No. 269  Scheierling, Overcoming Agricultural Pollution of Water: The Challenge of Integrating Agricultural and Environmental Policies in the European Union

No. 270  Banerjee, Rehabilitation of Degraded Forests in Asia

No. 271  Ahmed, Technological Development and Pollution Abatement: A Study of How Enterprises Are Finding Alternatives to Chlorofluorocarbons

No. 272  Greaney and Kellaghan, Equity Issues in Public Examinations in Developing Countries

No. 273  Grimshaw and Helfer, editors, Vetiver Grass for Soil and Water Conservation, Land Rehabilitation, and Embankment Stabilization: A Collection of Papers and Newsletters Compiled by the Vetiver Network

No. 274  Govindaraj, Murray, and Chellaraj, Health Expenditures in Latin America

No. 275  Heggie, Management and Financing of Roads: An Agenda for Reform

No. 276  Johnson, Quality Review Schemes for Auditors: Their Potential for Sub-Saharan Africa

No. 277  Convery, Applying Environmental Economics in Africa

No. 278  Wijetilleke and Karunaratne, Air Quality Management: Considerations for Developing Countries

No. 279  Anderson and Ahmed, The Case for Solar Energy Investments

No. 280  Rowat, Malik, and Dakolias, Judicial Reform in Latin America and the Caribbean: Proceedings of a World Bank Conference

No. 281  Shen and Contreras-Hermosilla, Environmental and Economic Issues in Forestry: Selected Case Studies in Asia

No. 282  Kim and Benton, Cost-Benefit Analysis of the Onchocerciasis Control Program (OCP)

No. 283  Jacobsen, Scobie and Duncan, Statutory Intervention in Agricultural Marketing: A New Zealand Perspective


No. 286  Tavoulareas and Charpentier, Clean Coal Technologies for Developing Countries

No. 287  Gillham, Bell, Arin, Matthews, Rumeur, and Hearn, Cotton Production Prospects for the Next Decade

No. 288  Biggs, Shaw, and Srivastiva, Technological Capabilities and Learning in African Enterprises

No. 289  Dinar, Seidl, Olem, Jorden, Duda, and Johnson, Restoring and Protecting the World’s Lakes and Reservoirs


No. 292  Gorriz, Subramanian, and Simas, Irrigation Management Transfer in Mexico: Process and Progress

No. 293  Preker and Feachem, Market Mechanisms and the Health Sector in Central and Eastern Europe

No. 294  Valdés and Schaeffer in collaboration with Sturzenegger and Bebczuk, Surveillance of Agricultural Price and Trade Policies: A Handbook for Argentina

No. 295  Pohl, Jedrzejczak, and Anderson, Creating Capital Markets in Central and Eastern Europe

No. 296  Stassen, Small-Scale Biomass Gasifiers for Heat and Power: A Global Review

No. 297  Bulatao, Key Indicators for Family Planning Projects

No. 298  Odaga and Heneveld, Girls and Schools in Sub-Saharan Africa: From Analysis to Action

No. 299  Tamale, Jones, and Pswarayi-Riddihough, Technologies Related to Participatory Forestry in Tropical and Subtropical Countries

No. 300  Oram and de Haan, Technologies for Rainfed Agriculture in Mediterranean Climates: A Review of World Bank Experiences

No. 301  Mohan, editor, Bibliography of Publications: Technical Department, Africa Region, July 1987 to April 1995

No. 302  Baldry, Calamari, and Yaméogo, Environmental Impact Assessment of Settlement and Development in the Upper Léraba Basin

(List continues on the inside back cover)
Global Food Supply Prospects

A background paper prepared for the World Food Summit, Rome, November 1996

Merlinda D. Ingco
Donald O. Mitchell
Alex F. McCalla

The World Bank
Washington, D.C.
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>v</td>
</tr>
<tr>
<td>Executive Summary</td>
<td>1</td>
</tr>
<tr>
<td>Recent Developments in the Global Situation</td>
<td>4</td>
</tr>
<tr>
<td>Why Did Grain Prices Rise?</td>
<td>5</td>
</tr>
<tr>
<td>Slower Growth in Consumption and Imports</td>
<td>7</td>
</tr>
<tr>
<td>Are Yields Stagnating?</td>
<td>8</td>
</tr>
<tr>
<td>Environmental Concerns</td>
<td>9</td>
</tr>
<tr>
<td>Global Food Prospects</td>
<td>10</td>
</tr>
<tr>
<td>Brown and Kane</td>
<td>10</td>
</tr>
<tr>
<td>Computer Simulations</td>
<td>10</td>
</tr>
<tr>
<td>Regional and Country Food Concerns</td>
<td>12</td>
</tr>
<tr>
<td>Large Developing Countries</td>
<td>13</td>
</tr>
<tr>
<td>Food Deficit and Import-Dependent Countries</td>
<td>15</td>
</tr>
<tr>
<td>Policy Environment: Implications for the World Food Situation and Food Security</td>
<td>17</td>
</tr>
<tr>
<td>Impact of the Uruguay Round Agreement</td>
<td>17</td>
</tr>
<tr>
<td>Industrial Country Policies</td>
<td>19</td>
</tr>
<tr>
<td>Developing Country Policies</td>
<td>19</td>
</tr>
<tr>
<td>Trade Liberalization</td>
<td>20</td>
</tr>
<tr>
<td>Poverty Reduction and Food Security</td>
<td>20</td>
</tr>
<tr>
<td>Conclusion</td>
<td>20</td>
</tr>
<tr>
<td>Notes</td>
<td>21</td>
</tr>
<tr>
<td>References</td>
<td>22</td>
</tr>
</tbody>
</table>
Foreword

Adequate global food supplies are essential to world food security, although they do not ensure food security for every country or person. Over the past several years concern has been raised about global food supply prospects because of the low level of world grain stocks and the sharp increases in grain prices. While this concern has lessened with the prospects for large food supplies in 1996, the uncertainty remains for the longer term. With world population expected to exceed 8 billion within thirty years, the demands on the world's natural resources will be substantial. The task is to feed an ever-expanding population while preserving the sustainability of the natural resource base. This will require investments that allow resources to be used more intensively while guarding their sustainability for future generations. It will also require policies that allow both producers and consumers access to world markets.

This volume examines global food supply prospects over the short and medium term. It examines the causes of the recent price increases, reviews the research on the medium-term outlook, and analyzes the implications of the Uruguay Round Agreement and post-Round reforms in agricultural policies. It also examines the cereal import dependence of low- and middle-income developing countries. It makes an important contribution to our understanding of the current supply situation and shows the challenge that faces the world in the next century. While the short- and medium-term global food supply prospects are relatively good, the longer-term outlook is more uncertain. If we are to be confident of our ability to supply the food demands of the world during the twenty-first century, then we need to make well-conceived investments now in agricultural research and rural development. Appropriate policies and institutions are also critical to long-run food security.

Sarwar Lateef, Acting Director
International Economics Department

Alex F. McCalla, Director
Agriculture and Natural Resources Department
Executive Summary

The sharp rise in grain prices during the past two years and the low level of world grain stocks have renewed concern about world food prospects. A recent decline in prices triggered by prospects of a large 1996 crop has diminished concern for the coming year, and stocks will probably be rebuilt over the next several years because of expanded production in the major exporting countries. The medium-term outlook is for adequate world food supplies, which should cause prices to remain below the levels seen in early 1996. However, concern still remains for the longer-term world food outlook because of slower yield growth in recent years and the uncertainty affecting demand growth.

Evidence on grain yields is mixed

One of the longer-term concerns is that environmental constraints are slowing gains in crop yields. The evidence is mixed. Many plant breeders believe that yield increases are still possible, although perhaps not as easy to achieve as in the past. Biotechnology is a source of potential yield increases as specific traits such as disease resistance are incorporated into new seed varieties, but the gains from biotechnology have been slow to develop. There is also evidence of slower yield growth in recent years and some evidence of problems in specific regions. The effects of environmental concerns such as global warming are difficult to evaluate. While it is generally agreed that human activities are causing the atmospheric concentrations of greenhouse gases to rise, there is less agreement on the consequences. It is not clear whether agricultural production would increase or decrease under a warmer, more humid climate. Regional shifts in production are expected, but beyond that little can be concluded. Issues of land degradation and competition for water add to the long-term uncertainty about production increases.

Food demand growth likely to be slower

An additional concern about the future is that food demand could grow so rapidly that it could overwhelm the ability of supply to respond. However, the dominant factor determining food demand has been population growth, and the UN population projections are for slower growth in the future. World grain consumption has grown even more slowly than world population for the past decade because of slow demand growth in the industrial countries and negative growth in the transition economies of Eastern Europe and the former Soviet Union. Growth in developing countries has averaged about 2.4 percent for total food and feed uses over the past decade. Projections of the world food situation over the next ten to twenty-five years by researchers at the Food and Agriculture Organization (FAO), the Food and Agriculture Policy Research Institute (FAPRI), the International Food Policy Research Institute (IFPRI), the U.S. Department of Agriculture (USDA), and the World Bank are for slower food demand growth and declining real prices. However, rising incomes in many of the poorest countries, such as China and India, could lead to rapid per capita increases in food demand.

Despite this concern, neither China nor India is expected to play a dominant role in world grain markets
over the next ten to fifteen years. Both countries have done remarkably well in increasing food production over the past several decades, and should continue to do so as long as prudent policies and investments are pursued. China's grain imports are expected to increase, but not beyond levels that can be supplied by world markets. India is expected to remain nearly self-sufficient in grains.

**Policy changes will continue to affect grain markets**

Recent policy changes at both the global and country level could also be important to the world food situation. The recent Uruguay Round Agreement on Agriculture is expected to lead to small increases in world grain prices and to higher world grain trade. Currently, about 10 percent of world grain production is traded. The level of government interventions in agriculture will gradually decline over the life of the agreement, eventually leading to more stable prices. Prices could remain volatile during the transition period, however, and grain prices are expected to increase as much as 4 percent relative to the levels that would have occurred without the agreement. Country policies are also important, and many countries have been liberalizing their agricultural policies. These reforms should increase the responsiveness of producers and consumers to international price signals. A more open trading regime will allow countries to specialize in producing the commodities that are most profitable for them and to refrain from costly policies of food self-sufficiency.

**Outlook varies from medium to long term**

The near-term outlook for the world food situation has improved with the large 1996 harvest. However, world grain stocks are still low, and it could take several years for stocks to rebuild. The medium-term outlook—the next ten to fifteen years—should be a period of relatively adequate world grain supplies and falling real grain prices compared with current levels. The longer-term outlook is much more uncertain and will depend on investments and actions still to be taken. Of particular concern is the need to boost crop yields despite environmental and resource constraints. This will require additional investments in research and a concerted effort by the World Bank and other organizations to develop agriculture and strengthen agricultural research.

**Disparity in food adequacy remains a concern**

The focus on the longer-term world food situation should not distract from the immediate concern over regional food problems and inequality within countries. Many people still suffer from hunger and malnutrition, even in countries where food supplies are adequate. And their situation did not improve despite falling world prices for most of the 1980s. This disparity amidst a generally favorable world food situation demands attention. The solution is widely recognized to be to raise incomes and reduce poverty in these countries. This is a primary challenge facing the international development community and a focus of the World Bank's development efforts.
Global Food Supply Prospects

The World Food Summit, to be held at the Food and Agriculture Organization (FAO) in Rome in November 1996, seeks to renew the commitment of world leaders to the eradication of hunger and malnutrition and the achievement of lasting food security for all (FAO 1996). The summit comes at a time when low food stocks and rising prices have led to concern that we may be nearing a world food crisis (Financial Times, September 17, 1996). Though not to be taken lightly, such concern must not be accepted blindly.

This volume examines the causes of recent price increases as well as the prospects for future production, consumption, and trade. It finds no strong evidence of an impending near-term world food crisis. There is, however, strong evidence of regional and country food problems that should be a priority for future policy action and economic assistance. Longer-term food prospects depend to a large extent on actions and investments that are yet to be made—and that can still be influenced.

The first World Food Conference, held in 1974, was the culmination of worldwide concern about the global food situation. Many of the same concerns have emerged again. Food reserves are low, as they were in 1974. The ratio of world end-of-year grain stocks to consumption, a common measure of food reserves, had fallen to 15 percent in 1974—the lowest level recorded until that time. The current ratio is even lower, at 13 percent. Food prices have been rising as they were from 1972 to 1974, although food prices remain well below the levels of 1974 when adjusted for inflation. And perhaps most troubling, despite an environment of general economic prosperity and falling food prices, many countries have not made significant progress in reducing hunger and malnutrition during the twenty-two years since the first World Food Conference. Finding ways to overcome this disparity is one of the greatest challenges facing the development community.

Despite the lack of progress in some countries, there have been steady improvements in the global situation. And food production and consumption have increased steadily in developing countries (figure 1): per capita food production increased 37 percent from 1961 to 1994, while calorie supplies increased 35 percent from 1961 to 1992. The increased food production has allowed most people in developing countries to increase the calories consumed and to improve the quality and variety of their diets. Calories available in developing countries increased from 1,923 calories per person per day in 1961 to 2,541 calories by 1992, bringing average available calories above the generally accepted minimum daily requirement of 2,200–2,300 calories set by the FAO. (Actual minimum daily requirements depend on many factors, including age, sex, and physical activity.)

These gains in food production and consumption were not evenly distributed among regions or within countries. Diets in Sub-Saharan Africa hardly improved during the past thirty years, and in many countries the food situation deteriorated. Average calories available for consumption in Sub-Saharan Africa remain below the nutritionally recommended minimums and were subject to large swings as a result of natural and human-made disasters. Nigeria’s average per capita calorie supplies went from 2,379 a day in 1961 to 2,124 by 1992 (FAO 1995), going as high as 2,492 and as low as 1,835 in some periods in response to economic and political changes. By contrast, Indonesia had steady gains in per capita food production and calorie supplies. Beginning from a lower level of consumption of
1,838 calories per day in 1961, Indonesia increased its per capita food production by 1.7 percent a year, raising calorie supplies to 2,752 by 1992.

The real incomes of consumers in developing countries have improved substantially during the past three decades, making it possible for many to purchase a better diet (table 1). Real per capita GDP grew 3.2 percent a year in the 1960s and 3.0 percent in the 1970s. Growth slowed in the 1980s to 1.1 percent a year. From 1990 to 1995, however, growth of real per capita GDP accelerated to an estimated 3 percent a year. As a result, per capita GDP has more than doubled since the early 1960s.

This volume provides historical perspective as well as a look at the future of the world food situation over the medium term—to 2010 and 2020. It begins by examining the recent increases in grain prices and the specific factors that led to these increases. It also looks at the role of the major grain exporters in the price increases. Several projections for the global food situation and the prospects for individual countries and regions are examined. The special problems and the performance of the large developing countries—China, India, and Russia—and of the food deficit and import-dependent developing countries are discussed. The changes in agricultural policies at the global and national level and their implications for the global food situation are also examined. Conclusions and recommendations are then drawn from the volume.

Recent Developments in the Global Situation

All food problems are local to the extent that they reflect the situations of individual consumers. However, the global situation often affects the severity of the local situation.

**TABLE 1**

Real per capita GDP has grown in most developing country regions since 1960

(average annual percentage change)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All developing countries</td>
<td>3.2</td>
<td>3.0</td>
<td>1.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>1.5</td>
<td>0.2</td>
<td>-1.1</td>
<td>-1.3</td>
</tr>
<tr>
<td>East Asia</td>
<td>4.0</td>
<td>4.3</td>
<td>6.1</td>
<td>9.2</td>
</tr>
<tr>
<td>South Asia</td>
<td>1.5</td>
<td>1.3</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>2.5</td>
<td>2.8</td>
<td>-0.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>5.1</td>
<td>3.1</td>
<td>-2.2</td>
<td>-0.5</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>5.1</td>
<td>4.4</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note: Growth rates are least squares growth rates. Sub-Saharan Africa includes South Africa; East Asia excludes the Republic of Korea. Eastern Europe does not include the former Soviet Union.

When global food supplies are abundant, imports are cheaper and the resources available for food aid go further. But an abundance of food at low prices in the world market does not ensure food security at the country or household level, nor does it help countries purchase imports to supplement domestic food supplies.

Why Did Grain Prices Rise?

Food prices began to rise in mid-1993, after declining for most of the 1980s. The World Bank’s index of food prices rose 56 percent from June 1993 to May 1996. Though grain prices increased sharply from their lows during 1990–93 to their recent highs, they remain well below the levels of the 1970s when measured in real terms (figure 2). Prices have fallen in recent months as the large 1996 world grain crop has been harvested.

The price increases of recent years followed a long period of declining prices and are consistent with the volatile nature of commodity prices, which often show sharp spikes (Deaton and Laroque 1992). Several factors contributed to the price increases. Below-normal U.S. grain production in 1995 because of poor weather was the specific event that led to the recent increases. But behind that event lay policy changes that had set the stage for the price increases. Slow demand growth for major agricultural commodities after the mid-1980s had caused world grain stock levels to rise, prompting policy changes to reduce production in the major exporting countries.

From 1980 to 1990 the five largest grain exporters accounted for 87 percent of world grain exports and 47 percent of world grain stocks. When demand growth slowed, these producers cut production. The United States, the largest exporter, idled nearly 15 million hectares of cropland under the ten-year Conservation Reserve Program, shrinking grain area from 72.7 million hectares in 1985 to 59.5 million hectares in 1995 (down 18.2 percent). In the European Union, the second largest exporter, grain cropland went from 42.2 million hectares to 34.9 million hectares (down 17.3 percent). Canada, Australia, and Argentina, the other major grain exporters, reduced land used for grain production by 14.0 million hectares from 1981–83 to 1994–95, equivalent to 32.0 million tons of grain production per year at 1990–95 average yield levels.

Together, these five major exporters reduced grain cropland by 34.5 million hectares, accounting for 53 percent of the global decline in grain area harvested of 63.3 million hectares from the high in 1981 to the low in 1995 (figure 3). The countries of the former Soviet Union also substantially reduced grain area from 1981 to 1995, shrinking it by 26.8 million hectares. For these countries, however, the decline was due to internal problems rather than to international market forces. Together, the five largest grain exporters and the countries of the former Soviet Union accounted for 94 percent of the decline in global grain area from 1981 to 1995.

This shrinking grain area contributed to declining world grain stocks and ratios of grain stocks to use

FIGURE 2
Grain prices have risen sharply from their 1990–93 lows but remain below the highs of the 1970s

Recent Developments in the Global Situation
FIGURE 3
Grain cropland shrank considerably after 1981

Note: The major grain exporters are the United States, the European Union, Canada, Australia, and Argentina.
Source: USDA data and World Bank staff calculations.

FIGURE 4
Grain stocks and stock-to-use ratios started downward after 1986

Note: The major grain exporters are the United States, the European Union, Canada, Australia, and Argentina.
Source: USDA data and World Bank staff calculations.

(figure 4). World stocks declined by 233 million tons from 1986 to 1995, while stocks in the five largest exporters plunged from 262 million tons to 58 million tons (88 percent of the decline in world grain stocks). The stock-to-use ratio for the major exporters fell from 40.6 percent during 1980–90 to 13.6 percent by 1995. For the rest of the world the ratio went from 15.9 percent to 13.2 percent.

On top of these reductions in world production and stocks, 1995 production was lower than expected. Prices rose sharply. World grain production in 1995 was 1,881 million tons, below the average of 1,917 million during the previous five years. Stocks declined from 300 million tons in 1994 to 236 million tons in 1995 (USDA data).

The transition economies saw production fall precipitously from 1990 levels as state-supported enterprises were forced to operate without government subsidies on fertilizer, fuels, and other inputs. The adjustment to market prices after years of heavy subsidies also reduced waste and lowered overall demand. Feed use fell, and as incomes declined consumers reduced their meat consumption. Global grain production grew only 1.09 percent a year from 1980 to 1995—2.37 percent when the major exporters and the transition economies are excluded. Global grain growth had been 3.1 percent a year from 1965 to 1980—3.45 percent when the major exporters and transition economies are excluded.

A recovery of world grain production is expected in 1996, with production up 7 percent overall from 1995
and up 15 percent in the major grain exporting countries (USDA 1996). If this outlook materializes, the grain harvest would exceed the previous record harvest of 1992. Stocks of grain will most likely rebuild in 1996, and further stock rebuilding is expected over the next several years. Both the United States and the European Union reduced planting restrictions in 1995/96. Larger areas have also been planted to grains in Canada, Argentina, and Australia since 1994/95. Grain prices have declined from the highs of this past spring.

**Slower Growth in Consumption and Imports**

Growth in world grain consumption and import demand has slowed significantly in recent years (figures 5 and 6). World grain consumption grew 1.20 percent a year from 1980 to 1995, well below the 2.97 percent a year growth during the previous fifteen years. Most of the decline was attributable to the slower growth in the countries of Eastern Europe and the former Soviet Union. Overall growth in demand in developing countries continues along historical trends, although in many developing countries total grain demand grew more slowly over the past decade compared with previous decades, reflecting the transition from calorie-deficit to more adequate diets. This slowdown is evident in China, where growth in grain demand went from 4.47 percent a year in 1965-80 to 2.30 percent in 1980-95. Economic problems slowed the growth in grain demand in some other countries, such as Nigeria and Mexico. In Mexico demand growth went from 5.54 percent a year in 1965-80 to 2.55 percent in 1980-95.

**FIGURE 5**

**Growth has slowed in world grain consumption . . .**

![Graph showing world grain consumption growth](image)

**FIGURE 6**

**. . . and in import demand**

![Graph showing world import demand growth](image)

*Source: USDA data and World Bank staff calculations.*
World grain imports also have not increased significantly over the past fifteen years, with imports ranging from about 200 to 250 million tons over the period (figure 6). Rising imports by developing countries have been offset by falling imports by the countries of the former Soviet Union and Eastern Europe. The European Union also reduced imports as domestic production increased faster than consumption. Total grain imports by developing countries continue to increase, however, going from 23 million tons in 1960 to 124 million tons in 1995, or from 32 percent of world imports to 54 percent. These expanding imports reflect rising incomes and changing diets as well as efforts to increase total food supplies through imports. Wheat accounts for 48 percent of total grain imports in developing countries, coarse grains for 41 percent, and rice for 11 percent. Imports accounted for 11.8 percent of total grain consumption in developing countries in 1995, up from 6.5 percent in 1960 (USDA data and World Bank calculations). World demand is expected to increase in the future as rising import demand in developing countries more than offsets declining import demand in the industrial countries and the transition economies.

Are Yields Stagnating?

Growth in world grain yields slowed during the first half of the 1990s (table 2), while yield growth in developing countries continued essentially unchanged. Yields in developing countries grew 2.08 percent a year during 1980–90 and 2.02 percent a year during 1990–95 (World Bank calculations, based on USDA data). Yield growth slowed most in Eastern Europe, the former Soviet Union, and the United States.

Some reasons for the slower world yield gains since 1990 are clear. Wheat yields in the countries of the former Soviet Union, which accounted for 17 percent of world production in 1990, fell from 2.11 tons a hectare in 1990 to 1.34 tons a hectare in 1995. If these countries were excluded, wheat yields would have grown 0.65 percent a year from 1990 to 1995 rather than falling at a similar rate. In the United States, spring flooding, summer drought, and harvest problems resulted in a poor 1995 crop, causing grain yields to fall 16.7 percent below 1994 levels and 2.5 percent below 1990 levels. Since the United States accounts for about 17 percent of world production, the yield losses for these two regions explain much of the global decline. In Eastern Europe lower input use and the transition from a centrally planned to a market economy caused total grain yields to fall from 3.91 tons a hectare in 1991 to 3.32 tons a hectare in 1995.

Comparisons of yields over short periods of time must be viewed cautiously because of the strong influence of events in one or two years. However, even after allowing for the specific events that have contributed to the slower yield growth since 1990, yield growth appears to have slowed (figure 7).

Several agricultural scientists and agronomists are confident that further yield increases are possible. Donald Duvick (1991), retired director of research for Pioneer Hybrid, notes that studies in Iowa show that genetic yielding ability has increased continually and uniformly since 1930, at annual rates of about 70-90 kilograms per hectare—equivalent to an average gain of 1.5 percent a year. These studies indicate that the gains are continuing, with no plateau in sight for increases in genetic yielding ability. But because yield gains are linear, the average percentage increase is falling.

Donald Plucknett (1993), former science adviser to the Consultative Group on International Agricultural Research (CGIAR), argues that the data do not indicate a leveling off of the top yields achieved or of the annual rates of gain. Wheat breeders at the International Maize and Wheat Improvement Center (CIMMYT) express similar views; Marten van Ginkel (1996) notes that “from a breeding standpoint, it is obvious that genetic yield potential is not near any definite limit.” It is also widely agreed, however, that future yield increases will not occur without continuing investments in agricultural research. Modern varieties, which were the foundation of the Green Revolution in rice and wheat, will also be an important source of future yield increases according to Derek Byerlee (1996). Although modern varieties have already been widely adopted, further yield increases can be expected, according to Byerlee, as newer generations of modern varieties with higher and more stable yields are adopted. Much of the expansion of modern varieties since 1980 has been in rainfed areas.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.84</td>
<td>3.06</td>
<td>1.99</td>
<td>2.89</td>
<td>-0.64</td>
</tr>
<tr>
<td>Rice</td>
<td>1.27</td>
<td>2.40</td>
<td>1.63</td>
<td>2.34</td>
<td>0.93</td>
</tr>
<tr>
<td>Maize</td>
<td>2.74</td>
<td>2.48</td>
<td>2.84</td>
<td>1.01</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Despite optimism about the ability of plant breeders to increase genetic potential, research by the International Rice Research Institute (IRRI) and CIMMYT has found significant slowing in the rate of yield increases of wheat and rice under experimental conditions (McCalla 1994, p. 21). Pingali and Heisey (1996) conclude that productivity growth has slowed in the most intensively cultivated cereal areas because of land degradation, less research and infrastructure investment, lower cereal prices, and higher agricultural wages.

**Environmental Concerns**

Environmental problems may be the most important factor affecting the sustainability of increases in crop yields. However, there has been little research on this issue. A recent International Food Policy Research Institute (IFPRI) report discusses the extent and effect of land degradation (Scherr and Yadav 1996). Some researchers suggest that land degradation is overestimated and relatively unimportant (Crosson 1995), while others argue that land degradation poses a threat to global food supplies (Brown and Kane 1994). Pingali and Heisey (1996, p. 52) argue that degradation of the land resource base as a result of intensive cultivation has contributed to the slowdown in productivity growth.

A study sponsored by the United Nations Environment Program, the Global Assessment of Soil Degradation, concluded that 15 percent of the world's land area is degraded as a result of human activities (Oldeman, Hakkeling, and Sombroek 1991). Wind and water erosion are by far the main source of land degradation, according to the study: water erosion accounted for 56 percent of the degradation and wind erosion for 28 percent (chemical degradation accounted for 12 percent and physical degradation for 4 percent). The U.S. Soil Conservation Service conducted a comprehensive, statistically reliable survey of the amount of soil erosion occurring annually in the United States in 1977, 1982, and 1987. The survey covered water and wind erosion on cropland, pasture range, and forest land (Crosson and Anderson 1992). Based on these surveys, average U.S. yields would decline by an estimated 3 percent after 100 years of erosion at the 1982 rate. Maize yields in the midwest would decline by an estimated 4 percent after 100 years. Few comparable estimates are available for other countries.

The increasing pressure on water resources from competing uses means that water will likely need to be used more efficiently in agriculture in the future, especially if additional land is brought under irrigation. There is considerable scope for improved efficiency, but there are also barriers to achieving such efficiencies (Rosegrant 1991). A 1990 World Bank–United Nations Development Program report found considerable potential for expanding irrigation in developing countries, with an estimated 59 percent increase possible over existing irrigation schemes (as cited in Crosson and Anderson 1992). Expanded irrigation will be more costly than in the past, however, because the best sites have already been developed in many countries.

Loss of land because of urbanization and other built-up uses reduces the amount of land that might otherwise be available to agriculture. The extent of such land use was
estimated by Crosson and Anderson (1992, pp. 23–26) based on average per capita urban land use and population growth projections. Their estimates show that such uses will not likely limit the supply of agricultural land in general over the next several decades but could be a problem in some regions, such as Asia.\(^2\)

**Global Food Prospects**

Several studies forecast the future of the world food situation. Most such efforts employ large computer simulation models that account for key variables such as population, income, prices, and production. Simulation models are not able to account for all key factors and thus are only approximations. Models also often depend on past performance as the basis of future projections. Results of such computer simulations are presented in this section.

A second method of forecasting is to extend concerns or recent events in a less rigorous way to project the future. This approach is used by Brown and Kane (1994), who come to much different conclusions about the future than do the studies that use computer simulation models. Brown and Kane argue that resource limits will prevent food production from growing as rapidly as food demand and that this disparity will lead to an increasingly tight world food situation and rising real prices.

**Brown and Kane**

Brown and Kane (1994) argue that there is little backlog of unused agricultural technology, that production of fish has reached its biological limits, and that the carrying capacity of rangeland has been exceeded. They also argue that the demand for water is pressing against hydrological limits, that in many countries crops are responding less to additional fertilizer, that much cropland is being lost to industrialization and urbanization, and that the efforts of many national governments to expand food production have failed.

Brown (1995) has extended these concerns to a study of China. What happens in China—with 1.2 billion people, the world’s most populous country—is important to the entire world. Brown argues that rising population and incomes will cause China’s demand for food, especially meat, to rise faster than supply, causing large increases in imports and sharply higher world prices.

Brown’s argument has two parts: first, that per capita demand for food will rise sharply, and second, that supply will not even maintain current levels because of sharp declines in cropland availability. While prices are essential to balance demand and supply, the effects of higher prices on demand and supply are not expected to elicit a significant response from China’s farmers, consumers, or government.

Since grains represent more than half of total food calories in China, Brown devotes most of the discussion to grain demand and supply. Brown predicts that rising population pressures and industrialization in China will reduce land used for agriculture dramatically and that China will lose roughly half of its grain land by 2030. Brown also argues that yields will not increase because they are already high now, fertilizer use is high, and soil erosion and lower water availability for agriculture will cause soil fertility to decline.

Critics of Brown’s analysis point to three potential weaknesses in his arguments (Crosson 1996). First, the steeply higher grain prices that Brown foresees would have demand-reducing and supply-increasing effects, which he does not consider. Second, the nearly 50 percent reduction in grain land that Brown predicts by 2030 is not consistent with recent trends or historical experience, nor does it take into account the continuous reclamining of land that occurs in China. Finally, the critics argue that current yields are lower than officially reported because cropland is underreported in China for tax reasons, implying that the potential for further increases is greater than Brown’s estimate. Other efficiency gains in Chinese agriculture are also possible, including more efficient livestock and poultry feed conversion rates, which would reduce overall feed requirements.

**Computer Simulations**

Several recent simulation studies have projected global cereal or food balances to 2005, 2010, or 2020 based on specific assumptions and computer models. Three studies make projections to 2010 and come to similar conclusions: Agcaoili and Rosegrant (1995) from IFPRI, Alexandratos (1995a) from FAO, and Mitchell and Ingco (1993) based on research done at the World Bank. The IFPRI study was later extended to make projections to 2020 (Rosegrant 1995).

The three studies reach similar conclusions, with some variations in results for specific countries. All three studies provide plausible descriptions of what the world food situ-
tion will be like in 2010 (table 3). Grain yields are expected to increase at rates comparable to those of recent years (1.5–1.7 percent a year), area harvested to grains is expected to increase modestly, global grain demand is expected to grow more slowly than in the past, and trade in grains is expected to increase. All three studies expect real grain prices to remain constant or to decline. Regional food problems are expected to persist, with the most severe problems in Sub-Saharan Africa.

Two recent studies of the next ten years reach conclusions similar to those of the longer-term simulations. The Food and Agriculture Policy Research Institute (FAPRI 1996) study concludes that world grain prices will decline from current high levels. Agricultural projections to 2005 by the Economic Research Service of the U.S. Department of Agriculture (USDA 1996) are for 1.55 percent annual growth in world grain consumption over 1995–2005. Prices of wheat, corn, and rice are expected to fall in real terms over the period.

**Projections to 2010.** The three projections of world and regional cereal production and consumption to 2010 were presented and reviewed at a conference sponsored by IFPRI in 1994 (Islam 1995). The conclusions of the modellers and conference participants were summarized by the organizers as follows:

There was general agreement that the world food supply in 2010 would probably meet global demand, but regional problems would occur. South Asia and Sub-Saharan Africa were recognized as the most vulnerable regions. The key to future food supplies was seen as increased productivity, that is, yields must continue to rise; to accomplish this, sustained support for investment in agriculture, including research expenditures, would be needed. (Islam 1995)

The three studies project an average annual increase in grain production over the twenty years 1989–91 to 2010 of 1.55 percent—1.94 percent for developing countries and 1.13 percent for industrial countries (see table 3). All three models project slower growth for world cereal production and consumption over the period to 2010 than over the period 1979–81 to 1989–91 because of slower population growth rates, which will reduce the rate of growth of demand. Cereal demand during the twenty years before 1989–91 grew 2.2 percent a year worldwide and 3.2 percent in developing countries (Islam 1995, p. 85). About 90 percent of the increase in aggregate cereal demand to 2010 is projected to be due to population increases.

The average cereal deficit of developing countries is projected to grow from 90 million tons during 1989–91 to 176 million tons by 2010. The three studies differ in their view of the rate of growth of world cereal trade, with Agcaooli and Rosegrant's (1995) and Alexandratos's (1995a) projections nearly identical and Mitchell and Ingco's (1993) projection significantly higher.

The three studies are conditional projections, based on specific assumptions about population and income growth.

### TABLE 3

**Computer-based projections of cereal production and consumption show adequate global supplies, but some regional difficulties**

(millions of tons)

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>World</td>
<td>Industrial countries</td>
</tr>
<tr>
<td>Actual 1989–91</td>
<td>1727</td>
<td>864</td>
</tr>
<tr>
<td>Projected 2010</td>
<td>2334</td>
<td>1016</td>
</tr>
<tr>
<td>Alexandratos</td>
<td>2405</td>
<td>1174</td>
</tr>
<tr>
<td>Agcaooli and Rosegrant</td>
<td>2311</td>
<td>1058</td>
</tr>
<tr>
<td>Mitchell and Ingco</td>
<td>2311</td>
<td>1058</td>
</tr>
<tr>
<td>Average growth rates</td>
<td>projected 1989–91 to 2010</td>
<td>1.55</td>
</tr>
</tbody>
</table>

**Note:** Developing countries include the transition economies of Eastern Europe and the former Soviet Union. Source: Islam 1995.
and yield increases based on continued investment in agricultural research. The study projections also assume normal conditions, and so would not reflect the effects of any major changes in crop production conditions or other abnormal events. The projections do reflect the expected economic responses of producers and consumers to changes in prices. The projections also reflect the continuing increase in international trade that would accompany trade reform.

IFPRI projections to 2020. Rosegrant (1995) revised and extended IFPRI's 1994 study (Agcaoili and Rosegrant 1995) to make projections to 2020 for country, regional, and global supply and demand balances, trade, and prices; per capita consumption of food and calories; and number of malnourished children. The model includes seventeen commodities (which account for nearly all of world food production and consumption) and covers thirty-five countries and regions. The model uses prices and investment (including agricultural research and irrigation) to estimate agricultural production increases, and incomes and prices to estimate per capita demand. Population is assumed to grow according to the medium-rate UN projections.

The IFPRI projections show a relatively good global food supply and demand balance in 2020. Food production grows fast enough to cause real cereal prices to fall nearly 20 percent between 1990 and 2020 and real meat prices to fall 10 percent. These declines are accompanied by increasing world food trade, including increased developing country imports from industrial countries. The net cereal imports of developing countries are projected to double by 2020, to 183 million tons. This increase in food imports by developing countries reflects growing incomes in East and Southeast Asia, but food supply problems in Sub-Saharan Africa, where imports are projected to triple. The level of imports needed by Sub-Saharan Africa is expected to exceed the ability of these countries to pay for them and will require assistance from the international community.

The IFPRI projections have cereal production growing at an average rate of 1.5 percent a year from 1990 to 2020. Most of this growth will come from yield increases, although yield growth will be slower than in the past. By 2020 world cereal production will be 56 percent above 1990 levels, while meat production will be 74 percent higher. In developing countries per capita demand for cereals will rise 12.3 percent over the period and per capita calorie supplies will rise 12.8 percent.

Despite this relatively favorable outlook for world food supplies, little improvement is projected in food security for the poor in many regions. Consumers in Sub-Saharan Africa face the bleakest prospects, with virtually no improvement in per capita calorie availabilities according to the IFPRI report. The prospects for South Asia are somewhat better, with both per capita incomes and per capita calorie supplies rising. However, the increase is not enough to close the gap with other regions. China and India, the two largest countries, are not expected to put severe pressure on the world cereal market. China is expected to increase its net cereal imports from 13 million tons to 27 million tons by 2020, while India is projected to remain essentially self-sufficient in cereals. Eastern Europe and the countries of the former Soviet Union are expected to become substantial cereal exporters as policy changes lead to a more market-oriented agriculture. The report cautions, however, that these projections assume that agricultural research investment is maintained.

In an alternative scenario the IFPRI projections consider the impact of lower investment in agricultural research combined with slower income growth. A decline in public investment in agricultural research has severe consequences for the global food situation. (The simulation assumes a significant weakening of the national and international agricultural research system equivalent to a $1.5 billion cut in public research expenditures in developing countries.) By reducing the rate of growth of crop productivity and food production in the developing world, the cutback in research reverses world price declines and causes malnutrition to rise.

Regional and Country Food Concerns

The food situation at the regional and country level is important because of the great disparity between rich and poor countries. This disparity exists despite the generally low world food prices and readily available export supplies in the world market for most of the past fifteen years. The food situation in individual countries is closely linked to overall economic growth: countries that experienced rapid economic growth also improved their food situation.
As discussed in the previous section, basic food staples such as grains are likely to be available from the world market at prices that are below current levels. However, this does not ensure all countries or all consumers an adequate diet. As was recently concluded at a conference on hunger:

There is widespread agreement that hunger must be tackled with a broad-based poverty reduction strategy; for it is extreme poverty that is the main cause of hunger, and not insufficient food production.

Ismail Serageldin (World Bank 1993, p. v)

The long-term solution to the hunger problem is to raise the level of economic growth so that countries that do not meet their food demand through domestic production can import from the world market.

**Large Developing Countries**

Large countries face special problems. They cannot import substantial shares of their food needs as easily as smaller countries because of the limits of the world market. For example, if China were to import 10 percent of its cereal consumption, it would account for 15 percent of the world market in cereals. Such imports could probably be accommodated if they grew gradually and steadily, but not if they occurred quickly or changed greatly from year to year. Perhaps partly because of this fact, large countries have often pursued policies of food self-sufficiency. From 1990 to 1995 the five largest developing countries (China, India, Indonesia, Brazil, and Russia) had net imports averaging just 12 percent of world grain trade, yet they accounted for 40 percent of world grain consumption and nearly half of the world's population.

These five countries differ greatly in per capita incomes and in growth rates of population and incomes (table 4). China and Indonesia have had per capita GNP growth rates of 6 percent or more for the past decade, while India's has been 2.9 percent and Brazil's and Russia's have been negative. Incomes have also differed greatly, with Brazil and Russia at significantly higher income levels than China, India, and Indonesia. Of the five, only India has an agricultural share of GDP above 20 percent. All except Russia increased their per capita food production from 1979–81 to 1994.4

These five countries have all had a high degree of government planning and intervention in agriculture. China and Russia exerted the tightest controls, although Brazil, India, and Indonesia have all had close government involvement in agriculture. In most cases governments intervened directly in food prices and also in the pricing and delivery of inputs to agriculture. All five countries have turned away from strict government controls, with China beginning agricultural reforms in 1978 and India in 1991. Russia also began to liberalize agriculture in 1991, following the dissolution of the Soviet Union and a crisis in food production and procurement. Brazil's economic reforms began in the late 1980s and early 1990s. Indonesia has slowly been reforming its agricultural policies. In nearly all cases reforms were introduced as a response to slow growth, increasing budget deficits, or a food crisis.

China and India, the two largest countries, account for 40 percent of the world's population and are among the

### Table 4

<table>
<thead>
<tr>
<th>Country</th>
<th>Population (millions)</th>
<th>GNP per capita</th>
<th>Agriculture as a share of GDP (%)</th>
<th>Per capita food production index (1979–81 = 100)</th>
<th>Per capita calorie supplies in 1992 (calories per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1191</td>
<td>530</td>
<td>19</td>
<td>113.4d</td>
<td>2734</td>
</tr>
<tr>
<td>India</td>
<td>914</td>
<td>310</td>
<td>30</td>
<td>125.2</td>
<td>2295</td>
</tr>
<tr>
<td>Indonesia</td>
<td>190</td>
<td>880</td>
<td>17</td>
<td>133.3</td>
<td>2752</td>
</tr>
<tr>
<td>Brazil</td>
<td>159</td>
<td>3370</td>
<td>10–19</td>
<td>117.0</td>
<td>2824</td>
</tr>
<tr>
<td>Russia</td>
<td>148</td>
<td>2650</td>
<td>7</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*— is not available.

a. Growth rates are for the period 1985–94.

b. The per capita food production index was not available for China, so the per capita index of grain production was used instead (computed from USDA data).

Source: World Bank 1996 for population, per capita real GNP and growth rates, and agriculture's share of GDP. The food production index and per capita average calorie supplies are from FAO data.
poorest countries as measured by real per capita GNP (World Bank 1996). Yet both have done remarkably well in food production over the past several decades. Since 1979–81 the index of per capita food production has increased 25 percent in India and the index of per capita grain production has increased 13 percent in China. Both countries faced an uncertain future in the 1960s, with food supplies that did not provide an adequate diet for most of the population. The situation has improved since then, although many people in these countries still fail to receive an adequate diet. In 1974 China had average calorie supplies of 2,081 per capita per day according to FAO—well below the minimum daily recommended requirement. By 1992 average calorie supplies were at 2,734 calories per capita per day, which is above the level considered to be adequate. India has also made large improvements, with average calorie supplies rising from 1,981 per capita per day in 1974 to 2,395 in 1992. From 1974 to 1995 grain production more than doubled in India and grew 83 percent in China (figure 8).

The dire view of Brown (1995) on food prospects for China is not shared by other researchers. In a recent article three IFPRI researchers (Rozelle, Huang, and Rosegrant 1996) examine Brown’s primary concerns. They conclude that although China will become a larger grain importer than it is today (43 million tons by 2010), its import needs can be met by traditional exporters. They do note, however, the importance of investment in agricultural research in China and conclude that a fall in research investment without an offsetting fall in demand could lead to the large imports suggested by Brown. Such a scenario could happen only if the government failed to maintain investments in research and also ignored rising import levels, an unlikely eventuality considering China’s strong attention to research and imports. The study also discounts Brown’s predictions of environmental problems. Even when assuming a doubling of the rates of erosion and salinity the study found that only extreme conditions would lead to sharply higher import levels.

Mitchell and Ingco (1993) conclude that China would likely increase its net grain imports in the future, but that such imports would only rise from 17 million tons in 1995 to 21.6 million tons by 2010. Their conclusions are based on UN projections of slower population growth after 2000 and on slower demand growth in line with that of recent years. China’s per capita consumption of grain would still exceed that of Japan, however, despite China’s much lower income. The IFPRI (Agcaoili and Rosegrant 1995) and FAO (Alexandratos 1995a) computer simulations differ somewhat from that of Mitchell and Ingco on growth prospects for China, but all agree that China’s cereal imports will remain modest (Islam 1995, p. 88).

India, the world’s second largest country, is also a potentially significant factor in the world grain market. From 1985 to 1994 India’s population grew 2 percent a year and its per capita GNP 2.9 percent (World Bank 1996). Per capita food production increased 25 percent from 1979–81 to 1994. Several studies predict that India will remain nearly self-sufficient in grain over the next ten to twenty-five years. The IFPRI projections (Rosegrant 1995) are for

FIGURE 8
Grain production has risen sharply in China and India

Source: USDA data and World Bank staff calculations.
India to remain self-sufficient through 2020. The FAPRI (1996) projections are for small net wheat imports by 2005, and Mitchell and Ingco (1993) project net grain imports of 13.7 million tons by 2010, which are still small relative to total consumption. None of the projections are for India to be a significant factor in the world grain market over the next ten to twenty-five years.

The Russian Federation, the fifth largest developing country, with a population of 148 million people, became an independent state at the end of 1991. Before that Russia was a member of the Soviet Union, which had had a highly centralized and increasingly inefficient production and distribution system for seventy years. Grain production had stagnated since the mid-1980s, and imports had increased sharply since 1970. By 1988 the Soviet Union was importing 52 million tons of grain—21 percent of world grain trade. Its per capita grain consumption was high, but a significant share of the grain was lost because of poor storage, transportation, and the inefficiencies of a nonmarket system. When the Soviet Union was dissolved, Russia was facing a food crisis resulting from both demand and supply problems. Grain production fell 26 percent in 1991, and sales by farms dropped because of the unrealistically low prices offered by the state procurement system (figure 9).

Faced with the possible collapse of food availability in 1992, the Russian government liberalized most retail prices in early 1992 and liberalized foreign trade and payments, including unifying the ruble exchange rate, in July 1992. The food economy underwent major adjustments following the liberalization of prices for most agricultural inputs and outputs in January 1992. Despite some signs of improvement, availability problems with inputs, credit, machinery, and fuel still plague the economy, and grain production in 1995 was down an additional 28 percent from the already low 1991 levels.

Russian grain imports also declined, dropping from 25.8 million tons in 1991 to 5.2 million tons in 1995. (For all fifteen countries of the former Soviet Union imports fell from 52.1 million tons in 1988 to 11.5 million tons in 1995.) With both production and imports down, consumption has also declined sharply since the late 1980s (see figure 9).

Despite the sharp declines in production, many analysts believe the region has the potential to become a major exporter because of the vast areas of productive cropland. The FAO (Alexandratos 1995a), IFPRI (Agcaoili and Rosegrant 1995), and Mitchell and Ingco (1993) projections are for the countries of Eastern Europe and the former Soviet Union to become net cereal exporters of 5 to 15 million tons by 2010. The FAPRI (1996) forecast also has Russia and the other countries of the former Soviet Union becoming net wheat exporters by 2004 and nearly self-sufficient in coarse grains.

**Food Deficit and Import-Dependent Countries**

The rise in grain prices over the past several years is especially important to food deficit and import-dependent developing countries. The FAO estimates that the rise in cereal prices in 1995 pushed the cost of cereal imports by developing countries up by $4 billion.
Although import dependence is not necessarily a problem, countries relying on food imports have two major concerns. They want to be sure that they can finance imports, and they want reliable access to world supplies. The capacity to import depends on the capacity to earn foreign exchange and on a country’s terms of trade. That makes the conditions facing the export markets of these countries particularly important. During the past two decades the price of agricultural commodities has fallen on world markets, while the price of manufactures has risen. As a result, the barter terms of trade between agricultural exports and imports of manufactured goods declined about 45 percent for developing countries during the 1980s.

An analysis of cereal import dependence shows that countries have in general become more dependent on imports since the early 1970s and that many of the poorest countries are the most dependent on imports for basic food supplies (table 5). Since cereals are the largest part of food trade, the share of cereals imported, the cost of cereal imports as a percentage of total export earnings, and the share of imported cereals in total calories consumed are used as measures of import dependence. The cost of cereal imports as a share of export revenue is perhaps the most useful measure of import dependence, since it shows the ability of a country to support cereal imports from export revenues. Developing countries in Latin America and the Caribbean, Asia, and Europe spent a smaller share of export revenues on imported cereals in 1988–92 than in 1970–74, while countries in the Middle East and North Africa and Sub-Saharan Africa spent a larger share.

Sub-Saharan African countries were in general more dependent on imports of cereals during 1988–92 than during 1970–74. Of the ten largest countries in Sub-Saharan Africa, seven imported a larger share of total cereals consumed in 1988–92 than in 1970–74 and eight spent a larger share of total export revenues on cereal imports. The share of total calories represented by imported cereals also increased for eight of the ten countries. Not all countries in Sub-Saharan Africa became more dependent on imported cereals for basic food supplies. Tanzania reduced the share of cereals imported from 3.0 percent in 1970–74 to 0.5 percent in 1988–92. But Tanzania was one of only seven Sub-Saharan countries to do so (of the forty-six countries for which data were available). And only seventeen of the forty-six reduced the share of export revenue spent on imported cereals.

The situation in Sub-Saharan Africa is not projected to improve, and this region remains the most vulnerable to hunger and malnutrition according to the various projections. Rosegrant (1995) projects a deterioration in food security and a rise in malnourished children through 2020. The consensus of the other studies (Alexandratos 1995a;

### TABLE 5

<table>
<thead>
<tr>
<th>Region</th>
<th>Share of cereal consumption imported</th>
<th>Cereal import costs as a share of export revenues</th>
<th>Share of calories from imported cereals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>45.0</td>
<td>42.7</td>
<td>8.1</td>
</tr>
<tr>
<td>Asia</td>
<td>39.3</td>
<td>39.1</td>
<td>26.7</td>
</tr>
<tr>
<td>Europe</td>
<td>17.4</td>
<td>16.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>39.5</td>
<td>56.2</td>
<td>13.0</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>29.5</td>
<td>37.8</td>
<td>19.4</td>
</tr>
<tr>
<td>Population-weighted average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>8.9</td>
<td>13.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Asia</td>
<td>3.3</td>
<td>2.3</td>
<td>18.8</td>
</tr>
<tr>
<td>Europe</td>
<td>7.1</td>
<td>2.6</td>
<td>4.7</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>23.7</td>
<td>43.1</td>
<td>11.5</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>7.7</td>
<td>15.2</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Source: World Bank and FAO data and World Bank staff calculations.

**Regional and Country Food Concerns**

16
Agcaoili and Rosegrant 1995; and Mitchell and Ingco 1993) is that population growth of approximately 3.0 percent a year from 1989–91 to 2010 will present a formidable challenge to this region. Whether production can respond will determine the outcome for this region. Imports of grain will be needed, but the foreign exchange to finance such imports may not be available and the region may need to rely on food aid.

Asian low- and middle-income countries remained about as dependent on imported cereals in 1988–92 as in 1970–74. Of the twenty-eight countries for which data were available, fifteen increased their share of cereals imported and thirteen decreased their share. The share of export revenues spent on imported cereals increased in seven countries and decreased in twenty-one. Of the ten largest developing countries in the region, only two—China and the Republic of Korea—increased their share of cereals imported. Vietnam experienced one of the most significant changes in cereal import dependence during this period, going from imports of 16.6 percent of cereal consumption in 1970–74 to exports of 8.2 percent of consumption in 1988–92.

East and South Asia are expected to increase net grain imports over the period to 2010. According to the average of the Alexandratos (1995a), Agcaoili and Rosegrant (1995), and Mitchell and Ingco (1993) projections, East Asia will increase its net imports from 27.4 million tons a year in 1989–91 to 43.7 million tons in 2010 and South Asia from 3.2 to 17.0 million tons.

Low- and middle-income developing countries in Latin America and the Caribbean were generally less dependent on cereal imports during 1988–92 than during 1970–74, as measured by the share of cereal imports and the share of export revenues spent on cereal imports. However, seven of the ten largest developing countries (based on 1988–92 population) increased their share of cereal imports between the two periods, while only two of the ten countries increased the share of export revenues spent on cereal imports. Net grain imports in Latin America and the Caribbean are projected to about double over the period 1989–91 to 2010, though the region will remain a relatively small net importer.

Countries in the Middle East and North Africa region are the most dependent on imported cereals, importing an average of 56.2 percent of their total cereal consumption, up sharply from 39.5 percent in 1970–74. The share of export revenues required to import cereals did not increase proportionately, however, rising only from 13 percent in 1970–74 to 14.5 percent in 1988–92. The Middle East and North Africa has been a large net importer of cereals since the 1970s, and this trend is expected to continue, with imports growing from 38.4 million tons during 1989–91 to 70 million tons by 2010 according to the three projections.

Low- and middle-income European countries reduced both the share of cereals imported and the share of export revenue expended on cereal imports from 1970–74 to 1988–92.

Policy Environment: Implications for the World Food Situation and Food Security

There are several important changes under way in the global policy environment that will significantly affect the world food situation. These include the Uruguay Round Agreement on Agriculture and the post–Uruguay Round changes in policies in industrial and developing countries. Although the extent of actual liberalization achieved in the Round is limited, bringing agricultural trade under multilateral discipline and converting nontariff barriers to tariffs are important steps. At the global level, the new framework of rules on market access, export subsidies, and domestic support provides the foundation for further liberalization. The challenge is to ensure that countries are choosing to implement their commitments in the spirit of the Agreement on Agriculture and that further commitments to liberalization are carried out. Improving the policy environment and opening domestic markets to world prices will be important if countries are to benefit from the new investments to raise the yield potential. While policy reforms to reduce protection may be accompanied by greater year-to-year price changes in the short run, these policy reforms should also result in more stable prices in the long term.

Impact of the Uruguay Round Agreement

The impact of the Agriculture Agreement on world prices depends on the extent of agricultural liberalization achieved. In general, industrial countries subsidize their agricultural sectors by protecting them from import competition and by
subsidizing exports. These policies have increased domestic production, reduced consumption, and reduced import demand or raised exportable supplies, all of which have tended to lower international prices. Thus liberalization of industrial country policies would have the opposite effects and tend to raise world prices. In contrast, developing countries have tended to tax agriculture and subsidize domestic prices, which has discouraged production, encouraged consumption, and increased import demand. Liberalizing developing country policies would lower world prices.

As shown in Ingco (1995a and 1996), the extent of actual agricultural liberalization achieved in the Uruguay Round is limited. Thus the impact of the agreement on average world prices of food commodities is estimated to be small, raising food prices by only as much as 4 percent relative to the levels that would have occurred without the agreement. Agricultural producers will benefit from the projected world price increases, particularly in countries where price transmission is not limited by domestic policies. At the same time, however, higher food prices will impose costs on net food deficit countries, especially in Africa. Agricultural importers and net food deficit countries may be hurt by the price increases. Provisions in the Agriculture Agreement to deal with these concerns are included in a Decision on Measures Concerning the Possible Negative Effects of the Reform Program on Least-Developed and Net Food-Importing Developing Countries.

For net importers of food commodities such as wheat whose price is expected to rise, there are several reasons why the negative welfare impact of the price increase is likely to be less than would be implied by simply applying the price change to recent trade values. First, the price changes would elicit adjustments in production and consumption and there would be some reduction in net food import demand, which would reduce the apparent cost of the price increase. This effect is likely if governments allow a full pass-through of world prices to farmers and consumers. Doing so would raise domestic output—of substitute goods if not of the products actually imported—and switch consumption to cheaper substitutes. The needs of the poorest segments of the population could be met by more targeted and cost-effective safety net measures.

Second, many food deficit countries import food partly because of poor policies—such as taxes on output or subsidies on consumption and imports. If higher world food prices affect production and consumption in these countries, they will reduce the burden of these distortions—maybe by enough to more than offset the extra costs of imports. For example, increased domestic production would boost tax revenue, and lower imports would reduce subsidy costs. More important, if higher food prices encourage governments to reform these policies, there will be further gains. Indeed, if this occurs, some net food importers could become net exporters and thus benefit directly from the higher world prices. Thus the removal of policy distortions could leave some countries better off.

For the food deficit countries that are heavily dependent on food aid, the implications of the Agriculture Agreement for the availability of food aid are an important issue. The agreement exempts bona fide food aid from the reductions on export subsidies. However, since food aid flows have often been related to the disposal of surpluses resulting from price support schemes, reductions in price supports might have an indirect impact on the availability of food aid. On balance, though, the Uruguay Round may not affect food aid flows in the early years of implementation.

The small degree of agricultural liberalization achieved will inevitably have a negative impact on some developing countries. However, recent analysis suggests that the impact will be small and, since implementation takes up to six years, slow to arrive. Ingco (1995b) estimates that the terms of trade effects due to the projected price increases will be small—about 1–2 percent of GDP. Such negative effects could easily be outweighed by even modest policy reforms designed to improve agricultural efficiency. In addition, other aspects of the Agriculture Agreement could provide gains that would balance the losses resulting from higher food prices. Overall, the agreement is expected to expand global trade and contribute to higher income growth. Direct benefits in the medium to long term will result both from increased access to industrial countries’ markets and from enhanced efficiency originating from countries’ own liberalization policies. Recent assessments indicate that the greater is the extent of a country’s own liberalization, the greater are the gains from liberalization (Martin and Winters 1995).

Beyond agricultural liberalization, more open trade in general contributes to economic growth in several ways. It enhances the production possibilities open to an economy.
by facilitating the development of production alternatives not previously available. And it is linked to greater opportunities for the transfer of capital, new technologies, and investments. Although in agriculture these benefits may initially go mainly to large farmers, growth could trickle down to smaller and poor farmers. Overall, the gains from trade liberalization could potentially be large in view of the significant distortions that exist today in both industrial and developing countries.

**Industrial Country Policies**

In industrial countries budgetary pressures, combined with the new multilateral agreement on agricultural subsidies and domestic support, are leading to further reforms of agricultural policies. In the United States freedom-to-farm provisions of the new farm bill have radically altered farm policy by removing the link between market prices and the level of government support payments. The new farm bill eliminates land set-asides and gives producers increased planting flexibility, allowing them to plant virtually any crop on land enrolled in the farm program and still receive annual payments. The impact of the new farm bill on market prices for grains and oilseeds is not expected to be significant in the short term because stocks are tight. Over the longer term, however, the farm bill is expected to stimulate U.S. production. In the European Union agricultural support payments until 1999 are limited by the financial guidelines agreed between the European Council and the European Parliament. An important aspect of the recent reform of the Common Agricultural Policy was to decouple support from market prices to prevent breaching the agreed ceiling on agricultural spending.

Overall, however, the level of support to agriculture is still high in industrial countries, albeit with wide variations across commodities. And despite recent reforms, market price support remains the most important form of assistance, although direct payments are playing a growing role. Continuing reforms in industrial countries will improve the global allocation of resources in agriculture and global food security by allowing domestic, regional, and world markets to function better.

Whether price and market instability will increase as a result of liberalization is a major concern of many developing countries. The effect of policy reforms on price stability is complex and depends on several factors. Reducing price insulation should improve adjustments to production shocks, thus facilitating a quicker return of prices to levels closer to long-term trends. And reducing protection in industrial countries need not result in lower stock accumulation. Ingco and Martin (1996) show that stock accumulation depends on the balance of protection instruments used. Since import protection and export subsidies are subject to stricter discipline than is domestic support, there could be a move back toward stockholding. Overall, however, the Uruguay Round cap on total price supports combined with policy changes in major exporting countries should lead to lower stocks. All in all, year-to-year variability in prices may rise because of lower stocks, but prices should be more stable in the long term.

There is also a concern that less government intervention in industrial countries, particularly less public stockholding, might result in a reduction in food aid commitments. The minimum guaranteed food aid quantities under the Food Aid Convention were revised downward from 7.4 million tons to 5.3 million tons a year for the three years beginning July 1, 1995. While actual food aid deliveries have exceeded this minimum during the past ten years, some reduction in program and project food aid is likely. In the longer term the volume of food aid will be influenced mainly by countries' perceptions of its usefulness.

**Developing Country Policies**

Many developing countries have preferred self-sufficiency policies to meet their food security objectives. During the 1970s and 1980s these countries followed growth strategies that emphasized public subsidies on production and direct government control of credit and prices. Low-income countries taxed agricultural exports and subsidized the domestic prices of food staples. High tariff and nontariff barriers were used to protect domestic production, while input markets were distorted by heavy subsidies, particularly for fertilizer and agricultural credit.

Although most developing countries have reformed their policies from the misdirected strategies of the 1970s and 1980s, many still have poor policies. Country experiences demonstrate that the economic and financial costs of pursuing self-sufficiency can be high. In contrast, policies
that facilitate more open trade will result in efficiency gains and allow domestic food needs to be met more cheaply by less costly imported supplies. In many countries, improving agricultural policies—which would enhance the productivity of existing technologies—may be as important as developing new technologies to increase yield potential and meet the food needs of growing populations.

The post-Uruguay Round global economic environment provides developing countries with a more favorable setting in which to accelerate and deepen reforms that will assist them in exploiting new opportunities in world trade. The gains will not be automatic, however, and will depend on effective implementation of the agreed reforms. The ability of developing countries to take advantage of the new trading environment depends on their own commitment to reform, their determination to allow market signals and price changes to be passed on to producers and consumers, and their willingness to pursue flexible economic policies.

Further liberalization is needed in sectors where applied protection remains high. Though the evidence is limited, the dynamic growth effects of liberalization—through increases in the incentives to invest and undertake research and development—could be an important source of second-round effects. The most important challenge to policymakers is to continue to strengthen the agricultural policy reform process, building on the recent progress achieved in the Uruguay Round. Greater efforts are needed to reduce the distortional effects of policies and to improve the targeting and cost-effectiveness of measures intended to address broader policy objectives, such as food security.

Trade Liberalization

The prospects for global trade growth have implications for food security. Increased trade leads to higher income growth, and that makes it easier for developing countries to finance their food import bills. A more stable trade regime will also enhance food security by reducing the uncertainty inherent in arbitrary trade policies, which could lead to disruptions in foreign exchange earnings and so to a fall in purchasing power with respect to food imports. There is strong evidence that trade liberalization is a basic element of growth-enhancing policies, although there is limited empirical evidence on causality between trade liberalization and poverty reduction. There is evidence, however, that rapid economic growth is accompanied by higher employment, improved income distribution, and lower levels of absolute poverty. A World Bank study (1995) found that real wages increased at about 3 percent a year in developing countries whose exports as a share of GDP were above the median and stagnated in countries whose exports increased the least. In broad terms, the impact of trade liberalization on poverty will depend on the nature of trade-induced growth.

Poverty Reduction and Food Security

While aggregate economic growth tends to reduce poverty (Bruno, Ravallion, and Squire 1996), rural economic growth appears to have a greater effect on overall poverty reduction. Ravallion and Datt (1996), using a consistent series of consumption-based poverty measures over forty years for India, found that rural economic growth reduced national poverty more than did urban economic growth, despite the rising urbanization of poverty in India over the period. Rural growth reduced poverty in both rural and urban areas, whereas urban growth benefited the urban poor but did not reduce rural poverty. A decomposition of the sources of growth showed that growth in primary and tertiary sectors tended to reduce poverty in both urban and rural areas. The main implication of these findings is that poverty can be effectively reduced through strategies that promote rural growth and incomes.

Conclusion

World grain stocks are low by historical standards, and prices rose sharply during the past two years before recent declines. However, the current situation does not appear to presage a near-term world food crisis, as some have argued. Rather, it is the result of specific events, such as policy changes in the major exporting countries that led to reduced stock levels, combined with below-trend grain yields in 1995. The price increases have already stimulated world production and are expected to lead to a record grain harvest in 1996. Cause for concern remains as long as stocks are near current lows. However, production potential in the major exporting countries is large and is expected to contribute to a rebuilding of world grain stocks.
The five largest grain exporting countries accounted for 88 percent of the total decline in world grain stocks from the 1986 highs to the 1995 lows. These declines were due to cutbacks in area planted to grains in response to low prices and policy changes during the 1980s. The major grain exporters reduced grain area by 34.5 million hectares from the early 1980s to the mid-1990s, an area with a production potential equal to about half of annual world grain trade. Much of this land could return to production if economic conditions justified it and government policies allowed it. Grain production in the five largest exporters is expected to increase 15 percent in 1996 over 1995.

Growth in world grain yields slowed during the first half of the 1990s, in part because of short-term factors such as the poor 1995 harvest and lower input use in the transition economies of the former Soviet Union. High fertilizer prices during the past several years also contributed to slower yield growth. In the developing countries, however, yields continued to increase at nearly the same rate as during the 1980s, despite the higher fertilizer prices. Over the longer term, plant breeders argue that yields should continue to increase if investments in research are maintained. The potential of biotechnology to increase yields and reduce environmental stress from agriculture is also promising but has been slow to materialize. Still, there are significant reasons to believe that yield increases will be more difficult to achieve in the future than in the past.

Policy changes at both the global and the country level should increase the responsiveness of agriculture to world price signals and lead to greater price stability over the longer term. Recent developments provide evidence to support this conclusion. Low stocks in 1995 led to significantly smaller price increases and a quicker response to production shocks than occurred during the mid-1970s with a similar stock situation. The Uruguay Round Agreement on Agriculture provides the foundation for a more open trading system in agriculture, and it provides developing countries with greater opportunities for exporting their products by reducing protectionist policies. The challenge is to ensure that countries implement policy changes in the spirit of the agreement.

Beyond the recent situation of high grain prices and low world stocks, the medium-term outlook for world food supplies appears potentially favorable. Studies by researchers at IFPRI, FAPRI, FAO, USDA, and the World Bank come to similar conclusions: world food supplies should be adequate to meet world demand over the next ten to twenty-five years without significantly higher real prices. However, such projections are conditional on a number of factors, including continuing growth in world crop yields along historical trends, which in turn depend on continuing investments in agriculture and agricultural research and on the policies pursued by governments.

The focus on the long-term world food situation should not distract from the immediate concern, which is the extent of regional food problems and the inequality of food distribution within countries. Many people still suffer from hunger and malnutrition, even in countries where food supplies are adequate. And despite falling world prices for most of the 1980s, their situation did not improve. This disparity in the midst of a generally favorable world food situation demands attention. The solution is widely recognized to be raising incomes and reducing poverty in these countries. This is a primary challenge facing the development community and a focus of the World Bank's development efforts.

Notes

1. Based on USDA data, the five largest grain exporters during 1980-90 and their share of world exports were the United States (41.4%), the European Union (21.7%), Canada (10.7%), Australia (6.9%), and Argentina (6.1%).
2. Crosson and Anderson (1992) based their analysis on an estimated 0.05 hectare of land per person for urban areas in developing countries.
3. FAPRI is a consortium of researchers at Iowa State University and the University of Missouri, along with researchers at the University of Arkansas, Texas A&M University, North Dakota State University, and Arizona State University.
4. Since food production data were not available for China or Russia, per capita grain production was used.
5. Ingeco (1995a and 1995b) found that countries took some liberties in converting former quantitative restrictions to tariff equivalents, with the result that nontariff restrictions were replaced by very high tariffs that will in many cases effectively limit trade to the minimum levels agreed and insulate internal prices from world prices. Most developing countries took an option that allowed them to bypass tariffification of nontariff barriers and merely declared bound tariffs for products on which nontariff barriers had been used. While several developing countries in Latin America and East Asia committed to binding their tariffs at relatively low levels (less than 30 percent), many countries in Africa and South Asia declared very high (over 100 percent) bound tariffs for agricultural products. For further discussion, see

Notes
References


References
| No. 303 | Heneveld and Craig, *Schools Count: World Bank Project Designs and the Quality of Primary Education in Sub-Saharan Africa* |
| No. 304 | Foley, *Photovoltaic Applications in Rural Areas of the Developing World* |
| No. 305 | Johnson, *Education and Training of Accountants in Sub-Saharan Anglophone Africa* |
| No. 306 | Muir and Saba, *Improving State Enterprise Performance: The Role of Internal and External Incentives* |
| No. 307 | Narayan, *Toward Participatory Research* |
| No. 308 | Adamson and others, *Energy Use, Air Pollution, and Environmental Policy in Krakow: Can Economic Incentives Really Help?* |
| No. 310 | Elder and Cooley, editors, *Sustainable Settlement and Development of the Onchocerciasis Control Programme Area: Proceedings of a Ministerial Meeting* |
| No. 311 | Webster, Riopelle and Chidzero, *World Bank Lending for Small Enterprises 1989-1993* |
| No. 312 | Benoit, *Project Finance at the World Bank: An Overview of Policies and Instruments* |
| No. 313 | Kapur, *Airport Infrastructure: The Emerging Role of the Private Sector* |
| No. 316 | Schware and Kimberley, *Information Technology and National Trade Facilitation: Making the Most of Global Trade* |
| No. 317 | Schware and Kimberley, *Information Technology and National Trade Facilitation: Guide to Best Practice* |
| No. 320 | Srivastava, Lambert and Vietmeyer, *Medicinal Plants: An Expanding Role in Development* |
| No. 321 | Srivastava, Smith, and Forno, *Biodiversity and Agriculture: Implications for Conservation and Development* |
| No. 322 | Peters, *The Ecology and Management of Non-Timber Forest Resources* |
| No. 323 | Pannier, editor, *Corporate Governance of Public Enterprises in Transitional Economies* |
| No. 324 | Cabraal, Cosgrove-Davies, and Schaeffer, *Best Practices for Photovoltaic Household Electrification Programs* |
| No. 325 | Bacon, Besant-Jones, and Heidarian, *Estimating Construction Costs and Schedules: Experience with Power Generation Projects in Developing Countries* |
| No. 326 | Colletta, Balachander, Liang, *The Condition of Young Children in Sub-Saharan Africa: The Convergence of Health, Nutrition, and Early Education* |
| No. 328 | De Geyndt, *Social Development and Absolute Poverty in Asia and Latin America* |
| No. 329 | Mohan, editor, *Bibliography of Publications: Technical Department, Africa Region, July 1987 to April 1996* |
| No. 332 | Pohl, Djankov, and Anderson, *Restructuring Large Industrial Firms in Central and Eastern Europe: An Empirical Analysis* |
| No. 333 | Jha, Ranson, and Bobadilla, *Measuring the Burden of Disease and the Cost-Effectiveness of Health Interventions: A Case Study in Guinea* |
| No. 334 | Mosse and Sontheimer, *Performance Monitoring Indicators Handbook* |
| No. 335 | Kirmani and Le Moigne, *Fostering Riparian Cooperation in International River Basins: The World Bank at Its Best in Development Diplomacy* |
| No. 336 | Francis, with Akinwumi, Ngwu, Nkom, Odhii, Olomajeye, Okunmadewa and Shehu, *State, Community, and Local Development in Nigeria* |
| No. 338 | Young, *Measuring Economic Benefits for Water Investments and Policies* |
| No. 340 | Rutkowski, *Changes in the Wage Structure during Economic Transition in Central and Eastern Europe* |
| No. 341 | Goldstein, Preker, Adeyi, and Chellaraj, *Trends in Health Status, Services, and Finance: The Transition in Central and Eastern Europe, Volume I* |
| No. 343 | Kottetal and Whitten, *Freshwater Biodiversity in Asia, with Special Reference to Fish* |
| No. 344 | Klugman, Schieber, Heleniak and Hon, *A Survey of Health Reform in Central Asia* |
| No. 347 | Stock and de Veen, *Expanding Labor-based Methods for Road Works in Africa* |
| No. 350 | Buscaglia and Maria Dakolias, *Judicial Reform in Latin American Courts: The Experience in Argentina and Ecuador* |
THE WORLD BANK

HEADQUARTERS
1818 H Street, N.W.
Washington, D.C. 20433 USA
Telephone: 202-477.1234
Fax: 202-477.6391
Telex: MCI 64145 WORLD BANK
MCI 248223 WORLD BANK
Cable Address: INTRAFRAD
WASHINGTON DC
E-mail: books@worldbank.org

EUROPEAN OFFICE
66, avenue d'Herou
75116 Paris, France
Telephone: 1. 40.69.30.00
Fax: 1. 40.69.30.66
Telex: 640661

TOKYO OFFICE
Kokusai Building
1-1, Marunouchi 3-chome
Chiyoda-ku, Tokyo 100, Japan
Telephone: 3. 3214.5001
Fax: 3. 3214.3657
Telex: 26838

ISBN 0-8213-3799-8