Rajul Pandya-Lorch, and Mark W. Rosegrant

In the two years since IFPRI's last biannual presentation on the world food situation at International Centers Week, developments in global food supply, demand, and trade have been widely discussed in both the general and the specialized news media. Rapid increases in the price of wheat and maize during 1995 and the first half of 1996, and associated rapid reductions in global cereal stocks, raised concerns about future food supplies. Adding to these concerns was China's substantial net imports of grain in 1995 following several years of net exports. Failure on the part of many of the countries of the former Soviet Union and Eastern Europe to make significant advances in economic transition and agricultural development compounded these concerns, as did rapid declines in the availability of food aid and in official development finance generally. More recently, the reemergence of El Niño is affecting temperature and rainfall patterns around the world and could have potentially severe implications for food security.

On the more optimistic side, the United Nations (UN) once again revised its population projections downward, thus reducing expected pressures on future food supplies. Although official development finance continued to decline, private capital flows to developing countries increased substantially. Progress was made on international trade liberalization along the lines suggested by the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The World Food Summit convened by the Food and Agriculture Organization of the United Nations (FAO) in November 1996 was effective in raising awareness of world food security problems and in building commitments for action. While it is premature to judge whether such action will in fact materialize, some countries and international institutions are placing increased emphasis on agricultural development.

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A number of issues that could significantly influence the future world food situation have begun to emerge. Dietary patterns are changing rapidly in many countries in response to income increases, urbanization, changing preferences, and government policy. Owing to large increases in demand for meat products, demand for cereals to feed livestock is growing fast. Rapid urbanization in low-income developing countries is placing increasing stress on food marketing and processing systems. Growing scarcity and inappropriate allocation of water, as well as declining soil fertility in many regions of the world, are beginning to constrain food production. Farm yields in parts of Asia are approaching economically optimum levels, and yield growth rates are slowing. The policy-induced slowdown in grain production in North America and Western Europe, combined with greater variability in agricultural production caused by weather fluctuations, such as those induced by El Niño, are likely to cause greater food price fluctuations in the future. In fact, large fluctuations in domestic grain prices are currently being experienced by several African countries because of a combination of climatic and policy factors and poor market integration. While modern science and biotechnology offer tremendous opportunities for reducing production fluctuations and increasing productivity on small-scale farms in developing countries, little investment is being made in these areas. Widespread conflict and instability are further adding to food insecurity in a number of countries. Developments in China and India are of particular interest because policy decisions made, or not made, in these countries are likely to affect not only large populations in these countries themselves, but also the rest of the world. Furthermore, recent developments in two other major regions—the former Soviet Union and Eastern Europe and Sub-Saharan Africa—deserve special attention because of their precarious food security situation. These issues suggest potentially larger fluctuations in food production and prices, and higher associated risks of food insecurity for the world's most vulnerable countries and people. The challenge for policymakers, researchers, and others is how best to minimize these risks to achieve food security for all people.

Drawing upon recently revised and updated information from IFPRI's global food model, which projects food demand, supply, and trade to the year 2020, this paper presents our best assessment of prospects for global food security over the next quarter century. Next, it reviews recent events that have significantly influenced food security as well as key emerging issues that have the potential to significantly affect food security in the coming years. The paper concludes with an analysis of the implications of these recent events and emerging issues for agricultural research and food policy reform in developing countries.
PROSPECTS FOR GLOBAL FOOD SECURITY

Prospects of a food-secure world—a world in which each and every person is assured of access at all times to the food required to lead a healthy and productive life—remain bleak if the global community continues with business as usual. IFPRI’s revised and updated global model, the International Model for Policy Analysis of Commodities and Trade (IMPACT), projects that, under the most likely or baseline scenario, 150 million children under the age of six years will be malnourished in 2020, just 20 percent fewer than in 1993 (Figure 1). One out of every four children will be malnourished in 2020, down from 33 percent in 1993. As Figure 1 shows, a reduction in child malnutrition is expected in all major developing regions except Sub-Saharan Africa, where the number of malnourished children could increase by 45 percent between 1993 and 2020 to reach 40 million. In South Asia, home to half of the world’s malnourished children in 1993, the number of malnourished children is projected to decline by more than 30 million between 1993 and 2020, but the incidence of malnutrition is so high that, even with this reduction, two out of five children could remain malnourished in 2020 (Figure 2). With more than 70 percent of the world’s malnourished children, Sub-Saharan Africa and South Asia are expected to remain “hot spots” of child malnutrition in 2020.

Projections by the FAO on the number of food-insecure people paint a similar picture (FAO 1996b). FAO projects that 680 million people, 12 percent of the developing world’s population, could be food-insecure in 2010, down from 840 million in 1990-92 (Figure 3). Food insecurity is expected to diminish rapidly in East Asia and, to a lesser extent, in South Asia and Latin America, but it could accelerate substantially in Sub-Saharan Africa and the Near East and North Africa. Sub-Saharan Africa and South Asia, home to a projected 70 percent of the world’s food-insecure people in 2010, will be the locus of hunger in the developing world. In fact, Sub-Saharan Africa’s share of the world’s food-insecure population is projected to almost quadruple between 1969-71 and 2010 from 11 to 39 percent (FAO 1996b). By 2010, every 3rd person in Sub-Saharan Africa is likely to be food-insecure compared with every 8th person in South Asia and every 20th person in East Asia.

IMPACT covers 37 countries and regions (which account for virtually all of the world’s food production and consumption) and 17 commodities (including all cereals, soybeans, roots and tubers, meats, and dairy products). The basic methodology of IMPACT is described in Rosegrant, Agcaoili-Sombilla, and Perez (1995), while revisions and updates to IMPACT are described in Rosegrant, Sombilla, Gerpacio, and Ringler (1997).

Malnourished children are those whose weight-for-age is more than two standard deviations below the weight-for-age standard set by the U.S. National Center for Health Statistics and adopted by many United Nations agencies in assessing the nutritional status of persons in developing countries.

FAO classifies these people as chronically undernourished; that is, their access to per capita food supplies is less than 1.55 times the basal metabolic rate (BMR).
Among the key forces influencing demand for food are population growth, income levels and economic growth, human resource development, and lifestyles and preferences. Even with the recently reduced population estimates, almost 80 million people are likely to be added to the world's population each year during the next quarter century, increasing world population by 35 percent from 5.69 billion in 1995 to 7.67 billion by 2020 (UN 1996). More than 95 percent of the population increase is expected in developing countries, whose share of global population is projected to increase from 79 percent in 1995 to 84 percent in 2020. Over this period, the absolute population increase will be highest in Asia, more than 1 billion, but the relative increase will be greatest in Sub-Saharan Africa, where the population is expected to almost double to 1.12 billion by 2020. Much of the population increase in developing countries is expected in the cities; the developing world's urban population is projected to double over the next quarter century to 3.6 billion in 2020 (UN 1995). Urbanization profoundly affects dietary and food demand patterns: the increasing opportunity cost of women's time, changes in food preferences caused by changing lifestyles, and changes in relative prices associated with rural-urban migration lead to more diversified diets with shifts from basic staples such as sorghum, millet, and maize to other cereals such as rice and wheat that require less preparation and to milk and livestock products, fruits and vegetables, and processed foods. Population growth will contribute to increased demand for food, while urbanization will contribute to changes in the types of food demanded.

Income conditions access to food. More than 1.3 billion people are absolutely poor, with incomes of a dollar a day or less per person, while another 2 billion people are only marginally better off (World Bank 1997b). Income growth rates have varied considerably between regions in recent years, with Sub-Saharan Africa and the Middle East and North Africa struggling with negative growth rates during the last decade while East Asia was experiencing annual growth rates exceeding 7 percent (World Bank 1997c). Prospects for economic growth during the next quarter century appear favorable, with global income growth projected to average 2.7 percent per year between 1993 and 2020 (Figure 4). The projected income growth rates for developing countries as a group are almost double those for developed countries. Growth rates are projected to be lowest in Eastern Europe and the former Soviet Union. Even Sub-Saharan Africa is projected to experience positive per capita income growth between 1993 and 2020, although it will be quite low. However, unless significant and fundamental changes occur in many developing countries, disparities in income levels and growth rates both between and within countries are likely to persist. Consequently, without concerted action, poverty is likely to remain entrenched in South Asia and Latin America and to increase considerably in Sub-Saharan Africa.

Under the baseline or most likely scenario, IMPACT projects global demand for cereals to increase by 40 percent between 1993 and 2020 to reach 2,490 million tons, for meat to increase by 63 percent to 306 million tons, and for roots and tubers to increase by 40 percent to 855 million tons (Figure 5). Most of the increases in demand between 1993 and 2020 are projected to occur in developing countries, which will account for more than 80 percent of the
increase in global cereal demand, nearly 90 percent of the increase in meat demand, and more than 90 percent of the increase in demand for roots and tubers. During this period, developing countries as a group are forecast to increase their demand for cereals by 58 percent, for livestock products by 118 percent, and for roots and tubers by 56 percent. Among the major developing regions, Sub-Saharan Africa is expected to experience the largest percentage increase in demand for all the major food commodities, albeit from low levels (Figure 6).

Demand for cereals for feeding livestock will considerably increase in importance in coming decades, especially in developing countries, in response to strong demand for livestock products. Between 1993 and 2020, developing countries' demand for cereals for feed is projected to increase by 101 percent while demand for cereals for food for direct human consumption is projected to increase by 47 percent (Figure 7). By 2020, 24 percent of the cereal demand in developing countries will be for feed, compared with 19 percent in 1993. Feed demand for cereals is projected to grow at an annual rate of 2.6 percent between 1993 and 2020, while food demand is projected to grow at 1.4 percent per year. However, in absolute terms, the increase in cereal demand for food will be higher than for feed. In developed countries, the increase in cereal demand for feed will outstrip the increase in cereal demand for food in both absolute and relative terms. Food demand is projected to grow at an annual rate of 0.2 percent in developing countries compared with 0.7 percent for feed demand between 1993 and 2020.

Because of substantial increases in demand for livestock products, especially in developing countries where primarily maize and other coarse grains are used for animal feed, demand for maize is projected to increase faster than for other cereals in both developed and developing countries (Figure 8). Global demand for maize is projected to grow at an annual rate of 1.4 percent between 1993 and 2020, followed by wheat at 1.3 percent and rice at 1.2 percent. In India and China, for instance, demand for maize and other grains for feed is projected to increase by around 3 percent per year between 1993 and 2020.

How will the expected increases in cereal demand be met? Not by expansion in cultivated area. IMPACT projects that the area under cereals will increase by only 5.5 percent or 39 million hectares between 1993 and 2020, almost two-thirds of which will be in Sub-Saharan Africa. Since growth in cultivated area is unlikely to contribute much to future production growth, the burden of meeting increased demand for cereal rests on improvements in crop yields. However, the annual increase in yields of the major cereals is projected to slow down during 1993-2020 in both developed and developing countries (Figure 9). This is worrisome given that yield growth rates during the preceding period, 1982-94, were already low compared with those experienced during 1967-82. There are two key reasons why cereal yield growth rates are slowing: (1) increasing intensification of cereal production is making it more difficult to sustain the same rates of yield gains as farmer yields approach the economic optimum yield levels in those regions where input use is high, such as in Asia; and (2) declining world cereal prices are causing farmers to switch from cereals to other, more profitable crops
and are causing governments to slow their investment in agricultural research and irrigation infrastructure. With the projected slowdowns in area expansion and yield growth, cereal production in developing countries as a group is also forecast to slow to an annual rate of 1.5 percent during 1993-2020 compared with 2.3 percent during 1982-94. This figure is still higher, however, than the 1.0 percent annual rate of growth projected for developed countries during 1993-2020.

Increased cereal production in developing countries will not be sufficient to meet the expected increase in demand. As a group, developing countries are projected to more than double their net imports of cereals (the difference between demand and production) from 94 million tons in 1993 to 229 million tons in 2020 (Figure 10). With the exception of Latin America, all major developing regions are projected to increase their net cereal imports: the quadrupling of Asia's imports will be driven primarily by rapid income growth, while the 150 percent increase forecast for Sub-Saharan Africa will be driven primarily by its continued poor performance in food production. While wheat is expected to constitute the bulk of the developing world's net cereal imports in 2020, the share of maize is forecast to sharply increase to 27 percent from 19 percent in 1993 primarily because of the rapid increase in demand for meat (Figure 11). Trade in rice is forecast to remain negligible. With an almost 60 percent projected increase in net cereal exports between 1993 and 2020, the United States is expected to capture a large share of the increased export market for cereals (Figure 12). Australia is forecast to almost double its net cereal exports during this period to 28 million tons in 2020. It is also noteworthy that under the baseline scenario, Eastern Europe and the former Soviet Union are expected to shift from being significant net cereal importers to significant net exporters by 2020.

With continued population growth, rapid income growth, and changes in lifestyles, demand for meat is expected to grow rapidly in developing countries. IMPACT projections indicate total demand for meat will increase by 2.9 percent per year during 1993-2020 in developing countries and by 0.5 percent per year in developed countries. Worldwide, demand for meat is projected to increase by 1.8 percent per year, with demand for poultry expected to increase fastest at an annual rate of 2.1 percent, compared with 1.5 percent for beef. In per capita terms, demand for meat products is projected to increase by almost 50 percent in developing countries to 31 kilograms in 2020, and by 4 percent in developed countries to 81 kilograms. In 1993, developing countries accounted for 47 percent of world meat demand; by 2020, they are projected to account for 63 percent. Meat production is expected to grow by 2.7 percent per year in developing countries during 1993-2020 (compared with 5.9 percent during 1982-94) and by 0.8 percent in developed countries (compared with 0.9 percent during 1982-94). At over 3 percent per year, production growth rates are forecast to be highest in China and Southeast Asia. Despite the quite high rates of production growth, developing countries as a group are projected to increase their net meat imports 20-fold, reaching 11.5 million tons in 2020 (Figure 13). Latin America will continue to be a net exporter of meat, but Asia will switch from being a small net exporter to a large net importer. Beef is expected to constitute 46
percent of the developing world's net meat imports in 2020, poultry 30 percent, pigmeat 13 percent, and sheep and goatmeat 11 percent.

Aquaculture has become the fastest-growing food production system in the world, with global production increasing on average by more than 11 percent annually between 1990 and 1995 (Ahmed 1997). In 1995, aquaculture contributed 19 percent of global fish production, compared with 13 percent in 1990 (FAO 1997f). With sustainable production from the world's natural fish stock at its limit, supplies from capture fisheries have stabilized after nearly three decades of steady growth at around 90 million tons. Income growth, changes in preferences, and health concerns about meat have considerably increased fish consumption in developed countries to about 27 kilograms per person per year (Delgado and Courbois 1997). However, fish consumption remains relatively low in developing countries, except for East Asia. China has experienced almost a tripling of per capita fish consumption from 3.6 kilograms in 1970 to 9.8 kilograms in 1990.

Projections of future fish consumption are scarce. IMPACT does not include fish because of data limitations. FAO projections suggest that direct human consumption of fish will increase from 75-80 million tons in 1994/95 to 110-120 million tons in 2010 (Delgado and Courbois 1997). Much of the increase in fish consumption is projected to occur in East Asia and, to a lesser extent, in North America and Australia. China's per capita consumption of fish is predicted to double from 9.8 kilograms in 1990 to 20 kilograms in 2010, driven primarily by income increases, and will be met increasingly from aquaculture production. Real fish prices have remained relatively stable since 1970, while real beef prices have declined substantially and are now less than one-third of the 1970 price. Delgado and Courbois (1997) report an emerging consensus that real fish prices are likely to rise by about 10 percent by 2020, while IMPACT projections suggest that beef prices will decline by about 5 percent between 1993 and 2020, implying a long-run increase in the relative fish/beef price and therefore major adjustments in the world markets for both fish and beef. This relative price increase for fish implies that fish demand in China could be about 13-16 percent lower in 2020 than if world relative prices had remained at around the 1990s level (Delgado and Courbois 1997). As consumption and trade patterns for fish change in both developed and developing countries, the fisheries sector is in the midst of a rapid transition; research on fisheries policy has an important role to play in facilitating a smooth transition (Ahmed, Delgado, and Sverdrup-Jensen 1990).

Net imports are a reflection of the gap between production and market demand. The gap between production and human needs is likely to be even wider, because many of the poor are priced out of the market, even at low food prices, and are unable to exercise their demand for needed food. The higher-income developing countries, notably those of East Asia, will be able to fill the gap between production and demand through commercial imports, but the poorer countries may be forced to allocate foreign exchange to other uses and thus might not be able to import food in needed quantities. It is the latter group of countries, including most of those in
Sub-Saharan Africa and some in Asia, that will remain a challenge and require special assistance to avert widespread hunger and malnutrition.

Worldwide, per capita availability of food is projected to increase around 10 percent between 1993 and 2020, from about 2,700 calories per person per day in 1993 to about 2,900 calories. Increases in average per capita food availability are expected in all major regions. China and East Asia are projected to experience the largest increase, about 400 calories per person per day, and West Asia and North Africa the smallest, about 60 calories (Figure 14). The projected average availability of about 2,311 calories per person per day in Sub-Saharan Africa is just barely above the minimum required for a healthy and productive life. Since available food is not equally distributed to all, a large proportion of the region’s population will have access to less food than needed and will thus remain food insecure and malnourished.

RECENT DEVELOPMENTS AND EMERGING ISSUES

Rising Cereal Prices and Falling Cereal Stocks

Sharp increases in international wheat and maize prices, along with significant reductions in global cereal stocks, received wide publicity and greatly excited concerns about food security during the past two to three years. Most of 1995 and the first half of 1996 were characterized by rising international prices of wheat and maize (Figure 15). The price of wheat peaked in May 1996 at around $260 per ton, 65 percent higher than the price one year earlier and more than double the price in May 1994. The price of maize also peaked in May 1996 at around $200 per ton, almost twice the price prevailing in May 1995 and May 1994. The run-up in prices resulted from an unusual combination of factors, including poor weather in some major cereal-producing countries such as Australia, Canada, and the United States; policy-induced reductions in price subsidies in Western Europe and North America that diminished production and stock-holding incentives; substantial drawdowns in cereal stocks to compensate for production shortfalls; significant declines in food production in the former Soviet Union; and adverse policies and weather combined with accelerating demand for meat and feed grain in China (Pinstrup-Andersen and Garrett 1996; FAO 1996c; Friedberg and Thomas 1997; Rosegrant, Sombilla, Gerpacio, and Ringler 1997). Between 1994/95 and 1995/96, global cereal production declined by 3.1 percent to 1,728 million tons, driven by a 10.7 percent reduction in production in developed countries that was only partly offset by a slight increase in production in developing countries (Table 1). However, global consumption of cereals outstripped production for the third year in a row, considerably depleting stocks and contributing to a rapid increase in prices.

If fully transmitted to domestic markets, these sharp increases in international cereal prices could have boosted producer incomes but hurt poor consumers in developing countries, given that many of them spend more than half of their income on food (Pinstrup-Andersen and Garrett 1996). However, many governments took measures to offset price increases, usually
trade-related measures, including tariff reductions and substitution with cheaper, lower-quality cereal imports (FAO 1996d; Friedberg and Thomas 1997). An FAO study of 30 developing countries found very low price transmission between international and domestic prices for cereals and noted that domestic price increases were less than world market price increases in the majority of countries (FAO 1996d). Friedberg and Thomas (1997) report that in 13 out of the 22 import-dependent developing countries studied, import bills rose less than they would have if imports had continued through 1996 at their 1991-93 levels, suggesting that many countries reduced their cereal imports significantly in response to higher international prices. Some major cereal importers such as India and Pakistan even became temporary net exporters. Moreover, according to Friedberg and Thomas (1997), the cereal price increases of 1995-96 were relatively mild compared with those experienced during the crisis of the early 1970s; at its peak, the 1996 wheat price was, in real terms, only one-third of the peak price in 1974, while the maize price was less than half of the 1974 peak price.

Closely associated with the cereal price increases of 1995-96 were substantial reductions in global cereal stocks, which reached a 20-year low of about 250 million tons in 1995/96 (Figure 16). As a share of consumption, global cereal stocks slipped to 14 percent in 1995/96, well below the 17 percent considered by FAO to provide the necessary margin of safety for world food security. Much of the drawdown in stocks occurred in the traditional exporting or stock-holding countries (Table 1). Since then, stocks are being gradually built up, but the ratio of stocks to consumption remains below the 17 percent minimum safe level. Additional analysis is needed to explore whether 17 percent is still necessary given the current market conditions.

The rising cereal prices of 1995-96 were indeed a short-run phenomenon and not the beginning of a permanent upswing in prices or the forerunner to another world food crisis as feared by some. As cereal production rebounded in 1996/97 and is forecast to further increase in 1997/98, international prices have returned to the pre-1995 declining trend. Futures prices suggest that wheat and maize prices will stay roughly constant in real terms over the next year or so, with slight increases in nominal prices (Figure 15). The long-term trend is for cereal prices to continue to decline, although at slower rates than in the past. Real wheat prices will decrease only slightly until 2010, maize prices are expected to stagnate, and rice prices are projected to increase (Figure 17). After 2010, the continued decline in the rate of population growth and declining income elasticities of demand for cereals will combine to reduce demand growth, and cereal prices are projected to drop by 11 percent between 2010 and 2020. Meat prices are projected to decline by only 5 percent between 1993 and 2010, and thereafter by another 1 percent to 2020 (Figure 17). Prices for roots and tubers are expected to slightly increase between 1993 and 2010 by 3 percent before declining by 7 percent to 2020.

Concerns are growing that cereal prices may be more volatile than in the past (FAO 1996e). Reduced stocks and uncertainties associated with developments in China and the former Soviet Union, among other factors, could increase price instability. On the other hand, market liberalization in developing countries, policy reform in developed countries, and more
consistent and transparent stock-holding and trade policies will make producers more responsive to price changes and could reduce price instability. How these factors play out will determine whether cereal prices will be more volatile in coming years. In addition to price fluctuations in the international market, many low-income food-insecure developing countries suffer from large domestic price fluctuations owing to lack of market integration, deficient infrastructure, and inappropriate policies and institutions. In addition, even small changes in production resulting from better or adverse growing conditions may cause large food price fluctuations. As an illustration of the large local price fluctuations in low-income developing countries, in Niger, for example, the price of millet during August 1997 was significantly higher than in August 1996 and almost double the price in August 1995 (Figure 18).

Concerns about Feeding China

With one-fifth of the world’s population and one of the fastest-growing and most rapidly transforming economies in the world, China has the potential to significantly affect global food security depending on the extent of its future demand for cereals, its capacity to meet its needs through production, and the degree to which it will enter world markets to satisfy its unmet needs (Rozelle and Rosegrant 1997). Concerns about how China will meet its food requirements escalated recently when China shifted from being a minor net exporter of cereals in 1992-94 to a substantial net importer in 1995 (Figure 19). These concerns became frenzied with the publication in 1995 of Lester Brown’s book Who Will Feed China? in which Brown predicted that China’s cereal import requirements would increase to 200-370 million tons in 2030, putting severe upward pressure on international cereal prices, forcing low-income countries out of the world cereal market, and severely compromising global food security. He argued that China would experience substantial reductions in its cereal production from about 340 million tons in 1990 to 270 million tons in 2030, while per capita consumption would increase by one-third to 400 kilograms per person. Brown’s gloomy predictions were refuted by Chinese government officials and other experts (Alexandratos 1996 and 1997; Paarlberg 1997; Rozelle and Rosegrant 1997; Information Office of the State Council of the People’s Republic of China 1996). China has since returned to past levels of virtual self-sufficiency in grain with small net cereal imports of 2-4 million tons annually. The concerns arising from China’s shift to being a net cereal importer in 1995 seem somewhat misplaced when it is noted that China has been a net importer in 13 of the 18 years since 1980 (Figure 19). Speculations about China’s foray into world cereal markets and its future cereal import requirements, coupled with the rapid rise in cereal prices in 1995-96 and the drawdown in global cereal stocks, have unfortunately served to distract global attention from the more silent food security crises under way in other parts of the world.

Views on the size and dominance of China’s food economy in the 21st century vary widely, with some forecasting that China will be a major cereal exporter (Chen and Buckwell 1991; Mei 1995) and others cautioning that China might become a major cereal importer, if not
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Pinstrup-Andersen, Pandya-Lorch, and Rosegrant
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The world's largest importer (Garnaut and Ma 1992; Carter and Funing 1991; Brown 1995). IMPACT projections indicate that, in the baseline scenario, total cereal demand in China will increase by 42 percent between 1993 and 2020 to 490 million tons, and cereal production by 31 percent to 449 million tons. At 41 million tons, China's net cereal imports in 2020 would represent 18 percent of the developing world's projected net cereal imports. Production is projected to almost keep up with increases in China's meat demand. A predicted increase in demand of 132 percent between 1993 and 2020 would result in net imports of only 0.3 million tons—3 percent of the developing world's projected net imports in 2020. While sizable, China's projected net cereal imports in 2020 are unlikely to pose an intolerable burden on the global food situation.

Alternative simulations suggest that only with extraordinarily rapid income growth, severe resource degradation, and failure to invest in agriculture would China's net cereal imports increase substantially and have a significant effect on world cereal prices (Rozelle and Rosegrant 1997). Even then, the effect would be muted by market operations. For instance, should there be no increase in government investment in the agriculture sector in China, cereal production could be 19 percent lower in 2020 relative to the baseline scenario (Table 2). This could lead to net cereal imports of 85 million tons in 2020, more than double the volume forecast in the baseline scenario, which would put pressure on world markets and cause world cereal prices to increase by 10 percent relative to the baseline scenario (Table 3). However, should China increase its government investment in agriculture by 5 percent annually in real terms, domestic production is forecast to increase to 573 million tons in 2020, 28 percent higher than production levels in the baseline scenario. In this scenario, China would become a net exporter, of as much as 31 million tons of cereals in 2020, easing pressure on the world market and causing prices to decline by 11 percent.

Other "what-if" scenarios simulate the impact of changes in Chinese government policies on world cereal prices (Fan and Sombilla 1997). For instance, if the Chinese government should adopt policies to promote the attainment of 100 percent self-sufficiency in cereals, world cereal prices are forecast to be 6 percent lower in 2020 relative to the baseline scenario (Table 3). China's cereal production would be higher relative to the baseline scenario, while demand would be lower (Table 2). By definition, there would be no net trade in cereals under this scenario. And should the Chinese government pursue a policy of 95 percent self-sufficiency in cereals, world cereal prices would only be slightly higher relative to the baseline scenario (Table 3).

Expanded livestock production in China will rely increasingly on grain-based feed with a reduction in reliance on roots and tubers and on backyard foraging. If China were to employ the same proportion of feed originating from cereals as that employed in commercial farms in the United States, it is projected that cereal demand would increase by 14 percent in 2020 relative to the baseline scenario, such that net cereal imports would increase to 69 million tons, almost 70 percent higher than in the baseline scenario (Table 2). This would put pressure on
world markets and cause world cereal prices to increase by 10 percent in 2020 relative to the baseline scenario (Table 3). More notably, China's net meat imports are projected to jump to 24.6 million tons in 2020, an extraordinary high level compared to 0.4 million tons in the baseline scenario (Table 4). Consequently, world meat prices are projected to be 17 percent higher relative to the baseline (Table 3). However, should the structural transformation in the Chinese livestock sector be accompanied by technical changes that promote efficiencies in animal feed use and improve the feed/meat conversion ratios, total cereal demand in 2020 is projected to be about 4 percent lower than in the baseline scenario while net cereal imports would be 36 percent lower. At 0.2 million tons, net meat imports in 2020 would be half the volume forecast in the baseline scenario.

China is already a significant player in world food markets and is likely to become increasingly important. However, it does not represent a major threat to world food markets. Considerable flexibility in supply response still exists, both in China and elsewhere in the world.

**Rapid Growth and Structural Changes in Indian Diets**

With a population of 930 million in 1995, India is the second most populous country in the world after China (UN 1996). Like China more than a decade ago, India is in the midst of major economic reform. If it succeeds, incomes in India will rise much faster than they have in recent decades, with significant effects on food demand and food security. In the baseline scenario, IMPACT projects an average annual economic growth rate of 5.5 percent during 1993-2020. With this growth rate, the number of malnourished children is projected to decline from 70 million in 1993 to 42 million in 2020, while the proportion of children who are malnourished is projected to decline from 60 percent to 40 percent. Daily per capita calorie availability is projected to increase from around 2,400 calories to 2,850 calories. If economic growth rates were even higher, further reductions in child malnutrition and other improvements in food security would occur.

Views are mixed about whether there will be a structural shift in Indian diets to livestock products as incomes increase or whether India will remain more or less vegetarian as its history and cultural traditions would suggest. In the baseline scenario, demand for livestock products is projected to increase by 4.6 million tons between 1993 and 2020 to 8.5 million tons. Note that the corresponding increase in meat demand in China is 51 million tons to 89 million tons in 2020. Although income elasticities for livestock are slightly higher in India than in China, the extremely low initial levels of livestock consumption in India preclude rapid growth in absolute demand for livestock, unless there is a dramatic structural change in demand patterns. In a scenario modeling the effects of rapid structural changes in Indian diets in which income elasticities for meat are set at 2.0, India's demand for meat products is forecast to increase almost 10-fold from 3.8 million tons in 1993 to 36.4 million tons in 2020. This increase in demand would have to be met through trade as meat production is not projected to increase
beyond the 8.5 million tons in 2020 projected in the baseline scenario. India's projected net meat imports of 28 million tons in 2020 under the scenario of rapid structural shifts in diets is a far cry indeed from the less than 0.5 million tons forecast in the baseline scenario. This increase in Indian meat demand and net imports is projected to increase world meat prices by 21 percent in 2020 relative to the baseline scenario, which would represent a 13 percent increase in world prices between 1993 and 2020.

Research by IFPRI and collaborating institutions in India on the potential for and implications of rapid structural shifts in Indian diets in response to income increases is still in its preliminary stages, but there are indications that such changes could significantly affect the world food situation. The share of feed originating from cereals is extraordinarily low in India, even when compared with other Asian countries. Such low shares could not be sustained if domestic livestock production were to grow in response to changing consumption patterns. How, then, the demand for cereals for livestock feed would change and at what rate is critical. It is instructive to note that, in the baseline scenario, IMPACT projects China to demand a total of 490 million tons of cereals in 2020 while India, with a population only slightly less than that of China, is projected to demand 250 million tons. Should a rapid structural shift in Indian diets occur and should India attempt to meet potentially large increases in livestock demand through domestic livestock production rather than imports, implications for global livestock and cereal trade and prices would be dramatically different from those predicted by the baseline scenario.

The Transition in Eastern Europe and the Former Soviet Union

The fall of the Berlin Wall and the associated political changes in the former Soviet Union and Eastern Europe brought great promise for rapid economic growth in that part of the world. Many projected that food production in a number of countries affected, including Ukraine and the Russian Federation, would expand rapidly and significantly, causing the former Soviet Union and Eastern Europe to switch from being net importers of grain to being significant net exporters over a short period of time (Tyers 1994). This scenario has not materialized in the former Soviet Union, although net imports have declined from about 39 million tons in 1991/92 to less than 2 million tons in 1996/97 (FAO various years). There is still a great deal of uncertainty regarding future food production and demand in those countries. Many of the countries of Eastern Europe and the former Soviet Union have tremendous agricultural potential that is as yet underutilized. Appropriate changes in institutions and policies (including property rights), increased market and trade liberalization, and investment in rural infrastructure could result in rapid production increases. However, such changes have been extremely slow. For example, grain production in Ukraine has decreased sharply since the beginning of the transition process from an annual average of 47.4 million tons during 1986-90 to 36.4 million tons during 1991-96 (von Cramon-Taubadel 1997). The decline continues and grain production fell to about 27 million tons in 1996. Appropriate institutions and policies could not only bring grain production back to pre-transition levels but could also turn Ukraine's large grain
production potential into major exportable surpluses. European Union membership by some of the countries of Eastern Europe could accelerate agricultural transformation in these countries with resulting expansions in food production.

IMPACT's baseline scenario projects that Eastern Europe and the former Soviet Union will become major net exporters of cereal by 2020, on the order of about 33 million tons. Cereal production is projected to increase by almost 40 percent between 1993 and 2020 to 341 million tons, while demand is projected to increase by 12 percent to 308 million tons. However, simulations suggest that should crop productivity increase at a slower pace than forecast, say at only 70 percent of the rate of increase projected for 1993-2020 under the baseline scenario, crop production would increase by only 10 percent between 1993 and 2020 to 273 million tons while demand would increase to 303 million tons, resulting in net cereal imports of 30 million tons in 2020—a very different outcome from that forecast in the baseline scenario. The impact of slow crop production in Eastern Europe and the former Soviet Union could cause world cereal prices to be higher by about 9 percent in 2020 relative to the baseline scenario. Changes in cereal production and demand in Eastern Europe and the former Soviet Union can have significant effects on the world food situation, but it will take very large declines in productivity growth in this region to dramatically drive up cereal prices.

Malthus's Shadow Waning in Sub-Saharan Africa

Economic recovery in Sub-Saharan Africa is raising hopes that the spectre of Malthus may finally be banished from this region. After a number of years of low or negative growth, gross domestic product (GDP) increased by 4.2 percent in 1995 and 4.8 percent in 1996, and is forecast to increase by 4.75 percent in 1997 (Figure 20). With population growing by about 3 percent per year, this implies that for the first time in many years, GDP per capita will have increased for three consecutive years. The economic recovery is widely shared, with 20 countries achieving a GDP growth rate of 5 percent or higher in 1996 (UN 1997). Spurred partially by favorable weather, agricultural growth is a key contributor to the overall economic recovery. Cereal production in Southern Africa, for instance, is estimated to have increased by 68 percent in 1996 (UN 1997).

The economic recovery in Sub-Saharan Africa is fragile. Some of the factors that contributed to the recovery are shorter-term in nature and cannot be expected to persist; these include the higher commodity prices during 1994 and 1995 and the favorable weather conditions in 1996 that enabled recovery from the effects of drought in 1994 (UN 1997). Other factors, such as policy reforms, an improved macroeconomic environment, and social and political stability, can have a more lasting effect on economic growth, if properly nurtured. Moreover, economic growth rates will have to be substantially higher if they are to make a dent in Sub-Saharan Africa's poverty; per capita incomes have fallen so much that even if economic
growth were to continue at the current pace (about 5 percent per year), it would still take at least a decade to recover to the levels prevailing in 1980 (UN 1997).

Nevertheless, could Malthus's shadow over Sub-Saharan Africa finally be waning? Malthus's basic argument was that the world's natural resources could not assure expansions in food supply that would match population growth. Region after region has disproved his prediction, but in Sub-Saharan Africa the population growth rate has exceeded the rate of growth in food production since the early 1970s and the gap is widening, resulting in declining food production per capita (Figure 21). Simple extrapolations of the trends in population and food production growth since 1961 show a further increase in the gap between population and food production. This is exactly the gap predicted by Malthus. However, Malthus's predictions grossly underestimated the potential of productivity-increasing technology. Where such technology has been effectively developed and utilized, such as in Asia, food production has expanded much faster than population (Figure 22).

In Sub-Saharan Africa, the potential of appropriate productivity-increasing technology has yet to be realized. Maize yields for Africa, Asia, and China were virtually the same in 1961, but since then they have tripled in Asia and quintupled in China while they have remained stagnant at around 1 ton per hectare in Africa (FAO 1997a; Byerlee and Eicher 1997). However, there are encouraging signs that productivity-increasing technology is beginning to accelerate yield growth of African food crops. For example, the introduction of improved maize varieties has resulted in productivity increases in West and Central Africa at rates as high as 4 percent per year during the period 1983-92 (CGIAR 1997). Some countries have experienced particularly high rates of growth in maize production during this period, including Burkina Faso (17.1 percent), Ghana (8.3 percent), and Mali (7.5 percent), albeit starting from low levels. If Malthus is to be proven wrong in Sub-Saharan Africa, a much greater effort must be made to assure that farmers have access to appropriate production technology and that policies are conducive to expanded productivity in staple food crops. Besides new initiatives and expanded support for agricultural development, more effort must also be done to reduce population growth. Although Sub-Saharan Africa's annual population growth rate is projected to decline, the number of people added to the region's population every year is projected to increase until at least 2020, a consequence of the past high rates of population increase (Figure 23). Moreover, Sub-Saharan Africa's projected annual population growth rate of 2.33 percent during 2015-2020 will be more than double the growth rates in other regions (UN 1996). Population growth of this magnitude will severely constrain efforts to increase income and improve welfare, while at the same time it will greatly increase the need for food.

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6 While Malthus argued that the population would grow geometrically and food production would grow arithmetically, the extrapolations shown in Figure 21 are based on a non-linear regression. Such a function showed a better fit than linear functions for either of the two variables. Extrapolations based on Malthus's argument would result in a larger gap.
Weather Fluctuations and Climate Change

With the resurgence of El Niño, a large-scale abnormal warming of the sea surface off the South American coast, major weather fluctuations are under way or imminent in many parts of the world. These weather fluctuations could lead to sizable food production shortfalls and deterioration in food security in many parts of the world. Many expect the current El Niño to approach, if not surpass, the last two major El Niños of 1982-83 and 1991-92. The 1982-83 El Niño caused severe flooding in Latin America, droughts in parts of Asia, decline in several fish stocks, and other weather-related damage estimated at over US$10 billion (FAO 1997d, 1997e). The 1991-92 El Niño resulted in a severe drought in Southern Africa that caused cereal production to drop by 60 percent or more in several countries, and imports and food aid substantially increased to meet more than half of the cereal consumption in at least five countries (Pinstrup-Andersen, Pandya-Lorch, and Babu 1997). The temperature and rainfall anomalies accompanying the current El Niño could have significant effects on agriculture and other sectors around the world. In Central America, which is particularly vulnerable, El Niño caused a warmer and earlier dry period, hindering the development of crops already in the ground and reducing the area planted (FAO 1997d). El Niño's effects are expected to intensify between December and March and could affect Central America's premier foreign exchange earner, coffee, which will be in a critical flowering stage at that time (FAO 1997d). In the Andean countries of South America, floods in the north and excessively dry conditions in the south may affect the planting of the 1998 main season cereal crops (FAO 1997d). Rainfall may be significantly below normal during the main rainy season in South Africa, southern Mozambique, Lesotho, and Swaziland (FEWS 1997). Indonesia, Papua New Guinea, the Philippines, and Thailand are currently gripped by their most severe drought in several decades, which exacerbated recent forest fires in Indonesia and cast a smoky haze over the entire region (FAO 1997e). Two-thirds of China is suffering from prolonged dry spells. Australia is in the midst of a severe drought that could cut its wheat harvest by more than 30 percent. Of course, in other parts of the world, El Niño could have positive effects on weather patterns and correspondingly perhaps on agricultural production. Nevertheless, El Niño adds a major element of uncertainty to agricultural production and livelihoods around the world. And concerns are growing that El Niños may become more frequent and more severe in the future as a result of climate changes.

While the trend of global warming is becoming increasingly clear, its effects on food production are still uncertain. Some research suggests that growing conditions will deteriorate in current tropical areas (where many of the developing countries are located) and improve in current temperate areas (where many of the developed countries are located) (Rosenzweig and Parry 1994; Fischer, Frohberg, Parry, and Rosenzweig 1996). However, effects on productivity and production will occur over a long period of time and will be very small in any given year. Therefore, it is reasonable to believe that policies and technologies can be developed to effectively prevent or counter the negative productivity effects of global warming. Failure by the public sector to act, and failure by the market and the private sector to respond, could result in
significant long-term effects on food supply. Such a scenario might include reduced food production in tropical and subtropical countries and increased production in temperate countries. Whether these opposing effects will cancel each other out through expanded international trade, with little or no effect on total world food supply, is yet to be determined.

**Growing Water Scarcity**

Unless properly managed, fresh water may well emerge as the key constraint to global food production. While supplies of water are adequate in the aggregate to meet demand for the foreseeable future, water is poorly distributed across countries, within countries, and between seasons. And with a fixed amount of renewable water resources to meet the needs of a continually increasing population, per capita water availability is declining steadily. Today, 28 countries with a total population exceeding 300 million people face water stress; by 2025, their number could increase to about 50 countries with a total population of about 3 billion people (Rosegrant, Ringler, and Gerpacio 1997; Population Action International 1995) (Figure 24).

Growth in irrigated area is projected to slow significantly. Worldwide, irrigated area is projected to grow at an average annual rate of 0.6 percent per year during 1995-2020, less than half the annual growth rate of 1.5 percent during 1982-93. In developed countries, irrigated area is projected to increase by only 3 million hectares (Figure 25), at an annual rate of only 0.2 percent, compared with 0.8 percent during 1982-93. Irrigated area in developing countries is projected to increase by 37 million hectares to 227 million hectares in 2020, at an average annual rate of 0.7 percent, far below the growth rate of 1.7 percent during 1982-93. The largest increase in irrigated area is expected in India (17 million hectares); public investment in irrigation has remained relatively strong and private investment in tubewells has been rapid. Acreage under irrigation will remain very low in Sub-Saharan Africa, despite a 50 percent increase to 7.4 million hectares in 2020. Simulations suggest that increased investment in irrigation can make a significant contribution to food production growth in Sub-Saharan Africa, although the amount of land under irrigation and the potential area exploitable relative to total crop area may not be large enough to generate revolutionary increases in crop production (Rosegrant and Perez 1997).

While water supplies will tighten, demand for water will continue to grow rapidly. Since 1970, global demand for water has grown by 2.4 percent per year (Rosegrant, Ringler, and Gerpacio 1997). Projections of water demand to 2020, consistent with the food supply and demand projections to 2020 from IMPACT, indicate that global water withdrawals will increase

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7 Their annual internal renewable water resources are less than 1,600 cubic meters per person per year.

8 Approximated by water withdrawals because of a lack of consistent data on consumptive use of water at national or regional levels.
by 35 percent between 1995 and 2020 to reach 5,060 billion cubic meters. Developed
countries are projected to increase their water withdrawals by 22 percent, more than 80 percent
of the increase being for industrial uses (Figure 26). Developing countries are projected to
increase their withdrawals by 43 percent over the same period and to also experience a
significant structural change in their demand for water. The increase in demand for water for
domestic and industrial uses is expected to outstrip the increase in demand for agricultural uses
such that the share of domestic and industrial uses in total water demand is projected to
double from 13 percent in 1995 to 27 percent in 2020. Among the developing countries, India
is projected to have the largest absolute increase in water withdrawals between 1995 and 2020
while China is projected to have the most dramatic transformation in water demand with the
share of domestic and industrial use in total water demand increasing from 13 percent in 1995
to 35 percent in 2020 (Rosegrant, Ringler, and Gerpacio 1997).

The costs of developing new sources of water are high and rising, and while
nontraditional sources such as desalination, reuse of wastewater, and water harvesting are
unlikely to add much to global water availability, although they may be important in some local
or regional ecosystems. So how can the rapid increases in water demand be met? The rapidly
growing domestic and industrial demand for water will have to be met from reduced use in the
agriculture sector, which is by far the largest water user, accounting for 72 percent of global
water withdrawals and 87 percent of withdrawals in developing countries in 1995 (Rosegrant,
Ringler, and Gerpacio 1997). Reforming policies that have contributed to the wasteful use of
water offers considerable opportunity to save water, improve efficiency of water use, and boost
crop output per unit of water. The key elements of required policy reforms include
establishment of secure water rights to users; decentralization and privatization of water
management functions; and utilization of incentives for water conservation, including markets in
tradable water rights, pricing reform and reduction in subsidies, and effluent or pollution
charges (Rosegrant 1997). Failure to address the disjunct between tightening supplies and
increasing demand for water could significantly slow growth in food production.

**Declining Soil Fertility**

Improved soil fertility is a critical component of low-income countries' drive to increase
sustainable agricultural production. Past and current failures to replenish soil nutrients in many
countries must be rectified through the balanced and efficient use of organic and inorganic plant
nutrients and through improved soil management practices. Of particular importance to
maintaining and enhancing soil fertility is the adoption of integrated plant nutrient management
(IPNM) practices. The goal of IPNM is to integrate the use of natural and human-made sources
of plant nutrients to increase agricultural productivity in an efficient and environmentally benign
manner without diminishing the productive capacity of soil for present and future generations.
While some of the plant nutrient requirements can be met through the application of organic materials available on the farm or in the community, such materials are insufficient to replenish the plant nutrients removed from the soils and will therefore also be insufficient to further expand crop yields. The use of chemical fertilizers has decreased worldwide during the last few years. The decrease has been particularly pronounced in the developed countries and in parts of Asia. While decreases in the use of fertilizers are warranted in some locations because of negative environmental effects, it is critical that fertilizer use be expanded in those countries where a large share of the population is food insecure. Fertilizer consumption in these countries is generally low. For example, on average, fertilizer consumption in Sub-Saharan Africa is about 14 kilograms per hectare as opposed to around 200 kilograms per hectare in East Asia (World Bank 1997b). Expanded use of fertilizers in Sub-Saharan Africa will help alleviate current production shortfalls as well as serious land degradation resulting from soil mining. One of the largest environmental problems in Africa today is the gradual decline in the fertility of much of the soil. Failure to deal with this problem will reduce future food supplies and accelerate soil degradation.

Between 1990 and 2020, global fertilizer demand is forecast to grow by 1.2 percent per year, a significantly lower rate than the 2.8 percent of the 1980s (Bumb and Baanante 1996). Average annual growth rates are projected to be about 1.8–2.4 percent in Africa, Asia, and Latin America. The projected growth in fertilizer use in developing countries will be inadequate to meet nutrient requirements for food production and for resource conservation (Bumb and Baanante 1996). Fertilizer applications are low in low-income countries because of high prices (resulting from thin markets, lack of domestic production capacity, poor infrastructure, and inefficient marketing systems), insecure supplies, and the greater risks associated with food production in marginal areas. Policies to help low-income farmers improve the content of plant nutrients in their soils must be strengthened. Such policies should provide incentives for farmers to use available organic materials effectively, and they should provide access by farmers to reasonably priced inorganic fertilizers.

In view of the size and seriousness of the soil fertility problem in many low-income countries, a cost-effective fertilizer sector and policies providing incentives for farmers and communities to implement integrated soil fertility programs are needed. Such policies should focus on supporting agricultural research to generate appropriate technology; clear long-term property rights to land; access to credit, improved crop varieties, water, and information about effective and efficient fertilizer use in various production systems; efficient and effective markets for plant nutrients; and investments in roads and rural transportation systems. Negative environmental and health consequences of fertilizer use must be avoided. In most developing countries, however, the environmental problem is not excessive but insufficient fertilizer use. The major challenge is to promote a balanced and efficient use of plant nutrients from both organic and inorganic sources at farm and community levels to intensify agriculture in a sustainable manner.
Diminishing Food Aid

At 7.5 million tons, global food aid deliveries in 1996 were less than half the 16.8 million tons distributed just three years earlier in 1993 and the smallest volume delivered in more than a decade (WFP 1997). Preliminary indications are that food aid deliveries during 1997 are likely to be the same or even slightly lower than in 1996. Changes in agricultural policies in North America and the European Union, the implementation of the Uruguay Round trade agreements, and changing geopolitical and domestic concerns within donor countries have contributed to diminished interest in and support for food aid among donors, especially the United States, which reduced its food aid deliveries from over 10 million tons in 1993 to less than 4 million tons in 1996 (WFP 1997). As Figure 27 shows, all regions, most notably Eastern Europe and the former Soviet Union, have experienced reductions in food aid deliveries. In Sub-Saharan Africa, food aid deliveries in 1996 reached their lowest level since 1983 (WFP 1997). An increasingly higher proportion of the reduced food aid is being channeled through targeted relief operations and development projects—60 percent in 1996 compared with 40 percent in 1990—rather than through untargeted program assistance (WFP 1997).

The substantial reduction in food aid deliveries, combined with the growing tendency to channel food aid through relief operations and development projects, has disturbing implications for food security unless other development assistance increases. The need for aid to combat food insecurity has not diminished. For instance, 29 countries are currently facing food emergencies due to man-made or natural disasters; of these, 17 are in Sub-Saharan Africa (FAO 1997b). Moreover, if the resurgence of El Niño has consequences similar to those experienced in earlier events, large volumes of food aid may be required to meet the needs of drought-stricken countries in parts of Africa, especially in Southern Africa, which was hit hard on the last few occasions. Food aid will have an important role for some years, not only in addressing humanitarian emergencies but also in directing resources to many of the world's most vulnerable food-insecure people and areas to help them permanently escape poverty and assure food security (Webb 1995).

Food aid has traditionally been driven primarily by the availability of excess food stocks in the United States, Western Europe, and other countries with quantity-related farm subsidies. As such stocks are reduced, however, an increasing amount of food aid will need to be purchased in the market. Given the high transaction costs usually associated with food aid, consideration should be given to the gradual replacement of program food aid with increasing cash assistance for commercial food import. It is, of course, not certain that surplus stocks will continue to be low. According to a recent European Commission study (1997), continuation of current farm policies will result in the rebuilding of large grain stocks during the next 10 years (Figure 28). Should the European Union be enlarged by inclusion of Eastern European countries and should these new members be permitted to obtain the benefits of existing common agricultural policies, grain stocks may increase even faster.
Declining Official Development Finance

Paralleling the rapid decline in food aid to developing countries has been a notable reduction in official development finance to developing countries (Figure 29). In nominal terms, official development finance has fallen almost 40 percent between 1991 and 1996 to US$41 billion. Between 1995 and 1996 alone, official development finance declined by almost 25 percent. Of course, in real terms the reduction is even sharper. While official development finance has been falling, net private capital flows to developing countries have been growing extraordinarily fast, increasing more than fivefold between 1990 and 1996, from $44 billion to $244 billion. However, most of the private capital flows have been directed to a handful of countries in East Asia and Latin America. Sub-Saharan Africa and South Asia are all but bypassed by these private flows—together they received less than 10 percent of the net private capital flows to the developing world in 1996—and remain dependent on shrinking flows of international assistance. This has significant implications for their capacity to engage in broad-based and sustained economic growth and thereby to improve their prospects for food security. Agriculture has been one of the sectors to suffer most from the decline in international assistance to developing countries. In real terms, external assistance to developing-country agriculture almost halved from a peak of $19 billion in 1986 to $10 billion in 1994 (Figure 30).

Trade Liberalization Issues

A large number of developing countries have liberalized foreign trade in food and agricultural commodities in response to the recent GATT agreement and structural adjustment programs. Unfortunately, the opening up of markets in developing countries has not been matched by market openings in the countries of the Organization for Economic Cooperation and Development (OECD). This asymmetry in trade liberalization results in reduced benefits to developing countries and raises questions about the viability of continued market liberalization in developing countries under these conditions. While preferential treatments are still in place for specific quantities of certain commodities, OECD countries have been reluctant to open up their domestic markets for imports from developing countries of high-value commodities such as beef, sugar, groundnuts, and dairy products. At the same time, developing countries are being encouraged through structural adjustment to emphasize production of high-value agricultural commodities for export. From the point of view of food security and poverty alleviation in developing countries, the next round of the World Trade Organization (WTO) negotiations should emphasize the opening up of domestic markets in OECD countries for commodities from developing countries.

Another important lesson from recent research on trade liberalization is that developing countries must improve their domestic policies to fully benefit from trade liberalization. Investments in domestic infrastructure, effective and efficient agricultural input and output markets, research and technology, and a more equal distribution of land and other productive
resources are critical if developing countries are to capture potential benefits from trade liberalization. Furthermore, while most poor and food-insecure people are expected to benefit from trade liberalization, the distribution of benefits will be determined largely by the distribution of productive assets. Countries with very skewed distribution of assets may experience an amplification of this pattern as a result of trade liberalization. Therefore, emphasis on trade liberalization should be matched with similar or stronger emphasis on rectifying domestic policies, including improved access by the poor to productive assets and employment.

Recent estimates (Andersen et al. 1997) indicate that the impact of the Uruguay Round on international food and agricultural prices is very limited indeed. It is estimated that the Uruguay Round will result in price increases for grains and livestock products between 2 and 5 percent by the year 2005. These small increases will not offset the long-term declining trend in food prices.

Population Growth Slower Than Projected

Recently, the United Nations concluded that its earlier projections had overestimated population growth. The actual annual population growth rate between 1990 and 1995 was 1.48 percent rather than the 1.68 percent estimated in 1992 or the 1.57 percent estimated in 1994 (UN 1993, 1995, 1996). In light of this development, the United Nations revised its projections for population growth in the next century. The annual rate of change in world population during 2015-2020 is now estimated at 1.03 percent instead of 1.13 percent as projected in 1992. Under the medium-variant estimates, the world's population is projected to reach 7.67 billion by 2020, about 300 million less than had been projected in 1992 and 200 million less than had been projected in 1994. Clearly, should these revised projections hold, pressure on the world's food supplies will be reduced. Nevertheless, there are no grounds for complacency since even under the revised medium-variant projections, the world's population is projected to increase by about 2 billion people between 1995 and 2020 (UN 1996).

Escalating Concerns about Food Safety and Genetic Engineering

The movement toward increasing food safety and consumption of organic foods produced without the use of chemical inputs such as fertilizers, pesticides, and herbicides is strong in the developed countries. Related to this movement is the possibility of rapid increases in the desire for purely vegetarian diets. The IMPACT projections do not effectively take into account an accelerated movement toward organic food. In the short run, such a movement would result in sharp reductions in agricultural productivity and food production. In the longer run, some of the negative productivity effects could be dealt with through accelerated agricultural research aimed at such issues as host-plant resistance to pests, nitrogen fixation from the air, and plants that are more efficient in extracting and utilizing plant nutrients. An
accelerated movement toward vegetarian diets would, on the other hand, reduce the demand for feedgrain and thereby reduce pressure on future grain supplies.

The current rate of increase in the demand for organic food in Europe and North America is likely to slow down in response to higher prices for such foods, and, while total demand will increase, organic food is unlikely to be a major part of total food consumed in these regions within the next 25 years. However, public pressure in Western Europe is likely to move governments to introduce legislation that will constrain or prohibit full use of the opportunities offered by genetic engineering and other tools of modern science for food production and processing. Should such legislation spread within Western Europe and to the rest of the world, including the developing countries, the consequences for food security and nutrition could be severe. Modern scientific methods, including molecular biology-based methods, offer tremendous opportunities for expanding food production, reducing risks in food production, improving environmental protection, and strengthening food marketing in developing countries (Pinstrup-Andersen and Pandya-Lorch 1996). Tolerance to drought in selected staple foods as well as resistance to other adverse conditions such as insects, diseases, and other pests could greatly increase and stabilize food production and incomes among small farmers in developing countries. Should such modern scientific methods not be applied to solving the problems of poor people, opportunities for assuring food security for all will be greatly reduced.

Policies aimed at the protection of natural resources and biosafety in agriculture may affect food security in ways similar to those related to food safety issues. Several countries have already implemented legislation that will curb the use of chemicals in agriculture, including chemical fertilizers and pesticides. Environmental protection legislation is also being introduced to regulate and curb animal production to avoid or reduce air pollution, carbon dioxide buildup in the atmosphere, and pollution of groundwater and streams due to excessive or inappropriate use of animal manure on the land. While some of this legislation can be justified on environmental grounds, the short-run effects are likely to be reduced food production. In the somewhat longer run, the negative productivity effects could be partially or totally eliminated through agricultural research aimed at host-plant resistance to pests, better utilization of plant nutrients, use of animal manure for biogas, and a number of other opportunities.

Unfortunately, there is also a trend in several European societies toward seeing the application of science to agriculture as part of the problem rather than part of the solution. This view, combined with a failure to appreciate the need for productivity increases in food production, has moved powerful societal groups to push for legislation that severely constrains agricultural research and the marketing of bioengineered foods. While the application of modern science, including genetic engineering and other biotechnology research, to solving human health problems is applauded and encouraged, there is an increasing suspicion that the application of such scientific methods to food production and processing will compromise agricultural production systems, food safety, and the health of current and future generations.
While it is critical that society establishes ethics and social norms for the use of results from scientific endeavor, it is important that governments not be pushed by vocal minorities and widespread misinformation to take the easy way out and simply outlaw all research results with unknown side effects. A more enlightened approach involves assessing the risks and opportunities and establishing sound biosafety rules based on the best available scientific knowledge. As part of such an enlightened biosafety policy, societies should decide on the extent to which consumers should be permitted to make their own judgments based on the best available information. Genetically modified maize, soybean, and tomatoes as well as livestock products produced with the use of synthetic growth hormones are cases in which society must determine whether it wants the state to judge for all or consumers to judge for themselves. The issues are far from resolved. For example, the EU recently appealed the WTO's conclusion that livestock products produced with the use of synthetic growth hormones in the United States could not be excluded from the EU market on health grounds.

Legislation in the developed countries constraining the application of modern science to improve productivity in food production and processing could have severe implications for long-term food supplies in developing countries, partly because of reduced exports by developed countries and partly because similar policies might be adopted in those countries as well. Use of food safety and biosafety policies may also be used by developed countries to maintain barriers to imports from developing countries.

Several developing countries are currently reviewing their biosafety legislation as well as the legislation related to the use of biotechnology in food production and processing, and the outcome of these deliberations is far from clear. Misinformation and lack of information on the potential environmental effects from the use of chemicals in agriculture and on the health effects from the use of genetically engineered foods could significantly affect food supply, demand, and therefore, food security for many millions of people in developing countries. For example, failure to assist African farmers in getting access to economically viable plant nutrients, including organic materials and inorganic fertilizers, because of the perceived negative environmental effect of fertilizers would make it almost impossible for them to expand productivity on the lands currently in production to the level needed to assure food security in the region. On the other hand, with the right policies for plant nutrients, agricultural research, rural infrastructure, and agricultural markets, African agriculture could accelerate its annual growth rate from the current 2 percent to at least 4 percent, while assuring sustainability in the management of natural resources.
Conflicts and Food Security

Widespread local, national, and regional instability and armed conflicts contribute to the persistence of poverty, food insecurity, and natural resource degradation. While relief agencies around the world are fully aware of the disastrous effects of conflicts on peoples' capacity to assure their food security, opportunities for preventing or resolving conflict through improvements in food security and more sustainable use of natural resources have received little attention until recently. It is becoming increasingly clear that poverty, food insecurity, and natural resource degradation contribute to the initiation or prolongation of instability or conflicts. Poor, food-insecure people may, in desperate circumstances, perceive no option but to engage in conflict to secure their access to resources that will assure future well-being. Of course, not all poor, food-insecure people engage in conflict, but the probability of instability or conflict rises in circumstances where people are forced to the limit and beyond to meet even their most fundamental needs. The complex, mutually reinforcing relationship between poverty, food insecurity, and natural resource degradation on the one hand, and social and political instability and conflict on the other hand, has not been fully recognized or acknowledged.

Yet, 57 percent of the countries considered to have low human development were gripped by conflict during 1990-95, compared with 14 percent of the countries considered to have high human development (Smith 1997). And more than half of the 17 Sub-Saharan African countries suffering from food emergencies also suffer from civil strife or armed conflict (FAO 1997c). Conflicts in countries such as Burundi and Rwanda are frequently characterized as resulting from tribal or political issues when, in fact, the underlying or catalytic causes are natural resource degradation, extreme poverty, and widespread food insecurity. Such conflicts in turn breed further food insecurity, poverty, and natural resource degradation, continuing a vicious cycle of hunger and instability. Rural populations are frequently forced to flee for their safety, leaving agricultural lands uncultivated and crops and livestock untended. Animal herds are raided, crops are burned, and productive assets are stolen (FEWS 1997). Conflicts disrupt traditional agricultural and pastoral practices, thus exacerbating the effects of weather fluctuations. Cattle herds that frequently are a significant buffer or safety net against negative food security effects of droughts are often reduced or eliminated during conflicts. The widespread use of land mines prohibits the use of much agricultural land in a large number of low-income countries (Bread for the World 1995; Smith 1997). Conflicts also tend to undermine trade between regions.

Degradation of natural resources, food insecurity, and conflict interact to cause rapid increases in the number of refugees and displaced persons, thereby aggravating both the consumption and production sides of food security. The number of international refugees has increased tenfold since 1974, from about 2.4 million to 23 million in 1995. In addition, an estimated 27 million people are displaced within their home countries (Bread for the World 1995). Large-scale movements of refugees and displaced persons interfere with production activities, disrupt food markets, and place severe pressures on local food supplies, which, in
turn, may further amplify tensions and civil strife. Large inflows of refugees and displaced persons also increase pressure on natural resources, often accelerating local deforestation, soil erosion, and water contamination and depletion.

The extent to which agricultural research and improved technologies can alleviate poverty, improve food security, and encourage sustainable use of natural resources will depend greatly on the extent to which conflicts are avoided. At the same time, the extent to which conflicts are avoided will depend greatly on the extent to which poverty is alleviated, food security improved, and sustainable use of natural resources encouraged. Technologies and policies capable of improving food security will decrease the probability of conflict. The interaction between conflict and the impact of agricultural research deserves more attention by the research community.

CONCLUSIONS: IMPLICATIONS FOR POLICY AND RESEARCH

During the next 25 years, an increasing share of the demand for cereals and meat in developing countries will have to be met through imports from developed countries. Food production will not keep pace with increases in food demand in developing countries. For those countries with the necessary foreign exchange, including the fast-growing Asian countries, this should not be cause for alarm. However, many of the low-income developing countries, including most of those in Sub-Saharan Africa, may not be able to generate the necessary foreign exchange to fill the gap between food demand and production through commercial imports. These low-income, slower-growth countries will also face a widening gap between food needs and economic demand because many poor people will lack the purchasing power to fully meet their needs. Enhanced risks and larger fluctuations in food availability and prices will exacerbate the precarious food security situation for low-income people in low-income countries. Unless new action is taken, the gap between food needs and availability in many low-income countries will widen, resulting in increasing food insecurity, hunger, and malnutrition.

The actions needed are comprehensively described in action plans from the World Food Summit and the 2020 Vision initiative (FAO 1996e; IFPRI 1995). Although increasing price fluctuations are expected in the world market, the most recent projections confirm that the long-run trend for world cereal and meat prices is downward in real terms. However, real price decreases will be limited over the next 10-15 years. Various factors described in this paper—unexpected cuts in public investments in agricultural research, environmentally or food safety motivated production restraints in developed and middle-income countries, adverse developments in China, Eastern Europe, or the former Soviet Union—could prove the price projections wrong.
The focus of agricultural research and policy aimed at reduced poverty and food insecurity should be on low-income developing countries, and particularly small farmers in those countries. Continued low productivity in food production not only contributes to food gaps in these countries, but also prevents attainment of the broad-based income growth and lower unit costs in food production needed to help fill the gap and improve food security. While efforts to improve long-term productivity on small farms must be accelerated, more emphasis must also be placed on research and policy that will help farmers, communities, and governments better cope with expected increases in risks resulting from poor market integration, dysfunctional or poorly functioning markets, climatic fluctuations, and a host of other factors. All appropriate scientific tools, including bioengineering, should be mobilized to help solve these problems facing small farmers in developing countries. Current investments are extremely small and must be drastically expanded.

The agricultural productivity increases needed to lift the populations of low-income developing countries out of poverty and food insecurity without doing irreparable damage to natural resources will be possible only if appropriate government policies are pursued and investments in the rural areas expanded. While the specific policy measures must be designed within each country, low-income developing countries should review their trade and macroeconomic policies as well as policies on water management and allocation, property rights to land and other natural resources, agricultural input and output markets, social safety nets for low-income families, rural infrastructure, rural financial markets, and various other incentives for small farmers including those needed to adjust to and benefit from further trade liberalization. Governments should also review their current allocation of public sector resources to agricultural research and extension, rural infrastructure, and other public goods needed to accelerate broad-based growth within and outside agriculture. Developed countries should consider reversing the downward trend of official development assistance finance, particularly to the most vulnerable developing countries. Failure to do the right thing will result in continued low economic growth and rapidly increasing food insecurity and malnutrition in many low-income developing countries, forgone opportunities for expanded international trade, widespread conflict and civil strife, and an unstable world for all.
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The state of world fisheries and aquaculture 1996. Rome: FAO.

Various years. Food Outlook.


## Table 1 — Cereal production, utilization, and stocks, 1993/94–1997/98

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing countries</td>
<td>932</td>
<td>931</td>
<td>959</td>
<td>1,008</td>
<td>1,003</td>
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<tr>
<td>Developed countries</td>
<td>797</td>
<td>851</td>
<td>769</td>
<td>868</td>
<td>865</td>
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<tr>
<td>World</td>
<td>1,729</td>
<td>1,782</td>
<td>1,728</td>
<td>1,877</td>
<td>1,869</td>
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<tr>
<td><strong>Utilization</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing countries</td>
<td>1,017</td>
<td>1,049</td>
<td>1,080</td>
<td>1,106</td>
<td>1,117</td>
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<tr>
<td>Developed countries</td>
<td>747</td>
<td>752</td>
<td>716</td>
<td>741</td>
<td>750</td>
</tr>
<tr>
<td>World</td>
<td>1,764</td>
<td>1,801</td>
<td>1,796</td>
<td>1,847</td>
<td>1,867</td>
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<td><strong>Stocks</strong></td>
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<tr>
<td>Developing countries</td>
<td>169</td>
<td>158</td>
<td>153</td>
<td>155</td>
<td>147</td>
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<tr>
<td>Developed countries</td>
<td>176</td>
<td>161</td>
<td>105</td>
<td>127</td>
<td>133</td>
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<tr>
<td>World</td>
<td>345</td>
<td>318</td>
<td>258</td>
<td>282</td>
<td>280</td>
</tr>
<tr>
<td><strong>Stocks as % of world cereal consumption</strong></td>
<td>19.1</td>
<td>17.7</td>
<td>14.0</td>
<td>15.1</td>
<td>14.9</td>
</tr>
</tbody>
</table>

**Source:** FAO (1997b).

* Forecast.
Table 2 — China's projected production, demand, and net trade of cereals, 1993 and 2020, various scenarios

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Demand</th>
<th>Net tradea (million metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1993</strong></td>
<td>343.3</td>
<td>344.3</td>
<td>-0.9</td>
</tr>
<tr>
<td><strong>2020</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline scenario</td>
<td>448.9</td>
<td>490.1</td>
<td>-41.1</td>
</tr>
<tr>
<td>Zero increase in government investment in agriculture</td>
<td>362.9</td>
<td>448.2</td>
<td>-85.2</td>
</tr>
<tr>
<td>5% annual increase in government investment in agriculture</td>
<td>572.8</td>
<td>541.6</td>
<td>31.2</td>
</tr>
<tr>
<td>100% self-sufficiency in cereals</td>
<td>469.5</td>
<td>469.5</td>
<td>0.0</td>
</tr>
<tr>
<td>95% self-sufficiency in cereals</td>
<td>457.2</td>
<td>481.8</td>
<td>-24.5</td>
</tr>
<tr>
<td>Structural change in livestock sector without technical change</td>
<td>488.1</td>
<td>557.1</td>
<td>-69.0</td>
</tr>
<tr>
<td>Structural change in livestock sector with technical change</td>
<td>447.0</td>
<td>474.1</td>
<td>-20.3</td>
</tr>
</tbody>
</table>


a Negative sign denotes net imports; positive sign denotes net exports.
### Table 3 — Projected world prices for cereals and meat products, 1993 and 2020, various scenarios in China

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario Description</th>
<th>Cereals (U.S. dollars)</th>
<th>Meat (U.S. dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td></td>
<td>164</td>
<td>1,576</td>
</tr>
<tr>
<td>2020</td>
<td>Baseline scenario</td>
<td>147</td>
<td>1,480</td>
</tr>
<tr>
<td></td>
<td>China: Zero increase in government investment in agriculture</td>
<td>162</td>
<td>1,486</td>
</tr>
<tr>
<td></td>
<td>China: 5% annual increase in government investment in agriculture</td>
<td>131</td>
<td>1,465</td>
</tr>
<tr>
<td></td>
<td>China: 100% self-sufficiency in cereals</td>
<td>138</td>
<td>1,461</td>
</tr>
<tr>
<td></td>
<td>China: 95% self-sufficiency in cereals</td>
<td>152</td>
<td>1,476</td>
</tr>
<tr>
<td></td>
<td>China: Structural change in livestock sector without technical change</td>
<td>162</td>
<td>1,735</td>
</tr>
<tr>
<td></td>
<td>China: Structural change in livestock sector with technical change</td>
<td>154</td>
<td>1,718</td>
</tr>
</tbody>
</table>

Table 4 — China's projected production, demand, and net trade of meat products in 1993 and 2020, various scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Production (million metric tons)</th>
<th>Demand (million metric tons)</th>
<th>Net tradea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>39.4</td>
<td>38.6</td>
<td>0.9</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline scenario</td>
<td>89.0</td>
<td>89.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>100% self-sufficiency in cereals</td>
<td>89.3</td>
<td>89.9</td>
<td>-0.5</td>
</tr>
<tr>
<td>95% self-sufficiency in cereals</td>
<td>89.1</td>
<td>89.5</td>
<td>-0.4</td>
</tr>
<tr>
<td>Structural change in livestock sector without technical change</td>
<td>100.4</td>
<td>125.0</td>
<td>-24.6</td>
</tr>
<tr>
<td>Structural change in livestock sector with technical change</td>
<td>89.3</td>
<td>89.5</td>
<td>-0.2</td>
</tr>
<tr>
<td>Zero increase in government investment in agriculture</td>
<td>89.0</td>
<td>89.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>5% annual increase in government investment in agriculture</td>
<td>90.4</td>
<td>91.1</td>
<td>-0.8</td>
</tr>
</tbody>
</table>


a Negative sign denotes net imports; positive sign denotes net exports.
Figure 1 -- Number of malnourished children, 1993, 2010, and 2020

Source: IFPRI IMPACT simulations

Figure 2 -- Percentage of malnourished children, 1993, 2010, and 2020

Source: IFPRI IMPACT simulations
Figure 3 -- Number of food-insecure people, 1990-92 and 2010

Source: FAO (1996a)

Figure 4 -- Projected average annual income growth rates, 1993-2020

Source: IFPRI IMPACT simulations
**Figure 5** -- Increase in total demand for cereals, meats, and roots and tubers, 1993-2020

![Bar chart showing increase in total demand for cereals, meats, and roots and tubers, 1993-2020.](image)

Source: IFPRI IMPACT simulations

**Figure 6** -- Increase in total demand for cereals, meats, and roots and tubers in major developing regions, 1993-2020

![Bar chart showing increase in total demand for cereals, meats, and roots and tubers in major developing regions, 1993-2020.](image)

Source: IFPRI IMPACT simulations
Figure 7 -- Absolute and relative increase in food and feed demand for cereals, 1993-2020

Source: IFPRI IMPACT simulations

Figure 8 -- Increase in total demand for major cereal commodities, 1993-2020

Source: IFPRI IMPACT simulations
Figure 9 -- Annual growth in cereal yields, 1967-82, 1982-94, and 1993-2020

Source: IFPRI IMPACT simulations

Figure 10 -- Net cereal imports of major developing regions, 1993 and 2020

Source: IFPRI IMPACT simulations
Figure 11 -- Composition of net cereal imports by developing countries, 1993 and 2020

Source: IFPRI IMPACT simulations

Figure 12 -- Net cereal trade of developed countries, 1993 and 2020

Source: IFPRI IMPACT simulations
Figure 13 -- Net trade in meat by major developing regions, 1993 and 2020

Source: IFPRI IMPACT simulations

Figure 14 -- Daily per capita calorie availability, 1993 and 2020

Source: IFPRI IMPACT simulations
Figure 15 -- Average monthly wheat and maize prices, 1994-97

Source: World Bank (various years)
Note: Futures prices as of Sept. 22, 1997, Chicago Board of Trade

Figure 16 -- World cereal stocks: Level and share of consumption, 1969/70 - 1997/98

Source: USDA (various years)
Figure 17 -- Real world prices for cereals, meats, and roots and tubers, 1993, 2010, and 2020

Source: IFPRI IMPACT simulations

Figure 18 -- Niger: Millet prices in selected markets

Source: FEWS (1997)
**Figure 19 -- China's net trade in cereals, 1980-97**

![Graph showing China's net trade in cereals, 1980-97.](image)

**Source:** State Statistical Bureau of China (various years); USDA (various years)

**Figure 20 -- Annual growth rate of real gross domestic product in Sub-Saharan Africa, 1987-97**

![Graph showing annual growth rate of real gross domestic product in Sub-Saharan Africa, 1987-97.](image)

**Source:** United Nations (1997)

**Note:** 1996 = preliminary, 1997 = forecast.
Figure 21 -- Actual and extrapolated population and food production indices for Sub-Saharan Africa, 1961-2020

Source: Data for 1961-96: FAO (1997a); Extrapolations for 1997-2020: Authors' estimates

Figure 22 -- Population and food production indices for developing countries in Asia, 1961-96

Source: FAO (1997a)
Figure 23 -- Annual population change and growth in Sub-Saharan Africa, 1950-2020

Source: UN (1996)
Note: Medium-variant projections for 1995-2020

Figure 24 -- Countries experiencing water stress, 1990 and 2025

Figure 25 -- Irrigated area in major regions, 1995 and 2020

![Irrigated area bar chart](chart.png)

Source: Rosegrant, Ringler, and Gerpacio (1997)

Figure 26 -- Water withdrawals for domestic, industrial, and agricultural uses, 1995 and 2020

![Water withdrawals bar chart](chart.png)

Source: Rosegrant, Ringler, and Gerpacio (1997)
Figure 27 -- Food aid deliveries to major regions, 1991-96

(million tons)

- Sub-Saharan Africa
- West Asia & North Africa
- South and East Asia
- Latin America
- Europe & former Soviet Union

Source: WFP (1997)

Figure 28 -- Total cereal stocks in the EU-15 (actual and projected), 1994/95-2005/06

(million tons)

- Intervention stocks
- Total stocks

Figure 29 -- Aggregate net long-term resource flows to developing countries, 1990-96

![Bar chart showing aggregate net long-term resource flows to developing countries, 1990-96.](image)

Source: World Bank (1997a)
Note: 1996 = preliminary

Figure 30 -- External assistance to agriculture, 1980-1994 (at 1990 constant prices)

![Line chart showing external assistance to agriculture, 1980-1994.](image)

Source: FAO (1996b)