

Global Food Projections to 2020: Implications for Investment

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Foreword

This is the fifth paper in the Food, Agriculture, and the Environment Discussion Paper series, a product of IFPRI's 2020 Vision initiative, which seeks to develop an international consensus on how to meet future world food needs while reducing poverty and protecting the environment. In this paper, Mark W. Rosegrant, Mercedita Agcaoili-Sombilla, and Nicostrato D. Perez examine projections of global supply of and demand for food through the year 2020.

Rosegrant, Agcaoili-Sombilla, and Perez look closely at how alternative population, investment, and trade scenarios will affect food security and nutrition status, especially in the developing world. They argue that the world is at risk of maintaining its two-tiered system of food security, with rich and rapidly growing countries enjoying abundant, affordable food supplies and poor countries suffering from malnutrition and food scarcity.

National governments and international agencies can alter this situation through their investment decisions. By increasing their agricultural and social investments, for instance, they can greatly improve food security and reduce malnutrition in developing countries. This paper offers data on the results to be expected from various decisions and points the way toward a future with food security for all.

**Per Pinstrup-Andersen
Director General, IFPRI**

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1. Introduction

The coming decades will pose complex problems for national policymakers and international institutions involved in agricultural development. On the one hand, there is cause for concern over future food availability. Growth rates in yield per hectare for cereals in the developing world and for the world as a whole have declined since the early 1980s. Progress in reducing malnutrition has been slow, and it is estimated that 184 million children under the age of five suffer from malnutrition in the developing world (ACC/SCN 1992a). On the other hand, daily food energy per capita consumed in the developing countries in aggregate increased by more than 7 percent during the 1980s (Pinstrup-Andersen 1993). Real world food prices declined sharply during the same period, indicating ample total food supplies at effective levels of demand. Most developing countries, with the notable exceptions of Sub-Saharan Africa and parts of South Asia, have steadily reduced the rate of population growth over the past two decades. In Asia, which accounts for a large share of total world food demand, the rate of growth in consumption of food staples due to increasing incomes is also declining, as diets diversify with rising per capita income and population shifts to urban areas (Bouis 1989, 1991).

By 2020, what outcomes in food availability, food prices, and food security will result from these seemingly contradictory trends, some indicating potential shortages as food production slows, others pointing to continued decline in demand pressure for

food and increasing availability of food? What policies will be necessary to ensure continued increases in food availability?

This discussion paper will provide an overview of the world food supply and demand situation to the year 2020, under a baseline scenario that incorporates the authors' best estimates of future growth in income, population, agricultural productivity, and other key factors. As the paper will show, the world will continue to have two distinct realities: wealthy countries, together with a number of rapidly growing developing countries (mainly in Asia), will enjoy low food prices and food surpluses or affordable imports, while poorer, slower-growing countries will make little progress in improving food security or reducing malnutrition, if present trends continue. In other words, the central paradox in the world food equation will remain. The aggregate global supply and demand picture will be relatively good, with food production growing fast enough that world prices of food will decline. But at the same time there will be little improvement in food security in much of the world, including most of South Asia, and food security will worsen in Sub-Saharan Africa.

Alternative population, investment, growth, and trade scenarios could change this picture. The analysis therefore explores the effects of these alternative scenarios on supply, demand, trade, world prices, and food security and derives policy conclusions based on the alternative projections.

2. Model Structure and Baseline Assumptions

The model used to generate the projections presented here is the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), developed at the International Food Policy Research Institute (IFPRI).¹ It is specified as a set of 35 country or regional models that determine supply, demand, and prices for 17 agricultural commodities (Appendix 1, Tables 20 and 21). Growth in crop area and yield per hectare for each crop and country are determined by crop prices and the rate of technological change due to research, irrigation, and other investments. Demand is a function of prices, income, and population growth. The 35 country and regional agricultural submodels are linked through trade, which highlights the interdependence of countries and commodities in the world agricultural economy. The world price of a commodity is determined at its market-clearing point (that is, when net world trade for the commodity is zero). When this equilibrium is disturbed (for example, through exogenous shocks to supply or demand), world prices readjust and are fed back to the country models through the price linkage equations (equations 13 through 15 in Appendix 1). The price adjustments lead to new production, demand, and trade quantities, and the process is repeated until a new world equilibrium with zero net world trade for all products is achieved.

The model is also used to project the percentage and number of malnourished preschool children in developing countries, based on the estimated relationship between the percentage of malnourished children by country and per capita calorie availability (which is determined within the model),

growth in social expenditures, female education, and access to clean water. Projected growth on these numbers was estimated based on recent trends.

Several economic, social, and political factors will continue to influence trends in food supply, demand, trade, and prices. Factors with potentially significant effects on future developments in the world food situation include population and income growth, urbanization, the rate of increase in food production due to technological change and productivity growth, prices of commodities, and the response of supply and demand to prices. The baseline scenario uses the authors' best assessments of future directions in these factors from 1990 to 2020. These assessments are reflected primarily in the growth rate parameters and elasticities of the model, which are derived mainly from direct estimation, analysis of recent past trends (and changes in trends), analysis of future potential relative to past growth, and synthesis of different sources and consultation with experts in the field.

Population, Income Growth, and Urbanization

Population and income growth will remain important determinants of food supply and demand balances in the future. The United Nations 1992 medium population growth rates are used as the basis for the IMPACT population projections, updated where possible by more recent evidence for specific countries. The growth rate in world population appears to have peaked at 2.1 percent per year in 1965–70 and it has declined progressively since

¹The structure of IMPACT is shown in detail in Appendix 1.

then to the current level of 1.7 percent per year (United Nations 1993). Further declines in global growth rates are foreseen as birth rates decline and the fall in mortality rates levels off. Thus, in the baseline projections, world population is expected to grow at an average rate of 1.4 percent to 2020. Population will rise by 2.7 billion in the next 30 years to reach about 8 billion in 2020 (Table 1). The rates will differ greatly by country, especially in the developing regions, where the major part of population growth will take place.

Population in the developing countries will grow at 1.7 percent per year, compared with 0.4 percent per year in the developed countries. In Sub-Saharan Africa, population will continue to increase at 2.9 percent per year, so that its population in 2020 will be more than double the 1990 level of about 500 million. The population of South Asia, with about 1.1 billion people in 1990, will increase at an annual rate of about 1.8 percent to reach 1.9 billion in 2020. Pakistan is projected to maintain its relatively high population growth rate of about 2.8 percent per year.

Table 1—United Nations and IMPACT population projections, 1990 and 2020

Country/Region	United Nations		IMPACT	
	1990	2020	1990	2020
	(millions)			
Australia and New Zealand	20.5	28.4	20.3	27.3
Eastern Europe	n.a.	n.a.	99.5	112.2
European Union	n.a.	n.a.	400.9	415.8
Former Soviet Union	281.3	336.4	288.9	350.9
Japan	123.5	128.7	123.5	130.3
United States	250.0	314.5	250.0	303.4
Other developed countries	n.a.	n.a.	69.4	79.1
Total developed countries	1,211.1	1,387.2	1,252.5	1,419.2
Latin America	441.0	670.7	435.0	654.9
Sub-Saharan Africa	489.3	1,146.2	484.9	1,136.7
Central and West	n.a.	n.a.	111.1	261.9
Eastern	n.a.	n.a.	79.7	193.5
Nigeria	108.6	255.6	108.6	248.7
Northern	n.a.	n.a.	116.1	273.7
Southern	n.a.	n.a.	69.4	158.9
West Asia and North Africa	305.5	600.9	308.7	591.4
South Asia	1,114.8	1,840.7	1,114.9	1,895.7
Bangladesh	113.7	209.2	113.7	200.0
India	846.2	1,328.6	846.3	1,362.5
Pakistan	118.1	240.9	118.1	270.4
Other South Asian countries	36.8	62.0	36.8	62.8
Southeast Asia	441.4	679.2	441.1	687.0
Indonesia	184.3	271.1	184.3	279.7
Malaysia	17.9	29.5	17.9	29.7
Philippines	62.4	100.2	62.4	102.0
Thailand	54.7	70.9	54.7	73.3
Other Southeast Asian countries	122.1	207.5	121.8	202.0
East Asia	1,226.5	1,601.1	1,200.4	1,583.0
China	1,153.5	1,504.2	1,133.3	1,482.8
Other East Asian countries	73.0	96.9	67.1	100.7
Asia	2,927.8	4,529.3	2,756.4	4,165.7
Total developing countries	4,084.2	6,662.7	3,985.4	6,549.4
World	5,295.3	8,049.9	5,237.9	7,968.7

Sources: United Nations 1993; IMPACT simulation results.

Note: n.a. is not available. United Nations figures are medium projections.

Growth rates in India and China, the two population giants, will be slower, at 1.7 percent and 1.0 percent, respectively. But because of their large population base, they will still account for about 37 percent of the total world population increment between 1990 and 2020.

Recently, developing countries as a group have exhibited higher growth rates of gross domestic product (GDP) than developed countries. GDP growth rates in developing countries ranged from 4.4 percent in 1991 to 5.5 percent in 1994, compared with 0.6 percent to 2.4 percent in the developed region (IMF 1994). These relatively high growth rates in developing countries are projected to continue in the future, although disparities in growth rates will remain large among the developing countries. Growth rates will be highest in the newly industrializing countries of East and Southeast Asia, averaging more than 6 percent a year. India's initiatives toward stronger implementation of macroeconomic stabilization and market reforms account for that country's projected improved income growth of 5.5 percent. China's economy, which has grown at nearly 10 percent per year for the last several years, is projected to stabilize at a lower growth level of 6 percent.

A number of reforming countries in Latin America, including Argentina and Chile, have shown improved economic prospects that will likely continue as a result of the large inflows of foreign direct and portfolio investments they have attracted in recent years. However, continued macroeconomic instability in the region is a significant factor in the projected continuation of the region's current modest GDP growth rate of about 3 percent.

In Sub-Saharan Africa, economic growth registered about 1 percent in the early 1990s. There is, however, considerable scope for recovery in this region with strengthened efforts to put in place reforms to stabilize the macroeconomic environment. Various international financial organizations are now initiating structural adjustment programs to provide concessional lending as well as timely and realistic debt relief for many of the poorest countries in the region. The recent devaluation of the CFA franc is expected to help improve the growth prospects of countries in the franc zone. In addition, reduced levels of political and civil strife should

help reinforce the incipient economic recovery and allow governments to embark on a program of reconstruction and development while safeguarding macroeconomic balance. These developments are reflected in somewhat more optimistic projections for future growth in the region; average GDP growth for the region as a whole is expected to be about 3.3 percent.

Signs of progress toward economic stabilization, restructuring, and recovery are mixed in Eastern Europe and the former Soviet Union. Some countries in Eastern Europe (such as Albania, the Czech Republic, and Poland) saw GDP growth go from negative rates in the early 1990s to positive ones in 1993, primarily owing to moves toward greater macroeconomic stability and significant progress on structural reforms. In contrast, Russia and most other countries in the former Soviet Union have generally made less progress on reforms. Economic growth in many countries of Eastern Europe and the former Soviet Union will be slow and difficult. However, continued popular support for establishing and strengthening more market-oriented economies will help their future growth and development. In Eastern Europe as a whole, GDP growth is projected to become positive by the turn of the century and would average about 3 percent annually after 2000; in the former Soviet Union, positive GDP growth of close to 3 percent per year is not expected until 2005.

Closely related to population and income changes is the transformation of demographic patterns. The most vital of these demographic characteristics, particularly for projecting future food needs in fast-growing economies, is the rate of urbanization. In developing countries, this rate has become more rapid with the relatively high population growth in the urban areas. Approximately 44 percent of the population of developing countries is projected to reside in the urban areas by 2000, up from 22 percent in 1960 and 30 percent in 1980 (Pinstrup-Andersen 1992, Table 15). The rate of urbanization has a significant effect on demand structures. Past studies have indicated that urbanization accelerates dietary transition from the basic staples such as sorghum, millet, maize, and root crops to cereals that require less preparation (such as wheat and rice) and to fruits, livestock products, and processed foods. This shift is expected to occur with urbanization in

Sub-Saharan Africa. In the more developed countries of Asia, greater urbanization has resulted in substantial increases in demand for meat and other livestock products and a further shift from rice to wheat (Bouis 1994). Urbanization is not explicitly incorporated in the model. Its effect, however, is reflected in the assumptions on income and price elasticities, as described in the next section.

Demand and Supply Elasticities

IMPACT uses elasticities and technical coefficients synthesized from other sources, primarily from past studies.² The structure of these elasticities, especially those on demand, takes into account the underlying assumption that there will be a shift in the demand structure from the main staples to high-value products such as meat and other livestock products, particularly in the developing countries. The structural change in demand is attributed to several factors, including the expected increases in per capita incomes from more rapid economic growth, the projected faster rate of rural to urban migration, and the continued commercialization of production (Bouis 1994). Urbanization and commercialization have accounted for significant shifts in diets away from less expensive, high-energy foods such as cereals. Thus in developing countries income elasticities for cereals range from -0.4 (for maize) to 0.26 (for high-quality *indica* and *japonica* rice), and for meats, from 0.2 to 0.9. (The income demand parameters represent a synthesis of average, aggregate income elasticities for each country, given the income level and the distribution of population between urban and rural areas over the period of projections.)

Price elasticities of supply for crops are generally fairly small, in the range of 0.05 to 0.4, with a few higher elasticities for some crops in specific countries. The relatively small supply elasticities are consistent both with a review of past literature and with recent estimates of dynamic sup-

ply response for China, India, Indonesia, and other Asian countries (see, for example, Huang, Rosegrant and Rozelle 1995; Kumar and Rosegrant 1995; and Rosegrant and Perez 1995).

Productivity and Area Growth

A fundamental assumption of the baseline productivity projections is that rates of public investment in agricultural research and infrastructure will continue at the already reduced levels prevailing in the late 1980s and early 1990s. Based on this assumption, Evenson and Rosegrant (1995) developed an accounting structure incorporating sources of growth for area and yield, independent of price effects. They used recent studies for evidence on the size of these sources of growth in order to establish base-case nonprice supply trends for use in IMPACT. The sources of growth considered in the analysis include public agricultural research, management research, conventional plant breeding, wide-crossing/hybridization breeding, biotechnology (transgenic) breeding, private sector agricultural research and development, agricultural extension, markets, infrastructure, and irrigation. Thus, projected growth in yields and area are derived from (1) analysis of recent past trends, (2) examination of future yield potential for crops and livestock, and (3) in-depth assessment of future sources of growth, including public investments in research, extension, and infrastructure and future patterns of growth in these investments. A more detailed description of the methods used is provided in Appendix 2.

The general pattern projected is for a small additional decline in the rates of growth of crop yields compared with the already lower rates of crop yield growth experienced during the past decade. However, if investment rates in agricultural research are maintained, this decline should not accelerate. Conventional plant breeding will produce additional yield increases in farmers' fields for the next 10 to 15 years, depending on the crop. As gains from con-

²Price and income elasticities of demand are taken from various sources as identified in Appendix 1, Table 22. Price and income elasticities of the Asian countries are updated using the results of the project study Projections and Policy Implications of Medium- and Long-Term Rice Supply and Demand. Feed demand ratios and elasticities are derived from unpublished documentation of the FAO World Food Model.

ventional breeding are gradually exhausted beginning early in the next century, further yield growth will be generated as conventional breeding is combined with wide-crossing, transgenic breeding, and other tools resulting from biotechnology research.

Baseline Policy Assumptions

As described in the model structure (Appendix 1), price and other market policies are expressed in the form of producer subsidy equivalents (PSEs) and consumer subsidy equivalents (CSEs). These measures reflect country and regional policies that prevailed before the start of the recently concluded negotiations on the General Agreement on Tariffs and Trade (GATT). In developing countries, these measures mainly taxed agricultural producers and directly or indirectly subsidized food consumers. Subsidy levels vary widely between countries and commodities; developing countries' support for agricultural producers tends to be less than that of

developed countries. It is beyond the scope of this study, however, to examine in detail the policy background of the countries, regions, and commodities for which PSE and CSE measures are calculated.

GATT participants agreed to substantial changes in price and other policies in the course of the GATT meetings, but detailed information on these proposed policy changes was not readily available for inclusion in a form applicable to the model. The baseline analysis does include, however, policy changes for some countries and commodities whose magnitude and direction of impact were clear and that are expected to have great influence on future food markets. The partial opening up of the Japanese market to world trade, for example, is incorporated in the baseline projection. Likewise, the baseline scenario reflects the elimination of subsidies in Eastern Europe and the former Soviet Union. In addition, the likely magnitude of the effect of GATT reforms is examined in an alternative simulation that assesses full trade liberalization.

3. Results of Baseline Projections

Aggregate Results

Projected World Prices

Projected world price trends of major food commodities to the year 2020 are cause for some optimism for future aggregate food supplies (an optimism that will be significantly dampened by the projected continued serious food security problems for much of the developing world, described later). Real world prices for most food commodities are expected to decline (Table 2). Cereal prices will decline more rapidly than meat prices. Real prices for all livestock products are also projected to fall, some quite significantly, such as those for eggs.³

These trends indicate that, under the baseline assumptions, if governments and international donors sustain their commitment to public investment in agriculture, there will be no overwhelming pressure on aggregate world food supplies from rising populations and incomes. However, these aggregate price trends mask severe food security problems at the regional and country level. The regional trends described later are cause for considerable concern about getting the food to where it is needed most.

Growth in World Trade

World trade is expected to expand significantly in the next 30 years as developing countries continue to display strong economic growth and boost their demand for imports of agricultural products (Table 3). World trade in meat will more than double, with the greatest increase occurring in poultry. Beef trade will increase by about 187 per-

cent, the bulk of which will be channeled to the developed and rapidly developing East Asian countries as they partially shift to importing meat rather than importing animal feeds and producing meat domestically.

Trade in cereals and other crops will not increase as much in relative terms as in livestock products, but their increase will still be substantial. Again, the rapidly industrializing Asian countries will play a prominent role as grain importers as their diets become more diverse with higher incomes. Wheat trade will increase by about 61 percent between 1990 and 2020 and will continue to account for the bulk of grain trade. Rice trade, which will remain a small portion of total grain trade, will more than double. Japan is projected to increase its *japonica* rice imports significantly as it partly opens up its market in compliance with new GATT policy. Because the growth of rice production is projected to slow down, some countries in Asia, especially those in South Asia where growth in rice demand will remain strong, will need to import rice to meet their domestic demand gap. In Sub-Saharan Africa rice imports will more than double over the projection period. Trade in maize, the major feed crop, will only increase by 37 percent, primarily as a result of the partial shift to importing meat rather than feeds in the fast-growing developing countries.

Projected Production and Consumption

Cereal production will grow at an average rate of 1.5 percent per year between 1990 and 2020 (Table 4). Most of this growth will come from yield increases, although yield growth rates will be slower than those

³Cereals include wheat, maize, other coarse grains (such as barley, oats, and millet), and rice. Livestock products generally include eggs.

Table 2—Projected real world prices of major commodities, 1990 and 2020

Commodity	1990	2020	Change
	(1990 US\$ per metric ton)		(percent)
Wheat	156	132	-15
Rice	231	181	-22
Maize	109	84	-23
Other coarse grains	89	67	-25
Soybean	247	219	-11
Roots and tubers	148	122	-18
Beef	2,062	1,947	-6
Pigmeat	1,664	1,500	-10
Sheepmeat	1,907	1,825	-4
Poultry	739	662	-10
Eggs	897	668	-26
Total cereals	144	116	-19
Total meats	1,587	1,441	-9

Source: IMPACT simulation results.

Table 3—World trade in major agricultural commodities, 1990 and 2020

Commodity	1990	2020	Change
	(thousand metric tons)		(percent)
Beef	3,020	8,679	187
Pigmeat	1,467	2,403	64
Sheepmeat	986	1,820	85
Poultry	1,602	5,242	227
Wheat	36,410	138,944	61
Rice	10,097	24,152	139
Maize	55,732	76,383	37
Other coarse grains	24,653	39,991	62
Soybeans	25,076	55,433	121
Roots and tubers	26,960	34,901	29

Source: IMPACT simulation results.

achieved in the past (see Appendix 3, Table 23). Yield growth rates will be faster in developing countries, especially for wheat and rice. Most developing countries will approach the average world yield levels for these commodities, and some of them will even exceed these levels. Expansion of area will not be a significant source of future growth

in cereal production as a whole. Area cultivated to these crops will actually decline in many developed countries, while developing countries will exhibit only marginal increases. Only in Latin America and Sub-Saharan Africa will significant area expansion take place (close to 2 percent per year in some sub-regions for some crops).

Production growth rates of livestock products are also projected to be lower than in 1982–90 (see Appendix 3, Table 24). Growth of pigmeat production will fall to 2 percent per year (compared with past growth of more than 3 percent). Growth of poultry production will decline by about 50 percent while that of eggs will fall by about a third, reflecting both the long-term slowdown in productivity-enhancing research advances and the declining prices of these commodities. The diminishing prices are partly due to a slowdown in demand growth, particularly in the former centrally planned economies.

Until 1991 urban consumption of meat and milk was heavily subsidized in the former Soviet Union. Subsidies, though generally of smaller magnitude, also existed in most countries of Eastern Europe in the late 1980s. Since subsidies have been eliminated, consumption of livestock products has declined. In Russia, for example, per capita meat consumption fell to 52 kilograms in 1992 from about 67 kilograms in 1990 (Foster 1993, 68). Significant increases in demand are not expected in these countries because of poor economic growth. China will also exhibit lower rates of increase in meat demand compared with the phenomenal growth rates of the 1980s while it continues to move toward greater efficiency in livestock production.⁴

Growth in demand is also projected to be lower than in the past (see Table 5 and Appendix 3, Table 25). Developing countries' consumption of food crops and livestock products will grow much faster than that of developed countries because of faster population and income growth and higher income elasticities of demand in these countries. For most cereals, demand in developing countries will grow by about 2 percent per year, while demand for meat will grow by about 3.2 percent per year. This

⁴China's historic high growth rates for the 1980s may have been due partly to erroneously low base data.

**Table 4—Projected average annual growth rates in production of major commodities, 1990–2020:
Baseline scenario**

Commodity	World			Developed Countries			Developing Countries		
	Area ^a	Yield	Production	Area ^a	Yield	Production	Area ^a	Yield	Production
	(percent)								
Beef	0.72	0.70	1.43	0.40	0.49	0.90	1.09	1.16	2.26
Pigmeat	1.44	0.60	2.04	0.29	0.32	0.61	2.36	0.90	3.28
Sheepmeat ^b	1.02	1.27	2.30	0.33	1.01	1.34	1.41	1.47	2.90
Poultry	1.42	0.56	1.99	0.82	0.41	1.23	2.11	0.90	3.03
Total meat	1.20	0.66	1.87	0.33	0.56	0.89	1.86	1.08	2.95
Eggs	...	...	2.20	...	...	0.86	...	...	3.23
Wheat	0.19	1.35	1.55	0.01	0.99	1.00	0.39	1.77	2.17
Rice	0.19	1.43	1.62	0.10	0.76	0.86	0.19	1.46	1.66
Maize	0.40	1.08	1.49	0.07	0.92	0.99	0.56	1.52	2.09
Other coarse grains	0.28	1.02	1.31	0.00	0.94	0.94	0.57	1.48	2.05
Total cereals	0.26	1.24	1.50	0.02	0.96	0.97	0.40	1.54	1.94
Roots and tubers	0.47	0.90	1.38	0.02	0.74	0.76	0.61	1.04	1.65
Soybeans	0.45	1.47	1.92	0.38	1.40	1.78	0.50	1.56	2.08

Source: IMPACT simulation results.

Note: Leaders (. .) indicate not applicable.

^aFor livestock products, area means number of animals slaughtered.

^bIncludes goat meat.

**Table 5—Projected average annual growth rates in total demand for major commodities,
1990–2020: Baseline scenario**

Commodity	Developed Countries	Developing Countries	Latin America	Sub-Saharan Africa	West Asia and North Africa	Asia
		(percent)				
Beef	0.37	2.81	1.86	3.29	2.83	4.11
Pigmeat	0.44	3.40	2.36	3.42	2.74	3.51
Sheepmeat	0.63	3.10	1.94	3.12	2.63	3.62
Poultry	0.93	3.28	2.42	3.41	3.03	3.90
Total meat	0.55	3.20	2.12	3.29	2.85	3.65
Eggs	0.77	3.27	2.58	3.57	3.04	3.48
Wheat	0.58	2.19	1.73	3.07	2.30	2.16
Rice	0.51	1.67	1.97	3.22	2.31	1.60
Maize	0.80	2.18	1.79	3.02	1.86	2.23
Other coarse grains	0.87	2.03	1.24	3.08	1.98	1.58
Total cereals	0.75	2.00	1.71	3.07	2.18	1.88
Roots and tubers	0.64	1.77	1.52	2.96	1.91	1.02
Soybeans	1.10	2.76	2.28	3.19	2.65	3.32

Source: IMPACT simulation results.

Note: Regional groups are defined in Appendix 1, Table 20.

relatively high consumption growth rate for livestock products will create pressure to increase output of crops to meet the strong demand for animal feeds.

Average per capita demand levels of foodgrains and livestock products are expected to increase, but at a lower rate than in the past. In developing countries, the average annual expansion rate of per capita consumption of cereals (primarily rice, wheat, maize, and other coarse grains) under the baseline scenario would only be about 0.4 percent, from 240 kilograms per capita per year in 1990 to 270 kilograms per capita per year in 2020 (Table 6). This growth rate is slightly smaller than that from 1980 to 1990, which was 0.5 percent per year.⁵ Increases in per capita demand for rice are projected to be very small (83 kilograms per capita in 1990 to 85 kilograms per capita in 2020). For wheat, however, per capita demand will rise from 73 kilograms to 86 kilograms, reflecting an annual growth rate of about 0.6 percent. Per capita demand for maize and other coarse grains will grow at rates of 0.6 percent and 0.4 percent, respectively.

These results are expected because of the diversification of diets away from rice in response to rapid income growth and urbanization, especially in the Asian countries where rice is the major staple. Growth rates in per capita demand for wheat are relatively high for this region. The increase in per capita demand for maize mainly reflects the large growth rates in the derived demand for animal feeds. Per capita demand for other coarse grains, especially in the developed countries, will increase for the same reason. In Sub-Saharan Africa and some parts of South Asia, however, per capita demand for other coarse grains for direct human consumption will rise significantly.

According to the baseline scenario, per capita demand for cereals in the developed countries will grow by 0.3 percent per year, which is almost the same rate as in the past. Again, a significant part of this trend is due to the demand slowdown in Eastern Europe and the former Soviet Union. Per capita demand for cereals for food in these regions is not expected to rise to its level of the 1960s, which was

about 210 kilograms. Neither will demand for cereals for feed significantly increase, because of similar declines in per capita meat intake. Total demand for cereals in all uses in both regions combined will fall from 726 kilograms per capita in 1990 to 697 kilograms per capita in 2020.

Baseline projections show slower annual growth rates in per capita demand for livestock products in the developed world than in the past. This trend is due not only to lower demand in Eastern Europe and the former Soviet Union, as in the case of cereals, but also to increasing health concerns related to consumption of meat. Declines in the rates of growth in per capita demand for meat in the developing world (compared with historic rates) will be smaller than in the developed countries primarily because of the rapid dietary transitions that will continue to take place in many countries. The largest increases in meat demand will come from pigmeat and poultry, and China will account for much of this growth. Growth in per capita demand for pigmeat in China, while down from the previous huge growth rate from a very low base, remains strong, at about 2.6 percent (from 19.2 kilograms in 1990 to 41.1 kilograms in 2020), while that for beef is projected at 3.9 percent.⁶ Countries in Southeast Asia (such as Indonesia, Malaysia, and Thailand) are also projected to exhibit strong per capita demand growth for most meat products. East Asian countries will remain the big consumers of beef.

Sub-Saharan Africa shows the lowest per capita consumption levels for most food categories covered in the study, and only small increases are projected in per capita consumption in the region compared with other developing regions. Roots and tubers remain a major portion of the total food intake in the region. Latin America's per capita consumption level is projected to show a rising trend, after several years of zero growth.

Food Security: Malnutrition in Preschool Children

Despite the seeming abundance of food on a global level to meet effective demand, there will be virtu-

⁵Past growth rates in per capita demand for commodities are estimated from the FAO Agrostat database (1992 version).

⁶Growth rates are computed from country results, which are available from the authors.

Table 6—Projected annual per capita demand for livestock products and crops, 1990 and 2020: Baseline scenario

Commodity	World		Developed Countries		Eastern Europe and Former Soviet Union		Developing Countries		Latin America ^a		Sub-Saharan Africa		West Asia and North Africa		Asia	
	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020
	(kilograms)															
Beef	9.52	9.76	25.78	25.59	21.97	21.12	4.41	6.29	21.01	25.57	4.26	5.24	7.38	10.65	1.48	3.21
Pigmeat	12.77	15.67	30.10	30.51	27.58	27.11	7.33	12.41	7.17	10.10	0.98	1.26	0.03	0.04	9.28	16.89
Sheepmeat	1.68	2.22	2.85	3.06	2.68	2.76	1.31	2.04	0.97	1.20	1.89	2.22	5.80	7.90	0.76	1.43
Poultry	7.12	8.61	18.73	21.97	10.14	10.93	3.47	5.68	10.87	15.59	1.94	2.48	6.88	10.50	2.18	4.43
Total meat	31.09	36.26	77.46	81.12	62.37	61.91	16.52	26.41	40.02	52.46	9.07	11.19	20.09	29.10	13.71	25.96
Eggs	6.76	8.69	14.58	16.29	13.50	14.66	4.31	7.01	8.51	12.77	1.39	1.86	5.41	8.30	4.03	7.28
Wheat	101.32	107.40	192.56	203.47	304.19	293.29	72.65	86.30	58.85	68.91	14.17	16.37	233.71	288.75	67.08	82.40
Rice	66.66	72.33	13.79	14.28	5.11	5.02	83.28	85.08	26.40	33.17	14.61	17.64	19.01	23.54	111.53	116.21
Maize	90.98	94.92	208.34	234.78	116.10	88.96	54.10	64.21	132.50	157.79	43.94	50.11	45.15	49.00	44.52	55.76
Other coarse grains	68.36	67.57	189.42	218.49	300.84	309.79	30.31	34.42	41.37	41.85	58.99	68.36	85.07	95.65	17.38	17.96
Total cereals	327.32	342.23	604.12	671.02	726.24	697.06	240.34	270.01	259.11	301.72	131.70	152.48	382.94	456.93	240.52	272.34
Roots and tubers	111.26	112.24	177.63	191.13	285.41	288.12	90.40	94.91	109.39	120.40	207.85	232.93	39.52	43.47	72.34	63.42
Soybeans	20.36	24.11	48.17	59.46	6.69	6.84	11.61	16.34	59.85	82.37	0.53	0.63	1.62	2.22	7.07	12.18

Source: IMPACT simulation results.

^aIncludes the Caribbean countries.

ally no improvement in food security in many developing countries, particularly in South Asia and Sub-Saharan Africa. Per capita food availability in the developing countries as a whole will increase from 2,500 kilocalories per day in 1990 to 2,821 kilocalories per day in 2020, remaining about 22 percent lower than that in the developed countries (Table 7). The modest increase in per capita calorie consumption plus the projected slow increases in expenditures on health, education, and nutrition will result in a reduction in the projected proportion of malnourished children between ages 0 and 5 years, from the 1990 level of 34 percent to about 25 percent in 2020 (Table 8). But despite the relative improvement in this nutrition indicator, the reduction in the absolute number of malnourished children will only be about 30 million by 2020, primarily because of high population growth in this

age cohort, particularly in Sub-Saharan Africa and South Asia (Table 9).

In Sub-Saharan Africa, the baseline projection shows a rise in the absolute number of malnourished children by 2020. Projected slow improvements in per capita food and calorie availability in the region, even given relatively rapid production growth assumptions, will not be adequate to reduce malnutrition. The situation is similar in Pakistan and other South Asian countries, where the number of malnourished children will also rise slightly over time. Although India is expected to achieve a significant reduction in the number of malnourished children, the proportion of malnourished children will remain nearly double that of developing countries as a whole. In Bangladesh, more than half of preschool children will still be malnourished.

Table 7—Per capita food availability, 1990 and 2020: Various scenarios

Region/Country	1990	2020				
		Baseline	Low Population Growth ^a	Low Investment/Slow Growth ^b	High Investment/Rapid Growth ^c	Trade Liberalization ^d
		(kilocalories per day)				
World	2,773	2,895	2,987	2,758	3,032	2,897
Developed countries	3,353	3,532	3,613	3,492	3,599	3,512
Developing countries	2,500	2,821	2,916	2,662	2,978	2,836
Asia	2,500	3,034	3,136	2,851	3,225	3,083
China	2,667	3,408	3,457	3,271	3,616	3,420
South Asia	2,297	2,640	2,778	2,425	2,831	2,711
Bangladesh	1,978	2,170	2,363	1,881	2,350	2,557
India	2,332	2,692	2,814	2,490	2,886	2,736
Pakistan	2,370	2,584	2,758	2,382	2,753	2,573
Other South Asian countries	2,239	2,565	2,686	2,328	2,787	2,532
Southeast Asia	2,555	2,840	2,914	2,712	2,953	2,853
Latin America and the Caribbean	2,722	3,026	3,135	2,878	3,185	2,963
Sub-Saharan Africa	2,053	2,135	2,219	2,021	2,227	2,093
West Asia and North Africa	2,988	3,114	3,267	2,943	3,234	3,081

Source: IMPACT simulation results.

^aThe low-population-growth scenario reflects the low-variant population growth projections of the United Nations.

^bThe low-investment/slow-growth scenario simulates the combined effect of a 25 percent reduction in nonagricultural income growth rates and reduced investment in agricultural public research and social services.

^cThe high-investment/rapid-growth scenario simulates a 25 percent increase in nonagricultural income growth and higher investment in agricultural research and social services.

^dThe trade liberalization scenario simulates full removal of tariffs and subsidies.

Table 8—Percentage of malnourished children in developing countries, 1990 and 2020: Various scenarios

Region/Country	1990	2020				
		Baseline	Low Population Growth	Low Investment/Slow Growth	High Investment/Rapid Growth	Trade Liberalization
Developing countries	34.30	25.40	23.78	33.16	19.04	25.12
Asia						
China	21.80	13.78	13.36	20.05	7.18	13.65
South Asia	58.50	41.37	37.12	52.49	31.77	38.97
Bangladesh	65.80	52.85	44.96	71.37	40.70	35.98
India	63.00	45.49	41.53	56.31	35.71	43.91
Pakistan	41.60	32.40	28.54	40.26	25.74	32.66
Other South Asian countries	37.00	26.59	24.19	36.94	17.28	27.26
Southeast Asia	23.97	16.58	15.20	23.79	10.61	16.32
Latin America and the Caribbean	20.40	14.05	13.04	22.90	5.40	14.69
Sub-Saharan Africa	28.39	25.29	23.69	31.20	19.98	26.19
West Asia and North Africa	13.40	9.70	8.79	17.02	2.88	9.92

Source: IMPACT simulation results.

Note: Data cover children 0 to 5 years old. See Table 7 for description of scenarios.

Table 9—Number of malnourished children in developing countries, 1990 and 2020: Various scenarios

Region/Country	1990	2020				
		Baseline	Low Population Growth	Low Investment/Slow Growth	High Investment/Rapid Growth	Trade Liberalization
Developing countries	184.33	154.73	131.01	205.14	108.88	152.23
Asia						
China	26.41	14.30	12.68	20.81	7.45	14.16
South Asia	95.81	72.94	59.58	92.54	56.01	68.70
Bangladesh	11.96	11.46	9.08	15.47	8.82	7.80
India	70.86	47.73	39.87	59.08	37.47	46.07
Pakistan	9.13	9.90	7.53	12.30	7.87	9.98
Other South Asian countries	2.01	2.13	1.82	2.96	1.38	2.18
Southeast Asia	15.04	10.40	8.78	14.77	6.81	10.28
Latin America and the Caribbean	11.71	8.12	7.00	13.23	3.12	8.49
Sub-Saharan Africa	28.61	42.67	37.72	52.75	33.61	44.16
West Asia and North Africa	6.76	6.30	5.25	11.05	1.87	6.44

Source: IMPACT simulation results.

Note: Data cover children 0 to 5 years old.

Country and Regional Results

Sub-Saharan Africa

The projected rapid growth in food imports, particularly cereals, in Sub-Saharan Africa will put a significant burden on these economies.⁷ Imports of cereals in the region are projected to increase at the rate of 3.5 percent per year, from 9 million tons in 1990 to about 27 million tons in 2020 (Table 10).⁸ The bulk of these imports will be wheat and rice. The largest rise in cereal imports will occur in east Sub-Saharan Africa, where they will grow at the rate of about 6.3 percent per year between 1990 and 2020.

These large increases in cereal imports are projected to occur despite relatively strong projected growth in cereal production (close to 3 percent per year during the projection period). Wheat and rice production will grow at an average rate of 3.3 percent per year, while production growth in maize and other grains will be under 3.0 percent per year. Expansion of cultivated area will continue to be an important source of growth in the region, particularly in Nigeria and the central-west Sub-Saharan African countries (see Appendix 1, Table 20 for the country composition of the subregions of Sub-Saharan Africa). Area expansion for cereals is projected to be 1.3 percent per year, while growth rates in yield for the various crops will average about 1.7 percent per year.

The predicted increases in imports of wheat and rice are driven by increased demand for cereals, projected to grow at more than 3.0 percent per year, resulting from expected modest increases in income (averaging about 3.3 percent for the region as a whole) coupled with rapid population growth in almost all of the subregions.

Production of roots and tubers, which remain the basic staple in many parts of Sub-Saharan Africa, will grow at about 3.0 percent per year.⁹ Demand for roots and tubers for food will grow rapidly, at about 2.9 percent per year, most of which will be supplied domestically. Demand for meat products is

also expected to rise in the relatively more developed countries of the region, but per capita intake will still be much lower than in the other developing countries (Table 11).

Bridging the food import gap in Sub-Saharan Africa would require very rapid production increases. Moreover, it will be difficult to finance cereal imports from domestic Sub-Saharan African sources. The international community will need to devise appropriate combinations of financing and food aid to bridge these gaps in the foreseeable future.

Directly related to the increase in imports, and of even greater concern, is the projected continued deterioration in food security for preschool children. Sub-Saharan Africa has the lowest per capita consumption and food availability (Table 7), and the small increases projected for the next decade are far from adequate for nutritional improvement. As a result, there will be a large increase in the number of malnourished children in all subregions of Sub-Saharan Africa (Table 9).

South Asia

Results for South Asia focus mainly on cereals, because of their importance in the subregion's diet. Meat consumption per capita is still small compared with neighboring Asian countries. The baseline projection results indicate that wheat imports will grow at 6.4 percent per year between 1990 to 2020 (Table 12). This increase is due to continued strong demand growth (in part because of high population growth in Pakistan) together with a slowdown in production, especially in Pakistan, where the bulk of wheat import demand will come. Rice, however, will be almost in balance, in contrast to the large export of the commodity in the base year. Again, this result is due to reduced rates of production growth, especially in Bangladesh and Pakistan. Imports of maize and other grains will also expand, and most will be used as feeds to support the expansion of the livestock industry.

⁷Detailed country results are not presented in this paper.

⁸All tons in this paper are metric tons.

⁹Because of limited data for variables used in the model, the category roots and tubers does not include plantains, which are also an important staple in Sub-Saharan Africa.

Table 10—Production of, demand for, and net trade of crops by region, 1990 and 2020: Baseline scenario

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
World	530,713	530,715	0	840,713	840,713	0
Developed countries	303,786	241,186	62,602	408,970	286,828	122,142
Developing countries	226,927	289,529	-62,602	431,743	553,885	-122,142
Asia	157,882	184,913	-27,031	286,702	351,238	-64,536
Latin America and the Caribbean	22,013	25,601	-3,588	39,286	42,855	-3,569
Sub-Saharan Africa	1,718	6,869	-5,151	4,510	16,997	-12,487
West Asia and North Africa	45,314	72,146	-26,832	101,245	142,796	-41,551
Rice						
World	349,466	349,179	-1	566,150	566,151	0
Developed countries	17,440	17,276	164	22,534	20,135	2,399
Developing countries	332,026	331,903	-165	543,616	546,016	-2,399
Asia	313,602	307,425	5,889	508,452	495,332	13,119
Latin America and the Caribbean	10,594	11,483	-889	17,041	20,625	-3,584
Sub-Saharan Africa	4,281	7,082	-2,801	11,495	18,319	-6,823
West Asia and North Africa	3,549	5,869	-2,320	6,628	11,639	-5,012
Maize						
World	476,561	476,560	1	743,040	743,041	0
Developed countries	277,022	260,942	16,080	372,347	330,964	41,383
Developing countries	199,539	215,618	-16,079	370,693	412,077	-41,383
Asia	117,803	122,725	-4,922	211,232	237,660	-26,429
Latin America and the Caribbean	52,521	57,637	-5,116	93,261	98,124	-4,863
Sub-Saharan Africa	21,068	21,308	-240	50,907	52,044	-1,135
West Asia and North Africa	8,145	13,939	-5,794	15,291	24,232	-8,941
Other coarse grains						
World	358,040	358,038	0	528,922	528,922	0
Developed countries	249,627	237,254	12,373	330,320	308,008	22,312
Developing countries	108,413	120,784	-12,373	198,602	220,914	-22,312
Asia	47,156	47,911	-755	75,887	76,568	-681
Latin America and the Caribbean	14,279	17,994	-3,715	23,044	26,024	-2,979
Sub-Saharan Africa	27,513	28,603	-1,092	65,344	70,991	-5,649
West Asia and North Africa	19,465	26,260	-6,795	34,328	47,301	-12,973
Total cereals						
World	1,714,780	1,714,492	0	2,678,825	2,678,827	0
Developed countries	847,875	756,658	91,219	1,134,171	945,935	188,236
Developing countries	866,905	957,834	-91,219	1,544,654	1,732,892	-188,236
Asia	636,443	662,974	-26,531	1,082,273	1,160,798	-78,525
Latin America and the Caribbean	99,407	112,715	-13,308	172,632	187,628	-14,996
Sub-Saharan Africa	54,580	63,862	-9,282	132,256	158,351	-26,095
West Asia and North Africa	76,473	118,214	-41,741	157,492	225,968	-68,476
Soybeans						
World	106,624	106,624	-1	188,710	188,711	0
Developed countries	57,925	60,334	-2,409	98,480	83,814	14,666
Developing countries	48,699	46,290	2,408	90,230	104,897	-14,666
Asia	15,352	19,497	-4,145	29,125	51,922	-22,796
Latin America and the Caribbean	32,714	26,036	6,678	59,800	51,223	8,577
Sub-Saharan Africa	259	256	2	583	656	-75
West Asia and North Africa	374	501	-127	724	1,097	-373
Roots and tubers						
World	582,767	582,766	1	878,573	878,573	0
Developed countries	196,659	222,484	-25,825	246,837	269,430	-22,593
Developing countries	386,108	360,282	25,826	631,736	609,143	22,593
Asia	225,076	199,391	25,685	295,533	270,306	25,227
Latin America and the Caribbean	47,825	47,584	241	74,444	74,873	-430
Sub-Saharan Africa	100,810	100,785	25	240,725	241,896	-1,171
West Asia and North Africa	12,024	12,199	-175	20,451	21,495	-1,044

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

Table 11—Production of, demand for, and net trade of livestock products by region, 1990 and 2020: Baseline scenario

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
(thousand metric tons)						
Beef						
World	49,879	49,879	0	76,415	76,415	0
Developed countries	32,580	32,291	289	42,564	36,069	6,495
Developing countries	17,299	17,588	-289	33,851	40,346	-6,495
Asia	3,443	4,087	-644	8,805	13,665	-4,860
Latin America and the Caribbean	10,099	9,140	959	17,800	15,903	1,897
Sub-Saharan Africa	2,099	2,064	35	4,088	5,443	-1,355
West Asia and North Africa	1,651	2,278	-627	3,147	5,268	-2,121
Pigmeat						
World	66,902	66,900	0	122,622	122,622	0
Developed countries	37,343	37,703	-360	44,796	43,003	1,793
Developing countries	29,559	29,197	360	77,826	79,619	-1,793
Asia	26,031	25,585	445	70,922	71,991	-1,068
Latin America and the Caribbean	3,073	3,119	-46	5,876	6,280	-404
Sub-Saharan Africa	451	476	-26	1,021	1,305	-284
West Asia and North Africa	4	8	-4	7	18	-11
Sheepmeat						
World	8,810	8,810	0	17,404	17,403	0
Developed countries	3,889	3,570	319	5,802	4,307	1,495
Developing countries	4,921	5,240	-319	11,602	13,096	-1,495
Asia	2,159	2,104	55	5,519	6,111	-593
Latin America and the Caribbean	309	420	-111	619	748	-129
Sub-Saharan Africa	916	916	0	1,837	2,301	-464
West Asia and North Africa	1,535	1,792	-257	3,622	3,909	-287
Poultry meat						
World	37,278	37,278	0	67,402	67,403	0
Developed countries	23,795	23,459	336	34,342	30,973	3,370
Developing countries	13,483	13,819	-336	33,060	36,430	-3,370
Asia	6,001	6,006	-5	17,462	18,900	-1,439
Latin America and the Caribbean	4,791	4,729	62	9,543	9,692	-149
Sub-Saharan Africa	852	942	-90	1,996	2,574	-579
West Asia and North Africa	1,838	2,124	-286	4,056	5,195	-1,139
Total meat						
World	162,869	162,867	0	283,843	283,843	0
Developed countries	97,607	97,023	584	127,504	114,352	13,153
Developing countries	65,262	65,844	-584	156,339	169,491	-13,153
Asia	37,634	37,782	-148	102,708	110,667	-7,959
Latin America and the Caribbean	18,272	17,408	864	33,838	32,623	1,215
Sub-Saharan Africa	4,318	4,398	-80	8,942	11,623	-2,681
West Asia and North Africa	5,028	6,202	-1,174	10,832	14,390	-3,558
Eggs						
World	35,420	35,420	0	67,988	67,987	0
Developed countries	18,351	18,261	90	23,714	22,967	747
Developing countries	17,069	17,159	-90	44,274	45,020	-747
Asia	11,074	11,109	-35	30,952	31,032	-80
Latin America and the Caribbean	3,690	3,702	-12	7,683	7,940	-257
Sub-Saharan Africa	682	675	7	1,816	1,931	-115
West Asia and North Africa	1,621	1,670	-49	3,818	4,105	-287

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 12—Production of, demand for, and net trade of crops in South Asia, 1990 and 2020:
Baseline scenario**

Commodity/Country	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
South Asia	65,780	69,092	-3,312	126,817	148,121	-21,303
Bangladesh	1,226	2,994	-1,768	1,580	6,031	-4,450
India	49,296	47,891	1,405	96,384	95,617	766
Pakistan	14,413	16,521	-2,108	27,463	42,913	-15,451
Other South Asian countries	845	1,686	-841	1,391	3,559	-2,169
Rice						
South Asia	101,430	99,315	2,115	197,617	197,588	29
Bangladesh	18,689	18,115	574	38,071	38,204	-132
India	75,388	74,758	630	145,777	144,792	985
Pakistan	3,448	2,101	1,347	6,207	5,309	898
Other South Asian countries	3,905	4,341	-436	7,561	9,283	-1,721
Maize						
South Asia	11,455	11,399	56	20,572	21,597	-1,025
Bangladesh	3	3	0	5	5	0
India	8,975	8,966	9	16,509	16,394	115
Pakistan	1,185	1,190	-5	1,895	2,748	-852
Other South Asian countries	1,292	1,240	52	2,163	2,450	-287
Other coarse grains						
South Asia	28,339	28,370	-31	49,012	49,422	-410
Bangladesh	94	98	-4	114	202	-87
India	27,471	27,468	3	47,895	47,513	382
Pakistan	571	573	-2	726	1,233	-507
Other South Asian countries	203	231	-28	277	475	-198
Total cereals						
South Asia	207,004	208,176	-1,172	394,018	416,728	-22,709
Bangladesh	20,012	21,210	-1,198	39,770	44,442	-4,669
India	161,130	159,083	2,047	306,565	304,316	2,248
Pakistan	19,617	20,385	-768	36,291	52,203	-15,912
Other South Asian countries	6,245	7,498	-1,253	11,392	15,767	-4,375
Soybeans						
South Asia	2,129	2,560	-431	3,542	7,576	-4,034
Bangladesh	0	0	0	0	0	0
India	2,108	2,107	1	3,510	5,963	-2,453
Pakistan	1	433	-432	2	1,547	-1,545
Other South Asian countries	20	20	0	29	66	-36
Roots and tubers						
South Asia	25,204	25,199	5	44,602	46,764	-2,162
Bangladesh	1,436	1,436	0	2,276	3,216	-941
India	21,570	21,569	1	39,090	38,974	117
Pakistan	747	745	2	1,276	1,776	-499
Other South Asian countries	1,451	1,449	2	1,959	2,799	-839

Source: IMPACT simulation results.

As shown in Table 7, South Asia will achieve gradual improvements in food security, mainly from the projected increase in daily per capita food availability from 2,297 kilocalories in 1990 to 2,640 kilocalories in 2020. This trend will translate into a reduction in the percentage of malnourished children from 58 percent in the base year to 41 percent in 2020. Despite this relative improvement, the reduc-

tion in the number of malnourished children will be moderate, declining from 96 million in 1990 to 73 million in 2020, with nearly all of the improvement occurring in India.

In India, production performance is relatively strong, and with moderately fast income growth of 5.5 percent and slower growth in population of 1.7 percent, per capita food consumption and food

security will improve. Production of rice, wheat, and maize is projected to grow faster than 2.0 percent per year, and production of coarse grains will grow by 1.9 percent. At the projected level of effective demand, India's agricultural trade position will be sound. Although meat imports will increase as demand grows quickly from a low base, they will remain small relative to the size of the Indian economy (Table 13). India will manage to be a

marginal exporter of cereals, the bulk of which will be wheat and high-quality *basmati* rice. Exports of maize and other grains will be small because production will cater primarily to local demand for feed for meat production. Demand for feed is shown to increase substantially over the projection period as continued economic growth generates a slow diversification of diets from cereals to meat and other processed products.

Table 13—Production of, demand for, and net trade of livestock products in South Asia, 1990 and 2020: Baseline scenario

Commodity/ Country	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Beef						
South Asia	1,332	1,385	-53	2,821	3,807	-986
Bangladesh	140	140	0	206	401	-195
India	851	786	65	1,812	1,924	-112
Pakistan	312	338	-26	764	1,109	-345
Other South Asian countries	29	121	-92	39	373	-334
Pigmeat						
South Asia	372	366	6	912	1,002	-90
Bangladesh	0	0	0	0	0	0
India	360	359	1	893	981	-88
Pakistan	0	0	0	0	0	0
Other South Asian countries	12	7	5	19	21	-1
Sheepmeat						
South Asia	1,044	1,110	-66	2,588	3,185	-597
Bangladesh	55	57	-2	127	174	-48
India	538	540	-2	1,203	1,398	-196
Pakistan	448	480	-32	1,254	1,507	-253
Other South Asian countries	3	33	-30	5	106	-101
Poultry meat						
South Asia	548	539	9	1,454	2,101	-647
Bangladesh	74	74	0	146	263	-117
India	282	283	-1	886	1,025	-200
Pakistan	171	162	9	381	679	-299
Other South Asian countries	21	20	1	41	72	-31
Total meat						
South Asia	3,296	3,400	-104	7,775	10,095	-2,320
Bangladesh	269	271	-2	479	838	-360
India	2,031	1,968	63	4,794	5,389	-596
Pakistan	931	980	-49	2,399	3,295	-897
Other South Asian countries	65	181	-116	104	572	-467
Eggs						
South Asia	1,475	1,475	0	4,161	4,240	-79
Bangladesh	75	75	0	206	266	-61
India	1,132	1,131	1	3,119	2,962	157
Pakistan	208	208	0	669	775	-106
Other South Asian countries	60	61	-1	167	236	-69

Source: IMPACT simulation results.

The expected growth in the Indian economy will bring about some progress in reducing food insecurity. Per capita food availability is projected to increase from 2,332 kilocalories per day in 1990 to 2,692 kilocalories per day in 2020. Thus, the number of malnourished children would drop from 71 million to 48 million.

More serious problems are expected to emerge in Pakistan and other South Asian countries. In Pakistan, wheat imports are projected to grow from 2.1 million tons in 1990 to 15.5 million tons in 2020. This rapidly increasing gap occurs despite relatively strong growth in wheat production (2.2 percent), as demand grows at about 3.2 percent per year, owing in large part to the very rapid population growth of 2.8 percent. Imports will also grow for maize and other coarse grains. Among the cereals, only rice will continue to be exported, but at reduced levels.

Pakistan's growing trade gap is accompanied by a worsening of its food security position. There is little projected improvement in food availability per capita through 2020, and the number of malnourished preschool children will increase by nearly 9 percent. Similar (though less severe) problems will arise in the aggregate grouping of other South Asian countries.

West Asia and North Africa

Cereal imports are also expected to grow steadily in West Asia and North Africa, from about 42 million metric tons in 1990 to over 68 million metric tons in 2020, with wheat accounting for more than half of cereal imports (Table 10). In general, growing cereal imports in West Asia and North Africa are not a cause for concern, because they are primarily the result of solid income growth, which will also generate the income to finance the imports. At the current level of aggregation of the model, however, it is impossible to isolate the non-oil-producing nations to examine whether their import needs are increasing rapidly.

Latin America

In Latin America, total cereal imports are projected to increase slightly from about 13.3 million tons in 1990 to about 15 million tons in 2020 as demand grows slightly faster than production (Table 10).

Maize and wheat demand for feed use will grow at more than 2 percent per year in response to the strong growth in the livestock industry, which is projected to generate significantly increased meat exports (Table 11). These shifts in the pattern of trade thus appear to be consistent with comparative advantage in the bulk of Latin American agriculture. For the region as a whole, there is a 31 percent reduction in the number of malnourished children. However, as with West Asia and North Africa, the degree of aggregation of the model does not permit a separation of the food security effects of the relatively fast-growing and relatively slow-growing countries in Latin America.

Southeast Asia

Southeast Asia is projected to be one of the most dynamic regions over the next three decades. The rice situation in Southeast Asia will be characterized by (1) moderate to strong increases in yields in Indonesia and the Philippines; (2) strong area growth in other Southeast Asian countries (mainly Burma); (3) very slow growth in demand in Malaysia and Thailand; and (4) modest demand growth elsewhere in the region. The last two effects are due to diversification of diets out of rice as a result of urbanization and continued strong growth in incomes. As a result, the regional export surplus in rice will more than double over 30 years, from 4.7 million tons to 11.5 million tons (Table 14).

Imports of other cereals will increase rapidly owing to strong income growth in the region, which will induce a shift from rice to wheat for direct consumption and cause an increase in demand for maize and other coarse grains for livestock feed. Wheat imports will more than double by 2020, to 9.8 million tons, and imports of maize and other coarse grains will amount to another 8 million tons. Indicative of the shift in demand and production patterns is the change of Thailand from a historical net exporter of maize to an importer of 2.1 million metric tons of maize by 2020 to fuel its rapidly growing pig and poultry sectors. With the shift in dietary composition, per capita cereal demand in Southeast Asia is projected to increase by only 16 percent, while per capita demand for meat will double. Even with the shift to a less cereal-dense

Table 14—Production of, demand for, and net trade of crops in China and Southeast Asia, 1990 and 2020: Baseline scenario

Commodity/ Country	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
China	91,256	106,206	-14,950	158,604	184,407	-25,803
Southeast Asia	126	4,695	-4,569	170	9,997	-9,827
Indonesia	0	1,791	-1,791	0	3,587	-3,587
Malaysia	0	701	-701	0	1,619	-1,619
Philippines	0	1,437	-1,437	0	3,261	-3,261
Thailand	0	295	-295	0	565	-565
Other Southeast Asian countries	126	471	-345	170	965	-795
Rice						
China	130,631	130,874	-243	170,547	168,054	2,493
Southeast Asia	72,268	67,594	4,674	127,647	116,125	11,522
Indonesia	29,163	29,262	-99	51,872	51,806	66
Malaysia	1,200	1,668	-468	1,945	2,283	-338
Philippines	6,050	6,388	-338	12,023	11,491	532
Thailand	12,667	8,476	4,191	17,081	9,783	7,298
Other Southeast Asian countries	23,188	21,800	1,388	44,727	40,763	3,964
Maize						
China	85,350	83,518	1,832	155,231	156,450	-1,219
Southeast Asia	16,441	16,691	-250	28,365	35,200	-6,835
Indonesia	6,445	6,449	-4	11,520	11,689	-169
Malaysia	35	1,340	-1,305	68	3,243	-3,175
Philippines	4,677	4,787	-110	8,203	9,271	-1,068
Thailand	4,263	3,057	1,206	6,759	8,864	-2,105
Other Southeast Asian countries	1,021	1,058	-37	1,814	2,134	-320
Other coarse grains						
China	17,383	17,218	165	24,896	22,609	2,287
Southeast Asia	645	781	-136	851	1,572	-721
Indonesia	3	30	-27	5	35	-30
Malaysia	0	72	-72	0	161	-161
Philippines	0	251	-251	0	360	-360
Thailand	250	244	6	307	602	-295
Other Southeast Asian countries	392	184	208	539	413	126
Total cereals						
China	324,620	337,816	-13,196	509,278	531,520	-22,242
Southeast Asia	89,480	89,761	-281	157,033	162,894	-5,861
Indonesia	35,611	37,532	-1,921	63,397	67,117	-3,720
Malaysia	1,235	3,781	-2,546	2,013	7,306	-5,293
Philippines	10,727	12,863	-2,136	20,226	24,383	-4,157
Thailand	17,180	12,072	5,108	24,147	19,814	4,333
Other Southeast Asian countries	24,727	23,513	1,214	47,250	44,275	2,975
Soybeans						
China	10,351	12,164	-1,813	20,672	31,603	-10,931
Southeast Asia	2,204	2,923	-719	3,898	9,670	-5,772
Indonesia	1,450	1,803	-353	2,840	5,431	-2,591
Malaysia	0	398	-398	0	1,527	-1,527
Philippines	6	30	-24	9	94	-85
Thailand	618	618	0	831	2,425	-1,594
Other Southeast Asian countries	130	74	56	218	193	25
Roots and tubers						
China	144,837	144,293	544	176,983	176,022	961
Southeast Asia	51,356	25,653	25,703	67,914	40,720	27,194
Indonesia	19,229	15,085	4,144	24,963	22,678	2,285
Malaysia	521	541	-20	726	945	-219
Philippines	2,748	2,716	32	4,365	4,320	45
Thailand	21,975	488	21,487	26,873	1,004	25,869
Other Southeast Asian countries	6,883	6,823	60	10,988	11,773	-785

Source: IMPACT simulation results.

diet, per capita calorie availability will improve by 11 percent and the number of malnourished children will drop by about 31 percent.

China

Patterns of growth in China are particularly important, because China accounts for a large share of global food production and consumption. Changes in the net trade position of China could therefore have significant effects on world agricultural prices. However, baseline projections do not show dramatic changes in net agricultural trade for China. Net total cereal imports in 2020 are 22 million tons (Table 14). Wheat imports increase from 15 million tons to 26 million tons, and maize shifts from an export to an import position. China is projected to increase the export of other coarse grains. It will also realize some rice exports, mostly of *japonica*, despite a rice production growth rate of less than 1 percent per year. The trends for wheat and rice trade reflect the continued increase in the share of wheat for food use and the decline in the share of rice. Shifts in preferences to higher-quality food, including wheat and livestock products, will continue as a result of rising per capita income and a faster rate of urbanization. Total meat demand is projected to grow at well in excess of 3 percent per year, and production is projected to keep pace, so there is little change in China's trade position for meat (Table 15).

Much of this growth in total meat demand is per capita growth, because of solid income growth (6 percent per year) and slow population growth (slightly less than 1 percent per year). Per capita meat demand will more than double by 2020, to 52 kilograms, and per capita cereal demand will increase by 20 percent. With rapid growth in per capita food consumption, China is projected to achieve a 46 percent reduction in the number of mal-

nourished children relative to the base year number, the largest of any country or region studied here.

Developed Countries

The main beneficiaries of increased import demand from the developing world will be the United States and, to a lesser extent, Australia, Canada, and Western Europe (Tables 16 and 17). The United States is projected to boost cereal exports from 89 million tons in 1990 to 122 million tons over the next three decades (Table 16). Despite relatively slow growth in production, slow growth in demand for cereals will permit expansion of exports. Australia and other developed countries (mainly Canada) will increase cereal exports from 9 million tons to 20 million tons, and the European Union and other Western European countries will boost exports from 24 million tons in 1990 to 30 million tons in 2020.

In a fundamental change in world cereal markets, Eastern Europe and the former Soviet Union will shift from being big importers to big exporters. From combined net imports of about 31 million tons in 1990 (which had already dropped to 20 million tons in 1993), these regions are projected to export about 15 million tons of cereals in 2020. Several factors will influence these trends. As mentioned earlier, the removal of food subsidies and other price distortions and sharp income declines in recent years have already resulted in falling cereal consumption (Table 6). Further increases in production will not come primarily from yield increases or area expansion but from improvements in harvesting, storage, and transport of grain that will significantly reduce losses and from more efficient use of grains for feeds. Feeding efficiency is expected to greatly improve in the livestock industry, and a projected gradual recovery in cereals production will cause production growth of cereals to outstrip demand growth.

Table 15—Production of, demand for, and net trade of livestock products in China and Southeast Asia, 1990 and 2020: Baseline scenario

Commodity/Country	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
(thousand metric tons)						
Beef						
China	1,109	989	120	3,752	4,056	-304
Southeast Asia	719	1,079	-360	1,752	3,786	-2,034
Indonesia	181	297	-116	579	1,214	-635
Malaysia	11	66	-55	21	271	-250
Philippines	81	97	-16	189	324	-135
Thailand	226	228	-2	551	898	-347
Other Southeast Asian countries	220	391	-171	411	1,078	-667
Pigmeat						
China	22,278	21,768	510	60,595	60,966	-371
Southeast Asia	2,453	2,422	31	7,560	7,420	140
Indonesia	286	283	3	1,059	963	96
Malaysia	226	193	33	610	653	-43
Philippines	687	690	-3	2,236	2,207	29
Thailand	335	334	1	1,132	1,104	28
Other Southeast Asian countries	919	922	-3	2,524	2,494	30
Sheepmeat						
China	829	825	4	2,446	2,426	20
Southeast Asia	177	146	31	343	438	-95
Indonesia	84	80	4	243	270	-27
Malaysia	0	8	-8	0	27	-27
Philippines	0	23	-23	0	58	-58
Thailand	1	1	0	1	3	-2
Other Southeast Asian countries	92	34	58	99	79	20
Poultry meat						
China	3,173	3,152	21	9,476	9,300	176
Southeast Asia	1,920	1,846	74	5,694	6,179	-485
Indonesia	451	450	1	1,758	1,714	44
Malaysia	340	336	4	813	1,157	-344
Philippines	233	241	-8	572	692	-120
Thailand	667	497	170	1,896	1,749	147
Other Southeast Asian countries	229	322	-93	655 866	-211	
Total meat						
China	27,389	26,734	655	76,269	76,748	-479
Southeast Asia	5,269	5,493	-224	15,349	17,823	-2,474
Indonesia	1,002	1,110	-108	3,639	4,161	-522
Malaysia	577	603	-26	1,444	2,108	-664
Philippines	1,001	1,051	-50	2,997	3,281	-284
Thailand	1,229	1,060	169	3,580	3,754	-174
Other Southeast Asian countries	1,460	1,669	-209	3,689	4,517	-828
Eggs						
China	7,578	7,540	38	20,113	20,050	63
Southeast Asia	1,459	1,426	33	5,075	4,938	137
Indonesia	486	486	0	1,927	1,783	144
Malaysia	193	172	21	624	682	-58
Philippines	322	323	-1	1,041	1,020	21
Thailand	249	240	9	947	891	56
Other Southeast Asian countries	209	205	4	535	561	-26

Source: IMPACT simulation results.

**Table 16—Production of, demand for, and net trade of crops in developed regions, 1990 and 2020:
Baseline scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
Former Soviet Union and Eastern Europe	107,245	118,147	-10,902	147,053	137,348	9,705
United States	59,433	29,303	30,130	85,672	38,369	47,303
Western Europe ^a	93,528	74,336	19,192	113,108	86,176	26,932
Other developed countries	43,580	19,400	24,180	63,136	24,936	38,200
Rice						
Former Soviet Union and Eastern Europe	1,391	1,986	-595	1,438	2,351	-913
United States	4,529	3,127	1,402	8,512	4,222	4,290
Western Europe ^a	1,605	2,122	-517	2,479	2,357	122
Other developed countries	9,915	10,041	-126	10,104	11,204	-1,100
Maize						
Former Soviet Union and Eastern Europe	29,228	45,092	-15,864	40,423	41,663	-1,240
United States	193,097	143,761	49,336	258,385	197,824	60,561
Western Europe ^a	37,663	39,769	-2,106	49,058	50,042	-984
Other developed countries	17,034	32,320	-15,286	24,482	41,434	-16,952
Other coarse grains						
Former Soviet Union and Eastern Europe	113,606	116,847	-3,241	152,741	145,077	7,664
United States	35,072	27,152	7,920	46,853	36,736	10,117
Western Europe ^a	75,069	67,703	7,366	94,211	89,910	4,301
Other developed countries	25,880	25,552	328	36,515	36,284	231
Total cereals						
Former Soviet Union and Eastern Europe	251,470	282,072	-30,602	341,655	326,439	15,216
United States	292,131	203,343	88,788	399,422	277,151	122,271
Western Europe ^a	207,865	183,930	23,935	258,856	228,465	30,371
Other developed countries	96,409	87,313	9,096	134,237	113,858	20,379
Soybeans						
Former Soviet Union and Eastern Europe	1,168	2,597	-1,429	1,473	3,201	-1,728
United States	52,965	35,716	17,249	91,561	49,959	41,602
Western Europe ^a	2,043	15,247	-13,204	2,837	19,656	-16,819
Other developed countries	1,749	6,774	-5,025	2,608	10,997	-8,389
Roots and tubers						
Former Soviet Union and Eastern Europe	107,857	110,852	-2,995	135,575	134,927	648
United States	18,544	18,487	57	23,132	23,958	-826
Western Europe ^a	58,756	80,028	-21,272	73,741	95,557	-21,816
Other developed countries	11,502	13,117	-1,615	14,389	14,989	-600

Source: IMPACT simulation results.

^aWestern Europe consists of the European Union and other western European countries.

Table 17—Production of, demand for, and net trade of livestock products in developed regions, 1990 and 2020: Baseline scenario

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Beef						
Former Soviet Union and Eastern Europe	8,353	8,535	-182	11,183	9,889	1,294
United States	10,543	11,057	-514	14,008	12,317	1,691
Western Europe ^a	9,188	9,021	167	11,213	9,779	1,434
Other developed countries	4,496	3,678	818	6,159	4,086	2,073
Pigmeat						
Former Soviet Union and Eastern Europe	10,604	10,712	-108	13,079	12,695	384
United States	7,027	7,400	-373	8,964	8,807	157
Western Europe ^a	16,531	16,245	286	18,891	17,811	1,080
Other developed countries	3,181	3,346	-165	3,863	3,689	174
Sheepmeat						
Former Soviet Union and Eastern Europe	998	1,040	-42	1,340	1,294	46
United States	162	176	-14	277	222	55
Western Europe ^a	1,219	1,473	-254	1,968	1,618	350
Other developed countries	1,510	881	629	2,218	1,173	1,045
Poultry meat						
Former Soviet Union and Eastern Europe	3,904	3,939	-35	5,092	5,117	-25
United States	10,085	9,593	492	14,890	13,160	1,730
Western Europe ^a	6,677	6,438	239	9,672	8,062	1,610
Other developed countries	3,129	3,489	-360	4,689	4,633	56
Total meat						
Former Soviet Union and Eastern Europe	23,859	24,226	-367	30,694	28,995	1,699
United States	27,817	28,226	-409	38,139	34,506	3,633
Western Europe ^a	33,615	33,177	438	41,744	37,270	4,474
Other developed countries	12,316	11,394	922	16,929	13,581	3,348
Eggs						
Former Soviet Union and Eastern Europe	5,275	5,245	30	7,030	6,866	164
United States	4,028	3,995	33	5,409	5,271	138
Western Europe ^a	5,743	5,666	77	6,791	6,560	231
Other developed countries	3,305	3,355	-50	4,483	4,270	213

Source: IMPACT simulation results.

^aWestern Europe consists of the European Union and other western European countries.

4. Alternative Global Scenarios

The baseline results described are the authors' best assessment of future developments in the world food situation. These results pose the central paradox in the world food situation: declining world food prices will coexist with sustained or increasing malnutrition in much of the world. The results, however, may be sensitive to rates of agricultural productivity growth stemming from assumptions about research investment levels or population and income growth. There are continuing debates in developed countries over possible large cuts in foreign aid that would slash public investment in agricultural research. What would be the effect on food prices and malnutrition if, instead of maintaining investments, national governments and international institutions were to continue to reduce their investments in agricultural research? Alternatively, given the seeming persistence of malnutrition in the face of declining food prices, can increased investment in agriculture, economic development, and social welfare have a significant effect on malnutrition? To explore these questions, this section examines how changes in fundamental assumptions influence projected world food trends. (Detailed results for the various scenarios are given in Appendix 3, Tables 26 through 33.)

Low-Population-Growth Scenario

The low-population-growth scenario assumes the low-population-growth variant projected by the United Nations (1993). Under this scenario, world population will grow 1.0 percent annually to reach about 7 billion in 2020, about 1 billion lower than the baseline result. This scenario will result in much lower price levels than those obtained in the baseline projections (Table 18). These lower prices are due to

a general reduction in the demand for the commodities, because of slow population growth. Prices of cereals will decline much faster than those of livestock products, because higher effective per capita income that improves purchasing power will create stronger demand for livestock products. Cereal demand will be as much as 5 percent lower than the baseline result while meat demand will only be 2 percent lower. Projected trade of cereals in 2020 under this scenario will be about 285 million tons, compared with the 273 million tons projected in the baseline scenario. This higher volume of trade is due to higher import demand for cereals, particularly in Sub-Saharan Africa, West Asia, and North Africa, as these products become more affordable, especially in areas where production is constrained by available resources. Trade of meat products, primarily beef and pigmeat, will rise to 21 million tons, compared with the baseline projected meat trade of 18 million tons. Asia will account for most of the rise.

Most important, reduced population growth will result in significant improvement in food security. Per capita demand for all commodities is projected to rise, and so are the calories available to meet individual energy requirements (Table 7). In developing countries, per capita food availability will increase by nearly 17 percent from the 1990 level (or about 3 percent higher than the level projected for 2020 in the baseline scenario). This figure would be translated into a reduction in the number of malnourished children in developing countries in 2020 of about 53.3 million from the 1990 figure of 184.3 million or about 23.7 million from the baseline projected 2020 figure of 154.7 million (Table 9). Sub-Saharan Africa will account for about 22 percent (5.0 million) of the total reduction from the 2020 baseline figure, even though the number of malnourished chil-

Table 18—Projected world prices in various scenarios, 1990 and 2020

Commodity	1990	2020				
		Baseline	Low Population Growth	Low Investment/Slow Growth	High Investment/Rapid Growth	Trade Liberalization
(US\$ per metric ton)						
Beef	2,062	1,947	1,756	1,971	2,035	2,143
Pigmeat	1,664	1,500	1,385	1,487	1,590	1,475
Sheepmeat	1,907	1,825	1,694	1,894	1,909	1,991
Poultry	739	662	616	660	688	703
Eggs	897	668	611	626	696	681
Wheat	156	132	105	166	128	136
Rice	231	181	141	256	161	199
Maize	109	84	68	106	85	85
Other coarse grains	89	67	56	81	66	86
Soybeans	247	222	208	226	231	217
Roots and tubers	148	121	97	160	111	114

Source: IMPACT simulation results.

dren there would be about 37.7 million, more than in 1990. Pakistan will also have about 2.4 million fewer malnourished children (or about 11 percent of the total reduction) compared with the baseline projection, thus bringing its total number of malnourished children down to 7.5 million.

Low-Investment/Slow-Growth Scenario

The low-investment/slow-growth scenario incorporates three assumptions:

1. International donors will eliminate public investment in national agricultural research systems and extension services in developing countries and phase out direct core funding of international agricultural research centers. The annual cut in public agricultural research expenditures in developing countries by all international sources would amount to about US\$1.5 billion. As a result, national and international agricultural research systems will weaken significantly relative to the base case. Under this scenario, crop and livestock yield growth relative to the baseline scenario would fall by 9 percent in 1995–2000; 20 percent in 2000–2005; 22 percent in 2005–2010; 20 per-

cent in 2010–2015; and 15 percent in 2015–2020.

2. Nonagricultural income growth will be reduced by 25 percent.
3. Investment in health, education, and sanitation will be reduced by 20 percent by 2020, leading to a worsening of projected indicators of female education, access to clean water, and social expenditures.

The results for this scenario, presented in Appendix 3, Tables 28 and 29, clearly show the negative effects of reduced public investment in research. Production of cereals would drop by 6 percent in the world as a whole compared with the baseline scenarios and by a larger proportion of about 10 percent in the developing countries. About 90 percent of this reduction is the direct effect of reduced research investment, and the rest is the indirect effect of slower economic growth. The hardest hit are the major staples, wheat and rice, which suffer the biggest declines in productivity from the reduction in public research investment. The decline in yield growth is only minimally offset by area expansion in response to higher prices.

Despite slower growth in income, prices of all commodities rise compared with the baseline scenario. Cereals show the largest increases, reversing the long-term decline in real prices (Table 18). Pro-

jected wheat prices in 2020 are 26 percent higher than the baseline projection result; rice prices, 41 percent higher; and maize prices, 26 percent higher. Projected prices of some meat products will also rise slightly under this scenario compared with the baseline result (for example, beef prices rise by 1 percent, and sheepmeat prices by 4 percent). As a result of declining production and rising prices, per capita food availability in the developing world rises only very slightly from the 1990 level (and actually drops by more than 6 percent compared with the baseline level projected for 2020).

This marginal improvement in energy intake leads to a worsening of food security. Under this scenario, the projected number of malnourished children will increase by 21 million to reach about 205 million in 2020 (Table 9). This represents an increase of 50 million, compared with the 2020 baseline projections. The increase in the number of malnourished children, relative to the 2020 baseline, is concentrated in South Asia and Sub-Saharan Africa, where the prevalence of malnutrition is already high. Reduced public investment in agricultural research as well as in social infrastructure and services thus has severe consequences for the global food situation, reversing long-term world food price declines and increasing the number of malnourished children.

High-Investment/Rapid-Growth Scenario

The high-investment/rapid-growth scenario examines the projected effect of more rapid income growth in agriculture in the developing countries from higher investment in agricultural research. The scenario incorporates the following assumptions:

1. Funding of national agricultural research and international agricultural research centers will rise by about US\$750 million per year, with an emphasis on advanced programs in wide-crossing, hybridization, and biotechnology. Yields for crops will be about 6 percent higher in 2020 than under the baseline scenario.
2. Nonagricultural income growth in developing countries will increase by 25 percent.
3. The proportion of public expenditures channeled to health, education, and improvement of the social state; the percentage of the population

with access to safe water; and the proportion of females enrolled in secondary schools will all rise by 20 percent by 2020.

The results are shown in Appendix 3, Tables 30 and 31. Under the high-investment scenario, annual cereal production in the developing world would be about 95 million tons higher by 2020 than under the baseline scenario. More than 90 percent of the rise would be the direct result of increased spending on agricultural research. The results indicate significant improvement in per capita demand for food, particularly in the high-value products such as meat, and a strong reduction in the number of malnourished children in the developing world as a whole, from 184 million in 1990 to 109 million in 2020 (Table 9). The greatest beneficiaries of higher research and social investments are China, Latin America, Southeast Asia, and West Asia and North Africa, where the number of malnourished children would fall drastically by 2020. This scenario would slow the growth in the number of malnourished children in Sub-Saharan Africa but would still leave about 34 million children malnourished. In India the number of malnourished children would fall by nearly one-half, and in South Asia as a whole the number would decline by 42 percent from 1990.

Thus, increased national and international commitment to development can make significant improvements in the malnutrition picture in developing countries. This increased commitment may also generate direct benefits to developed countries. Table 19 compares the gross value of food exports from the countries of the Organization for Economic Co-operation and Development (OECD) under the baseline scenario and the three alternative scenarios.

Under the low-population-growth scenario, the gross value of food exports is US\$4 billion higher than under the baseline scenario, reflecting increased demand for food imports by developing countries. The alternative investment scenarios provide an interesting comparison. Under the low-investment/slow-growth scenario, the value of exports from developed countries is a little higher than under the baseline scenario. With reduced domestic production, developing countries rely slightly more on food imports. This result could be used to argue for a "beggary-neighbor" approach to development spending by

Table 19—Gross export value of major agricultural products in OECD countries

Agricultural Products	1990	Baseline	2020		
			Low Population Growth	Low Investment/Slow Growth	High Investment/Rapid Growth
			(US\$ billion)		
Total livestock	3.5	18.6	18.6	15.3	32.2
Total crops and other processed products	17.0	21.4	25.4	29.5	23.6
All food products	20.5	40.0	44.0	44.8	55.8

Note: The OECD (Organization for Economic Co-operation and Development) includes all developed countries listed in Appendix 1, Table 20, except Eastern Europe, Japan, and the former Soviet Union.

the developed world, in which reduced development spending could increase exports from the developed countries.

Comparison with the high-investment/rapid-growth scenario shows the fallacy of this argument. This scenario results in a US\$16 billion increase in the value of exports from developed countries relative to the baseline case and a US\$11 billion increase relative to the low-investment case. Under the high-investment scenario, the value of cereals exported by the developed countries is virtually the same as under the baseline scenario, whereas the price of meat and volume of meat exports increase dramatically because of rapid income growth in the developing countries. International agricultural investment and rapid growth in developing countries would be beneficial for agricultural exports from the developed countries.

Trade Liberalization

The final scenario simulates the effect of liberalizing all commodity markets. It does not attempt to simulate the conditions agreed upon in the recently concluded Uruguay negotiations of the General Agreement on Tariffs and Trade, but rather examines the supply and demand trends when protection policies, trade subsidies and taxes are fully removed. As shown in Table 18, projected real world prices of most commodities will be slightly higher than in the baseline scenario. The direction and magnitude of price changes from liberalization represent the balance between production and demand effects from re-

moval of subsidies in countries that protect agriculture and removal of taxes in countries that tax agriculture. For example, for beef and sheepmeat, higher prices under this scenario will come from the combined effects of slightly smaller world production (increased supply in developing countries that currently tax their producers will be offset by supply reduction in developed countries where producer price subsidies are removed) and continued strong import demand from Japan, the Republic of Korea, and some countries in North America including Canada (Appendix 3, Table 32). Higher incomes that result from trade liberalization will lead to higher demand for pigmeat (compared with baseline results) in many developing countries, particularly in Asia. This increase will offset the slight demand reduction that is projected in the developed countries. For poultry, demand in Asia will fall relative to the baseline results. The price trends in pigmeat and poultry, however, will still be primarily influenced by China's market reforms. China, which presently produces about one-third of the world's pigmeat, is projected to slow production in pigmeat while demand will increase slightly. As a result, the country will import about 2 million tons of the commodity in 2020. Its poultry exports, however, will rise as production growth increases and per capita demand slows.

Trade in cereals will increase slightly under this scenario compared with the baseline scenario (Appendix 3, Table 33). Nonetheless, the price of cereals will rise to US\$126 per ton, higher than the baseline projected price of US\$116 per ton. The projected wheat price will almost be the same as in the base-

line scenario, for reduced exports from the European Union will be more than offset by continued surpluses from other sources such as the United States and other European countries (including Eastern Europe and the former Soviet Union).¹⁰ The United States will increase production (and subsequently exports) with the gradual removal of the area reduction program. Wheat trade will increase with greater import demand in China, Latin America, West Asia and North Africa, and most of the Southeast Asian countries. World demand for maize (primarily for feeds) will be slightly lower because of price rises, but trade will increase as a result of reduced production in many countries. Demand for other coarse grains will move upward a bit, and most of the increase will be met by slight rises in domestic production.

Trade liberalization will also open the highly protected, high-income rice markets of Japan, the

Republic of Korea, and other East Asian countries. Increased import demand in these countries, together with reduced domestic production incentives and increased domestic demand pressure resulting from removal of protection on rice in Asian developing countries, will push up the world price of rice by 10 percent relative to the baseline projection. With the changes in domestic incentive structures and increases in the world price of rice, rice exports from Asian developing countries will drop slightly to 12.7 million tons (from about 13.1 million tons in the baseline scenario), despite increases in imports by East Asia. Global production will actually rise, but most of this increase will be absorbed domestically as domestic prices adjust to reflect changes in the market conditions. Per capita demand for rice (especially for the standard rice type) will grow, especially in those countries that have high rates of protection in the baseline scenario.

¹⁰Exports from the European Union will fall from 25.6 million tons in the baseline projection to 18.1 million tons with trade liberalization.

5. Conclusions

Some clear messages have emerged in the course of this paper. First, the aggregate global supply and demand picture is relatively good. If governments and the international community maintain recent levels of commitment to agricultural growth through cost-effective investment in agricultural research, extension, irrigation and water development, human capital, and rural infrastructure, there will not be overwhelming pressure on aggregate world food supplies from rising populations and incomes. Projected per capita availability of food will increase slowly, and real world food prices will continue to decline for the main food crops.

World trade in agricultural commodities will increase substantially to the year 2020. Trade in meat products will nearly triple over this period, cereal trade will increase by two-thirds, and trade in soybeans will more than double. A large share of the increase in trade consists of rapidly growing imports of cereals for feed and food by the fast-growing Asian economies. The biggest beneficiaries of trade are the developed economies, and particularly the United States, which will rapidly expand its agricultural exports.

Nonetheless, despite gains from trade and the ability of the world's productive capacity to meet effective global demand for food, many regions will experience virtually no improvement in food security. The most dramatic evidence of this result is the projection that there will be very little reduction in

the number of malnourished children in the developing world as a whole. In Sub-Saharan Africa and parts of South Asia, the number of malnourished children will actually increase.

If national and international institutions further cut their investments in agricultural research, health, nutrition, and education instead of maintaining recent levels, the relatively favorable aggregate food situation will significantly worsen. World price declines could reverse, and the already bleak nutritional picture in the developing world will be made even bleaker.

On the other hand, there is also cause for hope for significant gains. Additional progress in reducing population growth could improve the food security situation, even in the medium term. Furthermore, the high-investment/rapid-growth scenario shows that a sharp reduction in the number of malnourished children is possible. But this progress requires three forces to be at work: increased income growth to generate effective demand for food; expanded investment in agricultural research to boost productivity to meet growing demand at reasonable prices; and higher expenditures on health, education, and nutrition, to translate effective food demand into nutritional improvement. Thus broad-based progress on food security for the poor will require increased national and international commitment to agricultural and economic development.

Appendix 1: The Structural Framework and Operation of IMPACT

The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) was developed at the International Food Policy Research Institute (IFPRI) to serve as a research tool in the analysis of the relative performance of commodities in the international market as they are affected by changes in the economic and social structures of countries and regions. IMPACT is built upon existing global trade models such as IFPSIM (Oga and Gehlar 1993), SWOPSIM (Roningan, Sullivan, and Dixit 1991), OECD/MTM (OECD 1991), and the FAO World Food Model (FAO 1986), with extensions that permit long-term projections of prices, supply, demand, and trade. In its present structure, IMPACT is (1) partial equilibrium with its focus on the agriculture sector; (2) global, covering 35 countries and regions and 17 commodities; (3) nonspatial (and thus cannot be used to analyze trade patterns); and (4) synthetic, because of its use of elasticities derived from other studies. Despite its focus on agricultural commodities, relationships have been incorporated in the model to link income growth in the agriculture and non-agriculture sectors.

IMPACT is a representation of a competitive agricultural market for crops and livestock. It is specified as a set of country or regional submodels, each with a particular structure within which supply, demand, and prices for some categories of agricultural commodities are determined. The 35 country and regional agricultural submodels are linked through trade, a specification that highlights the interdependence of countries and commodities in the world agricultural economy. Tables 20 and 21 list the countries, regions, and commodities covered in the model. Table 22 shows the data and parameter requirements and their sources.

The model uses a system of supply and demand elasticities, incorporated into a series of linear and nonlinear equations, to approximate the underlying production and demand functions. Sectoral growth multipliers are used to determine the intersectoral effects of changes in income in agriculture and nonagriculture sectors. A typical country or regional submodel consists of a set of these equations for each commodity, as well as the equations that link the agriculture and nonagriculture sectors.

Crop Production

Domestic crop production is determined by the area and yield response functions. Harvested area is specified as a response to the crop's own price, the prices of other competing crops, and the growth trend in harvested area (equation 1). Yield is a function of the commodity price, the prices of some inputs (such as fertilizer and labor), and a trend factor reflecting technology improvements (equation 2). Annual production of commodity i in country n is then estimated as the product of its area and yield (equation 3).

Area response:

$$AC_{ni} = \alpha_{ni} \times (PS_{ni})^{\epsilon_i} \times \prod_{(j \neq i)} (PS_{nj})^{\epsilon_{ij}} \times (1 + g_{ni}); \quad (1)$$

Yield response:

$$YC_{ni} = \beta_{ni} \times (PS_{ni})^{\gamma_i} \times \prod_k (PF_{nk})^{\delta_{ik}} \times (1 + g_{ni}); \quad (2)$$

Table 20—Countries and regions covered by IMPACT

Classification	Country/Region
Developed countries	Australia, Canada, Eastern Europe, European Union, other western European countries, former Soviet Union, Japan, New Zealand, United States, other developed countries
Developing countries	
Latin America and the Caribbean	Argentina, Brazil, Mexico, other Latin American countries
Sub-Saharan Africa	Central-west Sub-Saharan Africa, eastern Sub-Saharan Africa, Nigeria, northern Sub-Saharan Africa, southern Sub-Saharan Africa
West Asia and North Africa	Egypt, Middle East, other North African countries
Asian developing countries	Bangladesh, India, Pakistan, other South Asian countries, Indonesia, Malaysia, the Philippines, Thailand, other Southeast Asian countries, China (including Taiwan), Republic of Korea, other East Asian countries, Singapore
Rest of the world	Other developing countries

Note: Subregions in Sub-Saharan Africa are defined as follows: Northern Sub-Saharan Africa includes Burkina Faso, Chad, Djibouti, Ethiopia, Mali, Mauritania, Niger, Somalia, and Sudan. Central-West Sub-Saharan Africa includes Benin, Cameroon, Central African Republic, Comoro Islands, Congo, Côte d'Ivoire, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, São Tomé, Senegal, Sierra Leone, Togo, and Zaire. Southern Sub-Saharan Africa includes Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Réunion, Swaziland, Zambia, and Zimbabwe. Eastern Sub-Saharan Africa is composed of Burundi, Kenya, Rwanda, Tanzania, and Uganda. All other regional groups follow FAO classifications.

Table 21—Commodities covered by IMPACT

Commodity Group	Item
Crops	Wheat, high-quality <i>indica</i> rice, standard rice, <i>japonica</i> rice, maize, other coarse grains, soybeans, roots and tubers
Livestock products	Beef, pigmeat, poultry, sheepmeat, fluid milk, eggs
Processed products	Manufactured milk, meals, oil

Production:

$$QS_{tnl} = AC_{tnl} \times YC_{tnl} \quad (2)$$

t = the time index,
 g = growth rate,
 ϵ = price elasticity, and
 α, β = area and yield intercepts.

where AC = crop area,
 YC = crop yield,
 QS = quantity produced,
 PS = the effective producer price,
 PF = the price of factor or input k
 (for example, labor or fertilizer),
 i, j = commodity indexes,
 n = the country index,

Livestock Production

Livestock production is modeled similarly to crop production, except that livestock yield reflects only the effects of expected developments in technology (equation 6). Total livestock population is again a function of the livestock's own price and the prices of other competing commodities, the prices of inter-

Table 22—Data requirements and sources

Data and Parameters	Sources
Data	
1990 population	United Nations 1993
Gross domestic product (GDP)	World Bank, <i>World Development Reports</i> Asian Development Bank, <i>Key Indicators of Developing Asia and Pacific Countries</i>
1990 crop and livestock production	FAO Agrostat database
1990 demand and utilization	FAO Agrostat database
1990 commodity trade	FAO Agrostat database
1990 world reference prices	World Bank, <i>Commodity Trends and Prospects</i>
Producer subsidy equivalents and consumer subsidy equivalents for:	
Developed countries	OECD 1991
Developing countries	USDA 1991
Percentage of malnourished children	ACC/SCN 1992b
Other nutrition indicators (such as level of female schooling, access to clean water, and social expenditures)	ACC/SCN 1992b
Parameters	
Price elasticities	
Developed countries	OECD 1991
Developing countries	Ronngen, Sullivan, and Dixit 1991
Income elasticities	FAO 1987, various country studies
Feed ratios and elasticities	FAO 1986
Population growth rates	United Nations 1993
GDP growth rates	World Bank, <i>World Development Reports</i> Asian Development Bank, <i>Key Indicators of Developing Asia and Pacific Countries</i> IMF, <i>International Financial Statistics</i>

mediate (feed) inputs, and a trend variable reflecting growth in the livestock population (equation 4). The number of animals slaughtered for meat production is determined as a ratio of the present population to last year's population, applied to last year's slaughtered number (equation 5).

Number of heads (population):

$$AL_{mt} = \alpha_{mt} \times (PS_{mt})^{\alpha_1} \times \prod_{i \neq j} (PS_{mj})^{\alpha_j} \times \prod_{i \neq j} (PI_{mj})^{\alpha_j} \times (1 + g_{mt}); \quad (4)$$

Number slaughtered

$$AH_{mt} = AH_{t-1,mt} \times \frac{AL_{mt}}{AL_{t-1,mt}}; \quad (5)$$

Yield:

$$YL_{mt} = (1 + g_{mt}) YL_{t-1,mt}; \quad (6)$$

Production:

$$QS_{mt} = AH_{mt} \times YL_{mt}; \quad (7)$$

where AL = livestock population,
 AH = number slaughtered,
 YL = livestock product yield per head,
 PI = price of intermediate (feed) inputs,

and the rest of the variables are defined as for crop production.

Demand Functions

Domestic demand for a commodity is the sum of its demand for food, feed, and other industrial uses (equation 12). Food demand is a function of the price of the commodity and the prices of other competing commodities, per capita income, and total population (equation 7). Per capita income and population increase annually according to country-specific population and income growth rates as shown in equation 9. Feed demand is a derived demand determined by the changes in livestock production, feed ratios, and own- and cross-price effects of feed crops (equation 10). The equation also incorporates a technology parameter that indicates improvements in feeding efficiencies. The demand for other uses is simply a ratio of the previous year's demand, based on food and feed demand changes (equation 11).

Demand for food:

$$QF_{mi} = \gamma_{mi} \times (PD_{mi})^{\epsilon_i} \times \prod_{i \neq j} (PD_{mj})^{\epsilon_j} \times (INC_{mi})^{\eta_i} \times POP_{mi}, \quad (8)$$

where

$$INC_{mi} = INC_{t-1,mi} \times (1 + g_m), \text{ and} \\ POP_{mi} = POP_{t-1,mi} \times (1 + g_m). \quad (9)$$

Demand for feed:

$$QL_{mi} = \gamma_{mi} \times \sum_{ii} (QS_{mi} \times FR_{ii}) \times (PI_{mi}) \times \prod_{i \neq j} (PI_{mj})^{\epsilon_j} \times (1 + FE_{mi}); \quad (10)$$

Demand for other uses:

$$QE_{mi} = QE_{t-1,mi} \times \frac{(QF_{mi} + QL_{mi})}{(QF_{t-1,mi} + QL_{t-1,mi})}; \quad (11)$$

Total demand:

$$QD_{mi} = QF_{mi} + QL_{mi} + QE_{mi}, \quad (12)$$

where QD = total demand,
 QF = demand for food,
 QL = derived demand for feed,
 QE = demand for other uses,
 PD = the effective consumer price,
 INC = per capita income,
 POP = total population,
 FR = feed ratio,
 FE = feed efficiency,
 PI = the effective intermediate (feed) price,
 l = commodity index specific for livestock,
 η = income elasticity,
 γ = demand intercept,

and, again, the rest of the variables are as defined earlier.

Prices

Prices are endogenous in the system. Domestic prices consist of world prices, expressed in the respective country or regional currencies; the effect of price policies, usually expressed in terms of the producer subsidy equivalent (PSE) and consumer subsidy equivalent (CSE); and the marketing margin (MI), which reflects other factors such as transport costs or product quality differences. PSE and CSE measure the implicit level of taxation or subsidy borne by producers or consumers relative to world prices and account for most of the wedge between domestic and world prices. For some countries and commodities, however, other policy instruments that explicitly shift demand and supply relationships or limit trade are also modeled. The U.S. acreage reduction program, for example, is reflected in the model as a production control mechanism by limiting the area of production. In simulating a liberalized market environment, these policy variables are equated to zero. In the model, PSEs, CSEs, and marketing margins are expressed as percentages of the world price. The three domestic price equations are as follows.

Producer prices:

$$PS_{mi} = (PW_i \times XR_m) + MI_{mi} + PSE_{mi}; \quad (13)$$

Consumer prices:

$$PD_{mi} = (PW_i \times XR_m) + MI_{mi} + CSE_{mi}; \quad (14)$$

Intermediate (feed) prices:

$$PI_{mi} = (PW_i \times XR_m) + MI_{mi} + PSEI_{mi}, \quad (15)$$

where PW = the world price of the commodity
 XR = the foreign exchange rate per U.S. dollar,
 MI = the marketing margin,
 PSE = the producer subsidy equivalent,
 CSE = the consumer subsidy equivalent,

and

$PSEI$ = the producer subsidy equivalent for intermediate products.

Intersectoral Linkages

Although IMPACT is basically a partial equilibrium model focused on the agriculture sector, it incorporates a mechanism that links the agriculture and nonagriculture sectors through the use of intersectoral growth multipliers. Growth in one sector will have an effect on the other, the magnitude of which is determined by the intersectoral multipliers. The development of the nonagriculture sector, for example, is translated back to agriculture through its effect on production from improved delivery of necessary inputs, more rapid technology development, and increased investment in agriculture (Hazell and Haggblade 1990; McGuirk and Mundlak 1991). As nonagricultural income increases, agricultural production responds directly to higher prices from strengthened demand and indirectly from the effects of investments in capital, research, and development. Likewise, agricultural income growth creates a feedback effect on the nonagriculture sector

through increased demand for nonagricultural products and services (Bautista 1991; Badiane 1991).

Growth in total GDP is the weighted sum of agricultural and nonagricultural income growth expressed in the model as follows:

$$g_{gdp}^* = (1 - \omega)g_{na}^* + \omega g_{ag}^*, \quad (16)$$

where g_{gdp}^* , g_{na}^* , and g_{ag}^* are the respective baseline growth rates of GDP and nonagricultural and agricultural incomes, and ω is the historical share of agriculture in GDP. This relationship is established in the baseline simulation for use in the other scenarios. Note that g_{gdp}^* is exogenous while g_{ag}^* is the computed growth rate of the value of production in the model (that is,

$$g_{ag,t}^* = [\sum_i (QS_{it} \times PS_{it}) / \sum_i (QS_{i,t-1} \times PS_{i,t-1})] - 1,$$

where QS_{it} and PS_{it} are the quantity produced and the price of commodity i as defined earlier). The nonagricultural growth rate, g_{na}^* , is then obtained using equation (16). The sectoral linkage equations defined in equations (17) through (19) show how developments in one sector affect the other and GDP as a whole.

Nonagriculture to Agriculture Linkage

Equation (17) shows the effect on yield growth rates of an exogenous shock in the nonagriculture sector that leads to growth rates different from those computed in the baseline.

$$g_y = g_y^* + a_{na} (g_{na} - g_{na}^*), \quad (17)$$

where g_y = the effective yield growth rate,
 g_y^* = the initial (or baseline) yield growth rate,
 a_{na} = the nonagricultural growth multiplier,
 g_{na} = the nonagricultural growth rate (exogenously specified shock), and

g_{na}^* = the baseline growth rate of the nonagriculture sector.

(There is no exogenous change in nonagricultural income when $g_{na} = g_{na}^*$.)

Agriculture to Nonagriculture Linkage

Equation (18) shows the effect on the nonagriculture sector of exogenous development in the agriculture sector through rapid increases in production.

$$g_{na,t} = g_{na,t-1} + b_{ag} (g_{ag} - g_{ag}^*), \quad (18)$$

where $g_{na,t}$ and

$g_{na,t-1}$ = the nonagriculture growth rates in time t and $t-1$,

b_{ag} = the agricultural growth multiplier,

g_{ag}^* = the baseline agricultural income growth rate, and

g_{ag} = the agricultural income growth rate (exogenously specified shock).

Again, there is no additional effect on the nonagriculture sector when $g_{ag} = g_{ag}^*$. However, a difference between the nonagriculture sector's growth rates, g_{na} and g_{na}^* in equation (17), can cause g_{ag} to shift away from g_{ag}^* .

Using equation (16), the effects of the sectoral growth changes reflected in the GDP growth rate are as follows:

$$g_{gdp} = (1 - \omega)[g_{na} + b(g_{ag} - g_{ag}^*)] + \omega g_{ag}. \quad (19)$$

International Linkage: Trade

The country and regional submodels are linked to each other through trade. Commodity trade by country is the difference between domestic production and demand (equation 20). Countries with positive

trade are net exporters, while those with negative values are net importers. This specification does not permit a separate identification of countries that are both importers and exporters of a particular commodity. Stocks are not explicitly modeled because markets are assumed to be in equilibrium in the medium and longer term. Fluid milk is the only commodity in the model that is not internationally traded.

Net trade:

$$QT_{ml} = QS_{ml} - QD_{ml}, \quad (20)$$

where QT is volume of trade and QS and QD are domestic supply and demand of the commodity.

Algorithm for Solving the Equilibrium Condition

The model is written in the General Algebraic Modeling System (GAMS) programming language. The solution of the system of equations is achieved by using the Gauss-Seidel method algorithm. This procedure minimizes the sum of net trade at the international level and seeks a world market price for a commodity that satisfies equation (21), which is the market-clearing condition.

$$\sum_n QT_{ml} = 0. \quad (21)$$

The world price (PW) of a commodity is the equilibrating mechanism such that when an exogenous shock is introduced in the model, PW will adjust and each adjustment is passed back to the effective producer (PS) and consumer (PD) prices via the price transmission equations (equations 13 through 15). Changes in domestic prices subsequently affect commodity supply and demand, necessitating their iterative readjustments until world supply and demand balance, and world net trade is again equal to zero. For fluid milk, the market-clearing condition applies only domestically.

Food Security: Projection of Number of Malnourished Children

Finally, the model generates projections of the percentage and number of malnourished preschool children (0 to 5 years old) in developing countries. A malnourished child is one 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. To get the projected figures for malnourished children, the authors first estimated a functional relationship between the percentage of malnourished children, the average per capita calorie availability of food, and other nonfood determinants of child malnutrition such as the state of health (proxied by the percentage of public expenditures spent on health, education, and social security), education (proxied by the percentage of females undertaking secondary schooling), and sanitation (proxied by the percentage of the population with access to safe drinking water). The analysis employed a fixed-effect model on pooled, cross-section time-series data from 61 developing countries covering the years 1980, 1985, and 1990 (ACC/SCN 1992b). The estimated functional relationship, as shown in equation (22), is used to project the percentage of malnourished children.

$$\begin{aligned} \%MAL_t = & 0.69 - 0.00014KCAL_t - 0.004SOCEXP \\ & (-5.9) \quad (-6.6) \\ & - 0.0005SCH - 0.0002WATER \\ & (-1.1) \quad (-0.6) \\ & + 0.00009DUMMY, \end{aligned} \quad (22)$$

$$R^2 = 0.72,$$

where $\%MAL$ = percentage of malnourished children,
 $KCAL$ = per capita kilocalorie availability,
 $SOCEXP$ = percentage of social expenditures in total public expenditures,
 SCH = percentage of females with secondary education,
 $WATER$ = percentage of households with access to clean water, and
 $DUMMY$ = interactive dummy for South Asia and $KCAL$.

The numbers in parentheses are *t*-statistics. This percentage is then applied to the projected population of children 0 to 5 years of age to project the number of malnourished children (equation 23).

$$NMAL_t = \%MAL_t \times POP5_t, \quad (23)$$

where $NMAL$ = number of malnourished children, and
 $POP5$ = number of children 0 to 5 years old in the population.

Projected per capita calorie availability for food ($KCAL$) is made up of two components. One part (which accounts for about 80 percent of the total per capita calories) is derived from total supply (that is, production less exports, less other uses, plus imports) of commodities covered in the model and converted to kilocalories using the 1990 FAO estimates for each commodity as benchmarks. The other part comes from commodities outside of the model (such as sugar, fish, vegetables, and fruits), whose kilocalorie contribution is based on their historical share in total per capita kilocalorie values (Alexandratos 1995).

Appendix 2: Estimation of Future Yield Growth for Crops and Livestock

Guidelines and Principles

Evenson and Rosegrant (1995) developed the non-price area and yield projections for the 1990–2020 period that are used in the model. The first principle is that a data-based projection cannot be constrained to be constant over this period, so projections are developed for five-year periods 1990–95, 1995–2000, 2000–2005, 2005–10, 2010–15, and 2015–20. Defensible projections should be consistent with actual recent aggregate nonprice supply trends and the component nonprice sources of growth. Historical consistency is achieved by first imposing the constraint that actual nonprice yield and area trends for the 1983–92 period be the basis for projections for the 1990–95 period for each country. The projections then allow for a phase-in from the 1983–92 trends to the base case trends (thereby preserving the influence of recent trends in yield and area performance) over each of the periods from 1995–2000 through 2015–20 periods. The phase-in was accomplished by computing the projected trends for these latter two periods as weighted averages of the projected growth from different sources and the growth projection for 1990–95 estimated from the recent historical performance (with declining weights assigned to historical growth in succeeding periods).

The general slowdown in production growth rates during 1983–90 compared with earlier years is evident from the time-series data. Historical consistency requires that this slowdown be recognized. Thus, projections are started from these more recent rates of change, not from the higher rates realized in the 1962–82 period. (Part of the slowdown is due to a relative exhaustion of Green Revolution gains, a fact that Evenson and Rosegrant take into account in the growth component analysis). The projected future trends explicitly account for the slowdown in

yield growth for most commodities in most countries (as well as accounting for strong performers, such as rice yield growth in India and pigmeat and poultry production in much of Asia). To establish the 1990–95 nonprice yield and area growth rates for projection purposes, two additional adjustments were made. For countries where base or end-year values resulted in trend estimates that are clearly outliers from trends over the complete recent period, these estimates were modified to be consistent with the recent period. Finally, the trend rates were converted to a nonprice trend basis by simulating IMPACT over the period 1983–92 to estimate the "counterfactual" area and yield growth that would have occurred under constant commodity prices during this period. This procedure removes the price effects on yield and area, thereby isolating the nonprice productivity growth.

Projected Yield Growth: Nonprice Yield Projection Components

Nonprice yield trend projections are central to projecting yield in periods after 1990–95. The first step in making these projections is to break them into their components and subcomponents. Dealing with each component (or subcomponent) separately allows more information to be incorporated than in more aggregate projections. Evenson and Rosegrant (1995) develop the following component structure based on a study of India crop productivity (Evenson, Pray, and Rosegrant 1995):

1. Public research (by international and national agricultural research centers)
 - A. Management research
 - B. Conventional plant breeding

- C. Wide-crossing/hybridization breeding
- D. Biotechnology (transgenic) breeding
- 2. Private sector agriculturally related research and development
- 3. Agricultural extension and farmers schooling
- 4. Markets
- 5. Infrastructure
- 6. Irrigation

The growth contribution of modern inputs such as fertilizers is accounted for in price effects in the yield response function (see equation 2 in Appendix 1) and as a complementary input with irrigation and with the modern varieties generated by research.

To generate the projected time path of yield growth, the methodology makes use of before-the-fact and after-the-fact studies of agricultural research priority setting, studies of the sources of agricultural productivity growth, an examination of the role of industrialization in growth, and "expert opinion." Details on the procedure for estimating the future yield contribution from each of the sources of growth appear in Evenson and Rosegrant 1995. Finally, as already noted, projected yield growth in succeeding periods is then adjusted as a weighted average of its respective value and the 1990–95 period.

Projected Area Growth: Nonprice Area Components

Estimation of nonprice area growth for 1990–95 follows the same procedures described for yield. In later time periods, nonprice area components depend on the availability of cultivable land, irrigation and infrastructure investments, and productivity gains, as well as prices. Some of these effects operate through prices and, to the extent they do, the price response parameters within IMPACT will determine changes in area. But to the extent that investments expand the effective stock of land, they are nonprice components. In practice, aggregate land expansion has slowed to low rates in recent years as the stock of cultivable land has been exhausted. The chief component of aggregate area expansion has been investment in irrigation, which has also slowed dramatically in recent years (Rosegrant and Svendsen 1993). Projections of area expansion in subsequent time periods thus take the nonprice area growth trend estimated for 1990–95 and in most cases dampen it to reflect the lagged effects of declining investments in irrigation. Accordingly, except for a few crops in a few regions, projected rates of non-price area expansion are low.

Appendix 3: Supplementary Tables

Table 23—Average annual growth rates in production of crops by region, 1966–90

	Paddy Rice			Wheat			Maize		
	1966–74	1974–82	1982–90	1966–74	1974–82	1982–90	1966–74	1974–82	1982–90
Developed countries									
Area	3.62	3.82	-1.35	-0.92	0.65	-0.63	1.38	0.08	0.16
Production	3.85	4.03	0.83	1.92	2.30	1.11	3.73	3.83	0.67
Yield	0.24	0.17	2.24	2.86	1.66	1.73	2.37	3.83	0.62
Asia									
Area	1.01	0.20	0.12	2.47	1.58	0.49	1.12	0.94	1.43
Production	3.10	2.82	1.78	6.70	6.19	2.80	4.17	4.46	4.19
Yield	2.07	2.62	1.66	4.14	4.54	2.32	3.00	3.50	2.73
Latin America and the Caribbean									
Area	1.62	1.45	-0.86	0.18	1.07	-0.51	0.27	0.44	0.18
Production	2.71	2.56	1.93	2.09	2.83	0.84	2.04	3.66	0.63
Yield	1.08	1.08	2.81	1.97	1.68	1.35	1.77	3.18	0.47
Sub-Saharan Africa									
Area	3.44	2.63	4.24	-0.65	1.81	3.51	0.96	-2.18	2.84
Production	3.74	2.14	3.50	2.13	3.22	5.49	2.82	-0.02	2.38
Yield	0.29	-0.48	-0.70	2.75	1.31	1.98	1.82	2.39	-0.76
Other developing countries									
Area	0.37	0.14	1.04	1.45	-0.79	0.08	0.34	-0.17	-1.36
Production	1.53	0.94	1.76	3.11	1.91	3.11	1.60	1.51	4.35
Yield	1.17	0.80	0.77	1.60	2.75	3.03	1.24	1.69	5.78
World									
Area	1.10	0.35	0.36	-0.01	0.73	-0.58	1.03	0.36	0.60
Production	3.05	2.78	2.14	2.82	3.23	1.76	3.55	3.78	1.23
Yield	1.94	2.42	1.78	2.83	2.49	2.35	2.51	3.39	0.67

Source: FAO Agrostat database, 1992.

Note: Leaders indicate a nil or negligible amount.

Sorghum			Other Coarse Grains			Cassava			Other Roots and Tubers		
1966-74	1974-82	1982-90	1966-74	1974-82	1982-90	1966-74	1974-82	1982-90	1966-74	1974-82	1982-90
(percent)											
1.89	-1.58	-1.75	1.17	-1.59	3.36	...	...	...	-1.69	-2.51	-0.01
2.23	0.21	-1.09	3.28	-0.09	0.47	...	...	...	-0.66	-2.03	-2.10
0.33	1.82	0.83	2.08	1.52	-2.80	...	...	...	1.05	0.49	-1.98
-2.27	-1.21	-2.17	-1.01	-2.41	-1.74	2.35	3.61	0.98	0.23	-3.18	-4.78
-0.28	-0.15	-1.58	-0.21	-0.67	-0.16	4.74	5.84	1.72	3.10	-0.09	-6.46
2.04	1.07	0.60	0.81	1.79	1.61	2.31	2.18	0.70	2.87	3.19	-1.76
9.50	1.47	-5.01	-0.49	-3.81	0.35	1.92	0.06	-0.33	-0.43	-0.51	2.27
13.31	4.09	-6.13	1.98	-2.46	1.30	0.65	-0.71	0.95	0.75	0.75	3.13
3.48	2.58	-1.18	2.49	1.40	0.94	-1.24	-0.77	1.28	1.18	1.26	0.85
-0.85	1.17	1.85	0.52	0.36	0.61	2.22	0.44	1.25	3.56	-0.14	1.86
-0.04	1.96	2.94	1.90	0.20	1.43	2.64	2.14	2.91	3.37	1.41	-1.21
0.81	0.78	1.07	1.37	-0.16	0.78	0.42	1.70	1.64	-0.18	1.55	-3.02
3.43	3.24	-3.09	0.16	0.23	1.35	-6.26	2.31	2.36	3.40	3.86	3.67
0.97	1.53	-1.99	-0.68	2.65	2.97	-4.54	1.74	4.39	4.89	6.55	4.76
-2.11	-1.66	1.14	-0.84	2.42	1.59	1.77	-0.52	1.96	1.44	2.58	1.05
-0.36	-0.45	-1.17	0.48	-0.61	-0.09	2.13	1.07	1.16	-0.19	-1.95	0.28
2.17	1.05	-2.16	2.56	-0.05	1.16	2.41	2.52	2.28	0.81	-0.79	-0.40
2.54	1.51	-1.00	2.07	0.57	1.25	0.28	1.44	1.10	1.01	1.19	-0.67

Table 24—Average annual growth rates in production of livestock products by region, 1966–90

Region	Livestock Product	Growth in Livestock Number			Growth in Meat Production		
		1966–74	1974–82	1982–90	1966–74	1974–82	1982–90
(percent)							
Asia	Beef	0.722	0.799	1.386	3.252	2.324	4.306
	Goat meat	1.360	2.897	2.876	3.243	4.458	5.821
	Sheepmeat	1.428	2.181	1.167	3.346	5.090	6.128
	Pigmeat	4.837	1.942	2.098	3.654	6.339	6.777
	Poultry	2.792	4.711	7.044	6.668	6.396	5.517
	Total meat	...	...	...	4.005	5.569	6.166
	Eggs	...	...	...	4.416	4.462	7.746
	Milk	...	...	...	2.854	4.382	5.208
Latin America and the Caribbean	Beef	2.600	2.262	1.086	1.879	2.252	2.522
	Goat meat	-0.225	0.166	1.932	1.932	-0.041	2.256
	Sheepmeat	-1.768	0.330	0.562	-2.469	-0.584	0.738
	Pigmeat	2.299	0.876	0.447	3.655	4.416	-0.746
	Poultry	5.075	5.309	2.906	8.522	9.820	4.655
	Total meat	...	...	...	2.872	4.008	2.407
	Eggs	...	...	...	5.385	5.989	4.367
	Milk	...	...	...	3.702	2.331	1.815
Sub-Saharan Africa	Beef	0.960	1.592	0.898	1.169	2.217	2.564
	Goat meat	0.254	1.660	2.599	-0.490	2.764	3.310
	Sheepmeat	0.598	1.461	2.800	-0.160	2.989	3.212
	Pigmeat	4.087	3.892	6.384	4.391	3.307	6.740
	Poultry	3.320	2.809	3.795	5.308	4.917	3.805
	Total meat	...	...	...	1.574	2.877	3.318
	Eggs	...	...	...	3.372	5.680	1.931
	Milk	...	...	...	0.981	3.103	2.753
Other developing countries	Beef	1.839	1.651	-0.478	3.080	3.282	2.302
	Goat meat	0.631	1.596	0.477	2.213	0.419	2.454
	Sheepmeat	0.991	2.711	0.471	2.120	3.102	1.535
	Pigmeat	7.039	2.624	6.841	8.472	1.866	5.417
	Poultry	6.481	7.312	5.017	7.592	9.916	5.154
	Total meat	...	...	...	3.473	4.576	3.062
	Eggs	...	...	...	6.748	8.585	5.352
	Milk	...	...	...	1.842	3.316	0.878
World	Beef	1.548	0.838	0.551	2.660	1.124	1.658
	Goat meat	0.609	2.060	2.385	1.701	2.757	4.191
	Sheepmeat	-0.185	1.036	0.911	0.361	1.405	1.974
	Pigmeat	3.522	1.547	1.264	3.089	3.335	3.223
	Poultry	3.115	3.746	4.138	5.737	5.736	4.140
	Total meat	...	...	...	3.145	2.866	2.872
	Eggs	...	...	...	3.276	3.142	3.219
	Milk	...	...	...	1.420	1.597	1.344

Source: FAO Agrostat database, 1992.

Note: Leaders (...) indicate not applicable.

Table 25—Average annual growth rates in total domestic utilization (TDU) of food crops and livestock products, 1966–89

Region/Use	All Crops	Wheat	Rice	Maize	Sorghum	Cassava	Other Coarse Grains	Other Roots and Tubers	Pulses	Meat ^a	Eggs ^a
(percent)											
Asia											
TDU	2.58	4.89	2.62	4.64	-0.41	2.20	-0.62	0.81	0.41	5.83	8.59
Food	2.35	5.34	2.90	3.02	-0.46	1.99	-0.61	-0.63	0.34	...	...
Feed	4.02	3.10	1.06	6.02	0.35	5.96	-1.12	4.34	1.81	...	...
Other uses	1.90	3.33	1.54	3.99	-1.04	2.21	-0.83	1.64	-0.32	...	...
Latin America^b											
TDU	2.16	3.21	3.14	3.27	6.09	-0.52	1.54	1.09	0.81	2.43	4.02
Food	2.15	3.62	3.38	2.90	-0.03	-0.26	1.22	1.50	0.85	...	...
Feed	2.67	0.72	2.82	3.55	6.39	-0.28	1.07	-2.23	-4.24	...	...
Other uses	1.09	2.78	2.20	3.13	4.30	-1.25	1.38	0.64	1.26	...	...
Sub-Saharan Africa											
TDU	2.83	7.53	4.31	3.33	1.87	2.86	2.01	2.20	1.89	2.05	1.8
Food	3.22	7.72	5.13	3.65	2.26	3.16	2.64	2.49	2.00	...	...
Feed	2.05	5.29	-0.20	3.81	-0.43	0.22	3.14	-2.06	7.17	...	...
Other uses	1.72	6.48	1.95	1.24	0.58	2.01	0.03	1.82	1.34	...	...
West Asia and North Africa											
TDU	3.77	3.68	3.47	5.23	1.52	-1.01	3.24	5.92	2.74	1.85	3.54
Food	3.62	3.93	4.18	2.87	1.12	-1.20	-0.91	6.39	2.86	...	...
Feed	4.68	3.95	0.14	8.24	3.49	-0.74	4.20	9.47	1.63	...	...
Other uses	2.95	2.62	0.96	3.56	2.33	-0.19	3.74	3.87	3.26	...	...
Developing countries											
TDU	2.91	4.81	3.04	4.47	1.64	2.18	1.32	1.58	0.94	4.17	6.6
Food	2.57	4.90	3.04	2.97	0.28	2.30	-0.06	0.64	0.87	...	...
Feed	5.13	4.06	1.10	6.45	6.56	1.38	4.20	4.47	1.78	...	...
Other uses	2.58	3.55	2.54	3.98	0.80	2.29	2.09	2.14	0.84	...	...
Developed countries											
TDU	1.22	1.35	3.53	2.24	-0.18	10.18	1.10	-0.44	1.69	1.63	0.61
Food	0.80	1.15	2.44	2.74	2.23	-5.51	-1.04	0.46	-0.35	...	...
Feed	1.28	1.49	3.12	1.77	-0.27	11.13	1.24	-1.75	2.57	...	...
Other uses	1.52	1.30	7.07	5.09	3.82	3.94	1.60	-0.33	1.14	...	...
World											
TDU	1.91	2.80	2.71	2.97	0.95	2.28	1.19	0.07	1.70	2.59	3.05
Food	2.10	3.43	3.16	3.05	0.49	2.14	-0.05	0.02	1.27	...	...
Feed	1.85	1.88	0.05	2.67	1.37	4.03	1.46	0.18	2.92	...	...
Other uses	1.58	2.09	1.79	4.46	0.34	0.95	1.53	0.09	1.32	...	...

Source: FAO Agrostat database, 1992.

Note: Leaders (...) indicate not applicable.

^aGrowth rates for meat and eggs reflect the period 1982–89.

^bIncludes the Caribbean.

**Table 26—Production of, demand for, and net trade of crops by region, 1990 and 2020:
Low-population-growth scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
World	530,713	530,715	0	802,125	802,125	0
Developed countries	303,786	241,186	62,602	391,475	276,302	115,173
Developing countries	226,927	289,529	-62,602	410,650	525,823	-115,173
Asia	157,882	184,913	-27,031	274,453	326,789	-52,336
Latin America and the Caribbean	22,013	25,601	-3,588	37,114	41,956	-4,843
Sub-Saharan Africa	1,718	6,869	-5,151	4,211	17,036	-12,824
West Asia and North Africa	45,314	72,146	-26,832	94,873	140,042	-45,169
Rice						
World	349,466	349,179	-1	534,276	534,276	0
Developed countries	17,440	17,276	164	21,797	18,586	3,211
Developing countries	332,026	331,903	-165	512,479	515,690	-3,211
Asia	313,602	307,425	5,889	480,520	465,345	15,176
Latin America and the Caribbean	10,594	11,483	-889	15,312	21,038	-5,725
Sub-Saharan Africa	4,281	7,082	-2,801	10,541	18,076	-7,536
West Asia and North Africa	3,549	5,869	-2,320	6,105	11,138	-5,034
Maize						
World	476,561	476,560	1	719,215	719,215	0
Developed countries	277,022	260,942	16,080	369,617	324,130	45,487
Developing countries	199,539	215,618	-16,079	349,598	395,085	-45,487
Asia	117,803	122,725	-4,922	200,514	227,282	-26,768
Latin America and the Caribbean	52,521	57,637	-5,116	87,574	93,310	-5,736
Sub-Saharan Africa	21,068	21,308	-240	47,197	50,675	-3,477
West Asia and North Africa	8,145	13,939	-5,794	14,311	23,802	-9,490
Other coarse grains						
World	358,040	358,038	0	510,006	510,006	0
Developed countries	249,627	237,254	12,373	321,269	298,855	22,414
Developing countries	108,413	120,784	-12,373	188,737	211,151	-22,414
Asia	47,156	47,911	-755	72,583	69,354	3,229
Latin America and the Caribbean	14,279	17,994	-3,715	22,565	25,385	-2,820
Sub-Saharan Africa	27,513	28,603	-1,092	61,626	69,769	-8,144
West Asia and North Africa	19,465	26,260	-6,795	31,964	46,615	-14,650
Total cereals						
World	1,714,780	1,714,492	0	2,565,622	2,565,622	0
Developed countries	847,875	756,658	91,219	1,104,158	917,873	186,285
Developing countries	866,905	957,834	-91,219	1,461,464	1,647,749	-186,285
Asia	636,443	662,974	-26,531	1,028,070	1,088,770	-60,700
Latin America and the Caribbean	99,407	112,715	-13,308	162,565	181,689	-19,124
Sub-Saharan Africa	54,580	63,862	-9,282	123,575	155,556	-31,981
West Asia and North Africa	76,473	118,214	-41,741	147,253	221,597	-74,344
Soybeans						
World	106,624	106,624	-1	184,003	184,002	0
Developed countries	57,925	60,334	-2,409	95,620	81,290	14,330
Developing countries	48,699	46,290	2,408	88,383	102,712	-14,330
Asia	15,352	19,497	-4,145	28,467	50,359	-21,892
Latin America and the Caribbean	32,714	26,036	6,678	58,634	50,610	8,025
Sub-Saharan Africa	259	256	2	571	664	-93
West Asia and North Africa	374	501	-127	710	1,079	-369
Roots and tubers						
World	582,767	582,766	1	829,489	829,489	0
Developed countries	196,659	222,484	-25,825	230,036	254,243	-24,207
Developing countries	386,108	360,282	25,826	599,453	575,246	24,207
Asia	225,076	199,391	25,685	279,361	250,542	28,819
Latin America and the Caribbean	47,825	47,584	241	71,143	70,522	621
Sub-Saharan Africa	100,810	100,785	25	229,655	234,349	-4,695
West Asia and North Africa	12,024	12,199	-175	18,734	19,328	-594

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 27—Production of, demand for, and net trade of livestock products by region, 1990 and 2020:
Low-population-growth scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Beef						
World	49,879	49,879	0	73,691	73,691	0
Developed countries	32,580	32,291	289	41,040	32,924	8,116
Developing countries	17,299	17,588	-289	32,651	40,767	-8,116
Asia	3,443	4,087	-644	8,556	14,056	-5,500
Latin America and the Caribbean	10,099	9,140	959	17,102	15,575	1,527
Sub-Saharan Africa	2,099	2,064	35	3,916	5,626	-1,710
West Asia and North Africa	1,651	2,278	-627	3,069	5,440	-2,372
Pigmeat						
World	66,902	66,900	0	118,971	118,971	0
Developed countries	37,343	37,703	-360	43,494	39,815	3,679
Developing countries	29,559	29,197	360	75,477	79,156	-3,679
Asia	26,031	25,585	445	68,750	71,583	-2,833
Latin America and the Caribbean	3,073	3,119	-46	5,714	6,190	-476
Sub-Saharan Africa	451	476	-26	1,007	1,341	-335
West Asia and North Africa	4	8	-4	7	18	-11
Sheepmeat						
World	8,810	8,810	0	17,036	17,037	0
Developed countries	3,889	3,570	319	5,625	4,080	1,546
Developing countries	4,921	5,240	-319	11,411	12,957	-1,546
Asia	2,159	2,104	55	5,426	6,038	-612
Latin America and the Caribbean	309	420	-111	605	729	-125
Sub-Saharan Africa	916	916	0	1,783	2,328	-545
West Asia and North Africa	1,535	1,792	-257	3,593	3,834	-241
Poultry						
World	37,278	37,278	0	66,256	66,255	0
Developed countries	23,795	23,459	336	33,631	29,972	3,659
Developing countries	13,483	13,819	-336	32,625	36,283	-3,659
Asia	6,001	6,006	-5	17,052	18,767	-1,714
Latin America and the Caribbean	4,791	4,729	62	9,415	9,613	-198
Sub-Saharan Africa	852	942	-90	1,995	2,626	-631
West Asia and North Africa	1,838	2,124	-286	4,161	5,210	-1,049
Total meat products						
World	162,869	162,867	0	275,954	275,954	0
Developed countries	97,607	97,023	584	123,790	106,791	17,000
Developing countries	65,262	65,844	-584	152,164	169,163	-17,000
Asia	37,634	37,782	-148	99,784	110,444	-10,660
Latin America and the Caribbean	18,272	17,408	864	32,836	32,107	729
Sub-Saharan Africa	4,318	4,398	-80	8,701	11,921	-3,220
West Asia and North Africa	5,028	6,202	-1,174	10,830	14,502	-3,672
Eggs						
World	35,420	35,420	0	66,171	66,171	0
Developed countries	18,351	18,261	90	22,921	21,801	1,120
Developing countries	17,069	17,159	-90	43,250	44,370	-1,120
Asia	11,074	11,109	-35	30,255	30,495	-240
Latin America and the Caribbean	3,690	3,702	-12	7,419	7,852	-434
Sub-Saharan Africa	682	675	7	1,777	1,959	-184
West Asia and North Africa	1,621	1,670	-49	3,794	4,051	-256

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 28—Production of, demand for, and net trade of crops by region, 1990 and 2020:
Low-investment/slow-growth scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
World	530,713	530,715	0	793,152	793,152	0
Developed countries	303,786	241,186	62,602	415,499	276,378	139,121
Developing countries	226,927	289,529	-62,602	377,653	516,774	-139,121
Asia	157,882	184,913	-27,031	249,974	330,521	-80,547
Latin America and the Caribbean	22,013	25,601	-3,588	35,277	39,529	-4,252
Sub-Saharan Africa	1,718	6,869	-5,151	3,999	15,598	-11,599
West Asia and North Africa	45,314	72,146	-26,832	88,404	131,126	-42,722
Rice						
World	349,466	349,179	-1	527,789	527,788	0
Developed countries	17,440	17,276	164	22,526	19,937	2,588
Developing countries	332,026	331,903	-165	505,263	507,851	-2,588
Asia	313,602	307,425	5,889	471,347	462,215	9,132
Latin America and the Caribbean	10,594	11,483	-889	16,682	17,966	-1,284
Sub-Saharan Africa	4,281	7,082	-2,801	10,948	16,752	-5,804
West Asia and North Africa	3,549	5,869	-2,320	6,285	10,833	-4,547
Maize						
World	476,561	476,560	1	694,237	694,238	0
Developed countries	277,022	260,942	16,080	359,600	313,732	45,868
Developing countries	199,539	215,618	-16,079	334,637	380,506	-45,868
Asia	117,803	122,725	-4,922	189,276	216,944	-27,668
Latin America and the Caribbean	52,521	57,637	-5,116	85,937	92,005	-6,069
Sub-Saharan Africa	21,068	21,308	-240	45,491	49,206	-3,716
West Asia and North Africa	8,145	13,939	-5,794	13,932	22,334	-8,402
Other coarse grains						
World	358,040	358,038	0	504,863	504,863	0
Developed countries	249,627	237,254	12,373	327,873	295,754	32,119
Developing countries	108,413	120,784	-12,373	176,990	209,109	-32,119
Asia	47,156	47,911	-755	66,469	77,158	-10,688
Latin America and the Caribbean	14,279	17,994	-3,715	20,591	23,290	-2,699
Sub-Saharan Africa	27,513	28,603	-1,092	58,296	66,666	-8,371
West Asia and North Africa	19,465	26,260	-6,795	31,632	41,965	-10,333
Total cereals						
World	1,714,780	1,714,492	0	2,520,041	2,520,041	0
Developed countries	847,875	756,658	91,219	1,125,498	905,801	219,696
Developing countries	866,905	957,834	-91,219	1,394,543	1,614,240	-219,696
Asia	636,443	662,974	-26,531	977,066	1,086,838	-109,772
Latin America and the Caribbean	99,407	112,715	-13,308	158,487	172,790	-14,303
Sub-Saharan Africa	54,580	63,862	-9,282	118,734	148,222	-29,488
West Asia and North Africa	76,473	118,214	-41,741	140,253	206,258	-66,005
Soybeans						
World	106,624	106,624	-1	170,530	170,530	0
Developed countries	57,925	60,334	-2,409	94,043	81,626	12,417
Developing countries	48,699	46,290	2,408	76,487	88,904	-12,417
Asia	15,352	19,497	-4,145	24,429	43,326	-18,896
Latin America and the Caribbean	32,714	26,036	6,678	50,933	44,047	6,886
Sub-Saharan Africa	259	256	2	500	578	-79
West Asia and North Africa	374	501	-127	624	952	-328
Roots and tubers						
World	582,767	582,766	1	849,575	849,576	0
Developed countries	196,659	222,484	-25,825	254,359	263,812	-9,453
Developing countries	386,108	360,282	25,826	595,216	585,764	9,453
Asia	225,076	199,391	25,685	289,183	260,159	29,024
Latin America and the Caribbean	47,825	47,584	241	71,624	70,955	670
Sub-Saharan Africa	100,810	100,785	25	214,417	231,568	-17,151
West Asia and North Africa	12,024	12,199	-175	19,436	22,522	-3,086

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 29—Production of, demand for, and net trade of livestock products by region, 1990 and 2020:
Low-investment/slow-growth scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Beef						
World	49,879	49,879	0	71,288	71,287	0
Developed countries	32,580	32,291	289	41,627	35,935	5,691
Developing countries	17,299	17,588	-289	29,661	35,352	-5,691
Asia	3,443	4,087	-644	7,405	10,889	-3,485
Latin America and the Caribbean	10,099	9,140	959	15,900	14,924	977
Sub-Saharan Africa	2,099	2,064	35	3,621	4,861	-1,241
West Asia and North Africa	1,651	2,278	-627	2,727	4,627	-1,900
Pigmeat						
World	66,902	66,900	0	111,098	111,098	0
Developed countries	37,343	37,703	-360	43,305	43,534	-229
Developing countries	29,559	29,197	360	67,793	67,564	229
Asia	26,031	25,585	445	61,747	60,620	1,126
Latin America and the Caribbean	3,073	3,119	-46	5,151	5,729	-578
Sub-Saharan Africa	451	476	-26	889	1,176	-287
West Asia and North Africa	4	8	-4	6	16	-10
Sheepmeat						
World	8,810	8,810	0	15,488	15,489	0
Developed countries	3,889	3,570	319	5,669	4,213	1,456
Developing countries	4,921	5,240	-319	9,819	11,276	-1,456
Asia	2,159	2,104	55	4,576	5,017	-441
Latin America and the Caribbean	309	420	-111	553	687	-135
Sub-Saharan Africa	916	916	0	1,659	2,052	-394
West Asia and North Africa	1,535	1,792	-257	3,027	3,498	-471
Poultry						
World	37,278	37,278	0	62,244	62,245	0
Developed countries	23,795	23,459	336	33,507	30,925	2,583
Developing countries	13,483	13,819	-336	28,737	31,320	-2,583
Asia	6,001	6,006	-5	15,578	15,568	10
Latin America and the Caribbean	4,791	4,729	62	8,245	8,741	-496
Sub-Saharan Africa	852	942	-90	1,654	2,324	-671
West Asia and North Africa	1,838	2,124	-286	3,259	4,634	-1,376
Total meat products						
World	162,869	162,867	0	260,118	260,119	0
Developed countries	97,607	97,023	584	124,108	114,607	9,501
Developing countries	65,262	65,844	-584	136,010	145,512	-9,501
Asia	37,634	37,782	-148	89,306	92,094	-2,788
Latin America and the Caribbean	18,272	17,408	864	29,849	30,081	-232
Sub-Saharan Africa	4,318	4,398	-80	7,823	10,413	-2,590
West Asia and North Africa	5,028	6,202	-1,174	9,019	12,775	-3,756
Eggs						
World	35,420	35,420	0	63,921	63,921	0
Developed countries	18,351	18,261	90	22,660	23,271	-611
Developing countries	17,069	17,159	-90	41,261	40,650	611
Asia	11,074	11,109	-35	28,671	27,486	1,185
Latin America and the Caribbean	3,690	3,702	-12	7,295	7,447	-152
Sub-Saharan Africa	682	675	7	1,700	1,847	-148
West Asia and North Africa	1,621	1,670	-49	3,590	3,861	-271

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 30—Production of, demand for, and net trade of crops by region, 1990 and 2020:
High-investment/rapid-growth scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
World	530,713	530,715	0	889,477	889,477	0
Developed countries	303,786	241,186	62,602	428,850	299,209	129,642
Developing countries	226,927	289,529	-62,602	460,627	590,268	-129,642
Asia	157,882	184,913	-27,031	307,907	377,406	-69,499
Latin America and the Caribbean	22,013	25,601	-3,588	41,257	45,165	-3,909
Sub-Saharan Africa	1,718	6,869	-5,151	4,776	17,963	-13,186
West Asia and North Africa	45,314	72,146	-26,832	106,686	149,734	-43,048
Rice						
World	349,466	349,179	-1	589,917	589,919	0
Developed countries	17,440	17,276	164	23,366	20,205	3,162
Developing countries	332,026	331,903	-165	566,551	569,714	-3,162
Asia	313,602	307,425	5,889	530,850	515,216	15,635
Latin America and the Caribbean	10,594	11,483	-889	17,135	22,840	-5,706
Sub-Saharan Africa	4,281	7,082	-2,801	11,776	19,415	-7,640
West Asia and North Africa	3,549	5,869	-2,320	6,792	12,133	-5,342
Maize						
World	476,561	476,560	1	795,489	795,489	0
Developed countries	277,022	260,942	16,080	395,828	354,916	40,912
Developing countries	199,539	215,618	-16,079	399,661	440,573	-40,912
Asia	117,803	122,725	-4,922	229,146	257,980	-28,835
Latin America and the Caribbean	52,521	57,637	-5,116	99,420	103,299	-3,879
Sub-Saharan Africa	21,068	21,308	-240	54,760	53,992	768
West Asia and North Africa	8,145	13,939	-5,794	16,333	25,283	-8,950
Other coarse grains						
World	358,040	358,038	0	562,145	562,144	0
Developed countries	249,627	237,254	12,373	349,239	331,690	17,548
Developing countries	108,413	120,784	-12,373	212,906	230,454	-17,548
Asia	47,156	47,911	-755	82,409	77,150	5,258
Latin America and the Caribbean	14,279	17,994	-3,715	24,549	28,416	-3,867
Sub-Saharan Africa	27,513	28,603	-1,092	69,593	74,110	-4,519
West Asia and North Africa	19,465	26,260	-6,795	36,356	50,745	-14,389
Total cereals						
World	1,714,780	1,714,492	0	2,837,028	2,837,029	0
Developed countries	847,875	756,658	91,219	1,197,283	1,006,020	191,264
Developing countries	866,905	957,834	-91,219	1,639,745	1,831,009	-191,264
Asia	636,443	662,974	-26,531	1,150,312	1,227,752	-77,440
Latin America and the Caribbean	99,407	112,715	-13,308	182,361	199,720	-17,359
Sub-Saharan Africa	54,580	63,862	-9,282	140,905	165,480	-24,575
West Asia and North Africa	76,473	118,214	-41,741	166,167	237,895	-71,728
Soybeans						
World	106,624	106,624	-1	204,626	204,626	0
Developed countries	57,925	60,334	-2,409	106,181	82,719	23,462
Developing countries	48,699	46,290	2,408	98,445	121,907	-23,462
Asia	15,352	19,497	-4,145	32,038	62,440	-30,402
Latin America and the Caribbean	32,714	26,036	6,678	64,994	57,492	7,502
Sub-Saharan Africa	259	256	2	632	745	-116
West Asia and North Africa	374	501	-127	782	1,230	-448
Roots and tubers						
World	582,767	582,766	1	914,263	914,263	0
Developed countries	196,659	222,484	-25,825	252,895	282,521	-29,627
Developing countries	386,108	360,282	25,826	661,368	631,742	29,627
Asia	225,076	199,391	25,685	311,181	283,016	28,165
Latin America and the Caribbean	47,825	47,584	241	76,839	79,219	-2,379
Sub-Saharan Africa	100,810	100,785	25	251,854	248,400	3,454
West Asia and North Africa	12,024	12,199	-175	20,893	20,527	365

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 31—Production of, demand for, and net trade of livestock products by region, 1990 and 2020:
High-investment/rapid-growth scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Beef						
World	49,879	49,879	0	82,860	82,861	0
Developed countries	32,580	32,291	289	45,697	36,792	8,905
Developing countries	17,299	17,588	-289	37,163	46,069	-8,905
Asia	3,443	4,087	-644	9,849	17,349	-7,500
Latin America and the Caribbean	10,099	9,140	959	19,377	16,670	2,707
Sub-Saharan Africa	2,099	2,064	35	4,516	6,080	-1,562
West Asia and North Africa	1,651	2,278	-627	3,410	5,885	-2,475
Pigmeat						
World	66,902	66,900	0	137,699	137,698	0
Developed countries	37,343	37,703	-360	49,271	42,562	6,708
Developing countries	29,559	29,197	360	88,428	95,136	-6,708
Asia	26,031	25,585	445	80,839	86,817	-5,977
Latin America and the Caribbean	3,073	3,119	-46	6,460	6,835	-375
Sub-Saharan Africa	451	476	-26	1,121	1,436	-314
West Asia and North Africa	4	8	-4	7	20	-12
Sheepmeat						
World	8,810	8,810	0	19,157	19,158	0
Developed countries	3,889	3,570	319	6,323	4,264	2,060
Developing countries	4,921	5,240	-319	12,834	14,894	-2,060
Asia	2,159	2,104	55	6,156	7,334	-1,178
Latin America and the Caribbean	309	420	-111	675	786	-112
Sub-Saharan Africa	916	916	0	2,027	2,524	-498
West Asia and North Africa	1,535	1,792	-257	3,971	4,215	-244
Poultry						
World	37,278	37,278	0	73,571	73,572	0
Developed countries	23,795	23,459	336	37,006	30,529	6,477
Developing countries	13,483	13,819	-336	36,565	43,043	-6,477
Asia	6,001	6,006	-5	19,601	23,473	-3,872
Latin America and the Caribbean	4,791	4,729	62	10,364	10,747	-383
Sub-Saharan Africa	852	942	-90	2,192	2,892	-698
West Asia and North Africa	1,838	2,124	-286	4,405	5,846	-1,441
Total meat products						
World	162,869	162,867	0	313,287	313,289	0
Developed countries	97,607	97,023	584	138,297	114,147	24,150
Developing countries	65,262	65,844	-584	174,990	199,142	-24,150
Asia	37,634	37,782	-148	116,445	134,973	-18,528
Latin America and the Caribbean	18,272	17,408	864	36,876	35,038	1,838
Sub-Saharan Africa	4,318	4,398	-80	9,856	12,932	-3,076
West Asia and North Africa	5,028	6,202	-1,174	11,793	15,966	-4,173
Eggs						
World	35,420	35,420	0	74,640	74,640	0
Developed countries	18,351	18,261	90	25,629	22,724	2,905
Developing countries	17,069	17,159	-90	49,011	51,916	-2,905
Asia	11,074	11,109	-35	34,505	36,669	-2,163
Latin America and the Caribbean	3,690	3,702	-12	8,358	8,654	-295
Sub-Saharan Africa	682	675	7	2,004	2,109	-107
West Asia and North Africa	1,621	1,670	-49	4,139	4,470	-332

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 32—Production of, demand for, and net trade of livestock products by region, 1990 and 2020:
Trade liberalization scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Beef						
World	49,879	49,879	0	75,067	75,067	0
Developed countries	32,580	32,291	289	38,771	36,809	1,962
Developing countries	17,299	17,588	-289	36,296	38,258	-1,962
Asia	3,443	4,087	-644	9,065	13,414	-4,349
Latin America	10,099	9,140	959	19,865	14,306	5,559
Sub-Saharan Africa	2,099	2,064	35	4,258	5,145	-889
West Asia and North Africa	1,651	2,278	-627	3,098	5,330	-2,232
Pigmeat						
World	66,902	66,900	0	121,678	121,678	0
Developed countries	37,343	37,703	-360	44,716	39,577	5,139
Developing countries	29,559	29,197	360	76,962	82,101	-5,139
Asia	26,031	25,585	445	70,161	73,723	-3,562
Latin America	3,073	3,119	-46	5,779	6,980	-1,201
Sub-Saharan Africa	451	476	-26	1,014	1,355	-339
West Asia and North Africa	4	8	-4	7	18	-11
Sheepmeat						
World	8,810	8,810	0	17,187	17,187	0
Developed countries	3,889	3,570	319	5,231	4,814	417
Developing countries	4,921	5,240	-319	11,956	12,373	-417
Asia	2,159	2,104	55	5,744	5,690	54
Latin America	309	420	-111	645	739	-94
Sub-Saharan Africa	916	916	0	1,902	2,189	-287
West Asia and North Africa	1,535	1,792	-257	3,661	3,730	-69
Poultry						
World	37,278	37,278	0	67,539	67,539	0
Developed countries	23,795	23,459	336	33,758	31,769	1,989
Developing countries	13,483	13,819	-336	33,781	35,770	-1,989
Asia	6,001	6,006	-5	17,982	18,452	-470
Latin America	4,791	4,729	62	9,904	9,506	398
Sub-Saharan Africa	852	942	-90	2,016	2,488	-472
West Asia and North Africa	1,838	2,124	-286	3,876	5,258	-1,383
Total meat products						
World	162,869	162,867	0	281,471	281,471	0
Developed countries	97,607	97,023	584	122,476	112,969	9,507
Developing countries	65,262	65,844	-584	158,995	168,502	-9,507
Asia	37,634	37,782	-148	102,952	111,279	-8,327
Latin America	18,272	17,408	864	36,193	31,531	4,662
Sub-Saharan Africa	4,318	4,398	-80	9,190	11,177	-1,987
West Asia and North Africa	5,028	6,202	-1,174	10,642	14,336	-3,694
Eggs						
World	35,420	35,420	0	68,111	68,110	0
Developed countries	18,351	18,261	90	23,653	23,326	327
Developing countries	17,069	17,159	-90	44,458	44,784	-327
Asia	11,074	11,109	-35	31,027	30,918	109
Latin America	3,690	3,702	-12	7,774	7,869	-96
Sub-Saharan Africa	682	675	7	1,820	1,913	-95
West Asia and North Africa	1,621	1,670	-49	3,832	4,072	-241

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

**Table 33—Production of, demand for, and net trade of crops by region, 1990 and 2020:
Trade liberalization scenario**

Commodity/Region	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
	(thousand metric tons)					
Wheat						
World	530,713	530,715	0	843,564	843,564	0
Developed countries	303,786	241,186	62,602	407,350	291,620	115,730
Developing countries	226,927	289,529	-62,602	436,214	551,944	-115,730
Asia	157,882	184,913	-27,031	292,744	349,797	-57,053
Latin America	22,013	25,601	-3,588	37,463	43,138	-5,675
Sub-Saharan Africa	1,718	6,869	-5,151	4,545	16,967	-12,422
West Asia and North Africa	45,314	72,146	-26,832	101,462	142,042	-40,580
Rice						
World	349,466	349,179	-1	571,985	571,987	0
Developed countries	17,440	17,276	164	20,083	19,691	392
Developing countries	332,026	331,903	-165	551,902	552,296	-392
Asia	313,602	307,425	5,889	515,692	503,034	12,658
Latin America	10,594	11,483	-889	16,979	19,607	-2,626
Sub-Saharan Africa	4,281	7,082	-2,801	11,819	18,105	-6,287
West Asia and North Africa	3,549	5,869	-2,320	7,413	11,453	-4,039
Maize						
World	476,561	476,560	1	729,172	729,173	0
Developed countries	277,022	260,942	16,080	370,065	317,608	52,458
Developing countries	199,539	215,618	-16,079	359,107	411,565	-52,458
Asia	117,803	122,725	-4,922	211,676	236,611	-24,935
Latin America	52,521	57,637	-5,116	82,760	98,580	-15,819
Sub-Saharan Africa	21,068	21,308	-240	50,352	52,180	-1,829
West Asia and North Africa	8,145	13,939	-5,794	14,318	24,177	-9,859
Other coarse grains						
World	358,040	358,038	0	537,834	537,835	0
Developed countries	249,627	237,254	12,373	318,857	326,378	-7,521
Developing countries	108,413	120,784	-12,373	218,977	211,457	7,521
Asia	47,156	47,911	-755	83,445	74,822	8,623
Latin America	14,279	17,994	-3,715	24,568	25,185	-617
Sub-Saharan Africa	27,513	28,603	-1,092	72,346	67,572	4,674
West Asia and North Africa	19,465	26,260	-6,795	38,719	43,848	-5,129
Total cereals						
World	1,714,780	1,714,492	0	2,682,555	2,682,559	0
Developed countries	847,875	756,658	91,219	1,116,355	955,297	161,059
Developing countries	866,905	957,834	-91,219	1,566,200	1,727,262	-161,059
Asia	636,443	662,974	-26,531	1,103,557	1,164,264	-60,707
Latin America	99,407	112,715	-13,308	161,770	186,510	-24,740
Sub-Saharan Africa	54,580	63,862	-9,282	138,962	154,824	-15,862
West Asia and North Africa	76,473	118,214	-41,741	161,912	221,520	-59,608
Soybeans						
World	106,624	106,624	-1	185,780	185,780	0
Developed countries	57,925	60,334	-2,409	99,466	82,647	16,819
Developing countries	48,699	46,290	2,408	86,314	103,133	-16,819
Asia	15,352	19,497	-4,145	28,188	55,560	-27,373
Latin America	32,714	26,036	6,678	56,833	45,855	10,978
Sub-Saharan Africa	259	256	2	579	656	-77
West Asia and North Africa	374	501	-127	715	1,062	-347
Roots and tubers						
World	582,767	582,766	1	874,351	874,352	0
Developed countries	196,659	222,484	-25,825	252,383	257,290	-4,907
Developing countries	386,108	360,282	25,826	621,968	617,062	4,907
Asia	225,076	199,391	25,685	289,647	273,434	16,213
Latin America	47,825	47,584	241	74,676	77,371	-2,694
Sub-Saharan Africa	100,810	100,785	25	237,127	243,897	-6,770
West Asia and North Africa	12,024	12,199	-175	19,947	21,788	-1,841

Source: IMPACT simulation results.

Note: World net trade may not equal zero because of rounding.

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