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The World Food Outlook

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International Economics Department
of the World Bank

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Foreword

Hunger persists as a serious problem in many countries. However, this report clearly shows that the world food supply situation has been steadily improving and the prospects are good that this will continue, contrary to recent concerns. The issues of food production and poverty should be seen as ultimately separate issues. Hunger can persist amidst plenty. Hunger exists because poor people cannot buy enough food even when food prices are low. If the problems of hunger are to be overcome then the focus must be on alleviating poverty.

This is an especially important time to consider the prospects for the world food situation because of major changes in the developing countries and in the former centrally planned economies of Europe and the Soviet Union. The Green Revolution has matured in most developing countries and the rates of growth of cereals yields are expected to slow. However, the growth of demand for cereals is also slowing because diets have improved for most consumers in developing countries, and because a diversification of diets away from basic staples is occurring as consumers shift to meat, vegetables and fruits. Changes in the former centrally planned countries are even more rapid as consumption levels are falling due to reduced incomes and policy shifts away from subsidized consumer prices. Together these changes are expected to strongly influence the world's food supply/demand balance.

This report considers these important changes in an historical context and looking ahead to 2010. The conclusion reached is that the food situation should continue to improve for most households. This conclusion is supported by an analysis of past trends in world cereals markets as well as likely prospects for the future. The relatively optimistic outlook for the world food situation which the report projects should not be viewed as a reason for complacency. Continued investments in agricultural research are essential to continuing the past trends in production needed to achieve further gains in the world food situation.

Outlook work such as has been undertaken here is inherently difficult. The report illustrates how earlier forecasts have often fallen wide off the mark. The report recognizes this and tests the robustness of its conclusions over wide ranges of the basic assumptions. However, the inherent uncertainty does not invalidate the usefulness of undertaking studies such as this. It is an important input into the public debate.

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Malthus argued that world population would grow more rapidly than the capacity to produce food, and inevitably this would lead to hunger and malnutrition (Malthus, 1798). We have been able to escape his prediction in large part, although at certain times and in certain countries it has appeared that Malthus was correct. By committed effort, and perhaps good fortune, the mass starvation in developing countries which many feared has been largely averted. Will we continue to be able to escape his prediction as we enter the twenty-first Century?

In the 50 years since World War II, concern over this question has surged and waned--often in proportion to the size of the most recent year's harvest. The World Food Conference, convened in Rome in 1974, marked a pinnacle of concern in recent times and was inspired by two years of rapid food price increases. Since 1974, the world food problem has received less attention. Rather more attention has been given to specific countries or regions suffering from a drought or some other famine-inducing shock.

The last world food crisis occurred during the early 1970s when the world price of rice tripled and that of wheat doubled. This led to great concern about the world's ability to feed itself and caused significant hardship for many of the world's poor. Before that, two world wars had led to rapidly rising real food prices and concerns about shortages of food.[1] Following each crisis, food prices declined sharply as production caught-up with demand. The effect on wheat prices during each of these periods can be seen in Figure 1, which shows US wheat prices since 1800. As shown, real wheat prices have declined for more than a century--in terms of 1990 prices, from a high of $21.87 per bushel in 1855 to $3.43 per bushel in 1990.

The "world food problem" is often perceived in terms of the inability of production to keep up with the growth in world population. However, when we consider this, we often overlook the basic question of "at what price?" More food can be produced at higher prices and consumers will demand less, so within the question of "can we produce enough food to feed ourselves?" is an implied level of food prices. For example, when world grain prices rose sharply during 1972-74 to more than double their 1971 levels, grain consumption in the United States declined by 25%--a total of 46 million tons. This was more than equal to the total grain consumption of Egypt, Nigeria, and Pakistan combined in 1974 and nearly one-half of India's grain consumption. This rapid adjustment in the United States presents the world food problem in a dynamic context.

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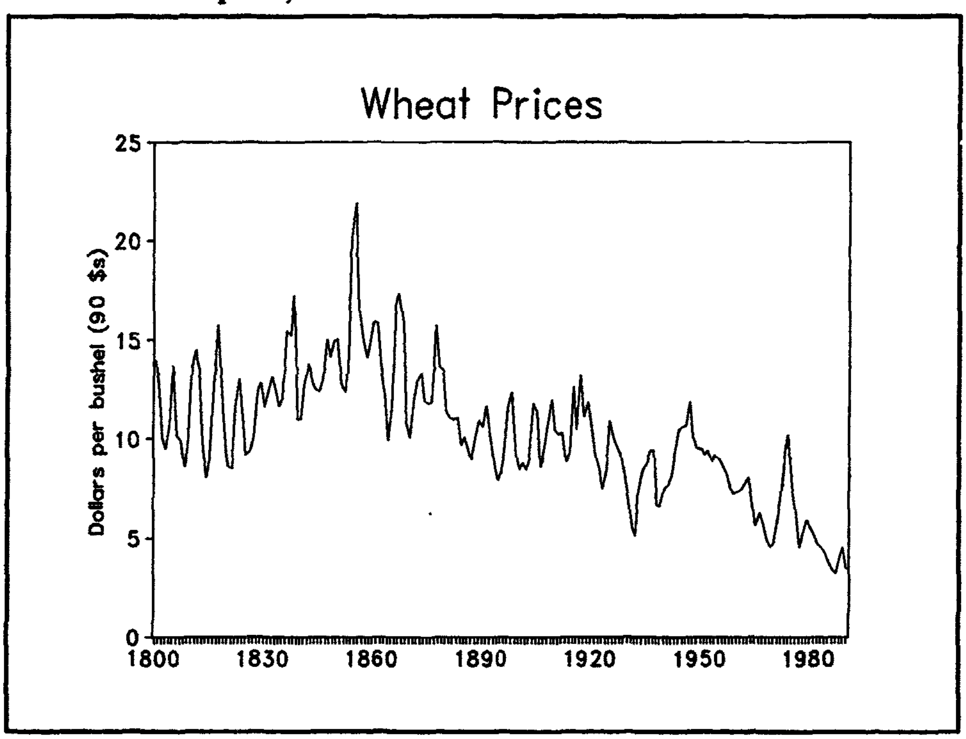
[1] Economists argue that a shortage does not exist as long as the market price adjusts to equate demand and supply. However, rapidly rising prices force the poorest consumers to reduce food consumption drastically--perhaps below the level needed to sustain life. Thus the popular definition of the term "shortage" is used in reference to food rather than the economists' definition.

Lower food prices are considered to be a necessary part of the solution to the world food problem. As shown above, food prices have declined in real terms for many decades. Moreover, food prices have been declining while food production has increased. This has only been possible because better technology and the resulting higher efficiency has allowed higher production on the same cropland.

We have come to expect improved diets for all as each decade passes. So the world food problem has another dimension--that of providing what is considered to be an adequate diet for all consumers. This is more a measure of economic development and the distribution of income among the world's consumers, but it has also been included as part of the conception of the world food problem. But, by broadening the definition in this way, it goes well beyond the question of food availability and includes the consumer's ability to purchase food. At times, consumers may not have the income needed to purchase an adequate supply of food for a variety of reasons ranging from temporary unemployment to extreme poverty, yet this is not really a world food problem.

Figure 1.1 US wheat prices, 1800 to 1990



Note: Prices are the US producer price of wheat deflated by the US producer price index.
Source: USDA, Agricultural Statistics; US Bureau of the Census.

What then is the world food problem? It is the problem of producing enough food for the world's population, but its many dimensions include the adequacy of consumer diets, the cost of food, and the level of production. The world food situation can best be understood within the context of economics and measured in terms of criteria such as the levels of prices, supply and demand. It must be described in terms of objective measures, such as the per capita level of consumption and the nutritional adequacy of diets, the per capita level of production, and the real price of food. These are the measures that we use to discuss the world food situation and its prospects in this book.

The Last World Food Crisis

It is important to understand the world food crisis of the early 1970s because it forms vivid memories for many of a world of shortages and yet the combination of factors which caused it were so unusual. Many factors combined to create the world food crisis and increasing population was only one of these. Further, it appears that many were unique and not likely to be repeated or to recur at the same time.

The most important of these factors was probably the sharp increase in crude oil prices. The average price of a barrel of crude oil rose from $1.90 in 1972 to $11.20 in 1974 (World Bank, 1992). This had many consequences, one of which was to cause a large redistribution of wealth. Oil-exporting countries, including a number of non-OPEC countries such as Mexico and the USSR, became substantially wealthier. This increased wealth provided the wherewithal for countries to change their consumption patterns and to increase food imports. Oil-exporting countries which were previously small participants in the world food markets became major grain importers, including Indonesia, Mexico, Nigeria, and the USSR.

Another important factor was the rapid income growth of oil-importing middle-income developing countries such as Brazil, China, the Republic of Korea, Hong Kong and Singapore. Economic growth in these countries was tied to manufacturing rather than petroleum, but the consequences were the same--demand for imported grain increased sharply.

Higher crude oil prices also contributed to the food crisis by increasing fertilizer prices sharply. For example, urea fertilizer prices rose from $59/ton in 1972 to $316/ton in 1974 (World Bank, 1992). This led to lower fertilizer use, lower grain yields, and increased demand for grain imports to replace the reduced production. Other important economic changes during the 1970s included the movement away from the fixed exchange rate system and the closer integration of the world's capital markets.

Besides these fundamental economic changes identified, other factors such as production shortfalls caused by poor weather in the USSR (grain production declined 7.4% in 1972) were also credited with causing the initial price increases. Subsequent production behavior in the USSR included a sharp decline in 1975, but it is difficult to determine whether this shortfall was caused by changes in economic variables such as fertilizer prices, by government policy changes, or by weather-related shocks--all concurrent events.

Government policy also played a role in creating the world food crisis. World grain stocks reached what were considered to be burdensome levels during the 1967-69 period and several major grain exporting countries implemented policies to reduce stocks quickly. The United States, Canada and Australia all reduced the area of grain production through a combination of government policies and producer responses to low prices. The immediate effect was to lower world grain stocks and to idle production capacity. Once done, the market was vulnerable to any shock either from a supply disruption caused by poor yields or a demand shock due to rising incomes. The first such shock occurred in 1972 when the USSR imported large amounts of wheat and caused world stocks to drop sharply. Prices rose, causing government policies to shift from restricting production to encouraging production through reduced restrictions on plantings. Producers also responded by increasing the area planted and inputs such as fertilizer. In this particular case, the high level of fertilizer prices due to the high energy prices dampened the response and slowed the increase in production.

Supply did increase, but not fast enough to keep up with demand which grew at rapid rates. The USSR, China and many other developing countries increased imports and kept up the pressure on prices. By 1981, world grain production had fully adjusted and production was 39% above the 1969-70 level. The demand for imports began to wane as a severe world recession began to weaken demand. The balance had shifted to surplus and grain stocks rose to historically high levels. The cycle was complete.

Views From The Past

The world food problem has long attracted comments and opinions from the expert and the not so expert. Views have most often been too pessimistic and ranged from concern to despair about the ability of the world to feed itself. But, in reality, we have done much better than almost anyone expected. As the FAO reported in 1988:

> "The outstanding fact in food and agriculture is that the past 25 years have brought a better-fed world despite an increase of 1.8 billion in world population. Average food availability rose from 2320 calories per caput in 1961/63 to 2660 calories in 1983/85. Earlier fears of chronic food shortages over much of the world proved unfounded."

World Agriculture Toward 2000
FAO, 1988, page 3

It is important to review the views experts and concerned observers from past times because it reminds us of the adaptability of people and resources to the needs at hand. The key element most often missing from past studies which concluded that food production would be unable to keep pace with population has been adequate consideration of the adjustments which are possible when events require them. Remember an example from the energy crisis of the early 1970s. After energy prices rose, cars were downsized, homes were better insulated, thermostats were lowered and manufacturing became more energy efficient. The same is true of food. If prices rise both consumption and production adjust. However, some of these adjustments require time and before they occur dire predictions about the future are often made. We present below a sampling of views from the past. We begin with a view from the very recent past and then consider views from the 1960s and 1970s.

In the State of the World 1990, Lester R. Brown, et al. of the Worldwatch Institute argue that feeding the world in the nineties will be a difficult, if not impossible, job. Brown et al. argue the case for a crisis in food production caused by environmental degradation. The argument appears convincing unless the complete story is known and understood. The issue is not just one of interpretation in which Brown sees a glass half-empty and others see a glass half-full. It is that Brown sees a glass which is nearly full, as empty.

Brown et al. states,

> "As we enter the nineties, the world has little to celebrate on the food front. Between 1950 and 1984, the world's farmers raised grain output 2.6-fold...since then, unfortunately, little progress has been made. ... Drought-damaged harvests in key producing countries in 1987 and 1988 brought world grain stocks to one of their lowest levels in decades...The 1989 world grain harvest ... depleted stocks even further. If stocks cannot be replenished in years of near-normal weather, when can they be?"

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The facts do not support this interpretation. World grain stocks reached their highest levels in history in 1986/87 at 28% of world consumption, causing grain prices to fall to their lowest level in many decades. The real prices of rice, wheat and maize declined 62%, 48% and 56%, respectively, relative to the highs at the start of the decade (World Bank, 1990). In response, the United States passed the 1985 Farm Bill which sharply reduced support prices to agriculture and reduced US cropland planted to grains by 19% in the period 1985 to 1987. The 1988 drought in the United States caused production to fall even further and world grain stocks fell to 17.7% of consumption in 1989. Even this was not critically low by historical standards. The average stock level from 1970 to 1990 was 20.5% of consumption and the stocks-to-consumption ratio was lower than the 1989 ratio four times during this period.

Brown et al. use the impact of the change in US policy to argue that production of grain is no longer increasing as it had from 1950 to 1984. But, in fact, the reason grain production slowed is because stocks became so large, particularly in the United States, that additional production could not be stored. A more relevant issue is, what did grain production do in the developing countries during the period from 1985 to 1990? The answer--it grew at its historical trend rate of 2.45% per annum (p.a.).

The Worldwatch Institute is not the first to worry about the ability of the world to feed itself, nor is this the first time that Lester Brown has worried about the problem. In fact, Brown has made a career of worrying. At an earlier time, he wrote:

> "In the early 'seventies the soaring demand for food, spurred by both continuing population growth and rising affluence, has begun to outrun the productive capacity of the world's farmers and fishermen. The result has been declining food reserves, skyrocketing food prices, and intense competition among countries for available food supplies."
>
> page 1

"The deterioration of the world food situation during the first half of the current decade, together with currently foreseeable trends, also makes it quite clear that the world cannot remain long on its present demographic path. The choice is between famine and family planning, ..."

Lester R. Brown with Erik P. Eckholm
By Bread Alone, 1974, page 12

A sampling of predictions about the world food situation are the following:

> "Americans are beginning to realize that the undeveloped countries of the world face an inevitable population-food crisis. Each year food production in undeveloped countries falls a bit further behind burgeoning population growth, and people go to bed a little bit hungrier. While there are temporary or local reversals of this trend, it now seems inevitable that it will continue to its logical conclusion: mass starvation"

Dr. Paul R. Ehrlich
The Population Bomb, 1968, page 17

"In thirteen years India is going to add two hundred million more people to their population. In my opinion, as an old India hand, I don't see how they can possibly feed two hundred million more people by 1980. They could if they had the time, say until the year 2000. Maybe they could even do it by 1990, but they can't do it by 1980."

Raymond Ewell as quoted from
The Population Bomb, 1968, pages 39-40

"The famines which are now approaching will not, in contrast, be caused by weather variations and therefore will not be ended in a year or so by the return of normal rainfall. They will last for years, perhaps several decades, and they are, for a surety, inevitable. Ten years from now parts of the undeveloped world will be suffering from famine. In fifteen years the famines will be catastrophic and revolutions and social turmoil and economic upheavals will sweep areas of Asia, Africa, and Latin America."

William and Paul Paddock
Famine - 1975!, 1967, page 8

Not even some of the most prominent agricultural economists expected the gains in food production which have occurred in the past several decades. Consider the following opinion from Earl O. Heady, a distinguished agricultural economist and noted authority on the world food situation.

> "... if population continues to grow at present rates, the world's population would double in the next thirty-five years and would press food needs hard against production potential. The world's land area cannot double; nor can food production easily do so. For the world as a whole, the problem is not whether there will be a food surplus, but whether the world can feed itself."

Earl O. Heady
A Primer on Food Agriculture and Public Policy
1967, page 160

The facts are that the growth of world grain production, which is a good measure of world food production, is ahead of schedule to double in the period of 35 years from 1967 when Heady wrote those comments. Yet land area used for grain production only increased by 3.6% from 1967 to 1991 while yields increased 59%. World grain production grew by 2.1% p.a. from 1967 to 1991 and it would seem to have been capable of even faster growth had it not been for rapidly falling grain prices, rising surpluses and government supply control programs--especially in the United States. Since the 1981 peak, world area used for grain production has declined by 5.7%.

Not all who have studied the world food situation have reached a pessimistic conclusion. Many have written optimistically about the future even while others predicted famine and hunger. Some prominent agricultural economists who have been more prescient have written as follows:

> "I should like to unfurl the banner of hope, a hope that arises because it now seems possible to win the war against hunger within the next ten or twenty years...My optimism arises out of the conclusions of a study [which] reveals the startling fact that some newly developing countries are already increasing their agricultural production at rates far higher than those ever achieved by the highly developed nations--including my own."

Orville L. Freeman
US Secretary of Agriculture
Address to FAO, 1965

"IT HAS BEEN THE BASIC THESIS of this study that population growth has not run away from food production in the developing world; we believe that a careful review of the recent historical records supports this thesis. Population growth, it is true, has been rapid and shows no signs of slowing down in the near future; but rates of increase in food production have been equally rapid. Both population growth and agricultural development have been, and continue to be, highly dynamic factors in the developing world."

Willard W. Cochrane
The World Food Problem, 1969, page 299

These views from the past should remind us how well we have done in solving the world food problem since the mid-1960s. The comments of noted experts such as Earl Heady reflected the magnitude of the task which the world faced. Having done so well, the future appears less daunting.

Major Changes Affecting the World Food Situation

Prior to World War II, the problem of food shortages was largely isolated within regions because the cost and capacity for large movements of food between countries prevented a global response to a food crisis. Among the many changes which occurred following World War II, possibly the most important was the rapid growth of population in the developing countries. From 1950 to 1970, population growth accelerated due to reduced infant mortality and increased life expectancy. During this period, population increased by 57% in the less developed countries and 26% in the more developed countries (UN data). This growth led to rapidly increased food demand, which was initially met by expanding cropland area. As less productive lands were used, yield levels fell and hunger and famine became a reality.

A second major change which was to have long-term implications for the world food situation came in response to the food crisis in India in the 1960s. The prospect of millions of starving people shocked the world and unleased a two-pronged attack on world hunger. The immediate response was large shipments of food aid from the surplus producers (mainly grain from the United States) to feed the hungry and the second was a long-term commitment by the developed countries to assist the developing countries in increasing food production. This second type of assistance took many forms and included large-scale investments in irrigation with the help of multilateral institutions such as the World Bank, technical assistance in the form of training agricultural researchers, development of extension programs to teach farmers better methods of production, and investment in an international complex of research stations which focused on improving yields for key crops. The effort was a success and led to what is now called the "Green Revolution". It allowed many countries to increase food production dramatically. This marked a turning point in the world food situation and allowed diets to begin to improve for most of the world's consumers.

A third major change which has occurred is the increased interdependence of the world economies. Closer international interdependence has been taking place for centuries, but the pace of change accelerated during the 1970s and 1980s. This has had major implications for the world food situation. As developing countries rapidly increased exports of manufactured goods and raw materials to the industrial countries and other developing countries, they were able to import food to add variety to their diets or to supplement their consumption of basic staples. This development broke the economic isolation that previously required each country to be nearly self-sufficient in food production. World grain trade doubled from 1970 to 1980 and most of the increase went to developing countries. The net grain imports of developing countries increased from 17.7 million tons in 1970 to 60.4 million tons in 1980--an increase from 3.5% of total consumption in 1970 to 8.2% in 1980. Since 1980, net grain imports by developing countries have been 7%-10% of consumption (based on USDA data).

A fourth major change has been the very recent political and economic disintegration of the communist bloc comprising the Soviet Union and Eastern European countries. These former centrally planned economies (former CPEs) were major grain importers during the 1970s and 1980s and their sharply increased imports contributed directly to the world food crisis of the 1970s. While the political and economic transition in these countries is still unfolding, it is very clear that major changes in food consumption and agricultural production will occur as a result of future developments in that area. Consumption levels of cereals were extraordinarily high in the former Soviet Union (FSU) and Eastern Europe compared to other countries with similar income levels because of the highly subsidized prices and probably also because of the shortage of other consumer goods. These levels have begun to decline and will most likely fall sharply before economic growth resumes. Agricultural production has also declined, but most experts agree that substantial production potential exists. There may well be a dramatic change in the pattern of world agricultural production and trade because the FSU and Eastern Europe have accounted for as much as 25% of world grain imports during the past 20 years and it is possible that they may become net grain exporters in the next decade or so.

The FSU has vast areas suited to grain production, as do parts of Eastern Europe. The reforms will probably focus on agriculture since this is one of the few sectors where quick results in the exploition of comparative advantage might be expected. Reforms will be needed in the transportation sector and improvements will be needed in harvesting and storage capacity. The timing of such reforms are only speculation, but their implementation could eventually lead to exports of 20-40 million tons of grain from the region. This would be a very significant change in world grain trade because these countries imported an average of 42 million tons per year during the 1980s (based on USDA data).

A fifth major change has been in the agricultural policies of developed and developing countries. In developing countries, agriculture has often been taxed while industry has received favored treatment (Krueger, Schiff and Valdés, 1988). Overvalued exchange rates have been widespread as have high production or export taxes on food production. Despite these policies, production has increased in developing countries due primarily to the technological developments of the Green Revolution. Since about 1980, however, policy reforms have taken place in many developing countries which have increased the competitiveness of their agricultural sectors. These changes can be expected to increase production in developing countries as farmers respond to higher prices. Even more significantly, producers in developing countries will be more responsive than they have been in the past to changes in world prices, which further reduces the chances of a world food crisis.

In developed countries, policies have increasingly favored agriculture over other sectors and this has led to over production and lower prices on world markets. This has both helped and hurt developing countries. Those developing countries which have imported grains and other food items from world markets have benefited from the lower world prices; but countries which export or have the potential for exporting have seen their markets diminish and the prices of their exports fall. The lower world prices have also hurt producers in developing countries by forcing down domestic market prices.

Each of these major changes has been important in shaping the world food situation. We can expect further changes. The next 20 years are probably the most critical to the future of the world food situation. Beyond that, population growth is projected to slow dramatically and most people should have achieved adequate diets. The growth in world food demand will probably be less than historical increases in crop yields. If genetic engineering and biotechnology fulfill their promise, agricultural productivity may even accelerate from past trends. Trade levels may increase as many countries find it less costly to import than to try to force self-sufficiency.

Chapter Outline

The remainder of the book will seek to answer the issues raised in this chapter. Chapter II measures changes in the world food situation since 1960 in terms of specific criteria relating to nutrition, production, prices and productivity. It shows how well the world has done with respect to the world food problem and it shows those regions and countries which have done well and those which have not done so well. Chapters III-V look at population, the agricultural resource base and consumption to better understand the key determinants of food demand and supply. Chapter VI considers the special problems of Africa. Chapters VII-IX report simulations of a model of the world grain market to 2010 within the context of the discussion in this chapter. They investigate the question: can the world feed itself at increasingly higher standards during the next 20 years, and what are the factors most critical to the world food situation? Finally, the last chapter summarizes the conclusions drawing together the lessons of the book. An Appendix chapter describes the simulation model of the world grain markets.

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Chapter II. Assessing the World Food Situation

The first task in understanding the world food situation is to assess the situation according to objective criteria. Several measurements can be taken to show how the world food situation or the situation in particular countries has changed in recent decades. We assess food prices, consumption and production. But, since no absolute level of these variables is "correct" we base our assessments on comparisons among countries and changes within countries. We focus mainly on the world situation and on the developing countries and give less attention to the developed countries where there is no widespread problem of undernourishment.[1]

The price of food is one of the most important measures of the world food situation since it reflects the overall demand/supply balance. If food prices are rising faster than other consumer prices then food is becoming relatively more costly for consumers, and vice versa. An index of food prices relative to income levels is also an important measure of the cost of food. If per capita incomes are rising faster than food prices, then the consumer can spend a declining share of income on food and maintain the same diet. We consider both of these indicators.

While not a complete measure of the level of nutrition, the calories consumed or available to consumers is a second useful measure of the food situation. The trend in per capita calories consumed shows whether diets are improving. This is an important measure in countries where undernutrition is a serious problem. We also consider quantities of food available for consumption, and protein and fat availability, per capita, for countries and regions.

A third useful measure of the food situation is food production, since domestic production is the major source of food supplies in most countries. In general, we expect consumers in countries which increase food production more rapidly than population to benefit from the larger volumes available and from falling real food prices. This criterion is not as important for countries which have high or rapidly rising income levels since they are able to import. Food production in these countries may also be increasingly unprofitable as wages and land prices rise due to competition for use in other economic activities. However, on a global scale increasing per capita food production is essential to increased consumption.

Together, these three measures provide a solid basis for assessing the food situation in a country, region, or the entire world. A caveat should be noted, that good data on all of these measures are not available for all countries. Particularly in Africa, data on food production,

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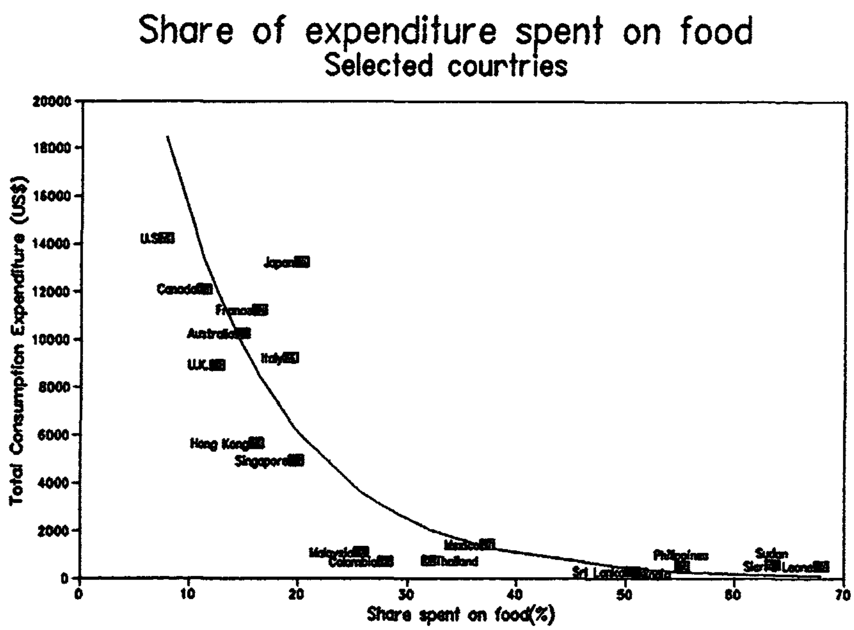
[1] The definition of developed and developing countries used in this chapter is taken from FAO, since much of the analysis is based on FAO data. The developed countries include the countries of North America, Eastern and Western Europe, the FSU, Australia, Iceland, Israel, New Zealand and South Africa. The developing countries include all other countries.

consumption, prices, and incomes are of poor quality. Also note that we are primarily considering national average data and the situation can vary substantially among groups within a country.

Food Prices

Food is the largest single expenditure for most consumers in developing countries and it accounts for more than one-half of total expenditures in many countries. In Sub-Saharan Africa, food expenditures account for as much as two-thirds of total personal consumption expenditures. Even in developing countries which have had rapid economic growth in recent years, such as India, food expenditures still account for about one-half of total personal consumption expenditures (Figure 2.1). In Mexico, food expenditures account for about 37% of total personal consumption expenditures and in Thailand the share is 31%.

Figure 2.1 Percentage of personal consumption expenditures spent on food consumed at home 1/



Source: Food Consumption, Prices, and Expenditures, 1970-90, USDA, Economic Research Service, Statistical Bulletin No. 840, August 1992.
1/ Food includes alcoholic beverages and tobacco.

The share of food in total personal consumption expenditures declines quickly as incomes and expenditures rise. Hong Kong and Singapore spend less than 20% of their total personal consumption expenditures on food--much the same as many Western European countries. Among developed countries, expenditure on food for at-home consumption ranges from a low of 7.8% in the United States to a high of 20.2% in Japan. Japan spends a higher share of personal expenditures on food than other countries with similar incomes due in part to restrictive import policies which maintain prices at higher levels than in other countries.

Information on food consumed away-from-home is less readily available, but for the United States where such data are available, this form of food consumption accounted for an additional 4.8% of total personal expenditure (USDA, 1992). Thus, the total expenditure on food in the United States was about 12.6% of total personal consumption expenditure in 1989. Countries with lower incomes are likely to spend a smaller share of their total expenditures on food for consumption away-from-home.

The price of food to the consumer consists of the price of the raw food product as well as the "marketing costs," which include the costs of transportation, processing, retailing, preparation, etc. In the US, only 24% of expenditure on food was accounted for by the farm value of the food (about 3% of disposable income), with marketing costs making up the balance (USDA, 1991).[2] The cost of raw food commodities has declined sharply in the post-war period except for the period during the 1970s, as indicated by the index of world food commodity prices in constant 1990 prices (Figure 2.2). From 1950 to 1992 the index fell by 78%.

While world food commodity prices have declined sharply, retail food prices have not because of rising marketing costs. In the United States, where 76% of retail food costs were marketing costs in 1990, the largest component of marketing costs was labor which accounted for nearly 50% of the total. Marketing costs are closely linked to the overall price level in the economy and increase at about the same rate as the consumer price index. This has caused the retail price of a market basket of food to increase at nearly the same rate as the consumer price index in the United States.

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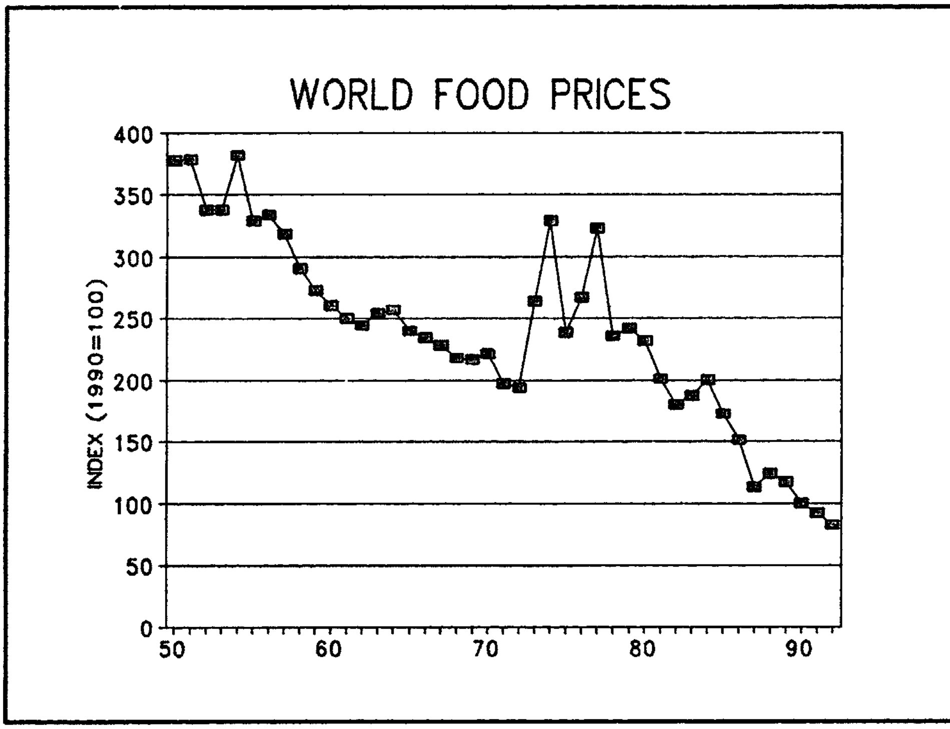
[2] As an aside, US consumers spend nearly as much on alcoholic beverages as on the farm value of US food production. In 1990, the farm value of US produced food products was $106.6 billion while the total expenditure on alcoholic beverages was $81 billion.

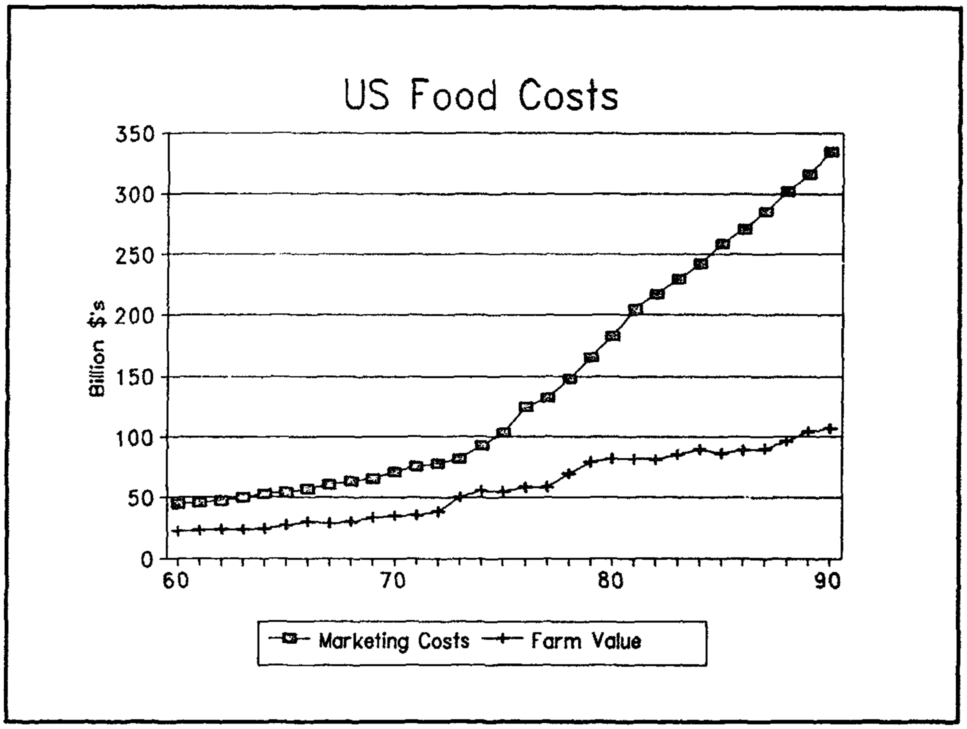
Figure 2.2 World food prices, 1950-92, in constant 1990 prices



Source: Market Outlook for Major Primary Commodities, Report No. 814/92, International Economics Department, World Bank, October 1992.
Definition: The index is the World Banks's index of food prices and it is deflated by the G-7 index of consumer prices, 1990=100.

The amount of processing going into food preparation has also increased over time in the United States and this increases the marketing bill for food even faster (Figure 2.3). This trend reflects consumer preferences for more prepared foods which take less cooking and less preparation time, and the trend towards eating more meals in restaurants. In 1970, marketing costs accounted for 61% of the retail cost of food in the United States, but by 1990 they accounted for 76% (USDA, Ag Stat, 1991). The increase in marketing costs reduces the sensitivity of retail food prices to changes in food commodity prices and causes food prices to more closely follow the trend of general consumer prices. As the farm value of retail food costs decline, consumers can control food costs by selecting the level of services. This can be done by purchasing food which has more or less preparation and by changing the proportion of meals eaten in restaurants. The fact that consumers make such choices is apparent by the number of restaurants which close during a recession.

Figure 2.3 US farm value and marketing costs of food



Source: US Department of Agriculture, Agricultural Statistics, 1991 and 1976.
Note: Marketing costs are the difference between total expenditures for domestic farm-originated food products and the farm value or payments received for the equivalent farm products.

An alternative measure of food prices is given by comparing per capita incomes with the index of retail food prices. This indicates how the consumer's ability to purchase a market basket of food has changed. Figure 2.4 shows the per capita disposable income and the retail food price index for the United States, both deflated by the US consumer price index for all consumer items. This figure shows that disposable income has more than doubled since 1950, while the cost of a constant market basket of food has remained about constant. Similar trends are observed in developing countries as retail food prices remained nearly constant and per capita incomes more than doubled since the early 1960s.

Real per capita GDP[3] increased an average of 162% for consumers in developing countries from 1960 to 1990 (computed from World Bank, GEP, Table 1, 1992). The growth rate was most rapid during the 1960s at 3.9% p.a. and 1970s at 3.7% p.a. The growth rate slowed during the 1980s to 2.2% p.a. Incomes of consumers in East Asian developing countries grew the most rapidly and Sub-Saharan African countries grew the least.

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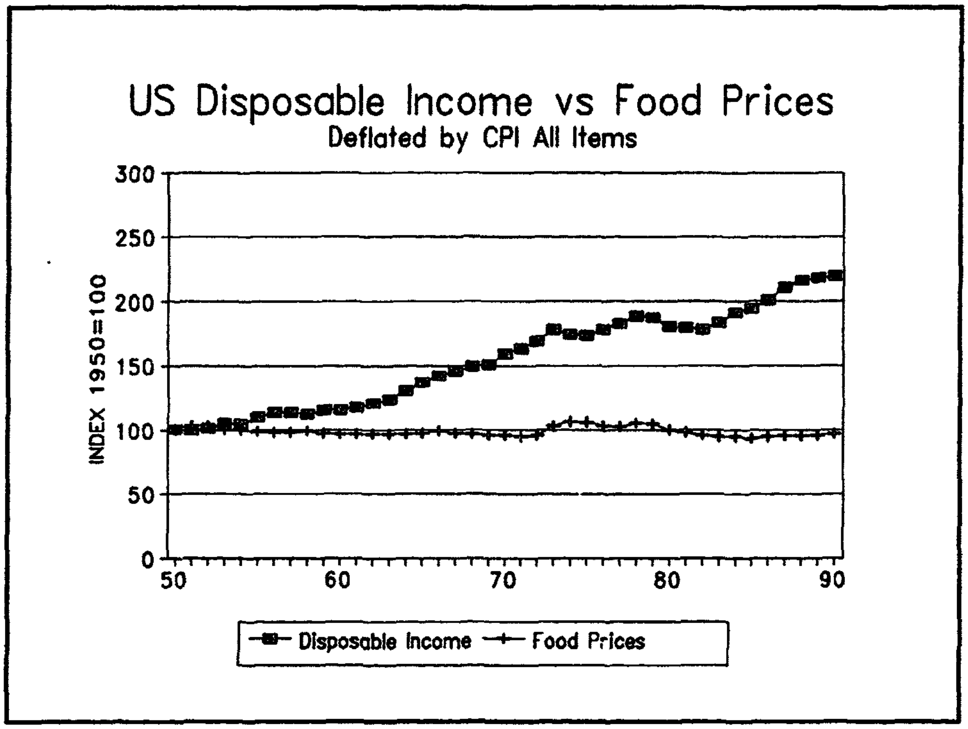
[3] Real per capita GDP was used as the measure of income in developing countries because of the difficulty of obtaining disposable income data.

Figure 2.4 US disposable income and food prices, 1950-90

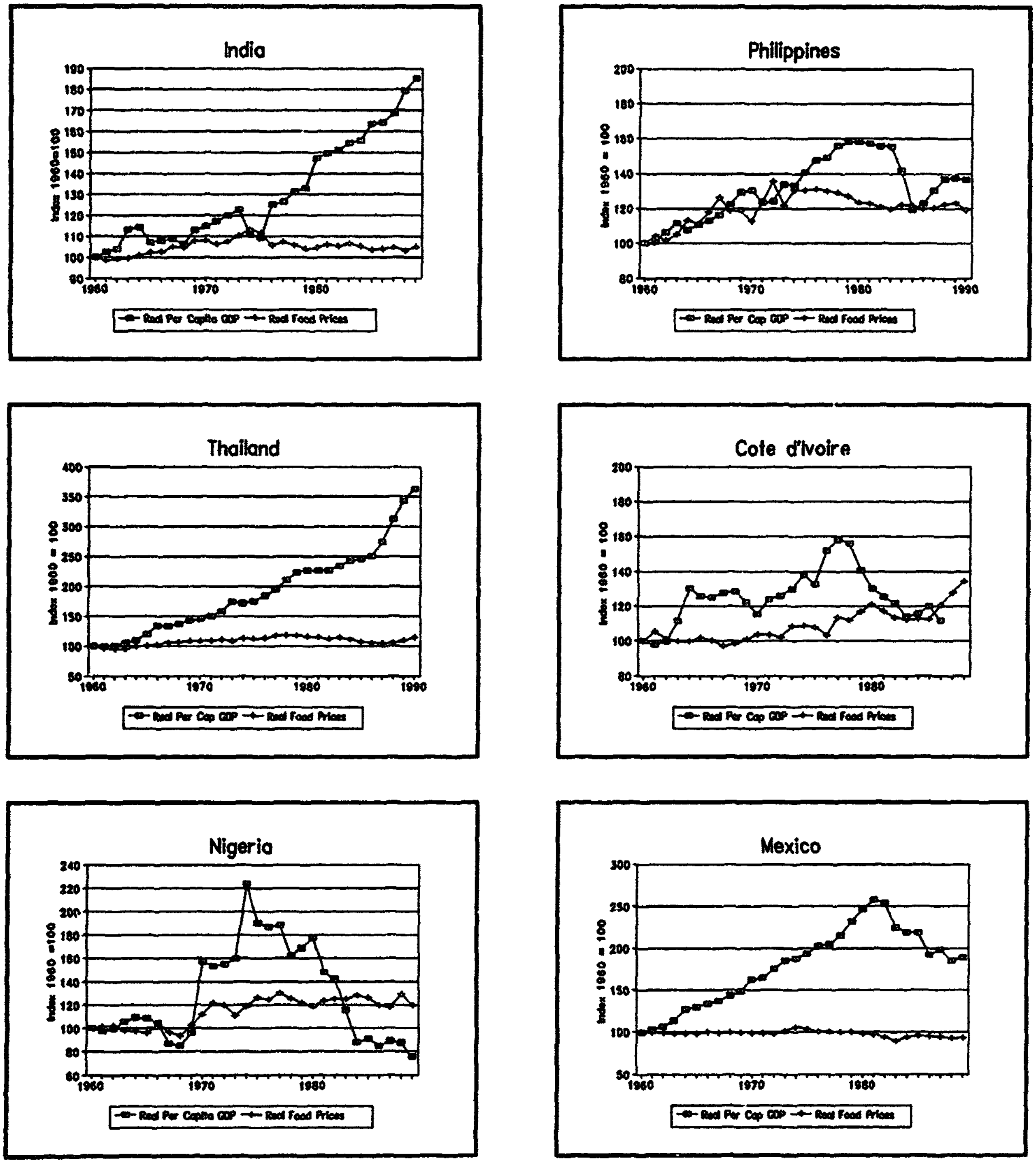


Source: USDA, Agricultural Statistics, various issues.

Figure 2.5 shows the indexes of retail food prices and per capita GDP for selected developing countries from 1960 to 1990. As with the case in the United States, retail food prices have remained relatively constant compared with the overall level of consumer prices, while per capita GDP has risen for many countries. India, for example, has had only a slight increase in the index of real food prices from 1960 to 1990, while real per capita GDP nearly doubled. This indicates a major increase in the ability of consumers to purchase food.

Thailand had an even more dramatic increase in real per capita GDP of more than 250%, while real food prices remained nearly constant. Mexico had rapid gains in the level of real per capita GDP during the 1960s and 1970s relative to real consumer food prices, but suffered a severe setback during the 1980s as GDP declined. The Philippines had significantly higher per capita GDP during the 1970s and early 1980s, but lost those gains during the transition from the Marcos rule during the early 1980s. Nigeria and Côte d'Ivoire both had rising per capita GDP for a period, but faltered while real food prices rose relative to other consumer prices.

Figure 2.5 Comparison of real per capita GDP and real food prices, selected countries, 1960-90



Source: International Monetary Fund, International Financial Statistics, (various issues) for GDP and consumer prices and, International Labor Organization, Yearbook, (various issues), for retail food prices

Consumers in Nigeria were less able to afford a constant market basket of food in 1990 than in 1960 as real per capita GDP declined from the peak reached in 1974 and the index of real food prices increased steadily.

The general rise in commodity prices during the 1970s had a small impact on retail food prices in most countries. This occurred for several reasons. In the United States, it was due primarily to the relatively small share of food products in total expenditures. In many developing countries, it was due to government policies which maintained food prices constant to the consumer even as international prices rose.

Food prices have declined relative to incomes for most consumers in both developed and developing countries. This has primarily resulted from rising real per capita incomes and nearly constant retail food prices. However, the retail expenditures on food have continued to increase because the cost of food has included an increasing level of services such as ready-to-cook, ready-to-serve and ready-to-entertain meals and of meals eaten in restaurants. When these factors are considered, consumers are better able to purchase food and they also have greater selection in the level of services which they are able to purchase.

Measures of Nutrition

The second measure of the food situation which we consider, is the level of nutrition. Per capita calorie supplies in developing countries rose by about 27% from 1961-63 to 1987-89 (see Figure 2.6). This rapid increase was helped by both increases in domestic food production and by increases in imports which became possible as incomes rose. Since 1980, the average level of per capita calorie supplies has exceeded the estimated minimum daily calorie requirement for developing countries. The minimum daily calorie requirement depends upon many factors such as the sex, age and activity level of each person. Therefore the requirement of 2,310 calories per day shown in Figure 2.6 is only an approximation.[4]

While the gains are impressive, we cannot conclude that all consumers have an adequate diet. The average for all developing countries hides the distribution of calories both within countries and among countries. Hunger, undernutrition and malnutrition are very serious problems for many people. A distinction between undernutrition and malnutrition should be made. Undernutrition is defined as a status resulting from insufficient food while malnutrition arises from diets based on the wrong kinds or proportions of food or from deficiencies of specific nutrients (FAO, 1987, page 17). In developing countries, undernutrition is the primary problem and it is caused by a dietary energy intake below the minimum requirement level. It is often accompanied by inadequate levels of protein or specific nutrients. Among developed countries, the principal nutritional problem is overnutrition and the improper composition of diets which leads to malnutrition (FAO, 1987, page 18).

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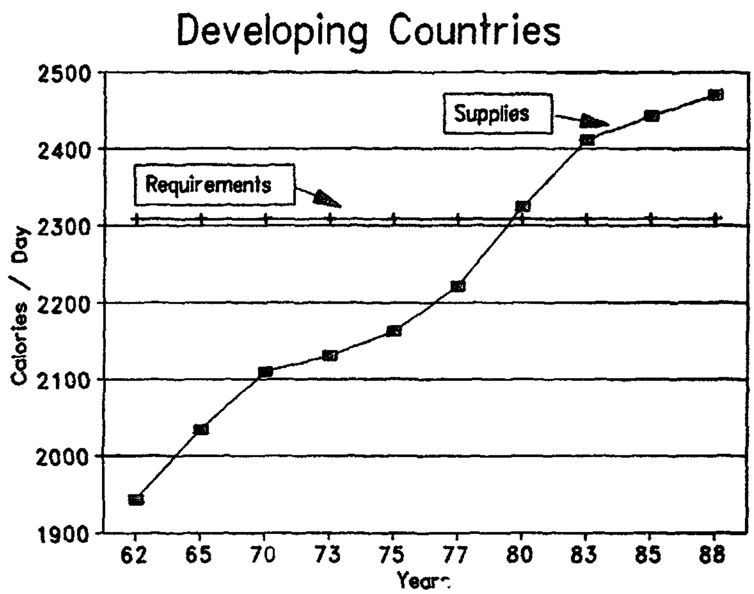
[4] The estimate is taken from the FAO, The Fourth World Food Survey, 1977. However, in discussions with nutrition experts, a range of estimates from 2,100 to 2,300 were suggested.

Figure 2.6 Per capita calorie supplies in developing countries



Source: FAO, Food Balance Sheets, 1991 and FAO, The State of Food and Agriculture, 1991 for calorie supplies and FAO, The Fourth World Food Survey, 1977 for calorie requirements.
Note: Years shown represent the center year of a three year average.

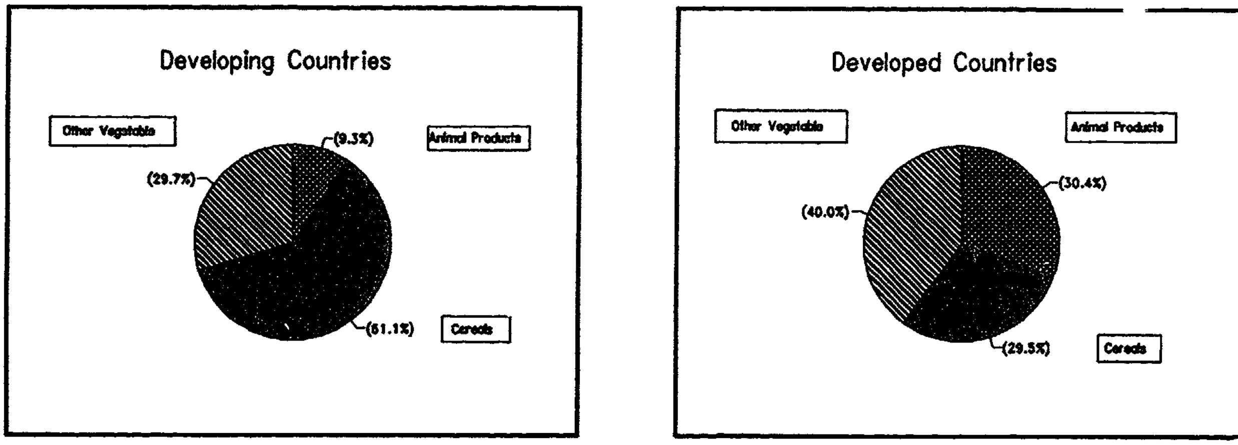
Despite steady increases in calorie supplies in developing countries since the 1960s, an estimated 20% of the population of the developing countries are chronically undernourished. The estimated number of people in developing countries sufferung from chronic malnutrition has declined from 941 million during 1969-71 to 786 million during 1988-90 (FAO, 1993, pages 42-43). The proportion of the population which is malnourished has declined from 36% to 20% over the 1969-71 to 1988-90 period. However, roughly 60% of the world's population now live in countries which have average daily calorie supplies of 2,600 or more--the level considered "relatively comfortable" by FAO (FAO, 1991, page 13).

Diets in Developed and Developing Countries

Diets vary greatly due to culture, income levels, prices, food availability and other factors. The global average for per capita food disappearance during 1986-88 was about 1.63 kg or 3.6 lb of food per day. In developed countries, disappearance was estimated at 2.55 kg, while for consumers in developing countries it was about one-half this amount--1.33 kg. Not all of this food was consumed, some was "wasted," some was fed to pets, but this was the quantity of food available on average according to the FAO. Data are not available for most countries to allow a further breakdown of food use into consumption, waste, etc., thus much of the discussion is on food disappearance rather than consumption. The disappearance data relate to the quantities of food available for consumption after allowing for "waste" on farms and during distribution and processing.

The diets of consumers in developing countries had a much higher proportion of cereals and a lower proportion of animal products, fruits, vegetables, meat and milk than diets in developed countries (see Figure 2.7). Consumers in developing countries consumed only 14% as much alcoholic beverages on average as consumers in developed countries. Meat and offal disappearance accounted for 9% of the diet in developed countries and 3.5% of the average diet in developing countries.

Figure 2.7 Contribution of major food groups to per capita calorie supplies, 1986-88



Source: FAO, Food Balance Sheets, 1991

The average calories available for consumption in developing countries was only 72% of the levels in developed countries. Cereals accounted for 61.1% of total calories in the developing countries but only 29.5% in the developed countries. Other vegetables accounted for 29.7% of total calories in developing countries but 40% in developed countries. Meat and offal comprised 13.3% of the calories in developed countries and 4.5% in developing countries. Animal products combined accounted for 9.3% of the calories in developing countries but 30.4% of the calorie consumption in developed countries.

The differences in protein consumption between developed and developing countries are even greater than for calories. Consumers in developing countries had only 58% as much protein available for consumption as consumers in developed countries. For developing countries, animal products accounted for only 22% of protein intake while in developed countries they accounted for 58%. Cereals accounted for 58% of protein intake in developing countries and 28.6% in developed countries.

Cereals availability, the main source of both calories and protein in developing countries, increased 26.4% while the contribution of starchy roots such as cassava declined 22% over the period. In developed countries, consumption of both cereals and starchy roots declined--by 12.7% and 19.2%--respectively, while fruits, vegetables, meat, fish and sweeteners all increased.

Diets in developing countries appear to have reached a turning point during the early 1980s. The share of cereals and starchy roots peaked while consumption of meat, fruits, vegetables, milk, fish and seafood continued to increase. Since 1982-84, cereals consumption has remained nearly constant at 203-205 kg per capita while the consumption of starchy roots has declined. If this trend continues it would reflect a shift from increasing quantity to increasing "quality" in the diet.

Per Capita Food Supplies

Food balance sheets present a comprehensive picture of a country's total food supplies. FAO first published food balance sheets in 1949 for 41 countries and expanded coverage to about 200 countries and territories from 1961 onwards. The statistics draw on some 300 primary crop, livestock and fishery commodities and about 380 processed products.[5] Data are presented in 3-year averages for individual countries and for developing and developed regions and the world. The food balance sheets include the total production in the country, imports and stock changes for each food item to arrive at the supply available during the period under analysis for each food item. Adjustments are made for livestock feed, seed, manufacturing or other uses or losses during storage and transportation to arrive at food supplies available for human consumption. These calculations lead to estimates of the quantities of food reaching the consumer, but losses within the household are not measured. Data on per capita food supplies are expressed in quantities and by calories, protein and fat. The data are the most comprehensive available for a large number of countries and cover nearly 100% of the population of both developed and developing countries.

Overall, the food balance sheets show that per capita food supplies in developing countries have increased at a steady pace since 1961-63. Since these data only measure food supplies available for human consumption, however, we cannot say that consumption itself increased proportionately, but it seems reasonable to believe that this was the case. Table 2.1 presents per capita food supplies by country. The minimum daily calorie requirements, as estimated by FAO, are also included along with the percentage of these requirements met by the 1986-88 calorie supplies.

The country results are varied, with some countries showing sustained increases in per capita calorie supplies over the period while others stagnated or even declined. These differences occur within regions so it is not possible to conclude, for example, that all Asian countries increased their per capita calorie supplies. Some did not. The level of calorie supplies also varies greatly between regions and most likely these differences reflect cultural and

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[5]FAO, Food Balance Sheets, 1991, Rome, Italy; page ix of introduction.

Table 2.1 Per capita calorie supplies, selected countries

Country	1961-63	1969-71	1979-81	1986-88	Minimum Daily Requirement	Share of Minimum Requirement in 1986-88
			Calories/Day			
Africa						
Burkina Faso	1747	1787	1815	2037	2370	86
Cameroon	2054	2205	2215	2180	2320	94
Côte d'Ivoire	2178	2392	2543	2448	2310	106
Ghana	2018	2200	1953	2201	2300	96
Mali	1866	1848	1714	2147	2350	91
Mozambique	1749	1802	1802	1622	2340	69
Nigeria	2187	2133	2255	2104	2360	89
Sudan	1854	2175	2354	2071	2350	88
Tanzania	1785	1813	2254	2228	2320	96
Asia						
Bangladesh	1975	2065	1906	1924	2310	83
China	1671	1989	2328	2637	2360	112
Hong Kong	2511	2648	2758	2883	2290	126
India	2036	2016	2091	2104	2210	95
Indonesia	1748	1982	2375	2631	2160	122
Japan	2535	2741	2791	2822	2340	121
Korea, Dem. P.R.	2272	2471	3013	3172	2340	136
Korea, Republic	2044	2528	2829	2867	2350	122
Malaysia	2337	2445	2623	2665	2230	120
Pakistan	1726	2031	2231	2167	2310	94
Philippines	1751	1819	2299	2235	2260	99
Singapore	2258	2693	2707	2882	2300	125
Sri Lanka	2102	2256	2256	2297	2220	103
Thailand	2019	2211	2305	2288	2220	103
Europe and Middle East						
Czechoslovakia	3370	3397	3418	3540	2470	143
Hungary	3105	3331	3478	3635	2630	138
Poland	3227	3390	3516	3434	2620	131
Turkey	2662	2851	3042	3084	2520	122
FSU	3147	3323	3370	3382	2560	132
Morocco	2190	2410	2723	2856	2420	118
Egypt	2277	2447	3031	3344	2510	133
Latin America & Caribbean						
Argentina	3130	3317	3243	3168	2350	135
Brazil	2321	2504	2623	2703	2390	113
Chile	2557	2659	2658	2581	2440	106
Colombia	2231	2167	2491	2544	2320	110
Cuba	2260	2569	2823	3103	2310	134
Dominica	2031	2178	2445	2884	2420	119
Haiti	2028	1959	2026	1992	2260	88
Jamaica	2034	2533	2575	2579	2240	115
Mexico	2493	2622	3014	3123	2330	134
Peru	2226	2289	2196	2277	2350	97

Source: FAO, Food Balance Sheets, 1991
FAO, The Fourth World Food Survey, 1977.

demographic as well as economic differences. For example, per capita calorie supplies in Hong Kong, the Republic of Korea, Singapore and Japan in 1986-88 were all near 2,800 calories. In Czechoslovakia, Hungary and Poland, per capita calorie supplies were 3,400-3,600. Thus, we may conclude that cultural and demographic differences play a part in determining food consumption since the four Asian countries all had higher per capita GNP's in recent years than the Eastern European countries (World Bank Atlas, 1991); although we know that food prices were subsidized in the Eastern European countries.

Only a few African countries have shown steady gains in per capita calorie supplies over the 1961-63 to 1986-88 period. Most countries did well for a period, but were not able to maintain the growth rates. However, most managed to reach a higher level of per capita calorie supplies in 1986-88 than in 1961-63. Sudan, for example, increased per capita calorie supplies from 1961-63 through 1979-81 but then calorie supplies declined during the 1980s. Côte d'Ivoire has done well over the whole period, with a 16.8% growth in per capita calorie supplies from 1961-63 to 1979-81, but then experienced a 3.7% p.a. decline from the 1979-81 peak. Tanzania shows even faster growth of 26.3% from 1961-63 to 1979-81 and only a 1.2% p.a. decline since. Mali's per capita calorie supplies rose sharply during the 1980s after declining from 1961-63 to 1979-81. Nigeria had lower per capita calorie supplies in 1986-88 than in 1961-63. In the 1980s, Mozambique has slipped well below its levels of per capita calorie supplies of the 1960s and 1970s due in large part to the civil wars in that country.

The majority of the Asian countries have seen large increases in per capita calorie supplies. For most of Asia, the 25 years from 1961 to 1986 saw substantially improved diets in terms of quality and higher levels of consumption. Some, such as Indonesia and China, increased per capita calorie supplies by more than 50% from 1961-63 to 1986-88. Bangladesh has not kept pace with the other Asian countries; in fact, it had lower per capita calorie supplies during the 1970s and 1980s than during the 1960s. India had only a modest 3.3% gain in per capita supplies from 1961-63 to 1986-88. Malaysia seems to represent a typical case for Asia with per capita calorie supplies 14% higher in 1986-88 than in 1961-63. The level of calorie supplies was 2,665 per capita in 1986-88 and this level was about constant during the 1980s. Higher supplies could probably have been attained through imports if demand justified it. Food consumption will probably grow slowly in per capita terms from current levels as incomes rise.

Countries in Europe and the Middle East have shown consistent increases in per capita calories available for human consumption, despite consumption levels well above the minimum daily requirements. Indeed, most have done very well. The former Communist countries of Eastern Europe and the former Soviet Union generally did not do as well as the non-communist countries such as Egypt, Morocco and Turkey, but they were at a much higher base level at the beginning of the period. Hungary, for example, increased calorie availability by 17% over the period. Among the non-communist countries in the region, Egypt increased supplies by 47%, Morocco by 30% and Turkey by 16%.

The growth in per capita calorie availability among Latin American and Caribbean countries was varied but with most countries doing well, and most countries well above minimum requirements. Mexico had an increase of 25%, Brazil 16%, Colombia 14% and Dominica 42% in per capita calorie supplies from 1961-63 to 1986-88. Cuba achieved a 37% increase in calorie supplies. Haiti experienced a slight decline over the period, while Chile and Peru saw only modest growth.

From a comparison of the data across the regions, we see that most European and Middle Eastern developing countries did very well. Most Asian and Latin American and Caribbean countries did almost as well. Few countries in Africa achieved satisfactory growth with many having about the same level of per capita calories available for human consumption during 1986-88 as in 1961-63. In other words, calorie supplies increased for most consumers in developing countries from the early 1960s to the late 1980s, but not for most African consumers.

The daily calorie intake provided by the 1986-88 calorie supplies was below the recommended minimum daily requirements for most African countries, while most other countries had diets which exceeded the minimums. In Asia, a number of large population countries--Bangladesh, India, Pakistan, and Philippines--had average intakes below the minimums, while all other countries examined were above the minimums. In Europe and the Middle East, the average calorie supplies far exceeded the minimums in all countries examined. In Latin America and the Caribbean, only Haiti and Peru among the countries examined had calorie supplies which were below the minimum requirements.

Food Production

A third useful measure of the food situation in a region or country is the level of per capita food production. This measure is particularly useful for most developing countries since domestic production provides the largest part of total food supplies. As income levels increase, domestic food production becomes less useful as a measure of the food situation since consumers can more easily turn to imports for increased quantities and varieties of food. In developed countries, the measure is even less useful because food is often produced in surplus of domestic requirements.

An aggregate measure of food output is difficult to compute because the aggregation of different foods requires the use of prices. Since prices vary from year to year, we must separate price changes from quantity changes. This is most often done by using fixed prices obtained from an average of several years to aggregate production into value terms. The resulting index measures the quantity of production at the prices (or aggregation weights) from a specified period. The FAO computes such an index and, according to FAO estimates, per capita food production increased 28.9% from 1961-65 to 1989-91 in the developed countries and by 19.3% in the developing countries. Among the developing countries, production increased in all major regions except Africa, which experienced a decline of 16.5% in per capita food production. The Far East had the most rapid increase (33.3%) followed by Latin America (12.7%). These increases in per capita food production in the developing countries are consistent with the above-mentioned data on per capita calorie supplies available to consumers. Per capita calories available for consumption were shown to have increased by about 27% from 1961-63 to 1987-89--similar to the increase in per capita production after allowing for food imports and the slightly different time periods.

Country data are shown for per capita food production in Table 2.2 for the same countries as listed in Table 2.1 where available. Among the African countries examined, only Côte d'Ivoire and Tanzania had higher per capita food production in 1989-91 than in 1961-65. The food situation in Africa has deteriorated rapidly since about 1970. For example, since 1969-71 per capita food production has fallen 40% in Mozambique, 31% in Cameroon, and 28% in Ghana. Nigeria, the most populous country in Africa, increased per capita food production during the 1980s, but only to the levels achieved during the early 1960s. Côte d'Ivoire has done well, with a 49% increase in per capita production from 1961-65 to 1989-91 and Tanzania has increased production 11.1% during this period. However, these are the exceptions and, even for these countries, per capita food production declined during the 1980s. In Sudan, the 1960s and 1970s saw 17.9% higher per capita production, but during the 1980s production declined 29%.

Countries in Asia have generally done very well, with many showing large gains in per capita food production since 1961-65. China, for example, increased per capita food production 66.8% from 1961-65 to 1989-91. This was possible both because of rapid increases in food production but also because population increased at only 1.8% per annum from 1960 to 1990. Indonesia did even better with an increase of 67.7% in per capita food production while population grew at a rapid 2.3% per annum during this period to increase by 93% from 1960 to 1990. Unlike Africa, where gains were often reversed in later decades, most Asian countries increased per capita food production in each decade. Bangladesh, however, experienced a decline of 11.5% in per capita food production due in part to rapid population growth. Total food production grew 45% but population grew by 70.8% during 1970-89.

European and Middle Eastern developing countries increased per capita food production significantly during the 1961-91 period with many countries increasing per capita production by more than 20%. Hungary and Czechoslovakia had especially rapid growth with increases of 77% and 67.8%, respectively, during the 1961-65 to 1989-91 period. Egypt, Morocco and Turkey all had significant increases, but the increases were less rapid than for most countries in Eastern Europe. The countries which were involved in wars such as Iraq did less well and neighboring countries such as Jordan had lower per capita food production during 1989-91 than in 1979-81.

Countries in Latin America and the Caribbean generally did well, although there were some exceptions. Brazil, with the largest population in Latin America (147 million in 1990) increased per capita food production 70.4% over the period. Mexico, the second most populous country with 86 million increased per capita food production a much less impressive 5.2%. Other countries such as Chile and Colombia increased per capita production by 19% and 25.6%, respectively. However, Haiti, Jamaica and Peru had declining per capita production over the period.

Table 2.2 Per capita food production indexes, selected countries

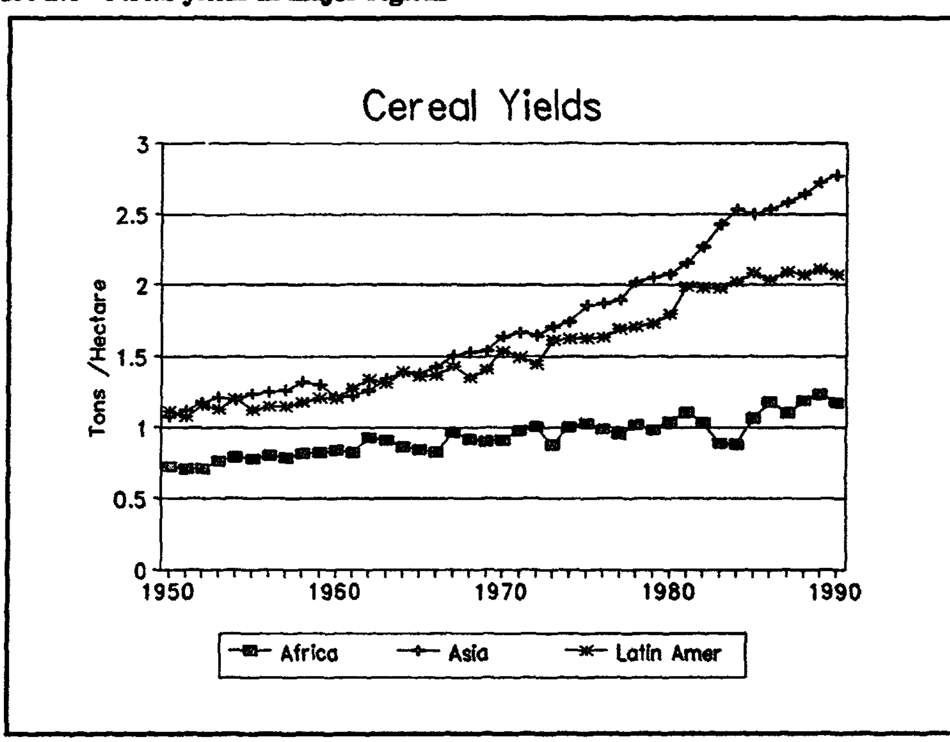
Region	1961-65	1969-71	1979-81	1989-91	% Change 1961-65 to 1989-91
		(Index 1979-81=100)			
All Developing	94.72	97.56	100.0	112.97	19.27
Africa	117.44	117.05	100.0	98.10	-16.5
Burkina Faso	120.51	119.71	100.0	112.68	-6.5
Cameroon	102.41	116.75	100.0	80.99	-20.9
Côte d'Ivoire	64.42	77.73	100.0	96.01	49.0
Ghana	152.90	149.84	100.0	107.79	-29.5
Mali	126.21	120.32	100.0	95.29	-24.5
Mozambique	129.19	137.80	100.0	82.29	-36.3
Nigeria	118.96	114.20	100.0	117.48	-1.2
Sudan	84.84	90.21	100.0	71.18	-16.1
Tanzania	75.98	78.01	100.0	84.41	11.1
Zambia	106.95	109.45	100.0	94.68	-11.5
Asia	91.15	94.49	100.0	121.52	33.32
Bangladesh	109.09	104.00	100.0	96.56	-11.5
China	80.52	87.23	100.0	134.30	66.8
India	97.65	99.60	100.0	120.26	23.2
Indonesia	78.79	84.57	100.0	132.12	67.7
Korea, De. P.R.	82.67	82.12	100.0	105.47	27.6
Korea, Republic	80.50	90.16	100.0	97.01	21.2
Pakistan	83.41	98.42	100.0	105.21	26.1
Philippines	83.86	84.70	100.0	89.66	6.9
Singapore	68.43	107.21	100.0	101.05	47.7
Sri Lanka	68.85	72.29	100.0	90.46	31.4
Thailand	86.03	91.77	100.0	104.59	21.6
Europe					
Czechoslovakia	73.81	85.87	100.0	123.84	67.8
FSU	87.59	101.31	100.0	106.95	22.1
Hungary	63.38	76.27	100.0	112.19	77.0
Poland	88.12	95.17	100.0	109.30	24.0
Middle East	92.51	94.67	100.0	95.96	3.73
Egypt	103.19	109.04	100.0	118.44	14.8
Iran	82.90	91.46	100.0	112.11	35.2
Iraq	83.84	82.75	100.0	88.78	5.9
Jordan	122.13	58.22	100.0	94.38	-22.7
Morocco	104.34	114.43	100.0	132.73	27.2
Syria	78.42	58.03	100.0	75.04	-4.3
Turkey	84.25	89.31	100.0	97.40	15.6
Latin America	91.63	95.60	100.0	103.29	12.7
Argentina	93.06	96.16	100.0	94.38	1.4
Brazil	78.63	88.07	100.0	133.96	70.4
Chile	96.92	100.80	100.0	115.31	19.0
Colombia	88.46	88.46	100.0	111.13	25.6
Haiti	100.79	103.14	100.0	90.57	-10.1
Jamaica	108.75	104.76	100.0	96.03	-11.7
Mexico	91.80	97.61	100.0	96.56	5.2
Peru	121.37	122.18	100.0	94.46	-22.2

Source: FAO, Production Yearbook, various issues.
Note: Production indexes for 1979-81 and 1989-91 were obtained by weighing the quantities of each commodity by 1979-81 average national producer prices, while the indexes for 1961-65 and 1969-71 were obtained by using 1961-65 prices. The two data series were combined into one series by expressing the 1961-65 and 1969-71 indexes in the 1979-81 base using the average of 1974-75 to adjust the two series.

Another measure of performance in food production, in addition to per capita production, is the trend in yields of the staple cereal. The yield trend gives an idea of how countries have benefited from scientific advances in improved varieties, new pesticides and herbicides, better machinery, and improved management techniques. Average cereal yields for major developing country regions--Africa, Asia, and Latin America--are shown in Figure 2.8 for the 1950 to 1990 period. Yields in all three regions increased gradually from 1950 until the mid-1960s and then "took-off" in Asia and Latin America. Africa was untouched by the improvements in varieties which boosted production in Asia and Latin America. The Green Revolution did not come to Africa.

Yields for individual countries are shown in Table 2.3, and they confirm the general trends shown in Figure 2.8. Few countries in Africa have increased yields at the rates of countries in other regions. A partial explanation is offered by the differences in cereal crops grown in Africa and in the rest of the world. The two cereals which have benefited most from improvements in the genetic potential of varieties are wheat and rice, neither of which are widely grown in Africa. The primary cereal staples grown in Africa are millet and sorghum and these crops have not received the same research focus given to wheat or rice and have not seen significant improvements in their yield potential. Irrigation, which is essential to higher yields has also not increased in Africa as rapidly as in other regions. Cereal yields in Africa averaged about 1.20 tons per hectare during 1988-90 compared to 2.71 tons per hectare in Asia and 2.09 tons per hectare in Latin America.

Figure 2.8 Cereal yields in major regions



Source: FAO, Production Yearbook, various issues.

Table 2.3 Yields of staple cereals, selected countries

Country	Staple Cereal	1959-61	1969-71	1979-81	1988-90	% Change 1959-61 to 88-90
			(Tons/Hectare)			
Africa Total	All Cereals	.826	.929	1.110	1.198	+45.0
Cameroon	Millet	.723	.718	.753	1.350	+86.7
Côte d'Ivoire	Rice	.741	1.169	1.147	1.180	+59.2
Ghana	Maize	.972	1.082	.982	1.28	+31.7
Mali	Millet	.665	.602	.716	.795	+19.5
Mozambique	Maize	.849	1.008	.632	.564	-33.6
Nigeria	Sorghum	.846	.658	1.092	.936	+10.6
Sudan	Sorghum	.916	.893	.731	.557	-39.2
Tanzania	Maize	.669	.813	1.306	1.441	+115.4
Zambia	Sorghum	.853	1.109	.550	.605	-29.1
Asia Total	All Cereals	1.246	1.618	2.106	2.713	+117.7
Bangladesh	Rice	1.616	1.678	1.952	2.545	+57.5
China	Rice	2.180	3.295	4.244	5.503	+152.4
India	Rice	1.489	1.668	1.857	2.625	+76.3
Indonesia	Rice	1.739	2.345	3.257	4.226	+143.0
Korea, Dem. P.R.	Rice	4.112	5.358	7.453	8.159	+98.4
Korea, Rep. of	Rice	3.882	4.628	5.513	6.444	+66.0
Malaysia	Rice	1.963	2.395	3.159	2.667	+35.9
Pakistan	Wheat	.811	1.109	1.566	1.808	+122.9
Philippines	Rice	1.173	1.685	2.249	2.719	+131.8
Sri Lanka	Rice	1.857	2.275	2.555	3.007	+61.9
Thailand	Rice	1.444	1.935	1.894	2.042	+41.4
Europe & Middle East						
Czechoslovakia	Wheat	2.405	3.190	3.982	5.278	+119.5
Hungary	Maize	2.382	3.568	5.537	4.56	+91.4
Poland	Rye	1.603	1.886	2.072	2.57	+60.3
Turkey	Wheat	1.016	1.307	1.841	1.852	+82.3
FSU	Wheat	1.072	1.425	1.510	1.978	+84.5
Morocco	Barley	.592	1.093	.785	1.172	+97.3
Egypt	Maize	2.177	3.741	3.948	5.215	+139.5
Latin America & Caribbean	All Cereals	1.228	1.480	1.838	2.086	+69.9
Argentina	Wheat	1.263	1.332	1.547	1.864	+47.6
Brazil	Maize	1.289	1.365	1.684	1.935	+50.1
Haiti	Maize	.853	1.057	.875	.804	-1.1
Mexico	Maize	.949	1.217	1.718	1.768	+86.3
Chile	Wheat	1.301	1.760	1.711	3.074	+136.3
Colombia	Maize	1.147	1.252	1.401	1.397	+21.8
Cuba	Rice	1.776	1.867	3.123	3.058	+72.2
Jamaica	Maize	.613	1.270	1.489	1.097	+79.0
Peru	Maize	1.338	1.622	1.663	1.972	+47.4

Source: Based on FAO Data.

Summary

The world food situation has improved dramatically since the early 1960s when measured by the criteria of the level of food prices, gains in per capita food production and gains in per capita food supplies available for consumption. World food production increased nearly 20% per capita from 1960 to 1990, while world food commodity prices declined by 60% in constant prices. Per capita GDP in the developing countries increased an average of 162% during this period, which further increased consumers' ability to buy food.

The gains in the developing countries have been dramatic. Per capita food supplies, measured in calories available for consumption, increased 27% from the early 1960s to the late 1980s. This gain allowed consumers to have both greater quantities of food and also a greater diversity of food products. Trade was an important factor contributing to the better diets, but domestic production accounted for the largest part of the increased food supplies. Per capita food production increased about 19% in the developing countries from 1961-65 to 1989-91, with 13% occurring in just the last decade.

The index of world food prices declined by 78% from 1950 to 1992 relative to the rate of inflation in the G-7 industrial countries. Not all of these declines were reflected in retail prices for food because of greater processing of foods and higher marketing costs. Most consumers saw retail prices rise at about the same rate as other consumer prices. However, per capita GDP increased sharply over this period. Food was therefore less expensive in terms of consumers' incomes.

Despite steady gains in food supplies, and estimated 20% of the population in developing countries remain chronically malnourished. This compares with an estimated 36% during 1969-71. In contrast, an estimated 60% of the world's population live in countries which have more than 2,600 calories/day/capita available for consumption (a level considered to be relatively comfortable by the FAO). Diets in developing countries still lack the quality and diversity of diets in the developed countries, but the differences narrowed over the 1960 to 1990 period.

These gains in the world food situation have not been equally shared by all consumers. Asian consumers have generally done very well as calorie supplies and food production have increased relative to population. Consumers in Latin America have also benefited from greater availability of food supplies and increased per capita food production; however, African consumers have generally not had the same gains. Most African consumers had about the same level of calorie supplies available for consumption in the early 1990s as in the 1960s and per capita food production has declined significantly in the past 20 years.

The share of the world's population which is better fed has increased largely because of the gains made by the large number of people in Asia. Approximately 59% of the worlds population is in Asia and this is the region which has experienced the largest gains in food production and consumption. Africa, which had the poorest performance, accounts for about

12% of the world's population while Latin America accounts for about 9%.

Overall, the world food situation has improved steadily since the 1960s and the pace of improvement actually increased during the 1980s. The major exception is in Sub-Saharan Africa where the food situation has deteriorated. Most African countries did well for a period, but were not able to maintain favorable growth rates. By contrast, most Asian countries continued to improve their food situation throughout the period.

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Chapter III. Population Growth and Food Demand[1]

The growth of population is the most important determinant of the growth of food demand in most countries. Other demand determinants such as changes in incomes or prices generally have a less than proportionate effect on food demand while population growth has a proportionate effect. Developing countries which have had the lowest population growth rates have also been most successful at increasing per capita food consumption. Those countries with the highest growth rates, such as many African countries, have had the most difficulty in maintaining or increasing per capita food consumption levels.

World population reached an estimated 5.3 billion people in 1990. It increased 75% during the 30 years from 1960 to 1990 and it is projected to increase about 50% during the next 30 years (UN, 1991). Despite the slower projected growth rate, world population would increase by 2.8 billion during the next 30 years compared with an increase of 2.3 billion people during the past 30 years. This population growth provides a formidable challenge to world agriculture.

Population growth accounted for about one-half of the increase in total cereal consumption in less developed countries and about two-thirds of the increase in more developed countries during the 1960s and 1970s (see Table 3.1). The percentage growth of both cereal consumption and population slowed during the 1980s compared with the previous decades, with cereal consumption slowing more than population growth. This reflects the slow economic growth during the 1980s but it may also reflect a leveling off of the growth of per capita demand in many countries. The growth of cereal consumption during the 1980s was about 3 percentage points faster than population growth. In the more developed countries cereal consumption increased by 9.5% during the 1980s, while population increased by 6.1%. In the less developed countries, cereal consumption increased by about 27% during the 1980s and population increased by about 23%. Unless per capita demand growth increases dramatically from that seen in the 1980s, population growth will remain the most important determinant of food demand.

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[1] The data on population in this chapter are taken primarily from the United Nation's World Population Prospects 1990. This report presents three sets of projections on the size and composition of population by regions and countries in five-year increments to 2025. The projections include a medium variant which is believed to be the most likely outcome as well as high-variant and low-variant scenarios based on different assumptions on fertility rates. The medium variant is used throughout this chapter except where noted otherwise.

The less developed and more developed country designations are the definitions used by the United Nations in its population projections. The less developed countries include all regions of Africa, Latin America, East and South Asia and Oceania (excluding Australia, New Zealand and Japan). The more developed countries include North America, all regions of Europe, Australia, New Zealand, Japan and the FSU. These country groupings are used in this chapter to conform to the UN aggregates.

Table 3.1 Total cereal consumption and population growth

Region	1960-70	1970-80	1980-90
		(percent increase)	
More Developed Countries			
Total Cereal Consumption	30.8	17.1	9.5
Population	11.0	8.4	6.1
Less Developed Countries			
Total Cereal Consumption	42.9	46.6	26.8
Population	27.7	25.0	23.3

Source: Cereal consumption is based on USDA data and population is from the United Nation's, World Population Prospects 1990.

The slowdown of the growth of world cereals consumption during the 1980s occurred despite generally declining real cereal prices.[2] A major cause of the slowdown was the poor economic growth in many developing countries especially in Latin America, the Middle East and North Africa, and Sub-Saharan Africa. Those developing countries which did not experience slower economic growth during the 1980s, such as those in Asia, also did not have the dramatic slowdown in cereals consumption. For example, Asian developing countries increased cereals consumption by 28% during the 1970s and by 34% during the 1980s. Latin American developing countries increased cereals consumption by 51% during the 1970s but only by 11% during the 1980s. Among countries in the more developed group, the slower economic growth occurred primarily in the FSU and Eastern Europe--from 27% during the 1970s to 8% during the 1980s. In contrast, the growth of cereal consumption in the developed market economies grew by 10% during both the 1970s and 1980s.

Given the important role of population in world food demand, it is essential to understand how demographic characteristics have changed in recent decades and how they are expected to change in the future. Unlike economic events, which change quickly, population changes slowly and the changes last for many years. For example, a small decline in the infant mortality rate can increase the rate of population growth for decades. Trends in demographic characteristics such as infant mortality rates, birth rates and death rates projected into the future imply much slower population growth during the next century than we have seen in this one. If these projections turn out to be correct, food demand growth will be slower because of slower population growth.

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[2] World wheat prices declined 41%, world rice prices declined 52% and world maize prices declined 37% in real terms from 1980 to 1990.
Source: Market Outlook for Major Primary Commodities, World Bank, International Economics Department, October 1992.

This chapter examines the United Nation's and World Bank's projections of population for the world and for its major regions. Changes in important population determinants such as birth rates, death rates, infant mortality rates since 1950 and projections to 2025 are presented. Although the demand analysis presented in later chapters only extends to 2010, the projected trends in population and the key characteristics are presented to 2025.

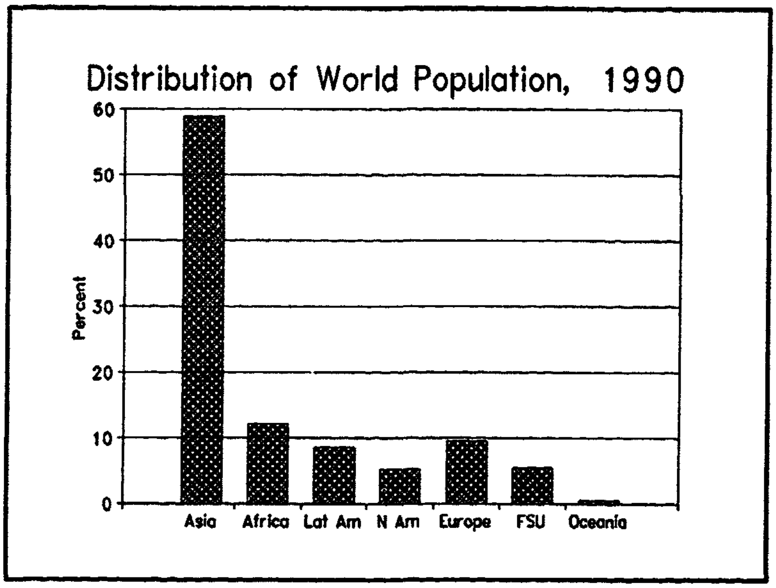
Important Changes in World Population

World population in mid-1990 was estimated to be growing by 1.74% per year. An estimated 77.2% of the world's population lived in the less developed countries, with 58.8% of the world's population in Asia, 12.1% in Africa, 8.5% in Latin America, 9.4% in Europe, 5.2% in North America, 5.4% in the FSU and 0.5% in Oceania (see Figure 3.1). The annual growth rate of population in 1990 was 2.99% in Africa, 2.06% in Latin America and 1.87% in Asia. Oceania had a growth rate of 1.48%, while North America's growth rate was .82%, Europe's was 0.25% and the FSU's 0.78% per annum (see Figure 3.2).

The more rapid population growth rates in Africa, Latin America and Asia has led to an increasing share of the world's population in these regions over time. By 2025, the share of population living in the presently less developed countries is projected to rise to 84% with the share of Africa projected to be 18.8% compared with 12.1% in 1990 and 8.8% in 1950. Asia's share is expected to decline slightly from 58.8% in 1990 to 57.8% by 2025 and Latin America's share to increase marginally to 8.9% from 8.5% in 1990. By 2025, North America is expected to account for only 3.9% of the world's population compared with 5.2% in 1990. Europe would account for 6.1% compared with 15.6% in 1950 and 9.4% in 1990. The FSU's share would decline to 4.1% from 5.4% in 1990 and 7.2% in 1950.

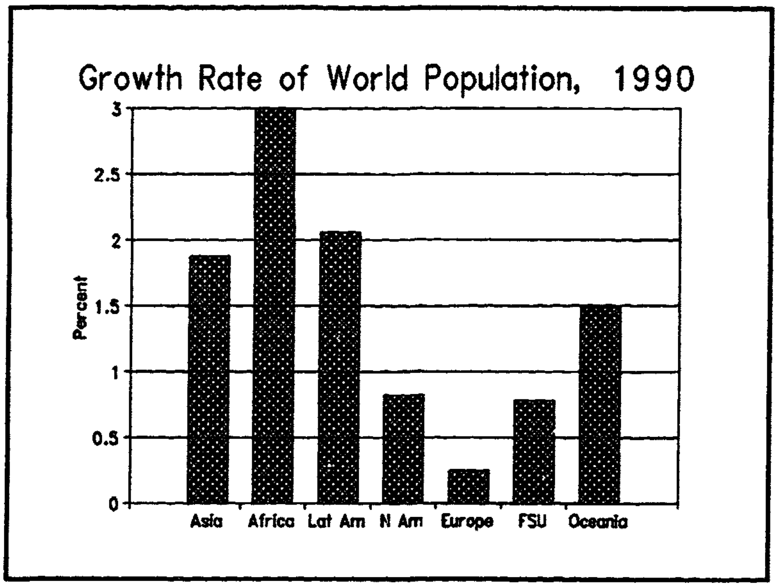
World population growth increased after the second World War, as sharp declines in death rates were brought about by improved medical care and better diets. Between 1950-55 and 1985-90, the world's annual death rate declined by one-half from 19.7 deaths per 1,000 people to 9.8 deaths per 1,000. In developing countries, the annual death rate declined by 60%, from 24.3 per 1,000 during 1950-55 to 9.8 during 1985-90. This led to an increase in the rate of population growth from 1.80% per annum during 1950-55 to 2.06% during 1965-70. This sharp increase occurred despite a decrease in the birth rate.

Figure 3.1 Population distribution, 1990



Source: United Nations, World Population Prospects, 1990

Figure 3.2 Population growth rates, 1990



Source: United Nations, World Population Prospects, 1990

The crude annual birth rate, which measures the number of births per 1,000 population declined from 37.5 births per 1,000 population during 1950-55 to 27.1 births per 1,000 population during 1985-90. In less developed countries, it fell from 44.6 to 31.0 births per 1,000 population over this period. In more developed countries, the decline was from 32.6 to 14.5. Continued declines are projected under the UN's medium-variant projection of population. By the 2020-2025 period, the world's crude birth rate is expected to decline to 17.5 births per 1,000 population--a decline of 35% from the 1985-90 rate. The decline is projected to be greater in the less developed countries, but both regions are expected to have further declines. In the less developed countries, the crude annual birth rate is projected to drop to 18.6 births per 1,000 population during 2020-2025, while in the more developed countries the rate is projected to fall to 11.9 births per 1,000 population.

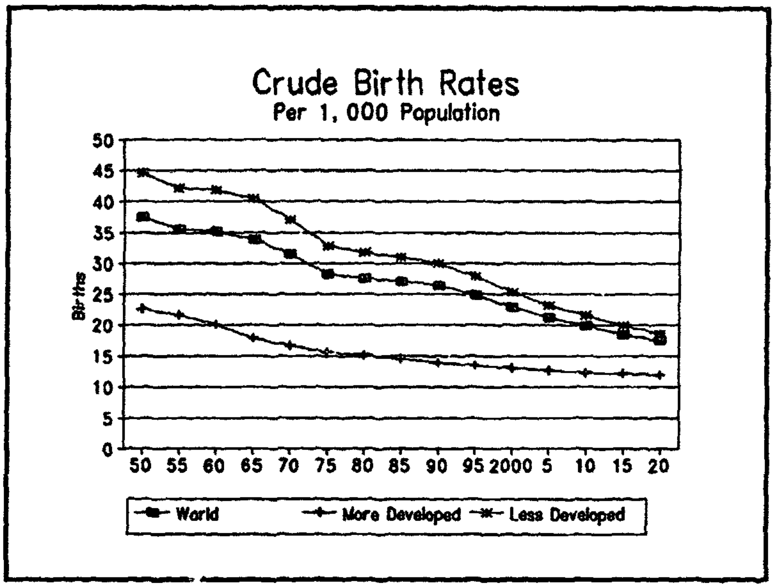
Africa had a crude birth rate of 44.7 per 1,000 population during the 1985-90 period. This was far in excess of the rates in the next highest regions--Latin America at 28.7 and Asia at 27.8 (see Table 3.2). The crude birth rates in North America and Europe were 15.0 and 12.9, respectively, during this period. Crude birth rates are projected to fall in Africa during the period to 2025 reaching 26.0 births per 1,000 population. Rates in other regions are also expected to continue to decline.

The crude annual death rate is projected to decline by an additional 22% by the 2020-2025 period under the medium-variant scenario of the UN population projection. The decline since 1950 has occurred almost totally in the less developed countries and the rate in less developed countries and more developed countries is now equal. The annual death rate in the less developed countries is projected to fall below the rate in the more developed countries in the future due primarily to the differences in the age distribution of the populations (i.e., higher percentages of younger age cohorts in the less developed countries due to the faster rates of population growth).

Asia has had the greatest decline in crude annual death rates since 1950, with a decline from 24.1 deaths per 1,000 population during 1950-55 to 9.0 deaths per 1,000 population during 1985-90. Other regions also had dramatic declines (see Table 3.3). Latin America's crude death rate declined by 52% over this period and Africa's rate declined 45%. Smaller declines occurred in the more developed countries due the lower rate during earlier periods.

Further declines in the crude annual death rate are expected to occur in the less developed countries, but the rate is projected to increase in the more developed countries. By the 2020-2025 period, the crude annual death rate in the more developed countries is projected to be 10.6 per 1,000 while in the less developed countries it is projected to fall to 7.1 deaths per 1,000 population.

Figure 3.3 Crude birth rates



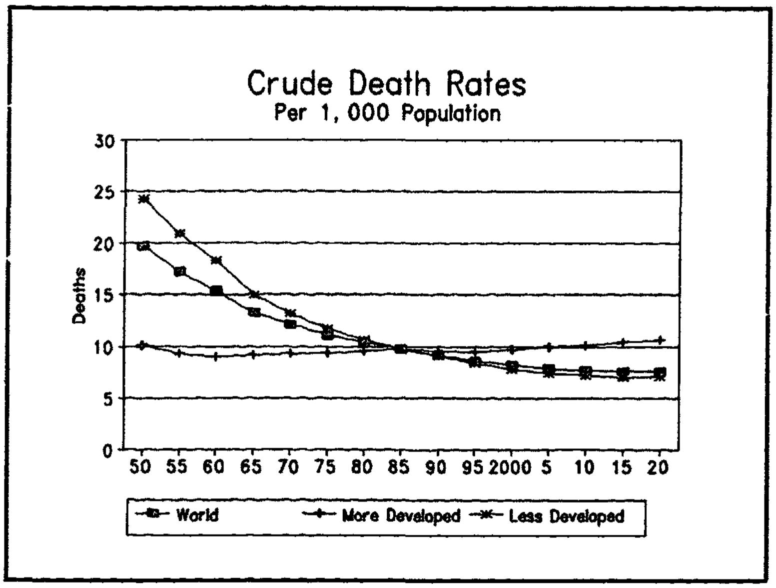
Source: United Nations, World Population Prospects, 1990
Note: The data are for 5 year averages beginning with the year shown.

Table 3.2 Crude birth rates by region /a

Period	Africa	Lat Amer	N Amer	Asia	Europe	Oceania	FSU
1950-55	49.2	42.5	24.6	42.9	19.8	27.6	26.3
1955-60	48.8	41.7	24.6	39.6	19.2	27.5	25.3
1960-65	48.7	41.1	22.2	39.5	18.7	26.7	22.1
1965-70	47.4	38.0	18.0	38.4	17.7	24.5	17.9
1970-75	46.6	35.4	15.7	34.8	15.7	23.9	18.1
1975-80	46.1	32.4	15.1	29.7	14.4	20.9	18.3
1980-85	45.3	30.6	15.6	28.4	13.3	20.0	19.1
1985-90	44.7	28.7	15.0	27.8	12.9	19.4	18.4
1990-95	43.5	26.8	13.9	26.9	12.8	18.6	16.7
1995-00	41.6	24.8	13.1	24.7	12.4	17.9	15.9
2000-05	39.5	23.1	12.6	21.7	11.9	16.9	15.7
2005-10	36.9	21.7	12.6	19.4	11.4	16.0	15.5
2010-15	33.5	20.5	12.4	18.0	11.2	15.3	15.0
2015-20	29.5	19.4	12.1	16.7	11.0	14.6	14.5
2020-25	26.0	18.4	11.7	161.1	10.9	14.0	14.1

Source: World Population Prospects 1990, Department of International Economic and Social Affairs, United Nations, New York, 1991.
a/ The crude birth rate is the number of births per annum per 1,000 population, without considering mortality.

Figure 3.4 Crude death rates



Source: United Nations, <u>World Population Prospects, 1990</u>
Note: The data are for 5 year averages beginning with the year shown.

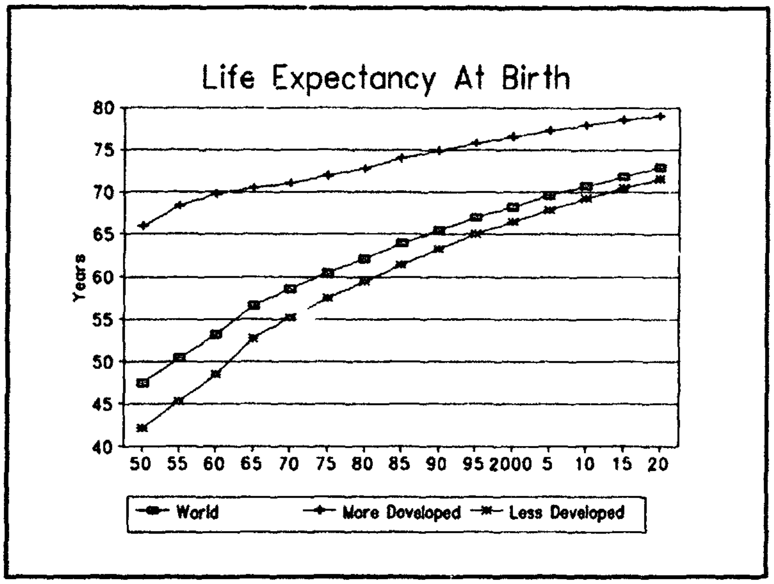
Table 3.3 Crude annual death rates by region /a

Period	Africa	Lat Amer	N Amer	Asia	Europe	Oceania	USSR
1950-55	26.9	15.4	9.4	24.1	11.0	12.4	9.2
1955-60	24.7	13.6	9.3	20.4	10.5	11.4	7.6
1960-65	22.9	12.1	9.2	17.7	10.2	10.6	7.2
1965-70	21.0	10.9	9.3	14.1	10.4	10.4	7.8
1970-75	19.2	9.7	9.0	12.4	10.4	9.8	8.6
1975-80	17.6	8.6	8.5	10.7	10.4	8.8	10.0
1980-85	16.4	7.9	8.5	9.7	10.5	8.2	10.7
1985-90	14.7	7.4	8.7	9.0	10.7	8.1	10.6
1990-95	13.2	7.0	8.7	8.4	10.6	8.0	9.9
1995-20	11.9	6.6	8.8	7.8	10.3	7.9	9.5
2000-05	10.6	6.5	8.8	7.4	10.6	7.8	9.6
2005-10	9.5	6.5	8.9	7.1	10.8	7.8	9.9
2010-15	8.5	6.5	9.0	7.0	11.0	7.8	9.8
2015-20	7.6	6.7	9.3	7.1	11.2	7.9	9.7
2020-25	7.0	7.0	9.9	7.2	11.5	8.3	9.4

Source: <u>World Population Prospects 1990</u>, Department of International Economic and Social Affairs, United Nations, New York, 1991.
a/ The crude death rate is the number of deaths per annum per 1,000 population.

Life expectancy at birth has increased on average about 18 years since 1950. In the less developed countries it has increased by about 21 years and in the more developed countries by about 9 years. The average difference in life expectancy between the more and less developed countries is now about 12 years. The life expectancy at birth in the more developed countries is estimated at 74.9 years during 1990-95 and 63.3 years in the less developed countries. By the period 2020-25, life expectancy is projected to be 79.0 for the more developed countries years and 71.6 years in the less developed countries. The change in life expectancy is expected to slow from an increase of 12.3 years during the past 30 years to an increase of 7.4 years during the next 30 years.

Figure 3.5 Life expectancy at birth

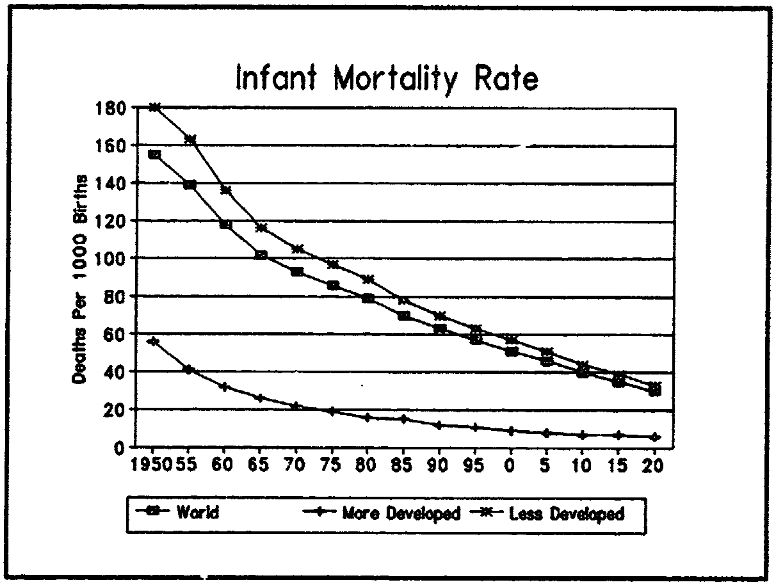


Source: United Nations, World Population Prospects, 1990
Note: The data are for 5 year averages beginning with the year shown.

One of the factors contributing to longer life expectancy is the dramatic decline in the infant mortality rate. From 1950-55 to 1985-90, the average infant mortality rate per 1,000 births declined from 155 to 70. For the less developed countries, the decline was from 180 to 78, while the decline in the more developed countries was from 56 to 15. Continued rapid declines in infant mortality rates are projected, reaching a rate of 30 deaths per 1,000 births by the 2020-2025 period. This corresponds to 33 deaths per 1,000 births in the less developed countries and 6 deaths per 1,000 births in the more developed countries.

The median age of the world population declined during the 1950s and 1960s as infant mortality and death rates declined. It began to rise during the 1980s as birth rates declined. The median age of the less developed countries' population declined from 21.2 years to 18.9 years from 1950-55 to 1970-75 and has increased to 21.0 during 1985-90. By 2020-25, it is projected to rise to 29.6. In the more developed countries the median age rose steadily from 28.2 years during 1950-55 to 32.5 years during 1985-90 and it is projected to rise to 40.8 years by the 2020-25 period.

Figure 3.6 Infant mortality rates

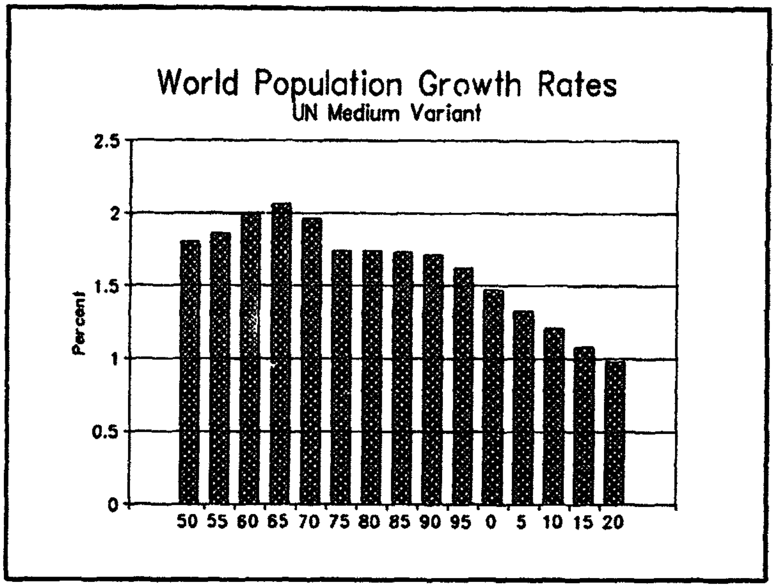


Source: United Nations, World Population Prospects, 1990
Note: The data are for 5 year averages beginning with the year shown.

Projected Population Growth

The rate of world population growth is projected to slow from 1.74% per annum during the 1990-95 period to 0.99% during the 2020-25 period under the medium-variant UN projection (see Table 3.4). This 43% decline in the rate of population growth is projected to occur primarily because of a rapid decline in birth rates and slower declines in the death rates. The World Bank projects an even more rapid decline in population growth in the near term, followed by a slower decline after 2000. Under both projections, population growth rates fall by about 40% during the next 30 years.

Figure 3.7 World population growth rates



Source: United Nations, World Population Prospects, 1990
Note: The data are for 5 year averages beginning with the year shown.

Table 3.4 World population (millions) and average annual growth rates (percent), 1950-2025 /a

Year	United Nations Population Medium	High	Low	Period	Average Annual Growth Rate Medium	High	Low	World Bank Population	Growth Rate
1950	2,516			1950-1955	1.79				
1955	2,752			1955-1960	1.86				
1960	3,020			1960-1965	1.99				
1965	3,336			1965-1970	2.06				
1970	3,698			1970-1975	1.96				
1975	4,079			1975-1980	1.73				
1980	4,448			1980-1985	1.74				
1985	4,851			1985-1990	1.74			4,827	1.75
1990	5,292	5,327	5,262	1990-1995	1.73	1.90	1.54	5,268	1.65
1995	5,770	5,857	5,682	1995-2000	1.63	1.83	1.40	5,721	1.51
2000	6,261	6,420	6,093	2000-2005	1.47	1.69	1.20	6,168	1.39
2005	6,739	6,986	6,469	2005-2010	1.33	1.59	1.04	6,612	1.28
2010	7,204	7,564	6,813	2010-2015	1.23	1.54	0.88	7,049	1.20
2015	7,660	8,169	7,120	2015-2029	1.10	1.49	0.71	7,484	1.13
2020	8,092	8,802	7,376	2020-2025	.99	1.41	0.57	7,919	1.05
2025	8,504	9,444	7,591					8,345	

Source: World Population Prospects 1990, United Nations, 1991.
World Population Projections, 1991-92 Edition (Forthcoming), World Bank, 1992.

Population growth rates for major world regions are shown in Table 3.5 for historical and projected five-year periods, based on the UN medium-variant projections. Africa currently has the most rapid rate of population growth and it is projected to remain the region with the most rapid population growth through 2025. Despite this, the rate of growth is projected to fall 36% by the 2020-25 period. Latin America and Asia, the next most rapidly growing regions, are projected to see growth rates decline by about one-half by 2020-25. The more developed countries are projected to experience further declines in population growth rates and in the case of Europe negative growth rates are projected for 2015-25.

Table 3.5 Population growth rates by region

Period	Africa	Lat Amer	N Amer	Asia	Europe	Oceania	FSU
1950-55	2.21	2.73	1.80	1.89	.79	2.25	1.71
1955-60	2.38	2.75	1.78	1.95	.80	2.18	1.77
1960-65	2.53	2.79	1.49	2.18	.92	2.09	1.49
1965-70	2.64	2.60	1.13	2.44	.66	1.97	1.00
1970-75	2.66	2.48	1.06	2.27	.59	1.81	.94
1975-80	2.88	2.29	1.07	1.86	.45	1.49	.85
1980-85	2.94	2.17	1.00	1.86	.32	1.51	.88
1985-90	2.99	2.06	.82	1.87	.25	1.48	.78
1990-95	3.02	1.91	.71	1.84	.23	1.36	.68
1995-00	2.97	1.76	.61	1.68	.23	1.24	.64
2000-05	2.89	1.62	.55	1.43	.15	1.13	.61
2005-10	2.74	1.49	.54	1.23	.08	1.03	.57
2010-15	2.50	1.36	.51	1.10	.03	.96	.52
2015-20	2.19	1.24	.44	.96	-.01	.86	.48
2020-25	1.90	1.12	.34	.89	-.05	.76	.47

Source: World Population Prospects 1990, United Nations, Department of International Economic and Social Affairs, United Nations, New York, 1991.

Summary

World population growth rates have slowed since the 1960s when they averaged more than 2% per annum and they are projected to slow further. For the years from 1975 to 1990, world population grew about 1.74% per annum and it is projected that there will be a rapid decline to less than 1% per annum during the next thirty years. These projections are based on long-term trends in demographic characteristics such as birth rates, death rates and life expectancies. They hold the hope for substantially reduced demands on the world food system and for increased per capita consumption. The exception to these trends is Africa where population is increasing at an estimated 3% per annum and where population growth rates are still increasing.

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Chapter IV. The Resource Base

The resource base available for agriculture includes factors of production such as land, labor and machinery. But it also includes the knowledge of farmers, the production potential of crop varieties, climatic factors such as sunlight and water, and the methods used to increase yields and control weeds, disease and insects. In this chapter we examine aspects of the resource base which are needed for agricultural production and try to evaluate potential productivity.

Modern crop varieties are more dependent upon non-land inputs to achieve their yield potential than were traditional varieties, which often relied on existing soil nutrients. Land's importance as a factor of production has declined as improved varieties of crops have increased yields per hectare and mechanization has reduced labor requirements. World cereal production increased 185% from 1950 to 1990, with 90% of the increase due to yield increases while only 10% was due to increased land area.

The size and quality of the resource base available to agriculture can be increased by investment or reduced by neglect. Nearly all aspects of the resource base can be altered. Land, for example, can be made more productive by leveling which allows easier access by machinery, better water control, and reduced erosion. Organic residue from either plants or animals can be added to aerate the soil, add nutrients and increase yields. Land can be double-cropped and in some cases three crops can be grown in a single year depending on the length of the growing season and the time required for the crop to mature. Land can also be shifted from less to more productive uses. Pasture land can be used for crop production when plowed and timber land can be used for livestock grazing or crop production when cleared of trees and brush. Research on improved crop varieties can lead to higher yields while a failure to invest in research can lead to lower yields as existing varieties become more susceptible to disease and pests, which constantly evolve and threaten crop yields. Land can also become less productive because of erosion, salinization, waterlogging or nutrient deficiency; all of which can be caused by poor farming practices.

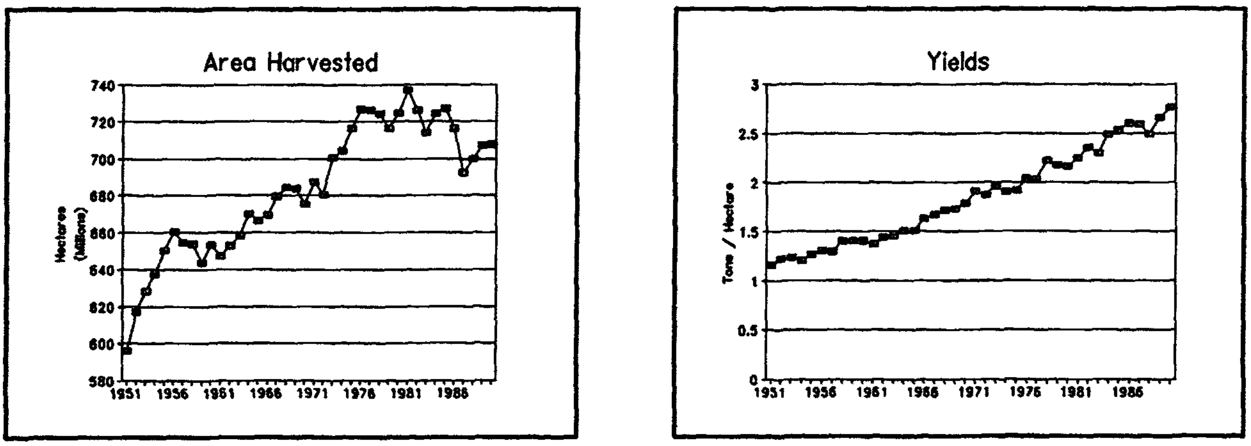
Government policies affect the resource base when they subsidize or tax certain factors of production at different rates. For example, many countries subsidize irrigation water by not fully charging farmers for the cost of constructing and maintaining the irrigation system. This results in farmers using more water than they would if full costs were charged. It also contributes to problems such as salinization, water logging and fertilizer runoff into streams and lakes, as well as reducing the water available for other agricultural and non-agricultural uses.

Many agricultural factors of production are difficult to quantify, the knowledge of crop scientists involved in research to increase yields, for example. Others, such as the hectares of land used for agriculture seem easier to quantify, but present problems in measuring the quality of the land for agricultural uses. Irrigation is difficult to measure because of the need to assess factors such as water availability, timeliness of delivery and salinity.

The resource base devoted to agriculture has historically responded to increased production requirements by expanding and becoming more productive. When land was idle or easily brought into production, additional production was obtained by extending the crop area. When additional land could no longer be brought into production easily, yields were increased by adding more fertilizer and irrigation and improving crop varieties to take advantage of these inputs. During the 1950s, land was relatively abundant and, as Figure 4.1 shows, world production of cereals was mainly increased by expanding area. When this was no longer easily done, yield increases became more important.

This pattern is being repeated in individual regions. Africa and Latin America are regarded as land surplus regions with large areas of land which could be used for crop production, while Asia and Western Europe have already put to use most of the suitable land. North America expanded cropland area during the 1970s as crop prices rose and reduced it during the 1980s as crop prices fell.

Figure 4.1 World cereal area harvested and yields



Source: Based on FAO data.

This pattern of resource use partially explains why yield growth varies among regions. When crop production can no longer be increased easily by expanding area, resources are invested in increasing yields by the use of more fertilizers and chemicals, increased investment in irrigation, and research into higher yielding varieties. This may explain why Africa and Latin America have substantially lower fertilizer use per hectare than Asia and why cereal yields are lower.

Irrigation increases the productivity of land and is a substitute for expanding cropland area. The highest level of irrigation as a percentage of total cropland area is found in regions where little additional land is available for cropping. Consequently, relatively little irrigation is found in Africa and Latin America, while a high proportion of the cropland in Europe, Asia and North America is irrigated.

Other aspects of the resource base which can be expected to substitute for land include conservation. If additional land can be brought into crop production relatively cheaply then this reduces the incentive for a farmer to preserve existing land quality through conservation practices. From the farmers' perspective, the optimal level of conservation depends on the cost of the resource and the value of the production from that resource. If land is cheap, then investments in conservation practices to enhance productivity are reduced. If land is relatively expensive then greater investments in enhancing its productivity are economically justified.

An often-raised concern in recent years is whether the production potential of agriculture is deteriorating because of changes in the quality of the resource base, particularly cropland. Because the resource base can adjust to economic incentives, its production potential is difficult to measure. Nevertheless, it is important to attempt to measure it as accurately as possible. This has been done in detail by the FAO and others. We review these studies and examine the question of sustainability of the resource base.

Maximum Food Production

An estimate of the theoretical maximum food production potential of the world was made by Buringh, van Heemst and Staring (1975). They estimated that cereal production could be increased to 30 times its level in the early 1970s (which would be about 18 times the 1990 level) using the same share of cultivated land for cereal production. They estimated that both land under cultivation and land under irrigation could more than double. They stress that this is a theoretical maximum, which could never be attained in practice. However, it is useful to know that current production is well below the biological production potential for crop production.

The study classified the world into 222 regions based on soil conditions and topography and then analyzed the soils, climate, vegetation and topography of each region. The researchers considered the suitability and quality of soils, the climatic conditions and potential dry matter production, and the quantity of water available for irrigation. Data on climate, including precipitation, temperature, sunshine, relative humidity and wind were collected for each of the regions and used to estimate their photosynthetic capacity and consequently the maximum dry matter production per hectare of a standard crop. Information on irrigation potential was used to distribute water to the most suitable soils first and then to the next most suitable soils, etc. They estimated that the area under irrigation, 201 million hectares, could be increased to 470 million hectares based on land suitable for irrigation and water availability. The total land which could be cultivated was estimated to be to 3,419 million hectares, an increase of 143% from the 1,406 million hectares cultivated during the early 1970s.

Land

Land is still one of the most important factors of production for agriculture in most countries. Still, of the world's total land area, only 11.3% was planted to crops in 1989 (see Table 4.1). Pastures and meadows accounted for an additional 25.3% and forests and woodlands accounted for 31.3%. Together, cropland, pastures and meadows accounted for most of the land used primarily for agriculture. Lands in forests and woodlands provide limited grazing for livestock and wildlife, but generally do not contribute much to agricultural production. The remaining 32.3% of total land area includes barren lands such as deserts, land used for settlements, roads and industrial uses, and land which has been abandoned.

Table 4.1 Land use by region, 1989

Region	Total Land	Crops	Pastures & Meadows	Forest & Woodlands	Other
			(Million Hectares)		
World	13,076	1,477	3,304	4,087	4,208
Africa	2,964	187	891	684	1,203
N C America	2,138	274	369	716	778
S America	1,753	142	479	891	240
Asia	2,678	453	678	535	1,012
Europe	473	140	83	157	93
Oceania	843	51	432	157	203
FSU	2,227	231	371	946	679

Source: FAO, Production Yearbook, 1990.
Definitions: Total area includes area under inland water bodies. Area used for crops includes arable land and permanent crops. Arable land is land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens (including cultivation under glass), and land fallow less than five years. Land under permanent crops refers to land cultivated with crops that occupy the land for long periods and which need not be replanted after each harvest, such as cocoa, coffee, and rubber; it includes land under shrubs, fruit trees, nut trees and vines, but excludes land under trees grown for wood or timber. Permanent meadows and pastures refer to land in herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land) for five years or more. Forests and woodland refers to land under natural or planted stands of trees, whether productive or not, and includes land from which forests have been cleared, but that will be reforested in the foreseeable future. Other land includes unused but potentially productive land, built-on areas, wasteland, parks, ornamental gardens, roads, lanes, barren land, and any other land not specifically listed.

The more densely populated regions tend to have a higher proportion of land used for crops. Europe, for example, has 29.6% of its total land in crops followed by Asia with 16.9%. Africa and Oceania, which are less densely populated, have about 6% of total land in crops. North, Central and South America and the FSU use from 8% to 13% of total land for crops. India has one of the highest cropping shares at 56.8% and it is also densely populated. The less densely populated regions have a high proportion of land in forest and woodlands, and pastures and meadows. South America has the largest share of land devoted to this use at 78.2%, followed by Oceania with 69.9%. The lowest share is in Asia at 45.3%. The other regions have between 50% and 60% of total land in forests and woodlands, and pastures and meadows.

Nearly one-third of all land is in uses other than agriculture (crops or pastures and meadows) or forests and woodlands. These uses include barren lands as well as lands used for settlements, roads, etc. Egypt, for example, has 97.4% of total lands classified in this "other" category--primarily because of its vast desert regions. South America has the lowest share of land in this category at 13.7%, followed by Europe with 19.7%.

World land use has changed slowly over time as shown in Table 4.2. Land in agricultural uses has gradually increased since 1960 with the largest increases being in land used for pastures and meadows. Forest and woodland areas have increased slowly and were slightly greater in 1989 than in 1960 or 1970. The increased land in these categories has come from "other" uses which include unused land, wasteland, barren land and built-on areas. Though the potential for expanding land in agricultural uses is not great based on past trends, cropland has continued to increase by about 0.2% per year since 1980 and land used for pastures and meadows has increased by about 1.2% per year.

Table 4.2 World land use, selected years, 1960 to 1989

Land Use	1960	1970	1980	1989
		(Million Hectares)		
Crops	1,409	1,432	1,452	1,477
Pastures & Meadows	2,569	3,059	3,117	3,304
Forests & Woodlands	4,046	4,028	4,093	4,087
Other	5,507	4,872	4,413	4,208
Total	13,531	13,391	13,392	13,390

Source: FAO, Production Yearbook, various years.

Some of the land currently used for pastures and meadows or forest and woodlands has potential for use in crop production. Buringh and Dudal (1987) estimate that about 30% of the land currently used for pastures and meadows and about 20% of the land currently in forests and woodlands could be used for crop production. Of this total of 1,800 million hectares, 300 million hectares are classified as having high potential for crop production, 600 million hectares are classified as having medium potential and 900 million hectares are classified as having low potential (Table 4.3). This estimate of potential considers the adequacy of climate, topography and soil condition for crop production. However, with rapidly declining crop prices[1] during the 1980s little incentive is provided for expanding the area used for crops.

Table 4.3 Crop production potential by land use

Current Use	High	Medium	Low
		(Million Hectares)	
Crops	400	500	600
Pasture	200	300	500
Forest	100	300	400

Source: Buringh and Dudal (1987).

Based on the estimates of Buringh and Dudal, less than one-half of the world's land area suitable for crop production is currently being used for this purpose. This would seem to suggest considerable scope for increased production. However, much of the unused land is located in remote areas not served by transportation capable of moving large amounts of grain or other bulky agricultural products to major markets. About 77% of the land described is located in the developing countries, and of this, about 45% is in Africa and 50% is in South America. The remaining 5% is in Asia and Central America. Both Africa and South America presently lack the transportation systems to link crop production in the interiors to ocean ports.

Although estimates suggest considerable potential for additional cropland, it is unlikely that much of this land will come into production in the foreseeable future (Crosson and Anderson, 1992). Pressures from urban and industrial development will also constantly remove cropland from agricultural uses. Since human settlements have been historically located in the most fertile agricultural areas, the lands taken from agricultural uses for urban and industrial use is often the most productive land. Expanding cropland significantly would be possible but would

[1]World wheat prices, for example, declined 41% from 1980 to 1990 in constant US $. (World Bank, "Market Outlook for Major Primary Commodities," International Economics Department, 1992).

only occur through government action or much higher crop prices. Environmental concerns about land use and global forest preservation would seem to preclude any major effort to convert forests and woodlands to crops. Expansion of cropland in many developing countries is continuing and this growth may offset the loss of land to other uses.

Cropland Use

The world's 20 largest crops ranked by area harvested are shown in Table 4.4. They account for 64.4% of total cropland. The four largest crops are cereals (wheat, rice, maize and barley). These, together with the four other cereal crops in the top 20 (sorghum, millet, oats and rye), make cereals by far the largest crop by area harvested accounting for 47.9% of total cropland in 1990. Oilseeds are the second largest group of crops, with soybeans, groundnuts, rapeseed and sunflower among the 20 largest crops. Together, these oilseed crops accounted for 7.5% of total cropland in 1990.

Table 4.4 Crops ranked by area harvested, 1990

Rank	Crop	Area ('000 Hectares)	Rank	Crop	Area ('000 Hectares)
1.	Wheat	231,548	11.	Groundnuts	19,968
2.	Rice	145,776	12.	Potatoes	17,854
3.	Maize	129,116	13.	Rapeseed	17,388
4.	Barley	71,493	14.	Sugar Cane	16,878
5.	Soybeans	56,339	15.	Rye	16,562
6.	Sorghum	44,352	16.	Sunflower	16,288
7.	Millet	37,565	17.	Cassava	15,635
8.	Cotton	33,768	18.	Sweet Potatoes	11,910
9.	Bean, Dry	26,407	19.	Coffee	11,251
10.	Oats	21,841	20.	Chick Peas	9,577

Source: FAO, Production Yearbook, 1990.

Yields of selected crops in 1990 are shown in Table 4.5. Cereals are relatively low-yielding compared with roots and tubers, and vegetables. Potatoes yielded 15.1 tons on average, compared with only 2.57 tons for wheat, 3.56 tons for rice (unmilled), and 3.68 tons for maize.

World area harvested of cereals grew 23.7% from 1951 to 1981 but has declined by about 4% since then. Since cereals are the most important food staple, either consumed directly or as a livestock feed, the area under cereals is a good measure of world crop production. Figure 4.2 shows the cereals area harvested and the yields for major regions from 1951 to 1990.

Yield levels :e shown on the same scale for all regions to illustrate the wide differences. During the 1950s, the world cereals area increased rapidly due to especially rapid increases in Asia. This was followed by slower but steady increases during the 1970s as concern about adequate world food supplies pressed farmers and governments to expand production. The peak in world grain prices and the increasing grain reserves in the major exporting countries during the early 1980s called a halt to further expansion. The major cereals exporting regions, including the industrial countries of North America, Western Europe and Oceania, have seen declining crop area since 1981. Asia and Africa, grain importing regions, have continued to increase the area planted to cereals in recent years. The only major importing region which has not increased the area harvested to cereals is Eastern Europe and the FSU. From a peak of 150.3 million hectares of cereals harvested in 1977, the area has declined to 132 million hectares in 1989.

Table 4.5 World average yields of selected crops, 1990

Crop	Yield	Crop	Yield
	(tons / hectare)		
Cereals		Roots & Tubers	
Maize	3.68	Cassava	10.08
Rice	3.56	Potatoes	15.10
Wheat	2.57	Sweet Potatoes	11.06
		Yams	10.06
Pulses			
Beans, Dry	.62	Vegetables	
Broad Beans, Dry	1.35	Beans, Green	6.33
Chick Peas	.72	Cabbages	21.56
Groundnuts	1.16	Carrots	21.07
Peas, Dry	1.89	Onions, Dry	14.12
Soybeans	1.91	Peas, Green	5.42
		Tomatoes	24.65

Source: FAO, Production Yearbook, 1990.

The trends in cereals area harvested have been a good measure of the world food situation for many regions. In the developing countries, the area has continued to increase as food demand has pressed production. In the developed countries, the area has fluctuated with cereal prices and agricultural policies such as the increase in set-aside land in the United States during the late 1960s and again in the early 1980s. Oceania, which primarily reflects cereals area harvested in Australia, has followed much the same pattern as in the United States. During the late 1960s, the area harvested to cereals declined in response to market prices and government policies. The decline was reversed during the 1970s as prices rose and exports of cereals increased. Since the early 1980s, prices and world export demand have declined and the area harvested has declined by about 25%. The reduction of area in Western Europe has been associated with ever-higher yields and continued production surpluses. Eastern Europe and the FSU also showed market responses during the 1970s as cereals area increased during the period of high world prices. However, since about 1980, the area devoted to cereals has declined persistently even as imports rose.

Yield levels for cereals vary greatly among regions. In Western Europe and North America, cereal yields were about 4.5 ton per hectare by 1990--about three times their 1951 levels. In Eastern Europe and the FSU, cereal yields were only one-half of the levels in Western Europe and North America, and they had increased only 1-1.5 by tons per hectare since the 1950s. This compares with a nearly 3 tons per hectare increase in yields in Western Europe and North America over the same period. Yields in Oceania show even less increase over the 1951-90 period than in Eastern Europe and the FSU, growir from about 1 ton per hectare in 1951 to about 1.75 tons per hectare by 1990.

Among developing countries, cereal yields were approaching 3 tons per hectare in Asia by 1990, while Latin America has slightly greater than 2 tons per hectare and yields in Africa are slightly greater than 1 ton per hectare. Yield growth has been greatest in Asia which has increased yields about 2.5 times since 1951. Latin America almost doubled cereal yields while Africa increased yields by less than twice.

Figure 4.2 Cereal area harvested and yields for selected regions, 1951-90

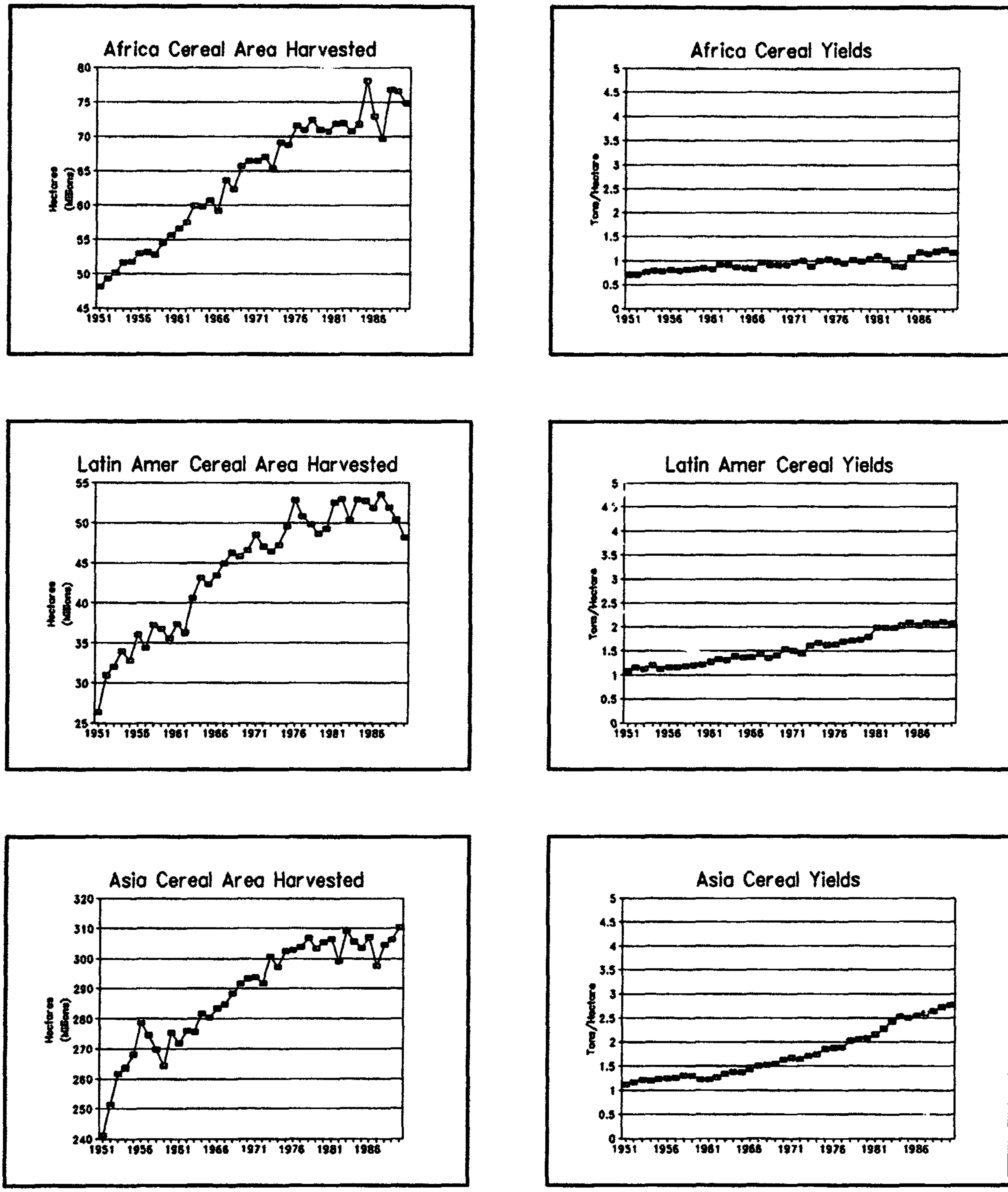
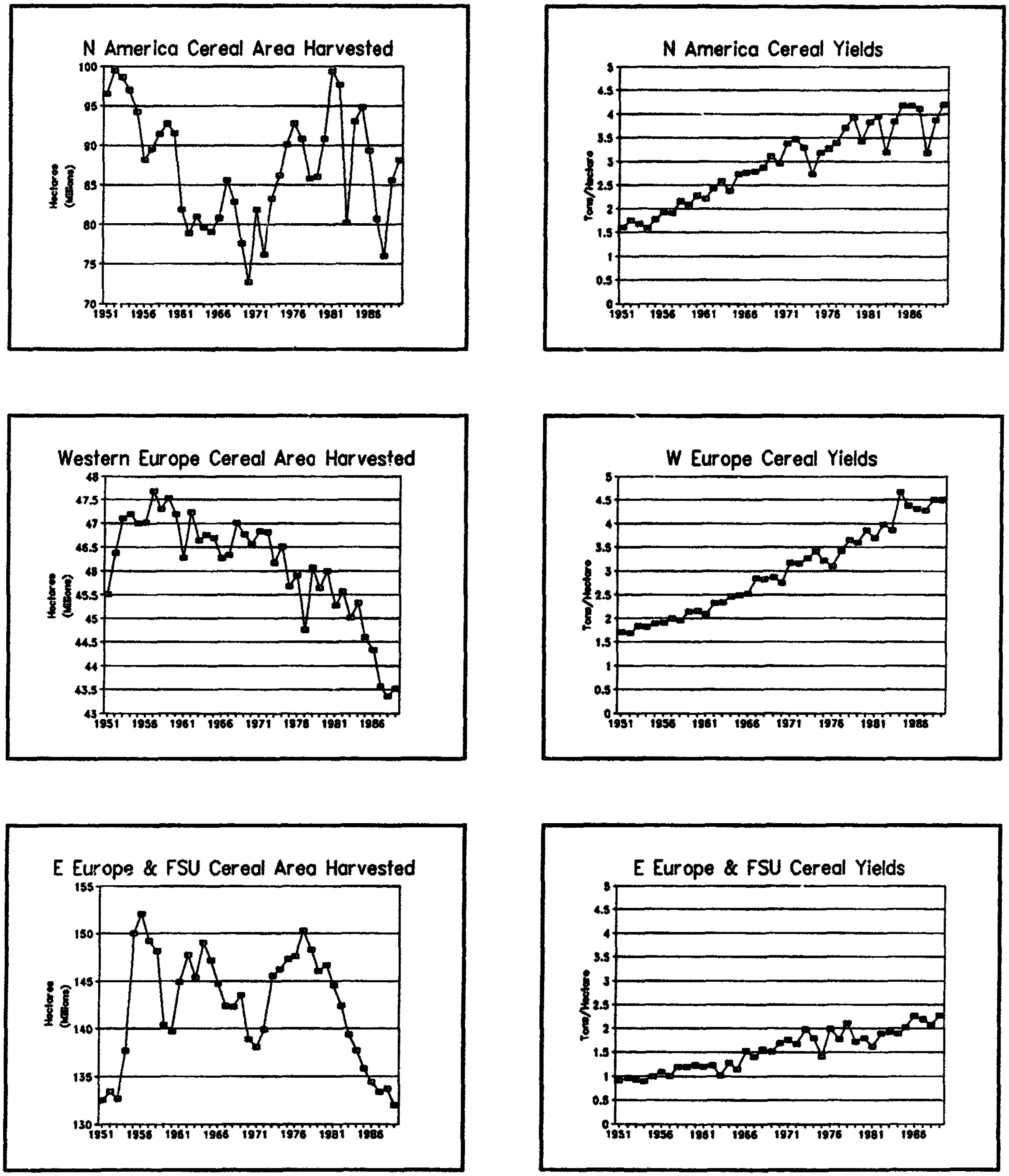


Figure 4.2 continued



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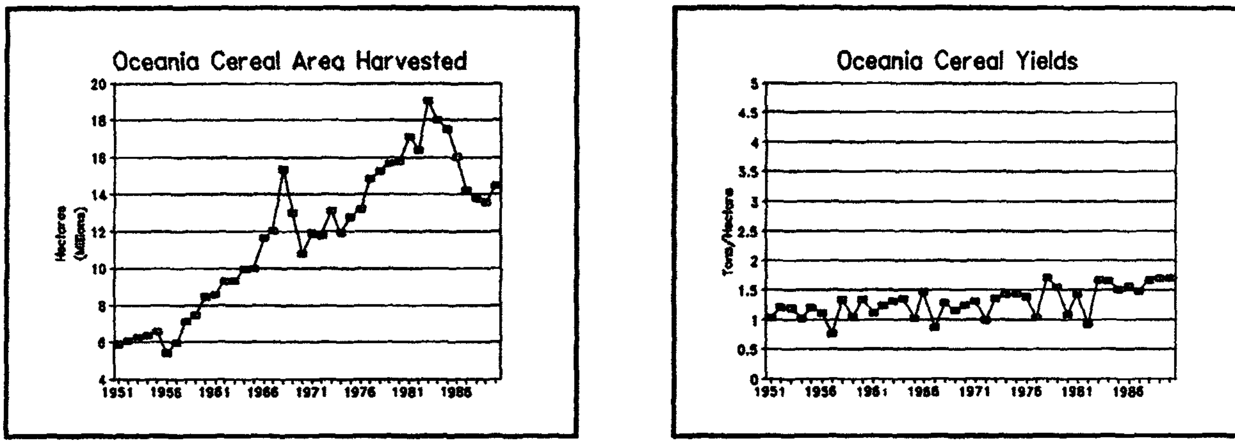


Source: Based on FAO data.

Cropland Quality

The quantity of land which is currently used for agriculture does not appear to be in question. Even the land area which could potentially be used for agriculture receives little debate, although the estimate of how much land could economically be brought into production is not as widely agreed. However, the quality of land which is used for agriculture has attracted widespread attention in recent years. Some studies have concluded that substantial portions of the world's cropland have been damaged or degraded by water erosion, wind erosion, chemical degradation (loss of nutrients, soil salinization, urban-industrial pollution, and acidification), and physical degradation (compaction, waterlogging and subsidence of organic soils). Other studies have concluded that these claims are exaggerated.

The future productivity of agricultural lands is an important issue for the long-term food balance. Is the productive potential of land being degraded and if so, at what rate? This is not a new issue, but it has emerged as a controversial one and part of a larger debate on the environment. A recent study sponsored by the United Nations Environment Programme (UNEP), the Global Assessment of Soil Degradation (GLASOD), surveyed more than 250 soil scientists and 21 regional coordinators of the study for their expert estimates of soil degradation (Oldeman, et al., 1990). The scientists were asked to estimate the degree, type and causes of the human-induced soil degradation that has occurred since World War II. This study concluded that 15% of the world's land areas were degraded due to human-induced activities. Water erosion accounted for 56% of the degradation, wind erosion accounted for 28%, chemical degradation accounted for 12% and physical degradation for 4%. Of the 15% of total land area judged to be degraded by human activity, 38% was believed to be lightly degraded, 46% moderately degraded, 15% strongly degraded and 0.5% extremely degraded. The causes of the land degradation were judged to be about equally divided among overgrazing, agricultural activities, and deforestation and land conversion.

The results of the GLASOD report suggest that land which is lightly degraded would have somewhat reduced agricultural productivity; moderately degraded lands would have greatly reduced agricultural productivity; strongly degraded land would not be reclaimable without major engineering work and would have largely lost its original biotic function; and extremely degraded land would have its original biotic function completely destroyed and the land would have been wholly lost to agriculture.

The credibility of these estimates is questioned, however, by comparisons with other studies and detailed examination. Crosson and Anderson (1992) point out that the GLASOD report classified 10-49% of six US states as being moderately degraded (greatly reduced agricultural productivity). These states; Illinois, Iowa, Kansas, Nebraska, North Dakota and South Dakota, are generally considered to contain the most fertile land in the United States. However, according to the GLASOD report, the soil is moderately degraded due to agriculturally-induced water and wind erosion. Crop yields have risen steadily in these states and this seems very inconsistent with the conclusion that "greatly reduced agricultural productivity" has been caused by wind and water erosion since 1945. Further, other studies have estimated the effects on US crop yields of water and wind erosion and concluded that maize and soybean yields were 2-3% lower than they would have been during the early 1980s without erosion (Crosson and Stout, 1983). Clearly this casts doubt on the strong conclusions of the GLASOD study.

Several problems emerge when trying to assess the degree of land degradation. First, few objective studies have been done which actually measure the degree of land degradation. This causes expert surveys to be used such as in the GLASOD study. The results of such studies may vary based on the participants selected, the methods and the objectives of the study. Secondly, the impact on yields of soil degradation are poorly documented and can be an additional source of uncertainty. Thirdly, the regenerative capacity of the soils may be greater than commonly believed.

Wind and water erosion are by far the main source of land degradation (accounting for 84% of land degradation according to the GLASOD study). A study by the US Soil Conservation Service, a comprehensive, statistically reliable survey of the amount of soil erosion occurring annually in the United States, was conducted in 1977, 1982 and 1987. The survey covered water and wind erosion on cropland, pasture range and forest land (Crosson and Anderson, 1992). Based on these surveys, Osborn and Colaccio (1989) estimated that national average US yields would decline about 3% after 100 years of erosion at the 1982 rate. Pieice et al. (1984) estimated the effect on maize yields in the midwest and obtained a 4% decline after 100 years. Very few comparable estimated are available for other countries.

Several other issues of land degradation need to be considered. The soil type and soil depth can have important implications for the effects of soil degradation on crop yields. If the soils are deep and the sub-soil is not dramatically different from the topsoil then yield potential can often be restored by the application of fertilizers. Soil erosion on tropical soils may reduce yields more than on temperate zone soils because organic matter, which is critical to soil fertility, is more concentrated in the top soil of tropical soils. Finally, soil erosion is not the same as soil loss because most eroded soil is redeposited and remains available to agriculture.

Only about 5% of soil eroded over the past 100 years was lost to agriculture, according to some studies.

The issue of land degradation is critically important, but estimates vary widely about the extent of land degradation and the implications for crop yields. The problem seems to be much less severe than some would suggest and probably does not threaten crop yields in the next several decades. Even based on the extent of degradation which GLASOD concludes has already occurred, the extent of the problem seems exaggerated. For example, the GLASOD survey concludes that 15% of the world's land areas were degraded due to human activity, and that 84% of this degradation was caused by water and wind erosion. A study by the US Soil Conservation Service using more reliable methods than the survey procedure used in the GLASOD study concluded that wind and water erosion at 1982 rates in the United States would only reduce national yields by 3% after 100 years. Therefore, we must be skeptical of the threat to food production of the level of land degradation from wind and water erosion reported in the GLASOD study. The remaining sources of land degradation, including chemical and physical degradation, accounted for 16% of land degradation activities according to GLASOD, but still reportedly affected only 2.4% of all lands. Even if this posed a greater threat than wind and water erosion, which it may not, it would still affect a small part of total land area. Whatever the extent of the problem, crop yields have increased despite the reported general degradation of the cropland.

Yield Levels and the Potential For Further Increases

Yield increases accounted for 90% of the growth of world cereals production from 1950 to 1990.[2] The annual rate of growth of yields was 2.24%. In the developing countries yields grew at 2.17% per annum and accounted for 82.5% of the increase in cereals production while in the developed countries, yields grew at 2.39% per annum and area devoted to cereals declined 3.6% from 1950 to 1990. Table 4.6 shows the least squares growth rates for world wheat, rice and maize for selected periods. The yields of maize during the 1980-90 period were lower than during previous periods, primarily due to the severe US drought in 1988. With this exception, yields continued to grow at nearly the same rate during the most recent decade as during previous decades.

Many factors contributed to the growth of yields including improved genetic potential, increased fertilizer use and expanded area under irrigation. In the developing countries, this combination of factors was part of the Green Revolution, the rapid advances in cereals

[2] Computed from FAO data as follows:

	World Prod (mil tons)	Ylds (t/ha)	Area (mil ha)
1950	684.93	1.138	601.87
1990	1954.68	2.763	707.45

The increase in cereal production was 1269.75 mil tons, area increased 105.58 mil ha, which produced 120.15 mil tons at 1950 yield levels or 9.46% of the increase which leaves 90.54% of the increase due to yields.

production in the developing countries which began in the mid-1960s when high-yielding varieties (HYVs) of wheat and rice were introduced. The high-yielding varieties were developed at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and the International Rice Research Institute (IRRI) in the Philippines and the International Center for Tropical Agriculture (CIAT) in Colombia. The distinguishing characteristic of the high-yielding wheat and rice varieties was their relatively short stem which allowed the plants to carry the increased grain resulting from heavy fertilizer application without lodging. They had other important features such as high tillering and sturdy stems; they were also generally early maturing which allowed two and sometimes three crops to be grown each year. Although semi-dwarf varieties had been known about for more than a century, the modern and improved varieties were widely adopted only following the food crisis in South Asia in the mid-1960s.

Table 4.6 World wheat, rice and maize yield growth rates for selected periods, 1951 to 1990

Commodity	1951-60	1960-70	1970-80	1980-90
		(% p.a.)		
Wheat	1.84	3.06	1.99	2.89
Rice	1.27	2.40	1.63	2.34
Maize	2.74	2.48	2.84	1.01

Source: Based on FAO data
Note: Growth rates based on least squares calculation

The development of improved varieties can be represented by three stages: (i) traditional varieties; (ii) improved varieties of normal height; and (iii) high-yielding varieties of shorter heights--principally semi-dwarf and intermediates. Each stage may include successive waves of new improved varieties. The most dramatic gains have been associated with the shift from stage two to stage three. The reference to high-yielding varieties, or HYVs, generally refers to varieties of the semi-dwarf type of stage three. The high-yielding varieties require high levels of fertilizer to achieve their yield potential along with timely application of water and good drainage.

The adoption of the high-yielding wheat and rice varieties was very rapid, often reaching 30-40% of total area within three to four years. This was possible because many governments made the package of technology available--including the HYV seeds and the necessary fertilizers and chemicals. Adoption rates began to slow after the initial push as the difficulty of extending the HYVs to the less desirable areas, with poorer water control or drainage, were encountered.

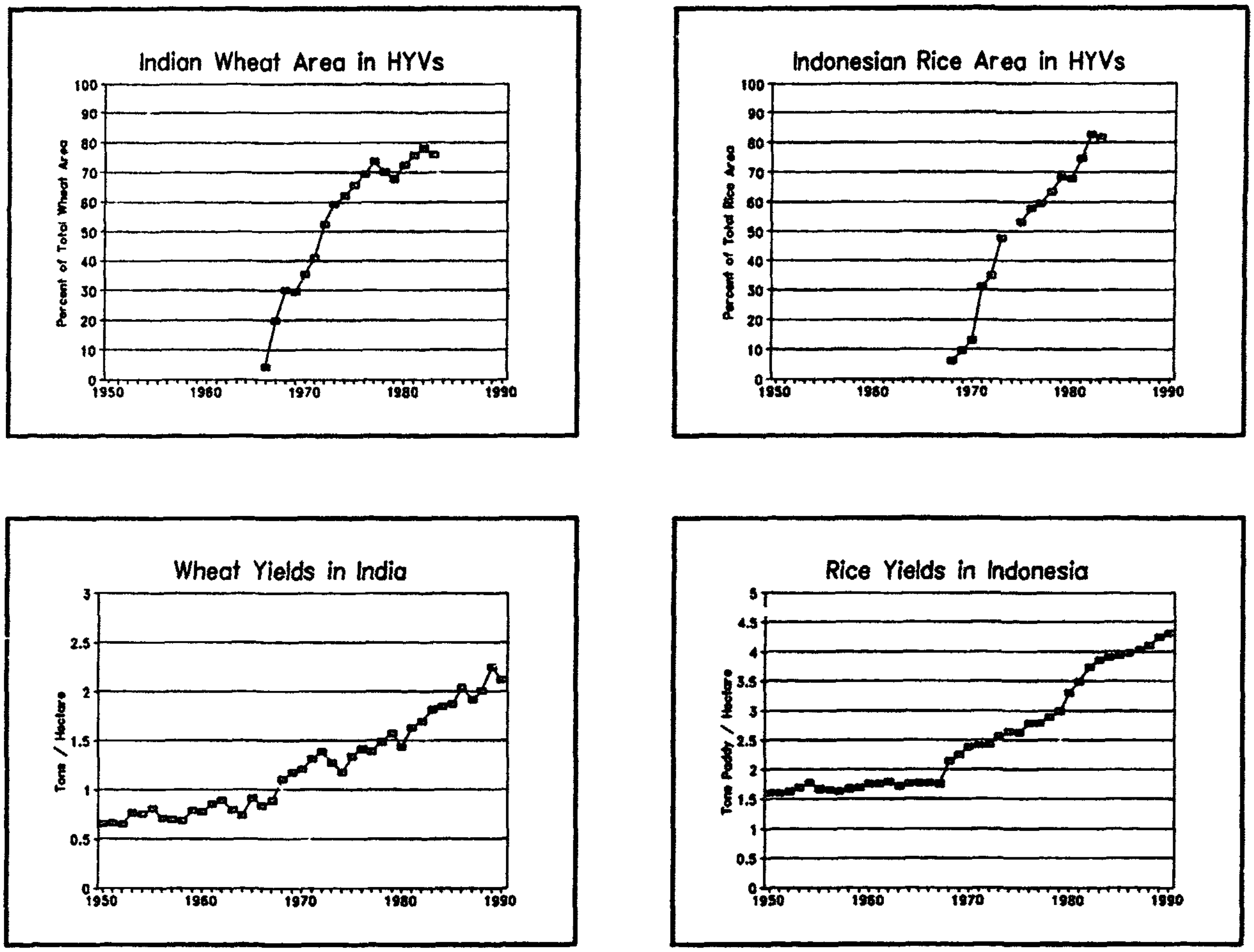
Wheat yields for India and rice paddy yields for Indonesia are shown in Figure 4.3 from 1950 to 1990. The rates of adoption of the HYVs are also shown, and reflect the strong influence of the high-yielding varieties. Yield levels are seen to rise sharply along with the introduction of the high-yielding varieties after being stagnant since 1950.

The adoption of the high-yielding varieties has been widespread and by the early 1980s the use of high-yielding wheat and rice varieties in developing countries had exceeded 50% of all areas planted to these cereals (Dalrymple, 1986b). The potential for increasing area planted to HYVs depends on suitable soils and climate, fertilizer availability, government policies and consumer preferences. In many cases further expansion is possible; but, further gains will occur more slowly than in the past because the best areas have already been switched to the higher-yielding varieties. Even as the HYV adoption levels taper off, yields will not necessarily stagnate or decline because new HYVs with greater yield potential are being developed. The use of inputs such as fertilizer is generally low and considerable potential for yield increases remain.

The next generation of high-yielding varieties is not yet available, but considerable progress has been made toward a higher yielding rice plant. The International Rice Research Institute, which developed the first high-yielding rice varieties released in the mid-1960s, is currently working on a new generation of high-yielding rice (Khush, 1991). The research is centered around modifying present high-yielding varieties to reduce the plant's production of unproductive tillers and increase the grains produced per productive tiller. Yield gains of as much as 50% are targeted for the new varieties which are expected to be ready within 10 years. The current varieties of rice have 20-25 tillers, of which only 15-16 produce small panicles and the rest remain unproductive. The unproductive tillers compete for nutrients and reduce yields. Current research is attempting to produce a rice plant with only 4-5 productive tillers and with higher grain production per panicle.

Other breakthroughs in yield potentials are also possible from improvements to existing varieties. For example, the International Maize and Wheat Improvement Center (CIMMYT) in Mexico announced in October 1992 that its researchers had used traditional plant-breeding techniques to develop a cure for wheat leaf rust (Science, 1992). The new rust-resistant strain of wheat was obtained by cross-breeding an old Brazilian-grown variety with a modern high-yielding variety. This development has enormous implications, according to CIMMYT officials, because farmers can now grow wheat in many humid parts of Africa, Asia and Latin America where leaf rust flourishes. Even farmers in traditional wheat growing areas, such as on the Great Plains of the United States, will benefit from the reduced threat of leaf rust. The overall consequences of this development are to raise average wheat yields and extend the areas which can grow wheat significantly.

Figure 4.3 Yields and HYVs in India and Indonesia, 1950-90



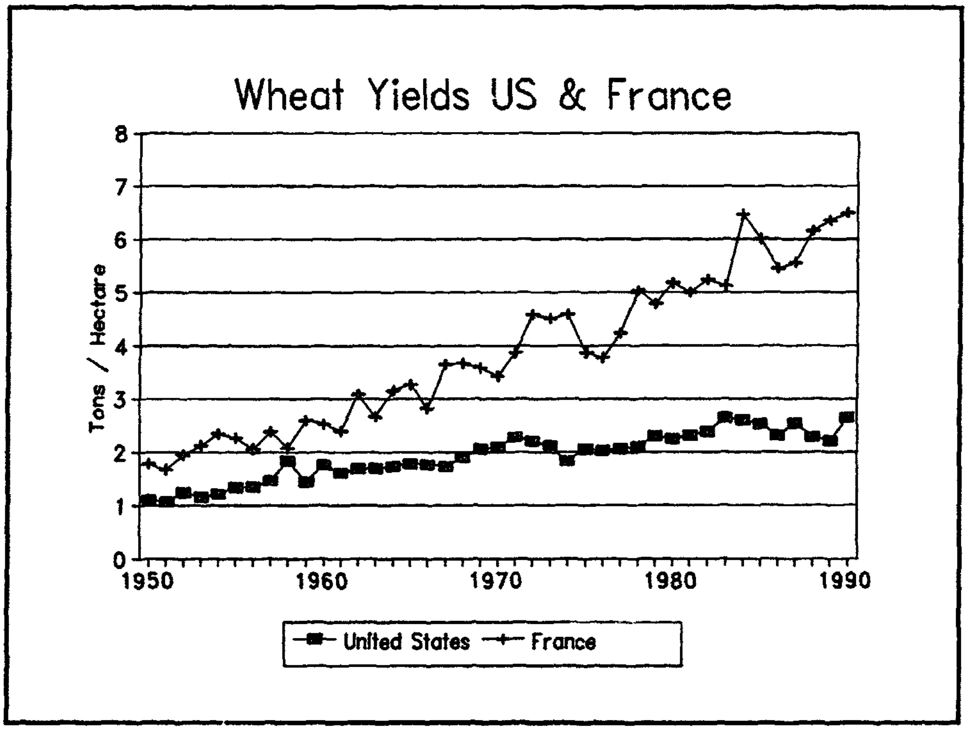
Source: Yield data are from FAO, and HYV adoption rates are from Dalrymple, (1986a and 1986b).

Scientists at CIMMYT also recently reported developing new varieties of maize which deliver 30% more grain in a drought season than conventional varieties. Even when there is not a drought, the new maize varieties outyield other varieties. Scientists took advantage of genetic variations which naturally occur in plants and then selected plants which had the best yields during droughts. This could be especially effective on maize grown in lowland tropics, which includes much of Africa, according to CIMMYT officials (Washington Post, 1993).

The potential for further yield increases depends on continued improvements in the genetic potential of crops and on the economic incentives facing farmers. Despite concern about the ability of crop scientists and farmers to maintain the growth rate in yields which have been achieved in the past, yields continue to increase. A comparison of wheat yields in the United States and France suggests that considerable potential exists even in countries which already have relatively high yields. Figure 4.4 shows wheat yields since 1950 in these two countries. France has had higher wheat yields than the United States throughout the entire period, but the margin has widened substantially during recent years. This is due in large part to the higher wheat prices received by French farmers because of the EC's Common Agricultural Policy. The supported prices have led to a higher use of inputs such as fertilizer and increased investment in land, equipment, research, etc.

The differences in crop yields between countries are often offered as the basis for potential growth in the country with the lower yields. However, the data suggest that the relativity between yields tends to remain constant and the relationship between France and the United States is the exception. For example, the five countries with the highest average rice yields out of 18 Asian countries in 1950-52 were China, Japan, Taiwan, the Republic of Korea and the D.P.R. Korea. These same five countries had the highest average yields in the 1960-62 period, the 1970-72 period and the 1980-82 period, with no exceptions (based on FAO data, 1987). Yields rose in every period and the ranking of the top five countries changed but these five always had the highest yields. Does this mean that factors such as soil type and climate are more important than crop breeding, irrigation and fertilizer application? Perhaps. It also suggests that few countries provide the extreme of profitability which France provided to its wheat producers.

Figure 4.4 Comparison of wheat yields in the US and France



Source: Based on FAO data.

The relationship between latitude and rice yields is graphed in Figure 4.5 for the five-year periods 1951-55 and 1983-87. The data for both periods show a "U" shaped relationship between rice yields and the location of a country relative to the equator. The lowest yields are for countries located about 15-20 degrees north of the equator and the highest yields are at 40 degrees north and 30 degrees south of the equator. Note that rice yields increased during this period of more than 30 years, but the relative position of most countries remains largely unchanged. The countries located at about 15 degrees north of the equator, Thailand, Philippines, Viet Nam, Laos, and Burma had the lowest yields during both periods. A possible explanation for this relationship is the intensity of the solar radiation relative to the equator.

Biotechnology

Yield gains in cereals have exceeded population growth for the past 40 years. New biotechnology holds the prospect that further advances in knowledge may be possible which will increase yields even faster in addition to the traditional research which continues to push yields higher. Biotechnology is defined by the Office of Technology Assessment of the United States Congress as

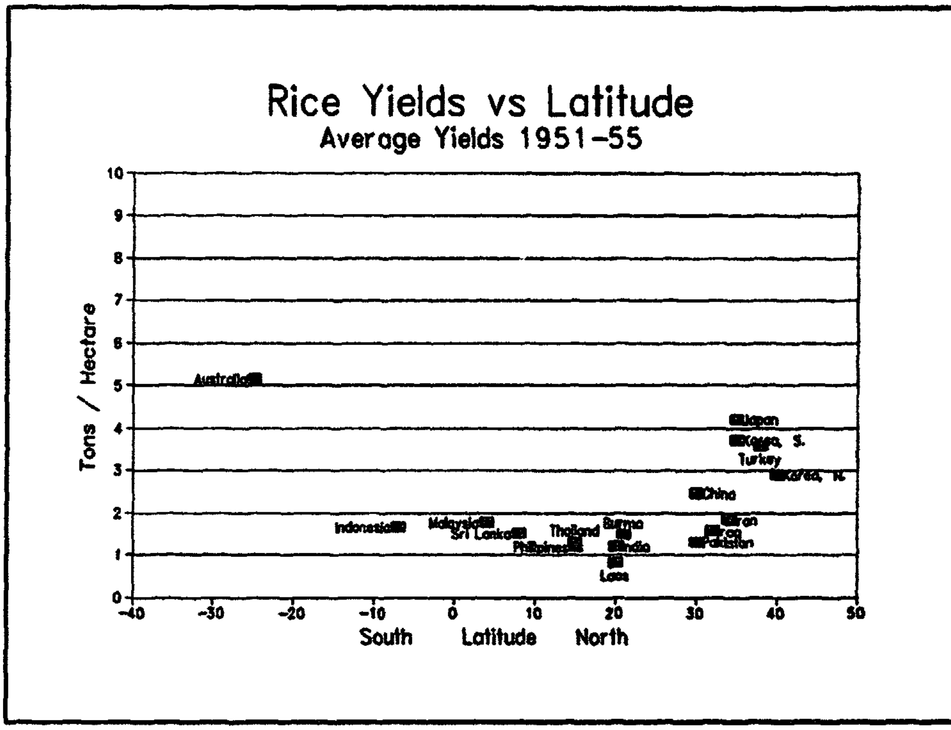
> "any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses"
>
> (OTA, 1989)

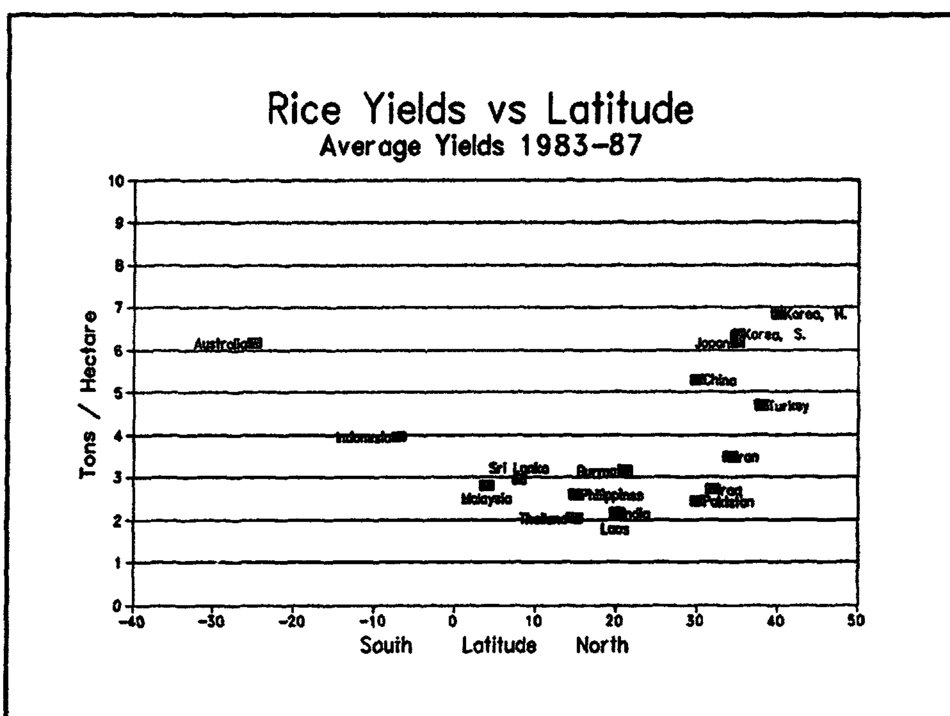
Biotechnology includes traditional biotechnology, which has commonly been used to control pests, develop animal vaccines and many other applications and the modern biotechnology which encompasses the use of more recently available technologies such as those based on recombinant DNA technology, monoclonal antibodies (MCA) and new cell and tissue culture techniques (Persley, 1990).

The basic principle of recombinant DNA technology (genetic engineering) is that genetic material which contains a specific trait can be transferred from one species to another, perhaps unrelated, species. The techniques which allow gene transfer have developed very rapidly. A major limitation is identifying specific genes which confer useful traits to the recipient species. In plants, biotechnology is being used in conjunction with conventional plant breeding to develop seeds of new plant varieties which have new characteristics such as herbicide tolerance or resistance to certain pests and diseases. In animals, biotechnology has been used to develop the recombinant growth hormone or bovine somatotropin (BST) which increases milk production in dairy cows by 15%-30% and increases the efficiency of feed intake. Great potential exists to improve disease resistance of both plants and animals.

Modern biotechnology provides researchers tools to complement traditional plant and animal breeding programs. Many argue that with biotechnology the time lag to produce a new

Figure 4.5 Rice yields vs latitude





Source: Yields are based on FAO data; computations by World Bank.

variety, which is currently about ten years, will be shortened substantially. Biotechnology allows researchers to target a certain problem or a desirable trait and attempt to isolate and transfer a gene from outside the plant variety or animal. Not all crops are equally amenable to biotechnology solutions, however. It depends upon the plant's genetic complexity, the natural variability which provides a source of potentially desirable traits, and our knowledge of the genetic map of the plant.

The World Bank commissioned a study in 1988 to assess the potential of biotechnology to contribute to increased agricultural productivity and to identify important issues which may affect its successful application (World Bank, 1989). The study identified commodities where substantial progress may be expected from biotechnology. Potatoes, rapeseed and rice were expected to see substantial progress within five years (by 1993); banana/plantain, cassava, and coffee were expected to see substantial progress within five to ten years (1993-98) and cocoa, coconut, oil palm and wheat were not expected to see substantial progress before ten years (after 1998).

The greatest gains from biotechnology for the world food situation may come not from cereals but from vegetables. For example, a US biotechnology company has produced a tomato which retains its freshness for about 10 days longer than a regular tomato. This type of advance could reduce vegetables' spoilage and reduce the land and other resources needed for production, which would free resources for producing other food crops. Biotechnology is also expected to increase the productivity of tree crops such as cocoa, coffee and oil palm.

Among major cereals, new rice varieties resulting from genetic engineering are expected to reach farmers' fields by the mid-1990s (Toennison, 1990). The progress in rice breeding using biotechnology has been especially rapid since 1987. At that time there was little application of modern biotechnology to rice. The Rockefeller Foundation decided to commit about US$ 6 million per year to support research on rice biotechnology through support to leading plant molecular and cell biology laboratories worldwide. The program now emphasizes targeted research on agronomic traits, technology transfer and establishing the capability to utilize the new technologies at the international centers and in developing countries. A genetic map of rice has been developed based on DNA markers and the markers are being linked to genes for important agronomic traits. Several rice genes governing important traits have been cloned and characterized, as have several alien genes with potential for rice improvement. Experiments are underway to introduce these genes into rice (Toennison, 1990).

Wheat is expected to benefit from biotechnology research, but because it is much more genetically complex than rice, progress will be slower. Wheat has approximately 17 times the genome of rice and this makes genetic mapping of wheat more difficult (Persley). However, we should not be surprised if developments take place more quickly than anticipated, as a recent breakthrough on wheat research shows. Scientists have been successful in genetically altering wheat, a previously unachieved goal (Bio-Technology, June 1992). This will make it possible to alter the major cereal crops--wheat, rice and maize--and allow gene-splicing techniques to be used. The breakthrough occurred when scientists developed wheat plants with resistance to an organic herbicide and achieved the transfer of this trait to two successive generations of wheat plants. The task of identifying genes which will confer agronomically useful traits into wheat remains to be achieved.

Water and Irrigation

Water for crop production can be derived from rainfall or from a variety of irrigation methods which allow the farmer some control over the timing and quantity of water used. Even in areas which receive abundant annual rainfall, it is desirable for farmers to control irrigation to ensure that adequate water is available at critical stages of plant development. The increased production possible from irrigated lands is due to both increased yields per crop and greater intensity of production which may allow an additional crop to be grown in the dry season. In arid areas, irrigation allows crops to be grown where otherwise none would be grown. Approximately 15% of the world's cropland receives some irrigation and this cropland is estimated to account for about 36% of total production (FAO, 1988, p. 132).

Many methods of water control are used for irrigation. The simplest are small diversion dikes which cause water to flow over a large area during spring floods rather than allowing the water to follow a stream channel. This method allows one irrigation per year in most cases and is sufficient to grow many crops. A small earth dam across a stream is another way for a farmer to control water, storing it for later use. Pumping from a flowing river is also used or in some cases the river can be tapped without pumping.

Wells are a common method of irrigation in many parts of the world. A hole is drilled to the depth of the water and a pipe is inserted in the hole to prevent the earth from caving in and filling the hole. A pump is then used to raise the water to the surface where it is transferred to the crops by ditches, pipes or sprinklers. Two of the more interesting examples of this are the shallow tubewells and the large center-pivot irrigation systems. Tubewells are used in most of Asia to irrigate crops during the dry season, but they are especially numerous in Pakistan. In a typical case, a farmer bores a hole as little as 10 feet deep to as much as 200 feet deep and inserts a plastic pipe to secure the well. The farmer then uses a pump run by an electric or diesel motor to pump water to the surface where it is diverted into a ditch for distribution to the crop. At the other extreme, US farmers invest heavily in center-pivot irrigation systems to irrigate their crops. A deep well is drilled to tap an underground water reservoir or aquifer. In some instances, wells are several thousand feet deep. If a large water supply is found, a metal casing is used to secure the well and a pump and sprinkler system are installed. The well becomes the center of a 127 acre circle with a sprinkler arm which extends from the well. The sprinkler crawls around the circle as it pumps water to the crop and requires no labor other than installation and maintenance.

Several issues are important to the contribution that irrigation can make to future increases in world food production. Firstly, the availability of water provides a limit to the amount of irrigation which is possible. In some regions this is already a constraint and, as population pressures increase, the amount of water available for agriculture will decrease further. Secondly, the availability of additional land suitable for irrigation is also limited as the best sites have already been developed. A third point is the efficiency of use of irrigation water. In many irrigation projects the efficiency of water use is well below its potential because much of the water is wasted. This results primarily from the management of the irrigation projects which underprices water to the farmer, reducing the incentive for efficient water conservation and reduces the amount of water available for downstream users.

The world's irrigated areas are shown in Table 4.7 by major region. Asia has more than 60% of total irrigated area and most of this is in India and China.

Table 4.7 Irrigated area by region, 1970 to 1990

Region	1970	1980	1990
		('000 Hectares)	
World	167,399	210,443	232,828
Africa	7,620	9,340	11,186
N C America	20,955	27,671	25,920
South America	5,681	7,386	8,835
Asia	109,727	132,217	146,422
Europe	10,728	14,658	17,240
Oceania	1,588	1,684	2,161
FSU	11,100	17,487	21,064

Source: FAO, Production Yearbook

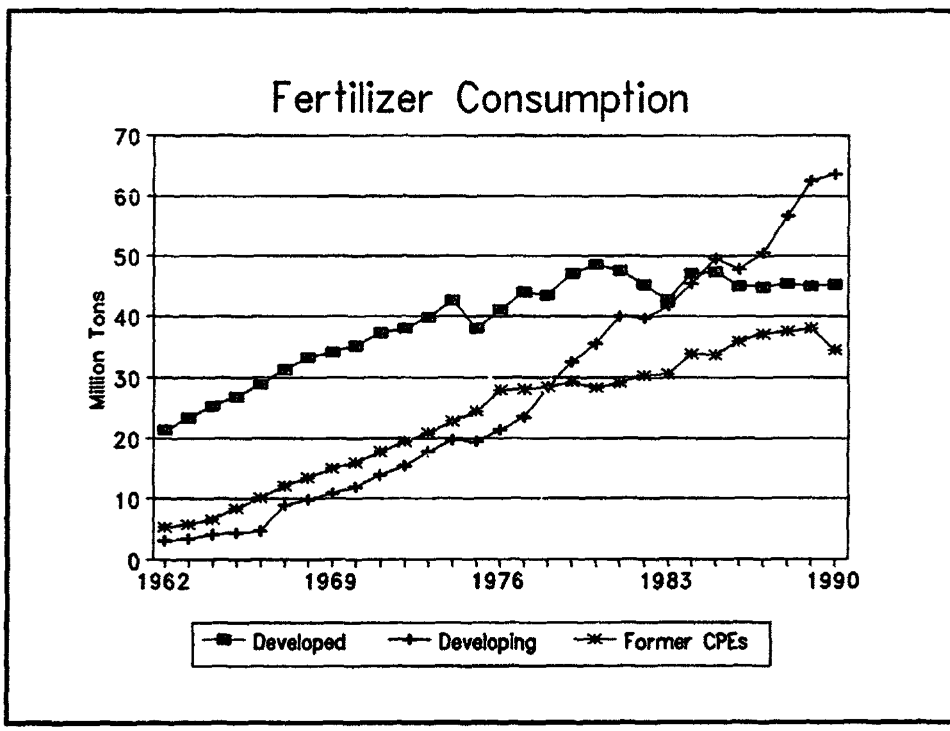
Fertilizer

Fertilizers can be obtained from a variety of sources--from organic manures and other wastes, mining, or manufacturing by chemical processes. Farmers still apply organic fertilizers such as manure to supply some nutrients and improve soil structure, however, the commercial fertilizer industry is based on inorganic chemical fertilizers. These inorganic fertilizers played a leading role in the increase in agricultural production over the past several decades, and their costs and availability will be essential to future production.

Plants need 16 different nutrients, in the right proportions specific to each plant, from the air, water and soil. The nutrients from soil consist of three primary nutrients (nitrogen, phosphorus and potassium), three secondary nutrients (calcium, magnesium and sulphur) and seven other nutrients known as micronutrients. The three primary nutrients are the most important in the sense that plants can effectively use much larger quantities of these nutrients than soils naturally provide. The secondary nutrients are needed in moderate to small amounts and the micronutrients are needed in only minute amounts (World Bank, 1989).

Fertilizer consumption has grown rapidly in the developing countries since the early 1960s when the Green Revolution began and by 1990 exceeded fertilizer use in the developed countries. Consumption in the developed countries and in the former centrally planned economies has slowed since the mid-1970s because of higher fertilizer prices and slow area expansion. Total fertilizer consumption is shown in Figure 4.6 for the major country groupings of developed countries, developing countries, and former centrally planned countries.

Figure 4.6 Fertilizer consumption by region, 1962 - 1990



Source: Based on FAO data

Inorganic nitrogen fertilizer is produced primarily from synthetic ammonia which is obtained by combining nitrogen (from air) and hydrogen (from natural gas, oil or coal) in the presence of a catalyst. Natural gas is the most common energy source and feedstock for ammonia synthesis. Once ammonia is produced, it can be used to produce various synthetic nitrogen fertilizers such as urea, which is the most common nitrogen fertilizer. The potential availability of nitrogen fertilizers is practically limitless since the nitrogen is fixed from the air and the hydrogen is obtained from an energy source such as natural gas. The production of hydrogen is highly energy intensive and the cost of natural gas accounts for an estimated 70% of the production cost of ammonia (Knopke and Towner, 1992).

Phosphate fertilizer is available in limited quantities from organic materials such as bone meal. However, it is primarily produced from phosphate rock which is found as the sedimentary deposits of marine organisms or bones of animals. Under certain conditions, phosphate rock can be finely ground and applied directly to the soil, however, it is normally mixed with sulfuric acid to produce water-soluble phosphate. Additional processing produces phosphoric acid which is used to produce more concentrated phosphatic fertilizers. Current known world reserves of phosphate rock and sulphur, the two primary minerals needed to produce phosphatic fertilizers are abundant for the foreseeable future. Reserves of phosphate rock are estimated at 33.8 billion tons, of which 12 billion could be commercially mined at current prices. At current usage rates of 160 million tons per year, the commercially viable reserves alone would last 75 years. Sulphur is even more abundant and long-term supplies are not considered to be a problem (US Bureau of Mines, 1992).

Potash is extracted from underground deposits of soluble potassium materials or potassium-bearing brines. Potash is mined and processed mainly as potassium chloride, with lesser quantities as potassium sulphate and potassium magnesium sulphate. Concentration and beneficiation operations are then used to produce commercial grade potash fertilizers. Known world reserves of potash are very large at about 9.46 billion tons compared to the 1991 consumption rate of 24.4 million tons. At current usage rates, known reserves would last about 400 years (US Bureau of Mines, 1992).

Despite large reserves of minerals for fertilizer production, several issues of availability still exist. About one-half of the commercial reserves of phosphate rock are located in the Middle-East and one-fourth in South Africa. Political instability in either of these regions could limit supplies for a period. The reserves of potassium are also concentrated in a relatively few countries and regional instability could lead to a temporary disruption in supplies. Nitrogen fertilizer production is dependent on energy prices, particularly natural gas prices, and this introduces the issue of long-term energy prices and stability of supplies from the Middle-East. Mining and manufacturing capacity in the fertilizer industry can also limit production of fertilizer for a period, but this would soon be overcome as capacity increased in response to increased demand.

A greater concern than the stability of fertilizer supplies could be constraints on fertilizer production and use due to environmental concerns. Releases of nitrogen gases into the air and run-off and leaching of nitrates into groundwater could lead to restrictions on fertilizer use. Consumer concerns over chemical use in food production could further support efforts in the United States and Western Europe to limit fertilizer use. The problem of fertilizer run-off should be addressed by improving the efficiency of application so that less fertilizer is wasted and plants are better able to utilize fertilizer. Scientists have been working towards these objectives in two ways: by designing improved fertilizer management practices such as finding the optimal soil depth for fertilizer application; and by breeding plants which have increased up-take capacity. Plants are also being developed which can fix nitrogen from the air instead of relying on chemical nitrogen.

Labor

In the poorest countries, over one-half of the labor force is employed in agriculture, while in the high-income countries less than 2% of the labor force works in agriculture. In few cases can labor be identified as a constraint to agricultural production because of the easy substitution of machinery for labor. When farm wage rates rise, machinery is substituted for labor and the productivity of the remaining labor increases.

The Environment

Changes in the environment could pose a challenge to world agriculture if temperature or precipitation levels were to change rapidly. Gradual changes would seem to pose less of a challenge since crop varieties can be adapted to climatic changes. Much recent concern about the environment is centered around the issue of the "greenhouse" effect and global warming. By some reckonings the earth's average temperature has increased by 0.3 to 0.6°C during the past century. This has alarmed many people, including many scientists, and recent events such as the 1980s being the hottest decade in history have heightened the concern. The concern is not so much what has happened to global temperatures, but what might happen in the future. Based on predictions from climatological models, global mean temperature could rise about 0.3°C per decade. This would result in a rise in global mean temperature of about 1°C above the present by 2025 and 3°C before the end of the next century.

The "greenhouse" effect refers to the accumulation of gases in the atmosphere which raise the earth's temperature by trapping incoming radiation from the sun and causing or contributing to global warming. These greenhouse gases reduce the amount of heat which escapes from the earth's surface, acting like a blanket. If the level of greenhouse gases increases, then theoretically this will lead to an increase in the earth's temperature. The evidence of global warming and an increase in greenhouse gases are largely agreed by the scientific community. The causality--that a buildup of greenhouse gases caused the increase in temperature--is not universally agreed and the consequences of a rise in temperature are not well understood.

The evidence supporting an average global temperature increase of 0.3 to 0.6°C during the past century appears convincing. The Intergovernmental Panel on Climate Change (IPCC), a United Nations committee of 300 leading earth scientists, came to this conclusion. Temperature measures of air over land, air over sea and the ocean support this conclusion. The eight hottest years this century have all occurred since 1979. And, most mountain glaciers have receded markedly during the past 100 years. The reasons for the temperature increase are less certain because temperatures have previously risen as much as one-half a degree celsius during a century. The IPCC panel therefore concluded that it is impossible to tell whether the temperature increase observed since 1900 has been caused by extra greenhouse gases in the atmosphere or whether it represents the ending of a Little Ice Age.

The rise in the levels of greenhouse gases in the atmosphere is also widely accepted.

Chemists have measured very precisely the levels of greenhouse gases--carbon dioxide, methane, nitrous oxide, ozone, and the chlorofluorocarbons (CFCs) and other halocarbons. The level of carbon dioxide concentration in the atmosphere is about 25% greater than in pre-industrial times and the level of methane is about double the level of pre-industrial times.

The third conclusion which has widespread scientific agreement is that human activities are substantially increasing the atmospheric concentration of the greenhouse gases. Primary among these activities is the burning of fossil fuels which accounts for about 60% of the increase of atmospheric gases (carbon dioxide) from human activity. Forestry accounts for about 24% of greenhouse gases from human activity due to deforestation and the decay of organic matter which accompanies it. Agriculture accounts for about 12%, primarily from rice paddy production and from ruminant animal production. Other human activities including industrial activities contribute an additional 4% of the greenhouse gases.

The implications for global warming of the increase in greenhouse gases is a subject of continuing scientific debate. The likely effects on global temperatures can only be estimated by climatological computer models which have not yet been able to predict the past accurately. This makes their predictions of future global warming, based on projected increases in atmospheric gases, uncertain. One of the problems is that little is known about how the earth responds to increases in greenhouse gases. Consequently, modelers must assume the response without the opportunity to validate the assumptions. When these models attempt to predict the global warming which should have occurred in the past, based on measured levels of atmospheric gases, they almost always overestimate the global temperature increases. Some scientists think that current projections of global warming based on current models are too high because the planet may respond in ways which mitigate warming. Others believe the opposite. It is impossible for the average person to know whether global warming poses a long-term threat to the planet or not.

Finally, we come to the question of the implications of global warming. This area seems to be even less well understood, but also less the focus of debate. The IPCC concluded that studies have not yet conclusively determined whether, on average, global agricultural potential will increase or decrease. On balance, the evidence suggests that food production at the global level can be maintained at essentially the same level as would have occurred without climate change. Regional production patterns could be altered as a result of changes in weather and pests associated with weather changes (IPCC). Some researchers have argued that higher levels of carbon dioxide in the atmosphere will stimulate crops and natural vegetation. Most of the warming which has already occurred has been during the night and during winter months, not during the day. If that trend continues, it could extend the growing season by delaying the first frost and actually increase crop production in many regions. Global warming would also increase rainfall because higher mean temperatures would increase evaporation from the oceans.

While the subject of global warming is very captivating, its effect on world agriculture is yet to be clearly articulated. If, as most scientists who study the subject suggest, the temperature changes are gradual then the effects on agriculture would likely be small.

Variations of existing crops could be developed and the patterns of production adjusted.

Summary

The resource base available to agriculture must be viewed as dynamic and responsive. It is dynamic in the sense that factors of production are constantly changing in quality and in their availability for agricultural production. Land quality, for example, can be improved by adding organic matter and chemical fertilizer or degraded through erosion or overly intensive grazing or cropping. Land is also changing in quality due to natural and man-made changes such as erosion and climatic shifts. It is responsive to economic incentives in the sense that land can be shifted from pasture or woodlands to cropland when economically justified. Other factors of production including the efficiency of resource use are also responsive to economic incentives. For example, farmers are likely to time fertilizer applications more carefully when the returns from production are high. The stagnation of agriculture in the FSU should be a reminder of that and of the importance of appropriate incentives to the efficient use of resources. The resource base is also responsive in the sense that investment in research, for example, to improve varieties of crops, increases when prices rise.

No single factor of production can be thought of as most important to agriculture since all factors can be substituted for by other factors. Over the past 40 years, expanding land area has contributed less and less to the increase in world cereal production. This is likely to remain true in the future since the potential for expanding cropland is limited unless crop prices rise sharply. Higher prices, for example, would make remote areas in Africa and Latin America profitable to farm; but before prices reached these levels, more intensive use of existing cropland would likely increase supply and force prices lower. This likely places the burden of future production on higher yields and more intensive use of the land resource in most regions. However, several world regions have idle areas which could be brought into crop production relatively easily, including North America, Oceania, Eastern Europe and the FSU. These regions currently have less land in cereals than during the early 1980s and they could bring some of that land back into crops if prices justified the change. Africa and Latin America are generally acknowledged to have large amounts of land which could be cropped, but not at current prices.

Reductions in land quality--deteriorating rapidly according to some--does not yet account for significantly reduced yields on a global or regional level. Certain areas have become eroded and in some cases contaminated by salinization or human-made chemicals but this is the exception and does not constitute a global threat. Most land degradation is caused by water and wind erosion with the effect on aggregate crop yields minimal according to best estimates. Likewise, changes to the environment cannot be clearly identified as a threat to agricultural production. Global warming may increase, rather than decrease, crop yields if the changes to the environment include higher precipitation and warmer nights which would delay frosts in northern climates.

Perhaps the factor holding the greatest potential change in agriculture is the contribution of biotechnology and genetic engineering on crop and livestock yields. These new research tools complement traditional crop and livestock breeding programs and reduce the time required to produce a new crop variety or animal trait. They allow researchers to target desirable traits to be introduced into a species or remove undesirable traits. Advances are being made more quickly than expected, making the early prospect of a second Green Revolution a possibility. Efforts to produce a new generation of higher-yielding rice varieties are underway at the International Rice Research Institute in the Philippines with promising results. Yield improvements in other crops such as potatoes, which have previously been difficult to genetically improve, are expected as a result of biotechnology research. As greater output is produced on each hectare of land, this will further reduce pressure on the resource base.

With agriculture continuing to become more intensive, as it must, resources such as water will need to be used more efficiently. Irrigation water is becoming a limiting constraint for agriculture in some areas; however, in most cases the problem is one of pricing policies rather than availability. When water is priced at less than its true cost, farmers use more than is necessary for crop production and this reduces the supply available for downstream users. If water continues to be subsidized by governments, there is likely to be increasing tension between farm and non-farm users.

Other inputs such as labor, machinery, fertilizer and energy are important to agriculture. Their availability depends on factors outside of the bounds of agriculture in many cases. Labor, for example, is generally available for agriculture unless rapid economic growth raises wages sharply. This leads to increased mechanization, as has occurred in most industrialized countries, not reduced output. Fertilizer and energy are not as easily replaced by substitute inputs. Fertilizer in particular seems to be an essential factor of production for more intensive agriculture. During the 1970s, when fertilizer prices rose sharply, crop yields declined.

The resource base available to world agriculture appears adequate when viewed as dynamic and responsive. Concerns about land and water availability and the changes to the environment do not appear to constitute a threat to global food production at this time; however, every effort must be made to preserve and improve the natural resource base. Exploitation of the genetic potential of plants and animals by means of traditional breeding programs and recent advances in biotechnology and genetic engineering offer the best hope for offsetting declines in other production factors such as land.

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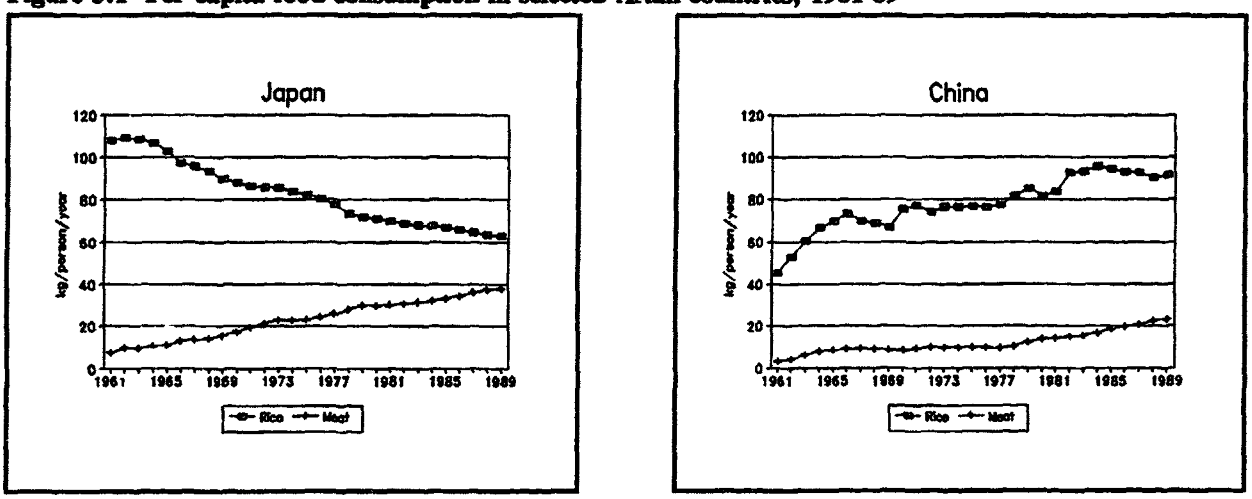
Chapter V. Diversification in Food Consumption Patterns

Future growth in demand is important in assessing the sustainability of the world food system. In this context, the role of structural changes in demand due to demographic transition and increasing incomes in developing countries is an important omission in previous assessments of the world food outlook. We examine these changes in this chapter. In Asia, direct per capita consumption of traditional foods is declining in most countries as people are adding variety to their diet by eating more higher-valued and more highly-processed foods. In Africa, millet, sorghum and starchy roots remain the major source of calories, but the per capita intake and their dietary share have declined in most countries while consumption of non-staple cereals (rice and wheat) have steadily increased. In the high-income countries, on the other hand, consumers are looking for "healthier" foods and are reducing consumption of red meats and animal fats.

Since 1961, the per capita consumption of rice in Japan has declined from about 107 kg to less than 65 kg, while meat consumption has increased from about 5 kg to nearly 40 kg (Figure 5.1). Japan is not typical of Asian countries since it has achieved the highest income level in Asia ($26,920 per capita in 1991, World Bank, Atlas), but similar changes in consumption patterns also appear to be underway in other countries, such as Malaysia, Nepal, Singapore, Thailand, and Taiwan. In China, per capita rice consumption has not increased in nearly a decade while meat consumption has risen rapidly (Figure 5.1).

Figure 5.1 Per capita food consumption in selected Asian countries, 1961-89



Source: Based on FAO data.

While there are numerous food demand studies, most have focused on single commodities. Very few have examined in a consistent framework the factors causing the apparent decline in demand for basic staples in relation to the demand for other foods. The implied changes in the demand elasticities as incomes and demographics change over time are important in evaluating the demand outlook. This chapter reviews the evidence at the national and household level across countries on the changes in food consumption patterns, focusing on the increasing diversity of diets in developing countries. The changes in the dietary structure as a result of economic development and demographic transition in these countries will have important implications for future global food production and trade.

Food demand patterns are known to change as a nation's level of economic development changes. Engle's law states that the proportion of a family's budget devoted to total food declines as incomes increase. While this may be true for food in aggregate, individual food items may show a range of increasing shares, particularly at extreme low income levels. Secondly, Engel's law implies that the income elasticity of demand for food is less than one. Although this seems true for aggregate food, individual food items, particularly non-staples may have income elasticities greater than one.

A second regularity, known as "Bennett's Law" states that the "staple ratio", which is the proportion of calories which an individual derives from basic staples, declines with rising incomes. This relationship was observed in seven countries using data for the late 1960s (Chaudri and Timmer, 1986). Despite the decline in the staple ratio, starchy staples, particularly one preferred staple (e.g., rice in Asia), have dominated most food consumption analysis. Timmer (1983) in evaluating the Indonesian food balance sheet for 1976 concluded the following:

> "entire categories of commodities--fruits, vegetables, fish, meat, milk, eggs, and animal fats--are virtually irrelevant to calorie intake. Indonesia is not unusual among developing countries in having animal protein contribute only 10% of average total protein intake."
>
> (Timmer, 1983, page 23)

More recent data indicate Timmer's observation would no longer be correct, particularly for many developing countries in Asia. The trend is towards declining consumption of traditional staples and increasing consumption of other foods. To explain these changes, we hypothesize that consumers choose a basket of food to maximize utility from a set of characteristics including energy, variety, taste, and health. At very low income levels, the utility derived from additional energy will be large and considerations about the level of energy derived from foods at given prices dominate the food consumption decision. As incomes rise, consumers desire some variety in their diet, for instance, some meat and vegetables to mix with the staples. At high income levels, taste and health characteristics of foods are hypothesized to weigh heavily in the food consumption decision. For instance, health concern about cholesterol and fats in red meats is a widely-cited cause in explaining the decline in meat consumption in high-income countries. As economic development proceeds, therefore, the demand for variety and quality of foods increases and non-staples become important sources of energy and protein.

The increasing participation of women in the labor force in developing countries is raising the opportunity cost of time used for food preparation. Senauer et al., (1986) provides evidence of this in Sri Lanka. As incomes increase, demand for food which requires less preparation increases. Since rice usually requires more household preparation time than wheat products such as bread and noodles, wheat products substitute for rice. Similar effects can be observed in high-income countries with the higher female labor force participation.

Urbanization is another factor influencing food consumption patterns in developing countries. Since rural activity levels tend to be higher than urban activity levels, holding income constant, the diet of rural consumers tends to have a higher proportion of staples than urban diets (Bouis, 1990). Changes in food consumption patterns may also result from other demographic characteristics, such as the aging of the population and the share of ethnic immigrants in the population.

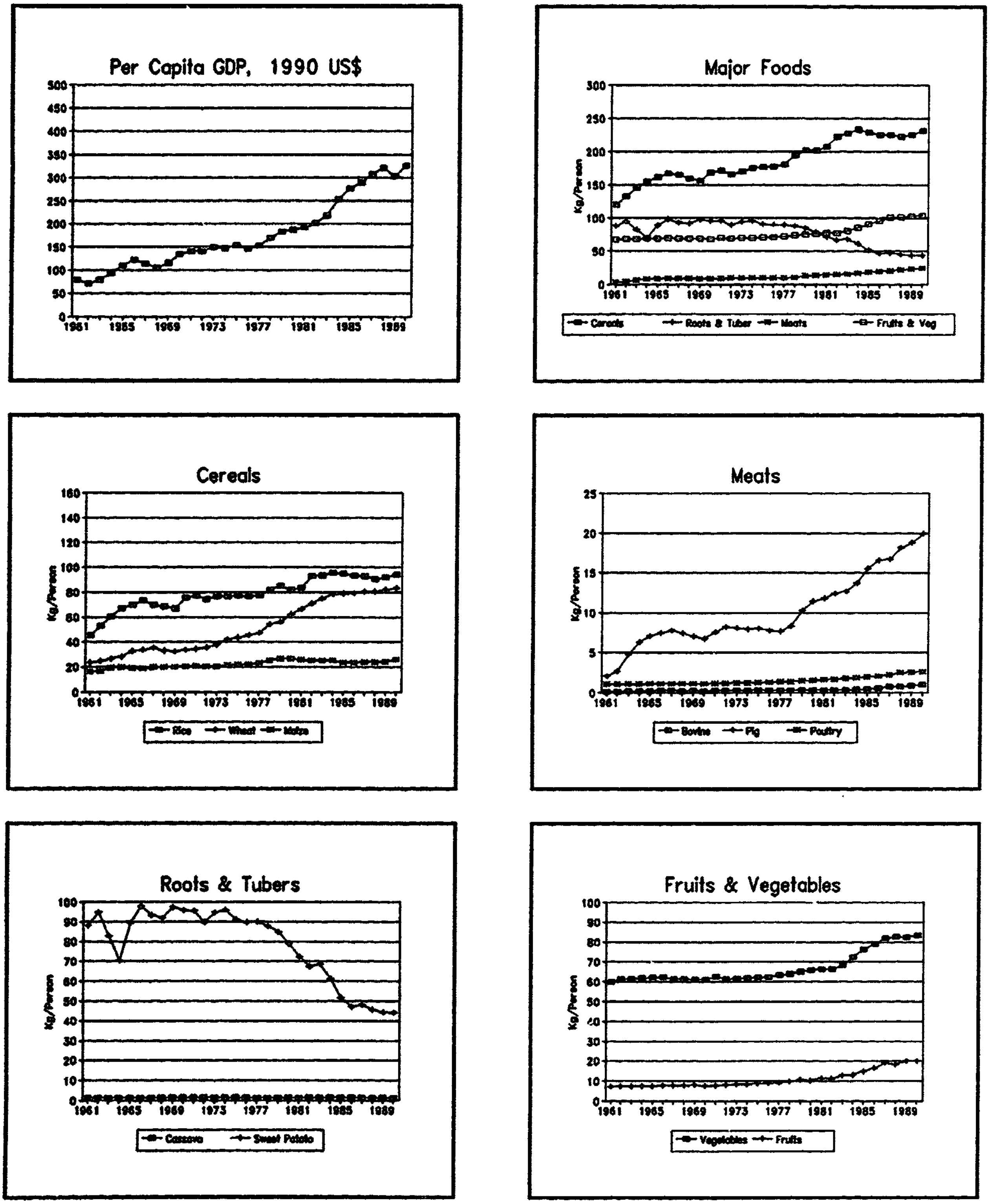
The changes in food consumption patterns are examined using three types of data. First, they are examined in relation to income in several countries with different levels of economic development using time-series data on per capita food consumption and their contribution to caloric and protein intake. Second, to obtain a global perspective, we review the changes in food consumption and expenditures across countries using data from the international comparisons project (ICP). Third, household survey data are used to examine the dietary changes of households in different income groups and locations (urban-rural) within a country. Since household surveys do not exist for many countries and the data are not comparable on a global basis, samples from each geographical region are examined. Analyses based on cross-section data complement time-series analyses and provide additional insights into the directions of change in consumption patterns as incomes and demographics change.

Evidence from Time-Series Data

The changes in food consumption patterns are shown for six developing countries in Figures 5.2-5.6. Data for additional countries in Asia, Africa, and Latin America are shown in Table 5.1. The figures show annual per capita consumption of major food groups and individual food items along with per capita GDP from 1961 to 1990. The countries represent a range of cultures and economic circumstances, yet all share common trends in their consumption patterns.

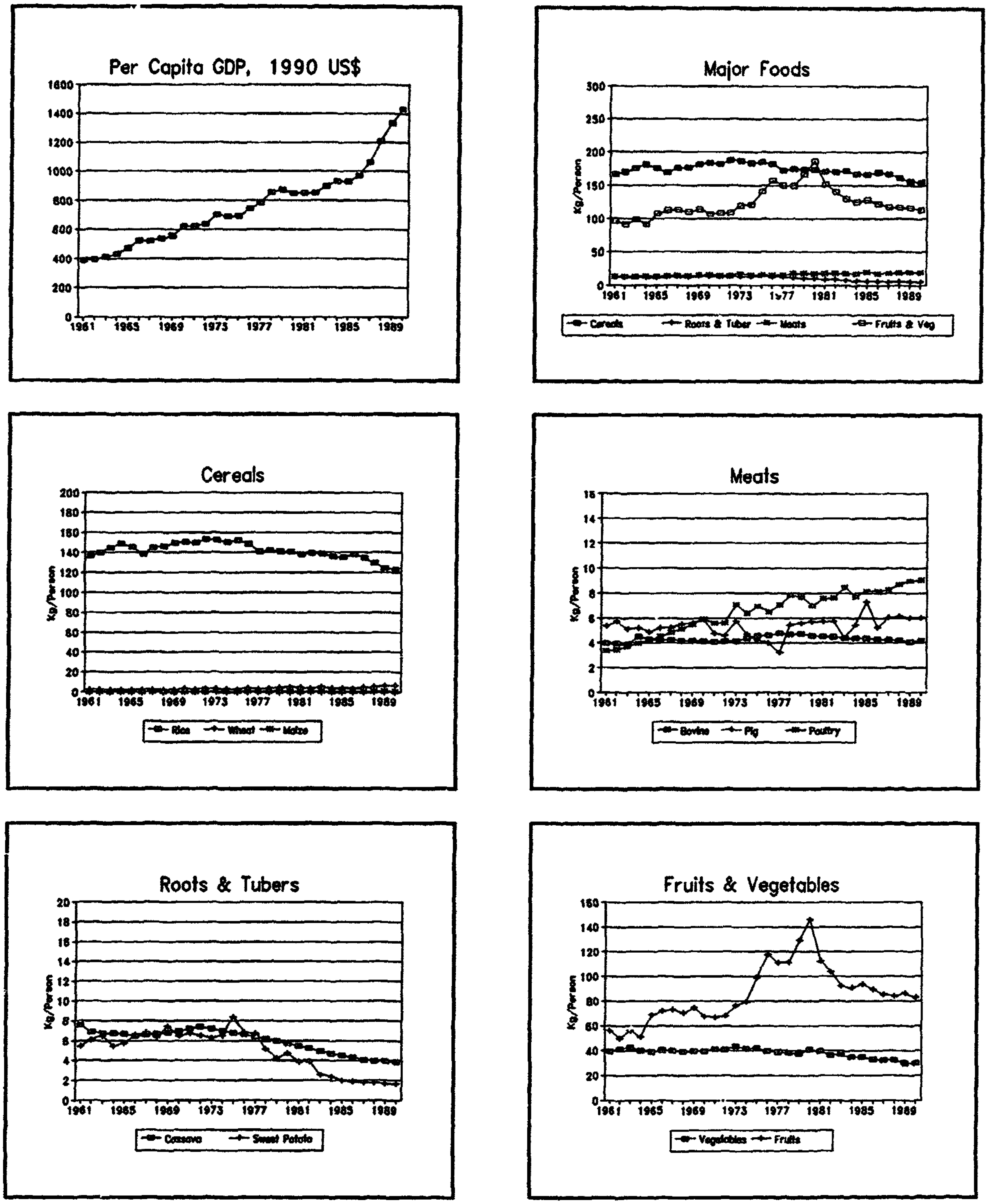
From these data we see the early stage of the transformation of diets as incomes rise. In countries where both cereals and starchy roots are staples, consumption of total cereals first increases replacing rootcrops. With further growth in incomes, the next stage has cereals reaching a peak, rootcrops continuing to decline, and non-traditional foods expanding. During this stage, intake of cereals is fairly stable or grows very little while consumption of livestock products and other foods increase rapidly. Within the cereals category, an important substitution occurs--the consumption of the staple declines and more non-staple cereals are consumed. The third stage sees the per capita intake of total cereals declining and livestock products continuing to increase.

Figure 5.2 China's per capita GDP and food consumption, 1961-90



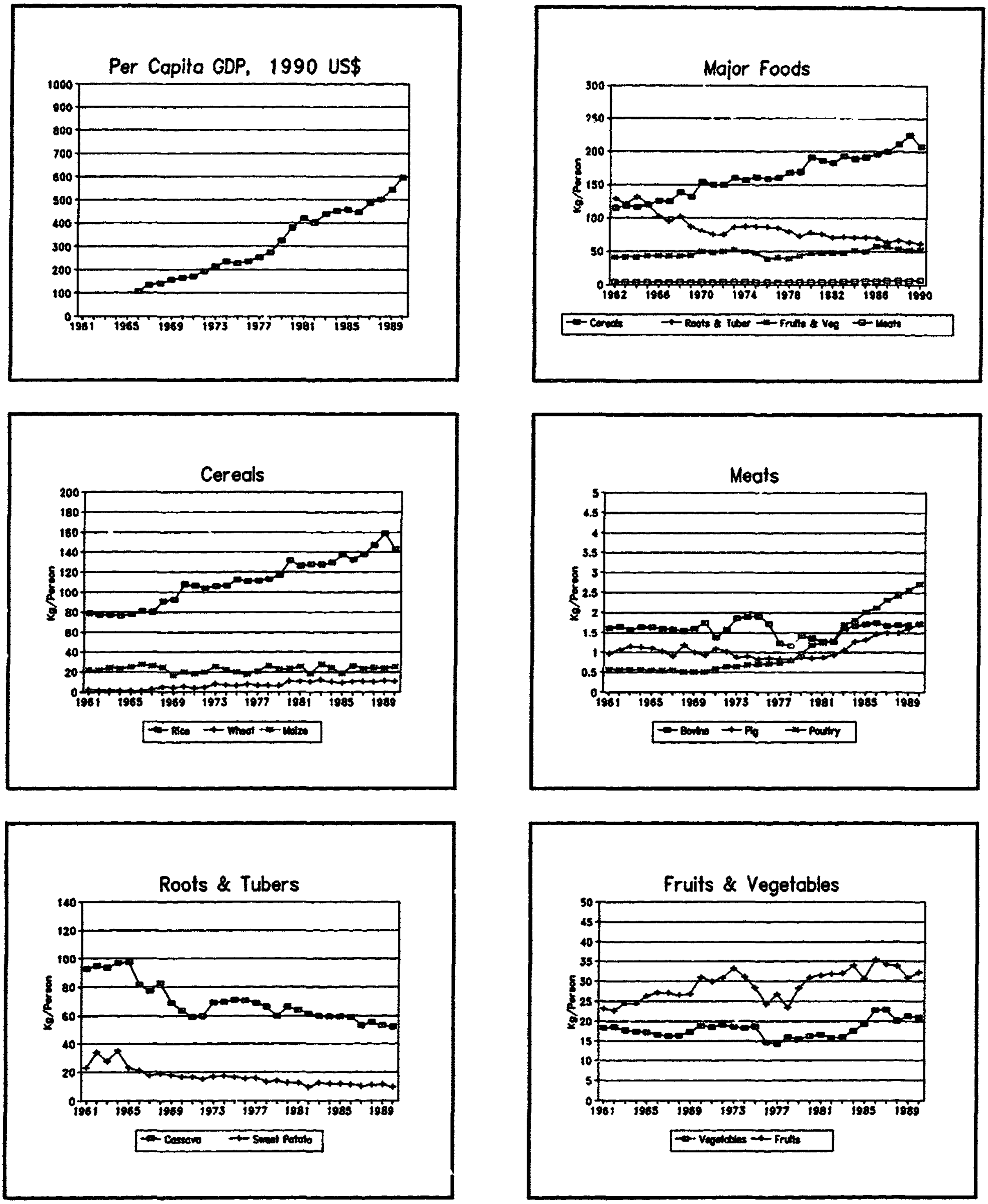
Source: Based on FAO data.

Figure 5.3 Thailand's per capita GDP and food consumption, 1961-90



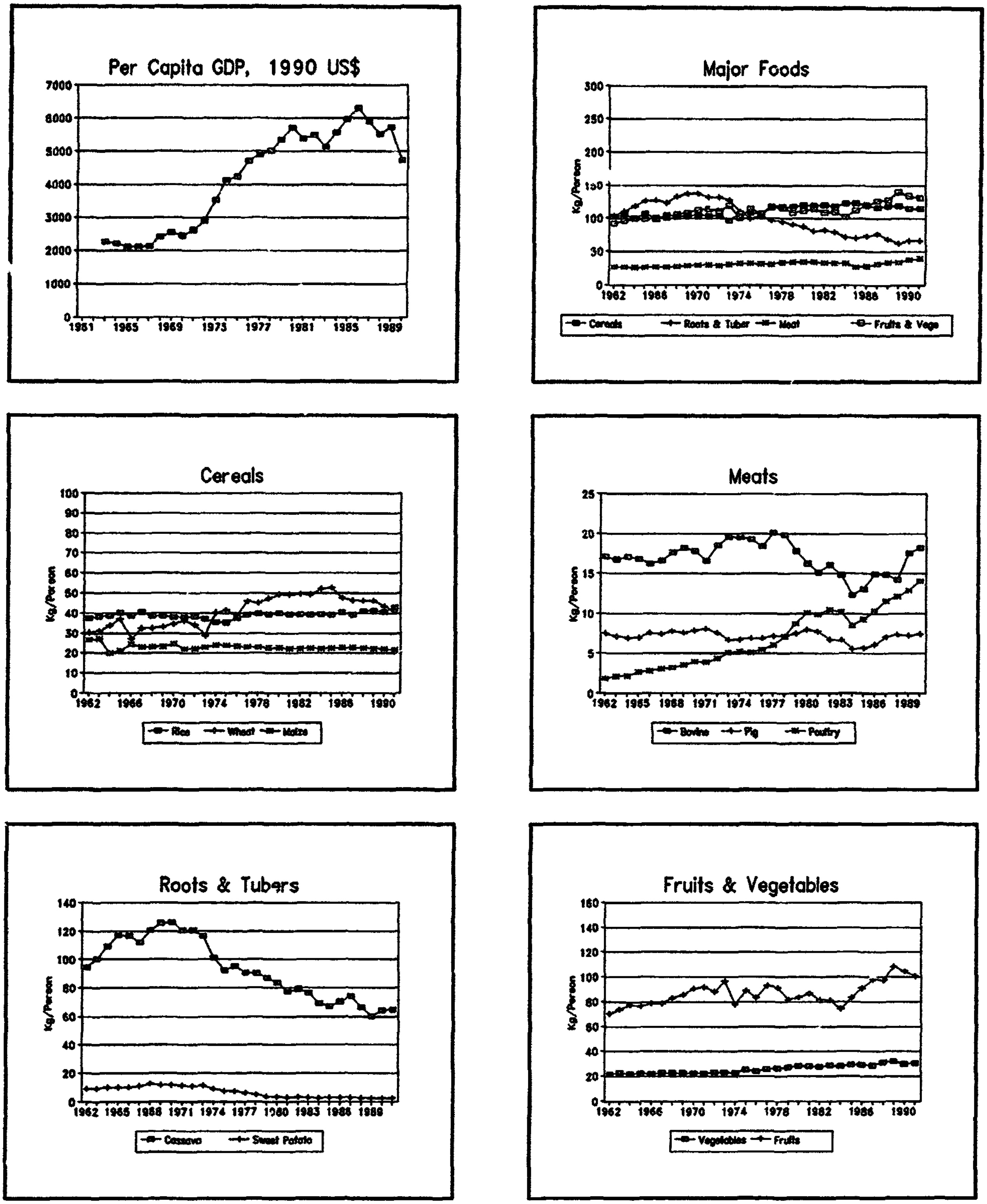
Source: Based on FAO data.

Figure 5.4 Indonesia's per capita GDP and food consumption, 1961-90



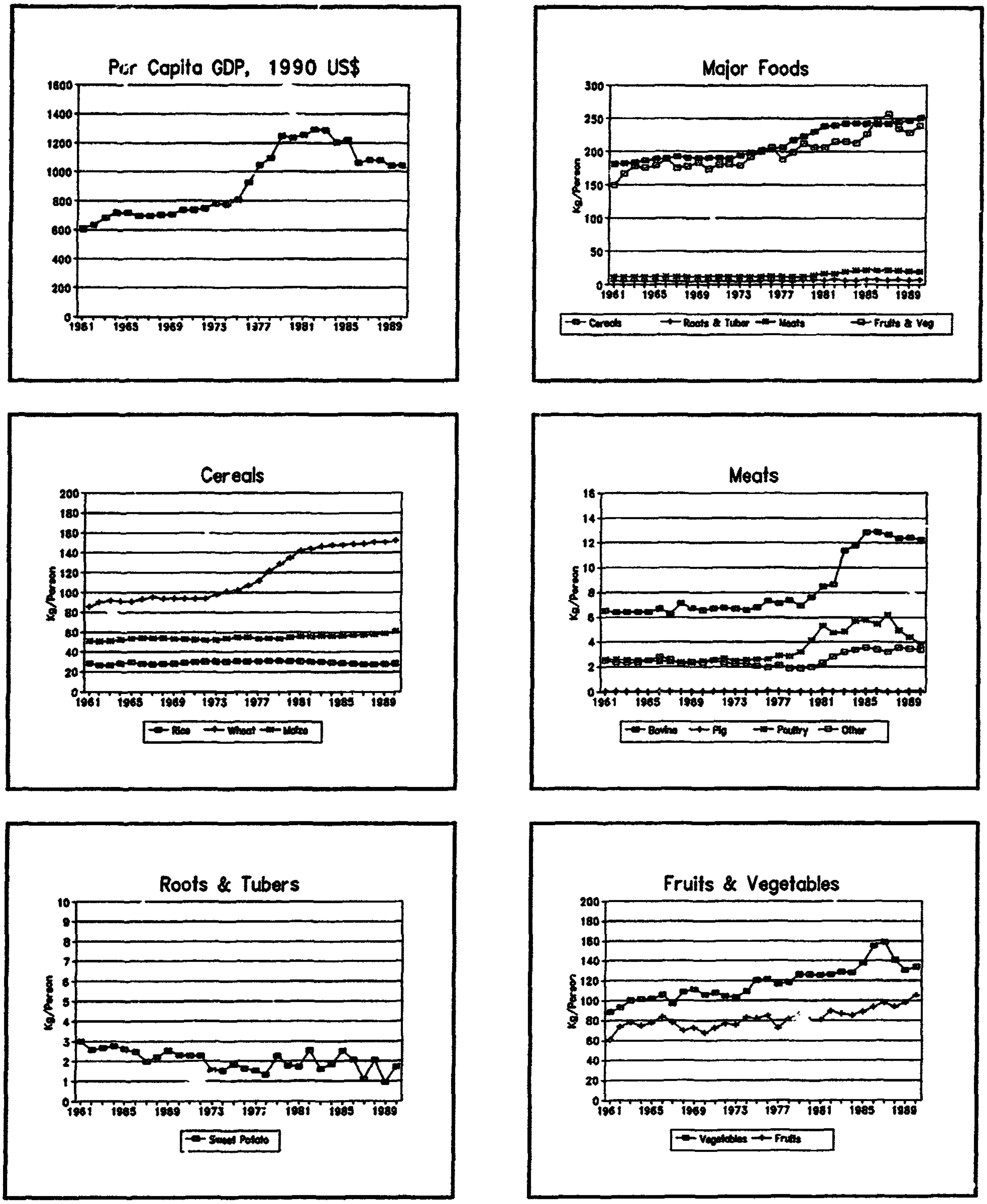
Source: Based on FAO data.

Figure 5.5 Brazil's per capita GDP and food consumption, 1961-90



Source: Based on FAO data.

Figure 5.6 Egypt's per capita GDP and food consumption, 1961-90



Source: Based on FAO data.

Table 5.1 Per capita food consumption, by product, selected countries, 1961-89

	Rice		Wheat		Roots & Tubers		Meat & Offals		Vegetables Oils		Milk & Milk Products	
	1961-65	1985-89	1961-65	1985-89	1961-65	1985-89	1961-65	1985-89	1961-65	1985-89	1961-65	1985-89
Asia												
Japan	107.1	64.2	35.4	43.2	38.7	27.0	9.0	33.8	4.4	11.7	17.7	41.6
Malaysia	114.8	83.5	32.7	35.0	11.4	20.7	14.3	33.2	8.1	17.6	11.3	12.4
Nepal	126.0	100.0	11.7	33.5	18.1	26.5	5.3	9.4	2.6	3.3	45.8	38.6
Thailand	143.0	129.8	2.0	5.2	12.4	5.5	14.0	19.8	1.2	3.8	2.2	2.7
China	59.2	92.4	27.2	81.1	97.5	60.3	6.4	21.8	1.4	4.4	2.0	3.6
India	67.1	68.8	29.4	53.6	7.3	14.8	1.9	2.2	4.6	6.3	33.2	49.2
Indonesia	77.5	143.9	1.3	10.7	100.2	49.0	4.2	6.6	2.1	4.7	2.1	2.8
Bangladesh	150.3	153.7	8.5	25.5	10.9	14.5	4.2	3.8	2.1	3.5	9.2	7.1
Korea, Rep.	97.3	96.5	19.5	46.3	51.0	12.2	4.6	19.0	0.4	7.2	3.2	10.3
Philippines	83.6	95.9	15.7	22.0	41.8	40.4	14.4	16.3	2.9	4.8	3.3	2.6
Sri Lanka	93.7	94.2	21.5	41.8	29.9	28.0	3.7	2.4	4.4	3.7	13.4	12.7
Africa												
Nigeria	1.9	11.3	1.6	3.5	134.3	159.9	9.1	7.9	7.6	9.2	1.8	1.5
Cote D'Ivoire	35.0	48.7	9.1	17.5	291.0	248.6	14.9	16.3	4.1	11.0	3.0	7.1
Mauritania	9.3	52.1	10.7	70.4	5.1	[illegible]	32.3	26.4	1.0	7.4	179.1	142.5
Gambia	68.6	97.4	6.3	28.2	16.6	[illegible]	12.7	11.4	10.4	12.0	8.5	9.6
Senegal	49.6	59.4	12.2	19.5	44.5	10.6	17.3	18.1	7.0	12.2	27.4	19.2
Cameroon	1.9	8.6	4.1	20.2	174.7	150.4	9.5	14.3	6.3	8.9	4.2	5.1
Mali	18.1	25.9	2.4	9.0	16.3	17.7	19.9	21.0	2.1	5.4	27.7	19.5
Central Africa	1.3	4.3	3.2	10.7	273.0	161.9	13.6	27.4	2.9	4.5	1.6	2.1
Congo	3.3	5.1	14.3	39.1	311.8	202.6	9.2	12.4	7.5	10.8	2.3	4.3
Liberia	83.3	104.8	4.8	6.9	248.7	175.5	10.4	9.9	7.6	15.4	2.8	2.2
Niger	2.2	12.8	1.0	6.3	40.1	28.8	18.2	18.1	1.5	2.7	30.9	19.4
Guinea	44.2	61.2	5.8	15.7	147.1	105.8	5.8	9.2	10.8	11.5	9.4	9.4
Latin America												
Argentina	4.0	5.8	128.8	117.2	84.3	78.8	104.2	100.2	9.6	13.0	76.7	82.2
Brazil	38.7	40.9	31.8	44.6	70.5	51.2	23.6	31.3	4.0	14.3	55.6	69.6
Chile	7.7	8.0	134.1	128.0	59.4	53.7	30.7	33.9	5.9	8.4	49.0	46.9
Honduras	3.5	6.7	12.9	22.8	12.6	4.7	10.2	11.2	2.1	8.7	31.7	41.5
Haiti	9.1	14.9	10.3	27.2	67.5	81.1	11.2	14.5	1.4	3.6	8.7	10.2
Mexico	3.5	4.3	29.3	41.5	10.9	11.1	26.8	42.6	6.2	12.4	35.7	55.9
Peru	18.8	34.4	49.5	45.9	152.1	94.5	25.1	27.6	4.3	5.7	34.2	36.1
Venezuela	6.2	10.4	41.1	52.6	43.2	22.2	26.5	39.7	10.3	17.4	32.2	31.3
Middle East												
Egypt	27.9	27.7	89.7	150.2	11.5	30.9	12.6	23.4	5.5	13.2	11.9	12.4
Morocco	0.5	0.8	107.9	161.6	7.8	26.1	13.9	16.1	5.0	10.5	21.8	27.7

Source: Based on FAO data.

The most dramatic transformations in diets have taken place in Asia. Over the past three decades, this region experienced the fastest growth in incomes and rapid migration of the population to urban areas. The growth in per capita real GDP (in US$) between 1965 and 1990 was highest at 7.1% p.a. in the Republic of Korea, followed by Singapore at 6.5% p.a., China at 5.8% p.a., and Indonesia at 4.5% p.a., Japan, Malaysia, and Thailand grew at more than 4.0% p.a. during the period.

Average per capita rice consumption in several economies has declined significantly (e.g., Japan, Malaysia, Nepal, Taiwan, and Thailand) and consumers there are eating more of other cereals such as wheat in the form of bread and noodles. Complementary to the increase in non-staple cereals is a rapid increase in the consumption of livestock products, vegetable oils, and other high-valued food items.

In China, direct per capita consumption of cereals rose more than 50%--from 120 kg in 1961 to 233 kg in 1984--but has declined since, while per capita meat consumption has more than tripled (from 3.4 kg in 1961 to about 25 kg in 1990). China experienced rapid economic growth during this period due to the economic reforms initiated since the late 1970s. Consumption of fruits and vegetables almost doubled--from 67 kg to 103 kg per capita--while per capita consumption of roots and tubers halved from 88 kg to 44 kg over this period (Figure 5.2). In Taiwan, China, the consumption of starchy foods has declined sharply over the past two decades, while the indirect consumption of grain for producing high-quality protein foods has increased. For instance, per capita annual consumption of rice fell from 141.2 kg in 1953 to 86.0 kg in 1985. In contrast, annual per capita consumption of meat rose from 17.8 kg to 54.3 kg, dairy products rose from 1.6 kg to 29.6 kg and the consumption of fruits and vegetables also rose significantly during the same period. Direct per capita consumption of cereals (including rice, wheat, maize, soybean, barley, and sorghum) rose from 157 kg in 1953 to 168 kg in 1974, then declined to 111 kg in 1985. Indirect per capita consumption of cereals, on the other hand, increased from 14 kg to 297 kg, resulting to a more than 200% increase in total cereal consumption (from 171 kg to 408 kg from the early 1950s to the mid-1980s).

In Thailand, per capita consumption of cereals reached a peak of about 150 kg in 1972-73 but has been declining since the mid-1970s (Figure 5.3). Average per capita consumption of meat increased from 13 kg per year to 19 kg per year between 1961-65 and 1986-90. Poultry consumption grew the most rapidly of the meats. Indonesia appears to be at a somewhat earlier stage in the pattern than China or Thailand. The consumption of cereals continues to expand, although the rate of growth declined from 2.2% p.a. in the 1970s to about 0.8% p.a. during the 1980s (Figure 5.4). Rice maintains its dominant position while wheat consumption has grown the most rapidly, but from a very low base. Per capita consumption of wheat increased from 1.3 kg per year during 1961-65 to about 11 kg per year during 1986-90. Root crops have been declining steadily for some time. Total meat consumption nearly doubled from 3.7 kg per year during 1961-65 to 6.2 kg per year during 1986-90. The growth in meat consumption accelerated in the 1980s--to 5% p.a. compared with about 0.7% p.a. in the 1970s. Per capita consumption of fruits and vegetables increased from 42 kg per year during 1961-65 to 55 kg per year during 1986-90, with growth of 2.6% p.a. during the 1980s.

Starchy roots and coarse grains (maize, millet, and sorghum) remain the leading source of calories in Africa; however, per capita consumption of these food items has declined in many countries, while rice and wheat have increased significantly (see Table 5.1). Between 1961-65 and 1986-90 cassava consumption declined from 393 kg to 187 kg in Central African Republic; from 462 kg to 328 kg in Congo; and from 107 kg to 69 kg in Guinea. Per capita consumption of rice increased, for example, in Cameroon (from 1.9 kg to 11.3 kg), in Cote d'Ivoire (from 35 kg to 49 kg), and Gambia (from 67 kg to 97.4 kg). Meat remains a small part of the diet, but the per capita consumption has gone up in several countries including Cameroon, Central Africa, Cote d'Ivoire, Guinea, Mali, and Senegal.

The main components of the diet in Latin America are livestock products, cereals, fruits and vegetables. Consumption of livestock products saw the greatest increase during the past three decades, with the most rapid growth in poultry in many countries. Consumption of total cereals has continued to expand, but the growth rates declined between the 1970s and 1980s. Substitution also occurred away from staple cereals to other grains. Wheat is the main cereal consumed in Argentina and Chile, while rice and wheat are important in Brazil. Maize is the main staple in several countries including Chile, Colombia, Honduras, Haiti, Mexico, and Venezuela. In these latter countries, direct consumption of maize has declined while consumption of rice and wheat has increased significantly over the past three decades. Consumption of roots and tubers has declined in many Latin American countries. For instance, in Brazil the intake of cassava declined from an average of 108 kg per year during 1961-65 to 66 kg per year during 1986-90.

During the 1960s, roots and tubers occupied the largest share in the average diet of Brazilians, followed closely by cereals and fruits and vegetables. Since then, per capita consumption of cereals, meat, and fruits and vegetables has steadily increased while consumption of roots and tubers has declined (Figure 5.5). Among the cereals, consumption of rice and maize has been largely unchanged, but wheat consumption has increased from an average of 32 kg during 1961-65 to 45 kg during 1986-90. Bovine meat has remained the most popular meat with average consumption of about 16 kg during 1986-90; but poultry consumption has grown rapidly from 2.1 kg to 12.2 kg over the past three decades.

Cereals are the main component of the diet in the Middle East, but significant amounts of fruits and vegetables and livestock products are also eaten. In Egypt, per capita consumption of cereals and fruits and vegetables has continued to increase despite the fall in per capita GDP during the 1980s (Figure 5.6). Wheat held the largest share of cereals consumption and experienced the fastest growth in direct consumption over the period. Meat consumption rose dramatically beginning in the mid-1970s, but has declined slightly since 1985.

Changes in Sources of Calorie and Protein Consumption

Reflecting the shifts in food consumption patterns described above are the rapid changes in the source of calories and protein consumption. The contribution of cereals to total calorie consumption per day (the cereal-calorie ratio) declined dramatically in several higher-income Asian countries between 1965 and 1989--for instance, from 57% to 40% in Japan, from 59% to 45% in Malaysia, from 71% to 59% in Thailand, and from 75% to 51% in the Republic of Korea (Table 5.2). The cereal-calorie ratio increased in several lower-income Asian countries including China, Indonesia and Bangladesh between 1965 and 1989. However, it has been fairly stable in these countries since 1985.

In contrast, livestock products have become an important source of protein and calories in many countries. The most dramatic changes have occurred in Asia. The contribution of animal products to total calorie intake tripled in the Republic of Korea (from 4% to 13.5%) and nearly doubled in Japan (from 12% to 21%) and China (from 5.9% to 11%). Its contribution also increased in India, Indonesia, Malaysia, Thailand, and Sri Lanka.

The share of animal products in total protein consumption has also risen sharply--for example, going from 32.7% to 55.5% in Japan, from 28.8% to 43.8% in Malaysia, from 22% to 30% in Thailand, and from 7.4% to 20.5% in China (see Table 5.3). In contrast, the contribution of cereals to total protein has declined significantly in Asian countries where the livestock-protein ratio has grown sharply. These countries include Japan (from 42% to 23%), Malaysia (from 57% to 43%), Thailand (from 63% to 50%) and the Republic of Korea (from 67% to 38%).

The increasing demand for livestock products has multiplied the demand for grains for animal feeding, particularly for maize. Table 5.4 shows the average annual growth rates of major grains by their uses by region. The food and feed use of total grains has expanded at an average annual rate of 1.9% and 2.2%, respectively, during the period 1965-90. Growth of the developing regions' utilization rates was much faster than those of the developed countries. In Asia, the average annual rate of increase of total feed use of all grains (4.9%) was more than double the rate of growth of direct consumption, estimated at 2.3% p.a. during 1965-90. Maize, which is also utilized for food, showed very rapid rates of growth in all regions. The use of roots and tubers for livestock feeding also grew faster than their use as food.

Table 5.2 Share of food group in total calorie consumption, 1965-89

	Cereals				Roots & Tubers				Animal Products				Meat & Offals			
	1965	1975	1985	1989	1965	1975	1985	1989	1965	1975	1985	1989	1965	1975	1985	1989
	(Percent)															
Asia																
Japan	57.1	47.8	42.0	40.0	5.08	2.36	2.64	2.52	12.18	17.48	20.14	21.01	1.86	3.85	5.30	5.92
Malaysia	58.6	55.2	45.1	45.1	1.75	2.20	2.99	2.76	11.10	12.88	14.61	14.83	4.05	5.27	6.38	7.07
Nepal	82.3	81.6	82.0	80.0	1.62	2.26	2.61	2.81	7.18	7.29	6.86	6.66	1.10	1.25	1.49	1.47
Thailand	70.9	68.4	61.5	58.7	2.57	2.71	1.38	1.20	7.04	7.00	9.05	8.45	3.87	3.91	5.53	5.04
China	66.2	69.0	71.3	70.3	14.19	13.70	6.95	5.64	5.90	6.26	8.75	10.78	4.09	4.39	6.56	8.06
India	64.7	65.5	63.2	63.5	1.35	2.01	1.96	1.75	4.73	5.10	6.59	6.87	0.45	0.47	0.48	0.52
Indonesia	60.0	69.2	70.0	71.2	18.60	10.87	7.12	6.51	2.74	2.48	3.12	3.15	1.29	1.06	1.23	1.31
Bangladesh	80.3	83.1	83.0	84.7	1.41	1.99	1.74	1.30	3.67	2.77	2.87	2.67	0.94	0.79	0.80	0.78
Korea, Rep	75.0	69.6	58.4	51.0	9.68	2.94	1.24	1.00	4.02	6.89	11.63	13.50	1.72	1.77	5.04	5.38
Philippines	61.9	64.0	60.7	59.6	5.67	4.56	4.96	4.32	11.70	11.36	9.12	10.69	6.03	4.99	4.13	5.24
Sri Lanka	54.0	61.0	56.1	57.3	3.50	6.52	3.60	2.79	4.85	3.90	4.28	5.14	0.81	0.74	0.46	0.44
Africa																
Nigeria	38.5	35.6	44.3	39.0	31.29	32.75	28.28	33.45	3.30	3.35	2.86	2.39	2.02	1.68	1.51	1.33
Cote d'Ivoire	35.8	32.8	37.6	40.8	33.70	33.13	28.61	25.12	4.93	5.98	6.06	5.92	2.70	2.85	2.71	2.85
Mauritania	44.3	54.8	52.6	55.6	0.66	0.51	0.37	0.37	32.46	26.36	25.70	18.36	7.29	5.92	4.45	3.97
Gambia	64.0	61.9	65.6	64.9	2.54	2.34	1.06	0.98	4.59	6.29	6.11	5.27	2.70	3.22	2.32	2.20
Senegal	63.5	65.4	67.5	62.5	4.96	2.99	0.80	1.20	9.15	7.91	7.80	8.74	3.55	3.29	3.34	3.85
Cameroon	37.1	34.5	34.3	35.0	21.65	20.54	20.04	19.75	3.94	4.61	5.89	5.56	2.24	3.01	3.45	3.24
Somalia	45.7	39.6	49.1	51.1	0.95	1.18	0.85	0.84	39.44	38.21	30.03	30.28	9.07	8.59	6.75	7.09
Mali	73.2	74.5	76.8	76.8	1.99	2.04	2.46	1.82	9.11	8.21	6.71	6.45	4.49	4.16	3.68	3.57
Central Africa	18.3	15.7	21.7	27.7	56.74	51.15	42.24	33.99	4.71	6.88	10.49	10.30	3.10	4.63	7.38	7.48
Congo	8.6	12.3	19.0	16.8	63.72	52.51	42.44	45.02	4.26	4.58	7.39	7.07	1.69	1.59	2.29	2.72
Liberia	39.1	44.8	48.5	49.0	33.12	24.39	18.71	22.59	4.79	4.25	4.45	3.60	2.37	2.09	2.28	1.98
Niger	72.4	71.2	72.7	72.4	5.92	5.16	3.84	3.63	9.21	7.07	7.00	6.01	3.84	3.12	3.23	3.02
Guinea	42.0	40.7	44.2	46.9	19.06	20.65	14.01	12.71	2.42	2.90	3.74	3.88	1.19	1.35	1.76	1.67
Latin America																
Argentina	32.3	28.5	30.8	32.1	6.83	3.99	4.82	5.32	28.58	32.39	30.80	30.78	18.48	21.47	18.99	18.30
Brazil	33.6	34.0	36.7	34.0	12.78	10.02	7.34	6.43	14.11	15.12	13.73	15.54	5.99	6.62	5.56	7.13
China	49.7	52.1	48.8	46.4	4.08	3.67	4.18	4.24	16.70	16.06	15.26	18.09	6.48	7.50	6.59	8.73
Honduras	55.5	54.3	55.6	52.9	[illegible]	0.66	0.49	0.45	11.11	11.89	11.10	11.05	2.26	2.14	2.27	2.45
Haiti	45.7	40.6	39.0	38.0	11.23	12.80	11.85	12.89	5.69	6.18	6.00	6.38	3.14	4.01	3.14	3.73
Mexico	52.5	50.0	46.4	46.2	0.78	0.85	0.72	0.68	11.98	15.50	17.55	18.72	7.01	7.51	8.68	9.86
Peru	40.2	41.1	47.0	46.4	13.70	10.93	8.75	9.41	13.84	12.17	11.59	11.80	4.55	4.70	4.59	4.89
Venezuela	36.2	38.0	36.0	37.9	4.26	2.54	1.88	1.93	14.32	16.52	16.70	14.10	4.67	6.09	6.31	5.35
Middle East																
Egypt	68.8	63.7	62.0	62.5	1.02	1.44	1.55	2.48	6.47	6.70	8.34	7.64	2.33	2.10	3.21	2.84
Morocco	65.4	66.8	63.6	60.8	0.90	0.47	1.98	1.70	7.41	6.23	6.28	6.11	3.04	2.35	2.34	2.51

Source: Based on FAO data.

Table 5.3 Share of food groups in total protein consumption, 1961-89

	Cereals					Animal Products				
	1961	1965	1975	1985	1989	1961	1965	1975	1985	1989
	(Present)									
Asia										
Japan	42.0	39.9	30.5	25.5	23.4	32.7	36.6	47.5	54.2	55.5
Malaysia	57.0	55.5	50.5	42.6	43.4	28.8	31.4	38.5	45.0	43.8
Nepal	72.9	72.4	[illegible]	74.2	73.1	14.6	14.0	14.6	15.1	14.8
Thailand	62.9	60.1	57.1	50.9	49.7	22.0	24.7	27.8	31.1	30.2
China	54.6	56.9	62.7	66.4	64.2	7.4	11.4	12.6	16.1	20.5
India	57.3	60.9	64.6	62.2	61.7	10.1	9.6	10.9	13.8	14.3
Indonesia	57.6	60.1	65.9	62.1	62.9	13.8	13.6	12.2	14.5	14.5
Bangladesh	70.8	71.7	74.6	77.6	79.9	16.7	16.7	11.0	11.4	10.7
Korea, Rep	66.7	64.5	56.9	44.1	38.5	12.1	13.6	18.9	31.3	33.4
Philippines	52.4	52.1	51.0	53.3	51.2	36.5	38.3	41.2	37.7	39.7
Sri Lanka	52.9	53.2	63.1	58.7	58.0	19.0	20.2	16.8	18.9	20.9
Africa										
Nigeria	52.4	47.2	44.0	55.8	50.1	12.4	13.4	14.4	12.5	11.6
Cote d'Ivoire	28.5	40.0	36.4	42.2	44.7	27.7	23.8	27.0	24.9	24.1
Mauritania	32.6	30.6	41.2	41.7	47.1	53.8	57.2	45.8	46.1	38.5
Gambia	67.1	63.2	57.3	61.0	63.9	14.3	16.9	22.6	24.5	21.6
Senegal	56.6	59.1	63.1	63.1	61.6	30.5	28.7	26.4	24.4	27.3
Cameroon	43.2	41.9	36.7	37.2	38.7	15.2	14.5	14.2	20.9	20.3
Mali	60.8	58.6	61.8	66.3	68.6	21.5	24.4	23.7	20.4	20.2
Somalia	39.5	35.4	31.9	41.5	43.7	57.2	60.1	61.2	51.6	51.6
Central Africa	24.2	27.9	21.0	25.7	30.8	18.4	18.0	22.3	30.7	28.0
Congo	10.8	15.1	20.2	26.0	24.6	36.2	34.1	32.5	40.9	40.0
Liberia	41.0	43.8	50.8	53.3	56.9	24.0	25.6	23.7	26.2	20.9
Niger	59.0	57.7	54.2	58.2	56.7	22.4	23.6	18.0	18.7	16.1
Guinea	43.1	47.6	44.9	46.5	47.6	8.4	8.7	11.7	14.9	14.6
Latin America										
Argentina	25.2	27.0	23.3	25.1	26.0	62.0	59.2	67.0	64.2	62.8
Brazil	33.0	29.6	32.7	37.4	34.4	31.4	31.5	37.1	36.2	41.3
Chile	48.4	49.7	51.4	49.4	45.1	34.1	34.8	34.7	35.7	42.4
Honduras	54.2	55.4	57.1	60.2	55.1	25.4	23.9	27.0	25.5	25.3
Haiti	51.5	51.8	45.7	43.7	42.7	13.4	12.8	15.9	17.7	17.6
Mexico	54.2	53.8	51.2	46.6	46.0	25.9	25.8	32.1	37.0	41.7
Peru	42.3	41.8	43.6	47.7	46.4	33.0	33.8	34.8	33.4	35.3
Venezuela	34.8	38.4	39.5	38.5	41.9	43.3	42.9	46.5	48.0	43.8
Middle East										
Egypt	70.2	69.7	68.0	68.2	69.1	14.9	14.0	14.5	19.0	17.2
Morocco	71.1	71.1	74.0	69.8	66.9	17.5	16.4	14.0	15.6	15.8

Source: Based on FAO data.

Table 5.4 Growth rates in total consumption of grains and rootcrops, by region, 1965-1990

Region	Rice	Wheat	Maize	Sorghum	Other Cereals	Cassava	Other Root-crops
Total Consumption							
Developed	3.34	1.42	2.49	-0.18	1.22	10.04	-0.87
Asia	2.80	5.09	4.97	0.29	-0.50	2.34	0.94
Latin America	3.21	3.42	3.36	6.41	1.84	-0.60	0.34
Sub. Saharan Africa	4.56	5.29	3.58	2.02	1.65	2.77	2.10
Middle East & North Africa	3.71	4.01	5.61	0.91	3.51	-2.37	5.57
World	2.87	2.91	3.13	1.02	1.19	2.22	0.07
Food Consumption							
Developed	2.12	0.64	2.38	1.58	-0.12	-6.08	0.03
Asia	2.80	5.52	2.98	-0.50	-0.78	2.12	-0.49
Latin America	3.22	3.36	2.84	0.17	3.91	-0.45	0.80
Sub. Saharan Africa	5.22	5.31	3.79	2.45	2.27	2.87	2.39
Middle East & North Africa	4.39	3.94	3.04	0.59	0.50	-2.43	6.25
World	2.98	3.07	2.92	0.40	0.12	1.97	3.4
Feed Consumption							
Developed	3.72	2.11	2.10	-0.23	1.39	10.99	-0.02
Asia	3.41	5.72	6.57	2.46	0.97	5.27	0.04
Latin America	3.72	3.89	3.73	6.72	1.03	-0.38	-0.03
Sub. Saharan Africa	2.77	6.35	4.59	2.49	2.54	0.38	-0.02
Middle East & North Africa	0.18	5.37	8.77	2.57	4.10		0.08
World	3.43	2.92	2.94	1.62	1.53	3.95	0.18

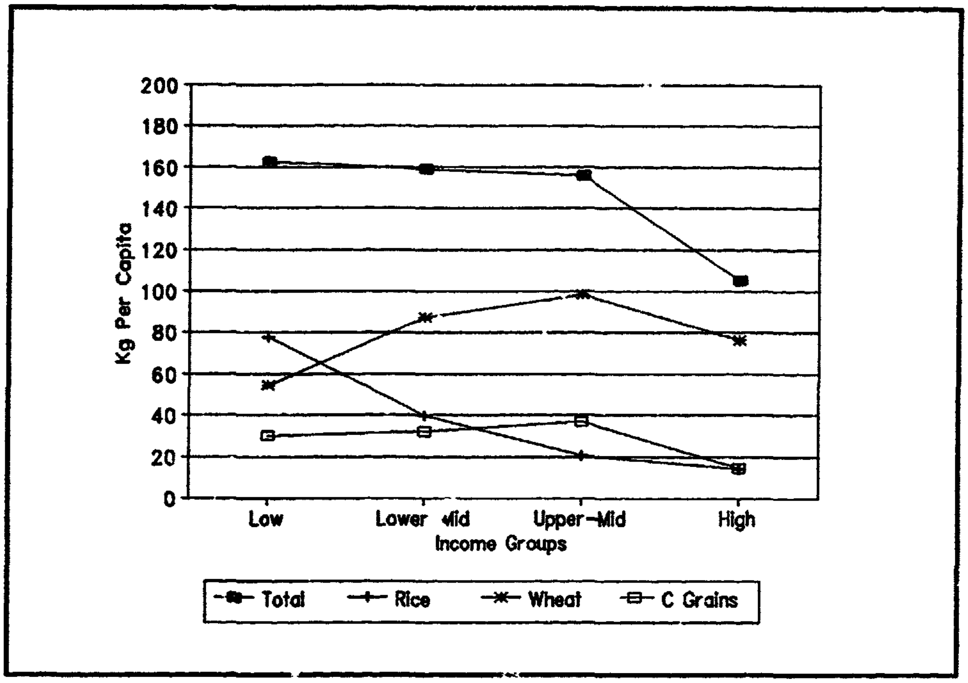
Source: Based on FAO data.

Evidence from Aggregated Cross-Sections

To obtain a global perspective, food consumption data from different countries were pooled by income group. The results are shown in Figures 5.7 and 5.8. The data show average per capita consumption of cereals and meats for different income groups during the 1981-90 period.[1] The pattern is clear that consumers shift among cereals as incomes rise--primarily from rice to wheat--but the total quantity of cereals consumed remains nearly constant until the highest income group, when it falls sharply. As incomes rise, the decline in rice is about offset by increases in wheat, while coarse grains consumption increases only slightly. Total meat consumption increases at each increase in income, but the increase is greatest in the highest income group. The share of individual meats remains fairly constant across the four income groups. The rise in meat consumption does not appear to substitute for cereals consumption until the highest income group.

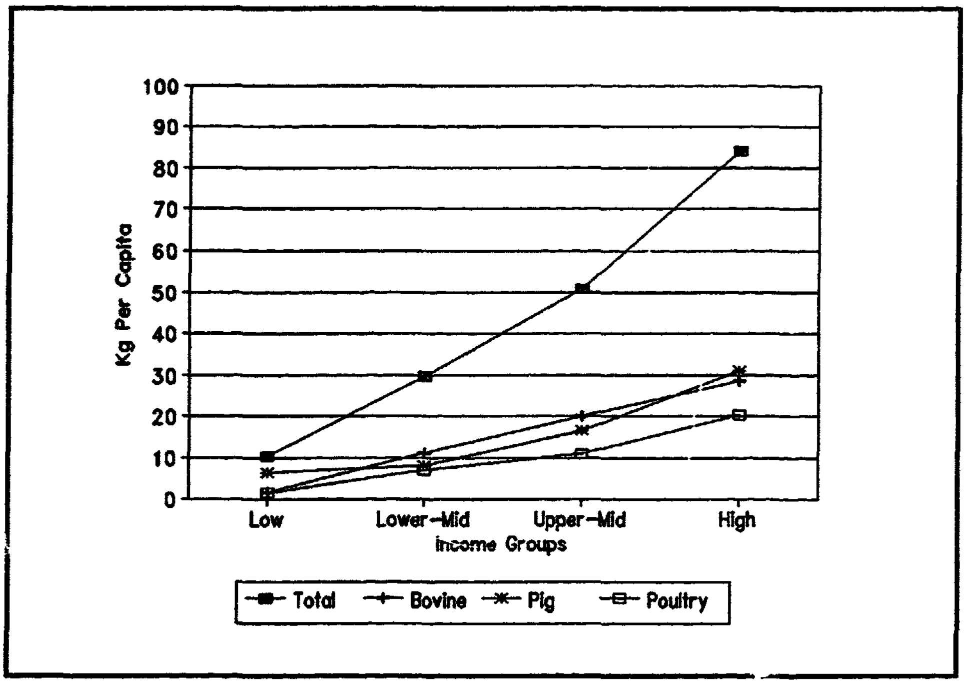
[1] Average per capita consumption for 185 countries (weighted by population) by income group according to the World Bank's classification of Low Income, Lower-Middle Income, Upper-Middle Income and High Income. The classification is based on 1990 per capita GNP in dollars and the four groups are: Low-Income is $610 or less, Lower-Middle Income is $611 to $2,465, Upper-Middle Income is $2,466 to $7,619, and High Income is $7,620 or more.

Figure 5.7 Per capita cereals consumption, by income group (average 1980-91)



Source: Based on FAO data; calculations by IECIT, World Bank.

Figure 5.8 Per capita meat consumption, by income group (average 1980-91)

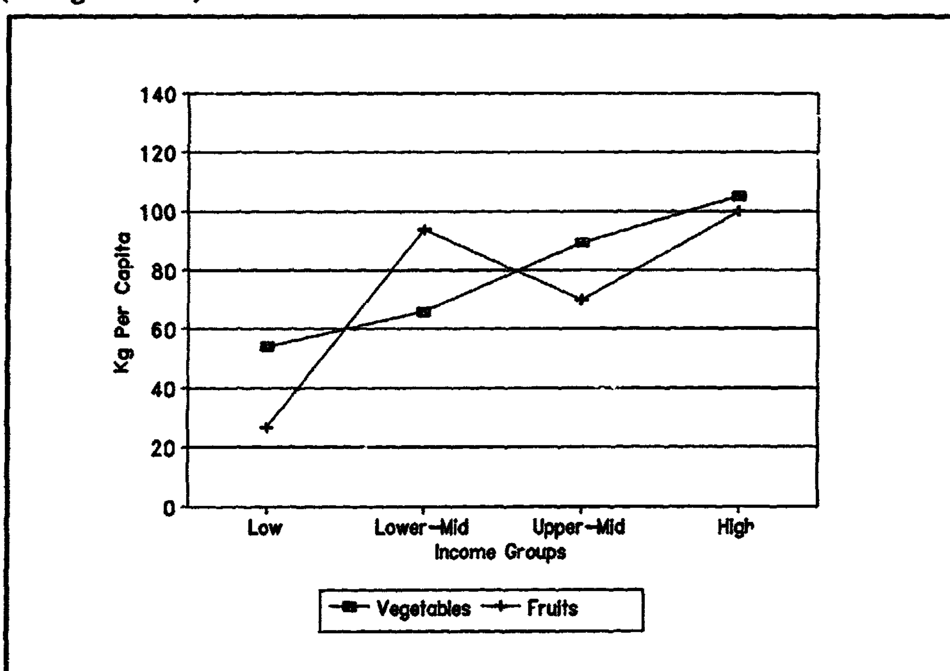


Source: Based on FAO data; calculations by IECIT, World Bank.

The implications of these patterns are for stronger demand for wheat and weaker demand for rice as consumers' incomes rise. The demand for coarse grains for human consumption remains relatively constant until consumers move into the highest income category; however, the dual use of coarse grains as food and feed provides additional demand. Because meat demand increases as incomes increase through all income categories, this leads to increasing demand for coarse grains for feed. Rice is clearly the least preferred cereal as incomes rise.

Per capita fruits and vegetables consumption are shown in Figure 5.9 for the same income groups as for the previous figures. The consumption of vegetables rises steadily as incomes rise. However, movement in the consumption of fruits is more difficult to explain, although the trend is certainly positive. The explanation of the anomaly may be in the types of countries which are in the lower-middle income and upper-middle income groups. The lower-middle income group contains many of the tropical Asian countries where fruits are abundant, while the majority of the upper-middle income group of countries are located in more temperate climates where fruits are less abundant and more expensive.

Figure 5.9 Per capita fruits and vegetables consumption, by income group (average 1980-91)



Source: Based on FAO data, calculations done by IECIT, World Bank.

Evidence from Household Survey Data

Household surveys provide data on consumption patterns of households with different incomes and socioeconomic characteristics. This type of data is typically used to estimate demand parameters for different sections of the population. With appropriate consideration of differential price effects, demand analysis using household survey data complements time-series analysis in predicting the direction of change that consumption patterns are likely to take as incomes and demographic characteristics of households change. Such information is useful in analyzing the effects of food policies on target groups such as low-income households. Household expenditure data for Indonesia, Japan, Republic of Korea, Kenya, and the Philippines are presented in Tables 5.5 to 5.9. The data are available separately by income group and for urban and rural households. Except for Indonesia and the Philippines, the expenditure data for each of the countries are given only for aggregated food groups such as bread and cereals, meat and fish, milk and milk products, fruits and vegetables, fats and oils, and meals outside the home. Thus, we can only estimate the budget shares for each of these food groups. The substitution among the cereals and among the meats cannot be ascertained.

In Indonesia (see Table 5.5), the budget shares of the staple foods--rice, maize, and root crops--decline with income, while the budget shares for wheat, livestock products, and fruits and vegetables increase with income. Households in urban areas had a lower average budget share for the staple food, rice, and a higher budget share for livestock products (beef, poultry, and milk products) and processed foods compared with rural households.

In Japan, the share of cereals and bread in total food expenditures declines between the lowest and highest income households, while there is an increase in the shares of meat and away-from home consumption (Table 5.6). A recent study showed that in Japan, the decline in the average number of persons per household (from 4.9 in 1955 to 3.2 in 1991) and the increase in the female labor force participation rate (from 45% in 1970 to 50% in 1989) have increased the demand for convenience foods and led to less frequent purchasing of food for in-home consumption (Meat and Livestock Review, 1992). The demand for "value-added" meat products and easy-to-prepare cuts of meat and processed products has also increased.

Similar patterns are observed in the Republic of Korea. The share of meat in total food expenditure doubles from 13% to 26% between the poorest and richest households (see Table 5.7). The share of cereals and bread remains very high, but declines from about 56% to 30% between the lowest and highest income group. Livestock products and meals away from home show significant increases with incomes, doubling or even tripling their budget shares. Fruits and vegetables also show an increase, but at a modest rate.

Household income and expenditure data published by the State Statistical Bureau (SSB) in China indicate that direct per capita consumption of cereals in urban areas declined from 167 kg (in trade grain equivalent) in 1957 to 145 kg in 1981 and to 137 kg in 1988. In contrast, a positive relationship is evident between income and consumption of meat and vegetable oils. Per capita consumption of meat increased from 14.3 kg for the "lowest" income group to 28.8

kg for the "highest" income group. Per capita consumption of vegetable oil increased from 4.3 kg for the lowest income households to 7.3 kg for the highest income households.

The declining trend in the share of cereals in total food consumption with increasing incomes is also found in household surveys in Kenya (see Table 5.8). The share of meat increases from the poorest to the richest households, but the increase is very small at about 4%.

Data on food quantities consumed per capita per week by urban and rural population and by income quartile in the Philippines are presented in Table 5.9 for major food commodities. Rice is the dominant food staple, accounting for 25% to 30% of food expenditures for the lowest income quartile. As in the other Asian countries, this percentage declines rapidly at higher income levels. Rice consumption in rural areas is about 25% higher than in urban areas. In contrast, wheat consumption rises with income and is higher in urban areas than in rural areas, suggesting a strongly positive income elasticity. On a percentage basis, meat consumption rises much more rapidly with income than does wheat consumption. The data indicate that income elasticities of demand for rice may be negative in urban areas and slightly positive in rural areas.

These trends support the notion that, with an increase in per capita income, a smaller percentage of income is spent on food and the structure of the diet changes. The household survey data indicate the importance of urbanization as a driving force influencing basic changes in food consumption patterns. Measurement of the importance of the various factors influencing the level and composition of diets is the main focus of the remainder of this chapter.

Table 5.5 Indonesia's food group shares in total food expenditure, by income group, 1980

	Rural Expenditure (Rp/person/mon)				Urban Expenditure (Rp/person/mon)			
	Under 7,200	7,200-11,400	11,401-19,000	Above 19,000	Under 7,200	7,200-11,400	11,401-19,000	Above 19,000
	(Percent)							
Cereals	47	36.4	29.1	20.5	42.2	32.2	24.3	16.8
Rice	42	34.8	27.6	19.2	41.2	31.7	23.7	16.2
Maize	4.0	1.[illegible]	0.9	0.4	0.8	0.2	0.2	0.2
Wheat	0.2	0.[illegible]	0.6	0.8	0.2	0.3	0.4	0.4
Roots & Tubers	3.3	2.6	2.4	2.5	1.8	1.4	1.3	1.3
Fish	8.3	11.4	12.7	12.0	7.8	11.3	11.6	10.8
Meat	1.7	3.9	7.5	11.2	1.8	3.8	7.2	11.0
Milk & Milk	0.3	1.1	1.5	2.1	1.2	2.1	3.3	4.4
Products	3.2	4.3	5.1	5.5	2.9	3.8	4.8	6.7
Fruits	7.8	8.2	7.7	8.0	8.8	9.2	8.9	7.5
Vegetables	3.6	4.6	5.2	6.7	6.1	7.2	8.9	13.4
Prepared Foods	79.0	76.8	72.6	62.8	7.4	70.2	63.8	53.6
All Food								

Source: 1980 Sugarsar Data.

Table 5.6 Japan's shares in food expenditure, by income group, 1989

Yearly Income Range (10,000 Yen)	Food Expenditure (Yen)	Cereals	Rice	Bread & Noodles	Fish	Meat	Dairy Product	Fruits & Vegetables	Eating Out
		(Percent)							
215- 313	50,607	13.87	8.59	4.69	15.23	8.75	4.85	18.80	10.69
314- 381	60,052	13.15	7.82	4.77	13.79	9.43	5.05	17.75	12.26
382- 446	66,751	12.53	7.17	4.85	13.19	9.68	5.05	16.45	14.43
447- 509	69,191	12.20	6.77	4.92	12.94	9.82	5.00	16.20	15.29
510- 578	74,876	12.36	6.84	5.03	13.03	10.23	4.87	16.13	15.67
579- 655	77,840	12.12	6.71	4.90	13.14	10.21	4.97	16.78	15.45
656- 754	83,208	12.24	6.91	4.84	13.21	10.30	4.69	16.74	16.14
755- 910	85,473	11.85	6.81	4.54	13.38	10.17	4.72	16.78	16.76
911-1,447	90,950	11.58	6.69	4.40	13.73	10.41	4.47	16.97	17.27
1,448+	99,540	10.65	6.09	4.06	14.12	10.44	4.31	17.60	18.47

Source of basic data: Government of Japan, Annual Report on the Family Income and Expenditure Survey, Statistics Bureau, 1989.

Table 5.7 Korea's shares in food expenditure, by income group, 1987

Household Income/Month (Won)	Cereals	Meat & Fish	Milk & Products	Fruits & Vegetables Home	Meals Outside
	(Percent)				
Less than 20,000	56.2	11.1	2.4	14.2	1.3
20,000-27,999	49.2	14.0	3.0	15.7	1.5
28,000-35,999	44.4	16.7	3.2	16.2	2.0
36,000-45,999	40.7	18.6	3.7	17.2	2.2
44,000-51,999	36.3	20.2	3.8	17.1	3.2
52,000-59,999	37.9	21.3	3.4	17.3	2.3
60,000 and +	29.9	22.2	5.0	17.8	4.1

Source of basic data: Republic of Korea, Annual Report on Family Income and Expenditure Survey, National Bureau of Statistics, Economic Planning Board, 1987.

Table 5.8 Kenya's shares in food expenditure, by income group, 1974

Household Income/Month (Shillings)	Cereals	Meat & Fish	Milk & Products	Fruits & Vegetables Home	Meals Outside
	(Percent)				
0-999	27.1	18.7	15.5	15.3	2.4
200-299	25.6	19.5	13.8	16.2	2.4
300-399	23.0	20.4	13.5	14.4	4.6
400-499	26.1	21.5	15.8	12.4	3.8
500-699	23.6	21.9	13.8	11.8	5.0
700-799	21.2	19.0	14.1	12.2	8.3
1,000-1,399	20.6	22.5	16.0	14.2	3.9
1,400-1,999	19.6	20.2	15.0	11.8	4.9
2,000 and +	15.9	22.6	16.4	10.3	8.9

Source: International Labor Organization, Household Income and Expenditure Statistics, 1974.

Table 5.9 Philippines' average one-day per capita food consumption, Philippines, 1987

	Mean of First Inter-Quartile Range		Mean of Second Inter-Quartile Range		Mean of Third Inter-Quartile Range		Mean of Fourth Inter-Quartile Range	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
	(grams/day)							
Cereals	322	350	312	358	322	376	315	370
Rice	281	286	256	309	269	327	254	322
Maize	13	47	16	27	7	17	11	16
Wheat/Bread	10	4	13	6	18	10	19	11
Roots & Tubers	20	28	17	26	16	18	18	26
Fish, fresh	74	53	66	67	75	75	75	80
Meat								
Pork	11	5	19	10	31	17	48	26
Beef	1	1	7	3	5	4	11	16
Poultry	3	4	11	7	11	9	14	14
Processed	1	1	5	3	10	5	14	8
Milk & Milk Products	31	21	50	29	48	45	83	59
Vegetables, green & leafy	31	35	24	30	24	31	24	32
Other Fruits & Vegetables	114	139	129	151	140	176	180	181
	28	22	34	27	44	44	59	39

Source of basic data: Republic of the Philippines, Food and Nutrition Research Institute, 1987.

Factors Influencing Changes in Food Consumption Patterns

Food consumption patterns are determined by the complex interaction of supply and demand factors. In the short-run, supplies are relatively fixed and what is produced is consumed. Long-run patterns of demand are influenced by changes in incomes, something that can be broadly called tastes, and demographic factors. The level of economic development appears to strongly influence the quantity and quality of food demanded in consumers' diets. Demographic transition (e.g. slowing birth rates and aging of the population) and changes in the structure of the population (e.g., urbanization and increasing share of immigrants) have different effects on growth in demand for different food commodities. These changes combined with the tendency for the population growth rate to decline as per capita incomes increase can be important factors influencing long-term changes in food demand.

A review of analysis of behavior in high-income countries indicates that factors other than income and prices have become important determinants of long-run shifts in food demand patterns. These factors include health concerns and changes in demographic characteristics. The general question of how population growth and the distribution of population (e.g. rural-urban) affects food consumption has been considered in a number of studies for the United States (Raunikar et al., 1969; Serow, 1972). Food consumption also has been shown to be sensitive to compositional changes in the population (e.g. household size, share of emigrants, aging of the population) (Salathe, 1979). Similarly, changes in disposable income and labor force productivity have been evaluated in consumption forecasts. Income growth still plays the largest role in changing food consumption, but in the United States income elasticities appear to be declining for foods generally (Musgrove, 1982). In the case of meat, income growth will most likely play the largest role in determining future consumption. Income effects are estimated to explain 55% of the aggregate increases in beef consumption in the United States by the year 2000, population scale effects are estimated to explain 40%, and population composition effects are estimated to account for only 5% of the growth in beef consumption (Gusemann and Sapp, 1984).

Several other studies of meat demand in the United States have reported changes in demand elasticities. Although the results of these studies are not always comparable due to differences in methodology and data, most indicate that since the mid- to late- 1970s, US beef demand has become less elastic with respect to own-price and income (see e.g. Chavas, 1983), while demand for chicken has become a stronger substitute for beef or more responsive to income (see Braschler, 1983; Moschini and Mielke, 1984). Evidence of change in pork demand is much weaker, but it also may have become less responsive to changes in its own-price. Overall, the evidence from these studies suggests a saturated but stable market for red meat and an increased preference for poultry.

Recent Demand Studies for Developing Countries

Most studies on developing countries' food demand focus on basic staples; few analyses have been done for a basket of food commodities. A study by Ito et al (1989) on rice demand in Asia showed that rice is becoming an inferior good in several countries. Estimates of income elasticities showed a declining trend over time, with values in 1984 reaching -0.71, -0.67, -0.35, -0.43, and -0.59 in Japan, Malaysia, Nepal, Singapore, Thailand, and Taiwan, respectively. Peterson et al. (1991) estimated that the income elasticity of demand for rice in China became negative in the early 1980s. However, these single-equation demand studies while providing interesting results fail to consider the likely systematic relationships between the demand for rice and the demand for other important components of the diet. Moreover, the estimated income elasticities may be biased downwards because, for example, the effect of increasing urbanization on the demand for rice was not considered.

To examine comprehensively the likely changes in the composition of diets, we need to analyze the demand for a system of major food commodities. Results of such demand studies are reported in this section for Japan, the Republic of Korea, and the Philippines. These three countries had traditional diets with heavy emphasis on rice and fish. The 1991 levels of real per capita income vary from $26,920 in Japan to $6,340 in the Republic of Korea to $740 in the Philippines (World Bank Atlas). Thus, analyses of the changes in food demand in the three countries provide useful information for drawing conclusions about future food consumption developments in many developing countries, particularly those in East Asia.

The changes which have taken place in food consumption patterns in these three countries can be observed in Table 5.13. Five-year averages of per capita consumption of major food categories for the period 1961-1988 are presented there. It is interesting to see how closely the Republic of Korea has followed Japan. Cereal consumption in Japan peaked in 1966-70 while the Republic of Korea's peaked in 1971-75. Meat consumption has been expanding rapidly in both countries, with the level of Korean meat consumption lagging about 10 years behind Japan.

In the Republic of Korea, seafood continues to be the major source of protein, with 60 kg per person consumed in 1987. However, since 1965 per capita meat consumption has increased almost five-fold, from 3.45 kg to 16.0 kg. Of the meats, chicken and pork consumption grew most rapidly at 7.3% and 7.2% p.a., respectively, followed by beef at 6.4% p.a. Chicken consumption has grown steadily over this period; however, per capita pork consumption has grown rapidly only since 1976.

In Japan, per capita pork and chicken consumption have both grown rapidly since 1966, with beef consumption growing at a slower pace. In 1965, for example, per capita beef, pork, and chicken meat consumption were nearly the same at about 1-2 kg/year. By 1987, per capita pork and chicken meat consumption had risen to 16.2 kg/year and 13.7 kg/year, respectively, compared to that of beef at only 7.2 kg/year. The more rapid production growth of chicken meat in these two countries has been due primarily to the rapid adoption of modern confined-feeding technology for chickens over the past decade while beef imports have been restricted.

The real retail price of beef in Japan increased by 41% between 1965 and 1987, while that of pork and chicken meat declined by 44% and 46%, respectively. A gradual increase in Japan's beef import quota has allowed a steady, but slow increase in beef consumption. There was an increase in real meat prices in the Republic of Korea at start of the 1965-87 period; but then followed a rapid decline, starting first with chicken prices in 1979 and then with beef since 1984. Obviously, therefore, other factors have been more than offsetting the effects of increases in meat prices on meat consumption.

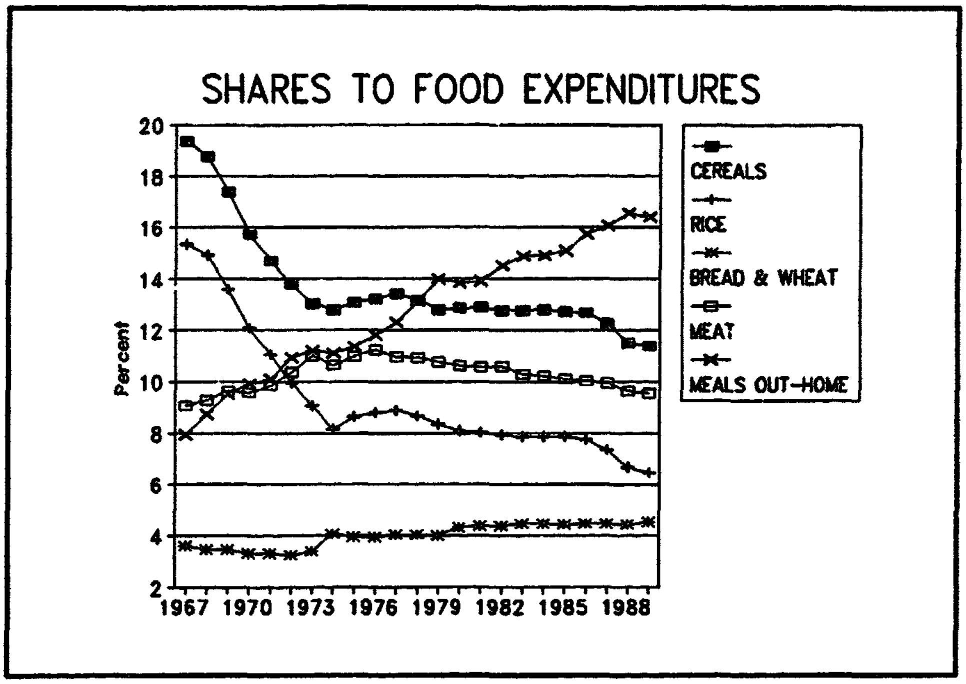
In the Republic of Korea, real per capita GNP (in Won, 1980 prices) increased at an annual rate of about 9% between 1965 and 1987. There has been a relatively high rate of population growth and migration of labor from rural to urban areas as the country has industrialized. The population growth rate has recently declined sharply, however, from about 2.6% p.a. in the mid-1960s to about 1.5% p.a. now.

Food consumption patterns in the Philippines are fairly typical of an Asian country at its stage of economic development. Cereals account for the majority of calories with smaller contributions from animal products and other commodities. Rice is the principal staple; however, maize and wheat have significant shares and they have long been more important than in many neighboring countries. Maize consumption has been increased by the limited area suitable for paddy in the southern regions where maize grits are the staple for about 20% of the country's population. Pork and poultry are the dominant meat products, and their consumption has risen steadily if somewhat slowly. A wide range of other commodities (dairy products, eggs, roots and tubers, fruits and vegetables, pulses, etc.) add variety to the diet. Per capita consumption of dairy products, eggs, and fruits and vegetables have risen with income while consumption of other foods (e.g., roots and tubers) have declined.

The agricultures and cultures in these three countries are centered on rice, although progressively less so. Average per capita rice consumption has fallen steadily in Japan since 1962, except for the period 1970-71. Per capita wheat consumption has risen slightly over this period. In the Republic of Korea, per capita consumption of foodgrains (including rice, wheat, and barley) fell from 210 kg in 1973 to 188 kg in 1987. Per capita rice consumption was largely unchanged around 110 kg over the period 1961-73 but has been on an uptrend until the early 1980s where a downward trend is observed. Per capita wheat consumption has behaved in the opposite manner, rising during the 1961-73 period and stagnant since then, except for a recent upswing. In the Philippines, rice remains the dominant staple with consumption rising steadily. Maize consumption has remained fairly steady, but declining in per capita terms, while wheat flour consumption has risen particularly rapidly since the mid-1980s.

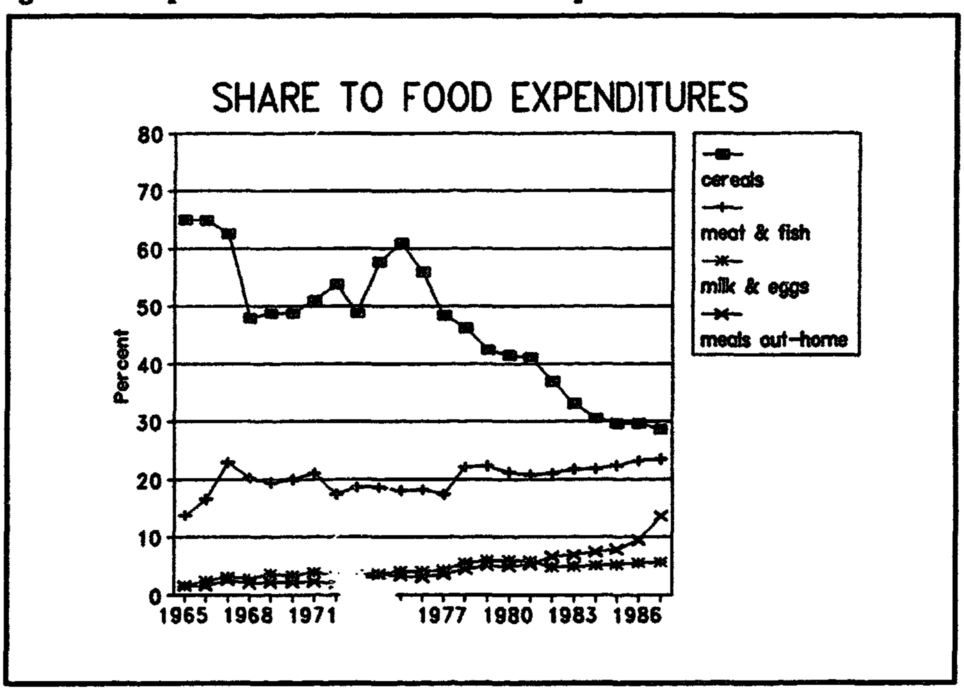
These trends in per capita consumption are reflected in the behavior of the budget shares (Figures 5.10 and 5.11). The shares of cereals, particularly rice have declined while the share of meat in total food expenditures has increased as incomes rose until very high income levels were reached (in Japan), then declined.

Figure 5.10 Japan's shares in food expenditure



Source of basic data: Government of Japan, Annual Report on the Family Income and Expenditure Survey, Statistics Bureau, various issues.

Figure 5.11 Republic of Korea's shares in food expenditure



Source of basic data: Republic of Korea, Annual Report on the Family Income and Expenditure Survey, National Bureau of Statistics, various issues.

Modeling Food Consumption Patterns

The following section reviews the results of three case studies. To estimate the effects of changes in income, prices, and urbanization on food consumption, a demand systems estimation using the Almost Ideal Demand System (Deaton and Meullbauer, 1980)[2] was carried out for each country. The present analysis improves on previous work in several ways. First, the consumers' demand decisions on commodity composition are modeled simultaneously using the systems approach. Instead of focusing on a single commodity as done in other studies, the demand for staples is examined simultaneously with the demand for non-staples. Instead of assuming separability of rice, or cereals, as a group we analyze a total demand system which includes the major food groups. The separability assumption implies that the demand for rice or cereals is independent of the demand for other foods in the diet and other consumer goods outside the cereal group. In other words, the prices of other foods, such as meat and fish are assumed to be either uncorrelated with cereal prices and cereal expenditure or irrelevant to cereal demand. While this assumption simplifies the empirical analysis, it has important implications for the estimates of the elasticity parameters. Whether or not it is appropriate to assume separability is an empirical question. Intuitively, the marginal rate of substitution between two staple foods is not independent of the level of other major foods in the diet and vice-versa.

Second, budgets shares are allowed to vary with real per capita income. This is an improvement over previous demand systems analysis which assumed constant budget shares (e.g., the Linear Expenditure System and the Rotterdam model). It is hypothesized that at different levels of per capita income there are systematic patterns in the responsiveness of the average consumers' food demand behavior to changes in prices and incomes. The data used include per capita expenditures, prices, and per capita food consumption for beef, pork, chicken, fish, rice, wheat, and other foods. The period covered by the analysis is 1961-87 for Japan and the Republic of Korea and 1965-90 for the Philippines.[3]

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[2] See Appendix for model specification.

[3] The data for the Republic of Korea came from several sources. Retail prices are from the Monthly Review published by the National Agricultural Cooperative Federation. Data on income and total expenditures are from the Annual Report on the Family Income and Expenditure Survey published by the National Bureau of Statistics, Economic Planning Board. The expenditure and income data used in the demand analysis for Japan are from the Annual Report on the Family Income and Expenditure Survey published by the Statistics Bureau, Management and Coordination Agency of Japan. The price data came from Price Indexes Monthly, Research and Statistics Department, the Bank of Japan. Per capita consumption data were from the Statistical Yearbook of the Ministry of Agriculture, Forestry, and Fisheries. Food consumption data for the Philippines are from the FAO Supply and Utilization Accounts Database. Prices are from the Bureau of Agricultural Statistics, the National Statistics Office and the Central Bank. Total personal consumption expenditures are from the National Economic Development Authority.

The parameter estimates for the demand system model for the three countries and the details of hypotheses testing and price elasticities are reported in Ingco (1990, 1991) and in Ingco and Mitchell (1991). Most of the estimated demand coefficients are significant at the 5% level, indicating that the budget shares for each commodity are responsive to changes in prices and income. The food budget shares are strongly responsive to own-prices and real per capita expenditures.

The nature of the demand for food commodities can be directly inferred from the signs of the structural parameters. Commodities with negative expenditure parameters ($\beta_i < 0$) have income elasticities less than unity, and those with positive parameters ($\beta_i > 0$) have income elasticities greater than unity. Commodities with positive own-price parameters ($\gamma_{ii} > 0$) are price inelastic and those with negative parameters ($\gamma_{ii} < 0$) are price elastic. In Japan and Korea, the estimates of β classify beef as a relative luxury good ($\beta > 0$) and the rest of the commodities as relative necessities ($\beta < 0$). These imply that increased income led to an increased budget share for beef and decreased shares for the rest of the commodities. The estimated income elasticities over the period are positive for all meats in the three countries. In the Philippines, meat is a relative luxury good ($\beta > 0$) and rice, maize, wheat, fish, and fruits and vegetables are relative necessities ($\beta < 0$). These results imply that increased real per capita expenditure income led to an increased budget shares for meat and decreased shares for the rest of the commodities.

Demand elasticities were calculated from the system of equations with adding-up, homogeneity, and symmetry restrictions imposed. All the own-price elasticities are negative while most of the compensated cross-price elasticities are positive. In Japan and the Republic of Korea, the following cross-commodity relationships were found to be net substitutes: beef and pork, beef and chicken, pork and fish, beef and wheat, pork and wheat, chicken and fish, and rice and wheat. Beef and rice are found to be net complements, as well as pork and chicken, pork and rice, and chicken and rice. In the Philippines, the compensated price elasticities suggest that rice, maize, wheat, and meat are net substitutes, while rice, fish, and fruits and vegetables are net complements. Wheat is a net substitute for rice, maize, fish, and fruits and vegetables, but a net complement to meat.

The values of the estimated cross-price elasticities suggest that food demand is responsive to relative price changes in the three countries. Most of the food groups are particularly responsive to changes in rice prices. However, changes in the price indexes of the other food groups had less effect on the demand for rice. This asymmetry in cross-price effects partly reflects the relatively large share of rice in expenditures.

Based on the elasticities estimated at the means, if income increases by 10% the quantity of beef demanded would increase by 18.5% in the Republic of Korea. Pork and chicken meat demand would increase by 9.4% and 4.1%, respectively. In contrast, if income increases by 10% in Japan, the quantity of beef demanded would increase by 10.4%. Pork and chicken demand in Japan would increase by 9.7% and 6.1%, respectively. In the Philippines, demand for meat would rise by an average of 9.5% if incomes increase by 10%.

The income elasticity estimates for the three countries reveal interesting trends (see Table 5.10). First, there is a declining trend in the income elasticity of rice. The income elasticity of demand for rice in Japan was positive but very small in the mid-1960s, and has been negative since the late 1960s. In the Republic of Korea, the elasticity declined from 0.28 in 1965 to 0.03 in 1978 and has been negative since the mid-1980s. Interestingly, Korea's real per capita income in 1988 (in US$) was about the same as Japan's in 1965. Estimates of the income elasticity for rice for Korea published by the Korean Rural Economic Institute (1984) are -0.245 for urban households and 0.263 for rural households. Since the urban population currently represents more than three quarters of the total population, the negative income elasticity of the urban area dominates the positive elasticity of the rural areas. Thus, the declining aggregate income elasticity that we have estimated also reflects the increasing urbanization of the 1980s. In the Philippines, the income elasticity of demand for rice is estimated to be positive over the sample period, but appears to decline from about 0.44 in the mid-1960s to about 0.18 during the late 1980s.

The income elasticity for wheat is larger than that for rice in the three countries, indicating that wheat is the preferred food. Over time and as incomes rise, the elasticity has been declining. In Korea, it declined from about 0.5 in 1965 to about 0.3 in 1987, which is the level at which it appears to have stabilized in Japan. Wheat demand is the most price-responsive of the cereals in all three countries, and is very responsive to changes in rice prices. In contrast, the demand for rice appears to become less responsive to its own-price. The cross-price elasticity of demand for rice with respect to wheat tends to increase over the period of the study, indicating that wheat is becoming more of a substitute for rice.

The incorporation of urbanization effects, proxied by the female labor force participation rate in Korea and Japan and by the proportion of the population in urban areas in the Philippines, improved the significance of the estimates of the other coefficients. The rate of urbanization shifted both the intercept and the slope of income in the budget share equations. Urbanization showed a significant negative effect on the shares for rice and positive effects on beef, pork, chicken, and wheat in Korea and Japan. Likewise, urbanization in the Philippines has a positive effect on the consumption of wheat, fish, and fruits and vegetables and a small negative effect on rice consumption.

The demand elasticities estimated from cross-section studies appear to confirm the results from the time-series analysis. The demand elasticities estimated by Bouis (1991) for the Philippines based on the data shown in Table 5.9 are presented in Table 5.11. First: the income elasticities declines from the lowest to the highest income groups as has been observed in the time-series studies. Second: the income elasticity of demand tends to be lower in urban areas than in rural areas. Bouis found that incomes are lower and calorie intakes lower in rural areas so that the marginal utility from increases in energy/calories in rural areas is higher than in urban areas.

Table 5.10 Income elasticities for meat and foodgrains in Korea, Japan, and the Philippines

Year	Beef	Pork	Chicken	Rice	Wheat
I. Korea					
1965	2.500	0.950	0.250	0.280	0.520
1970	2.120	0.949	0.596	0.190	0.510
1975	1.977	0.948	0.415	0.100	0.580
1980	1.786	0.963	0.460	0.020	0.490
1985	1.693	0.965	0.353	-0.190	0.350
1987	1.689	0.954	0.295	-0.230	0.301
At sample means	1.850	0.950	0.410	0.150	0.350
II. Japan					
1965	1.575	0.975	0.648	0.030	0.305
1970	1.250	0.977	0.693	-0.684	0.368
1975	1.080	0.979	0.695	-0.685	0.354
1980	1.030	0.971	0.622	-0.672	0.396
1985	0.985	0.963	0.533	-0.686	0.350
1987	0.955	0.957	0.462	-0.692	0.303
At sample means	1.040	0.970	0.610	-0.570	0.320

III. Philippines

Year	Meat	Fish	Fruits & Veg	Rice	Maize	Wheat
1965	1.4749	0.4088	0.0979	0.4825	0.1875	0.8016
1970	1.4917	0.5851	0.0933	0.3620	0.0156	0.8501
1975	1.4538	0.7037	0.2094	0.4672	-0.3685	0.8509
1980	1.4936	0.6489	0.4902	0.1903	-0.2681	0.8448
1985	1.6605	0.6395	0.4556	0.3494	-0.1468	0.8333
1987	1.5345	0.6597	0.4608	0.2175	-0.3223	0.8413
1990	1.4647	0.6327	0.4322	0.2495	-0.5574	0.8637
At sample Means	1.4955	0.6053	0.2932	0.3508	-0.2155	0.8492

Source: Ingco (1990, 1991); Ingco and Mitchell (1992).

Table 5.11 Philippines' income elasticities of demand by income group, urban and rural

Food Item	Income Group	Urban	Rural
Rice	1	0.14	0.51
	2	0.12	0.25
	3	-0.03	0.13
	4	-0.16	0.08
Maize	1	-0.33	-0.43
	2	-0.83	-0.40
	3	-0.57	-0.88
	4	-0.02	-0.76
Wheat/Bread	1	0.47	1.39
	2	0.52	0.36
	3	0.34	0.40
	4	0.07	0.18
Pork	1	1.41	--
	2	1.18	2.07
	3	0.76	1.40
	4	0.35	1.04
Beef	1	1.99	2.18
	2	1.35	1.91
	3	1.00	1.82
	4	0.68	1.02
Poultry	1	2.08	0.55
	2	1.35	0.57
	3	0.96	0.35
	4	0.69	0.38
Fruits & Vegetables	1	0.44	0.96
	2	0.58	0.73
	3	0.56	0.64
	4	0.55	0.55
Fresh Fish	1	0.34	0.69
	2	0.09	0.58
	3	0.07	0.62
	4	-0.03	-0.09

Source: Bouis (1991).

Implications for Developing Countries

This analysis of food consumption data shows that diets in developing countries have improved both in terms of energy level (calories) as well as in variety. In Asia at least, increasing incomes and urbanization are leading to declining rice consumption and increased demand for wheat products, livestock products, fruits and vegetables, and processed foods. The food demand analysis shows declining income elasticities and, in Asian countries where incomes and urbanization have grown rapidly (e.g. Japan and the Republic of Korea), rice has become an inferior good. In Africa, staples such as cassava, millet and maize remain the dominant foods consumed, but even there the demand for imported non-staple cereals (rice and wheat) has increased during periods when incomes rose. If these trends in income growth and urbanization continue, consumption patterns should change further in these directions. The Republic of Korea, the fastest-growing country over the past two decades, provides an extreme example of what can be expected in other developing countries.[4]

As diets diversify and income elasticities for rice decline to low and negative levels, population growth will be the main driving force behind future increases in Asian demand for rice. Whether the decline in per capita rice consumption leads to exportable surpluses in Asia will mainly depend on how production adjusts to the structural changes in demand. Income growth will be the most important determinant of demand for non-staples such as wheat, livestock products, and fruits and vegetables. Future growth in incomes should result in rapid increases in demand for these commodities, as indicated by the high income elasticities. In addition, the relatively large own-price elasticities of demand for meats, particularly for beef and pork, imply that a reduction of protection in developing countries would result in a significant increase in per capita meat consumption.

The long-run changes in dietary patterns have important implications for developing countries. First, the likely continued growth in demand for livestock products will fuel the demand for cereals as livestock feed. Second, policies and investment strategies designed to promote continued increases in rice production need to be modified in light of these changes. Large investments in rice production may no longer be warranted as consumers shift their demand to wheat, meats, fruits, and vegetables. This is especially important since rice production systems are often not designed to produce other crops efficiently. The role of improved trade policy in achieving food security should be evaluated. Third, these changes provide a strong case for reducing policy distortions that discriminate among crops and principally against non-traditional commodities. The self-sufficiency goal which has been

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[4] Although no developing country has matched Korea's sustained economic growth rate (real GNP per capita in US$ grew at 7.7% p.a. between 1980 and 1988), a number of developing countries in Asia have been growing rapidly and have approached Korea's income growth in recent years. Between 1986 and 1988, real GNP per capita (in US$) increases were recorded as follows: Thailand (8.0% p.a.), China (9.0% p.a.), Singapore (8.8% p.a.), Hongkong (9.2% p.a.). While other countries such as India, Indonesia, and Malaysia registered lower growth rates, at 4.4% p.a. 1.6% p.a. and 3.3% p.a., respectively, between 1986 and 1988, they were also exhibiting diversification in the diet with increasing consumption of livestock products and wheat.

achieved through high levels of protection of the rice sector have led to inefficiencies in resource allocation and rigid systems of production and marketing which discriminated against other products. These systems have been unable to adjust rapidly to rice surpluses, declining prices and incomes as supplies exceed demand. Efforts to diversify away from heavy reliance on rice have been slowed by the inflexible farming and political systems that resulted from decades of concentrated support and protection of the rice sector.

Finally, changes in the structure of demand and diet diversification should be considered in developing an appropriate mix of agricultural policies and production technologies. An integrated, rather than piecemeal approach, to policy making is required. The goal of this process should be to develop flexible production systems that can respond to evolving patterns of market demand. That this can be done with little direct government intervention is exemplified in Thailand. Without significant protection, farmers have diversified production and exports as markets opened up--maize and cassava compete with rice as leading exports, while broilers, shrimp, and processed fruits and vegetables are gaining rapidly.

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Appendix

Demand Model

Among the empirical demand systems reported in the literature, the Almost Ideal Demand System (AIDS), (Deaton and Muellbauer, 1980) has provided the most robust estimates. This model combines the best of the theoretical features of both the translog and Rotterdam models. Food consumption behavior is analyzed by estimating a complete food demand system using the AIDS model. The resulting parameter estimates are used to derive expenditure or income elasticities, own-price elasticities, and cross-price elasticities. The theoretical restrictions of adding-up, homogeneity, and Slutsky symmetry are imposed and tested.

An estimable variant of the Almost Ideal Demand System with the addition of dynamic factors can be specified as

$$w_{it} = \alpha_i + \Sigma_j \gamma_{ij} \ln P_{jt} + \beta_i \ln (Y_t/P_t) + \delta_i \ln Z_t + U_{it} \quad (1)$$

$i,j = 1,\ldots, n$ commodities

where w_{it} is the average budget share of the ith commodity in time t, P_{jt} is the jth commodity price at time t, Y_t is per capita expenditure, P_t is an aggregate price index, and Z represents dynamic factors. α, γ, β, and δ are parameters to be estimated. The aggregate price (P_t), used to normalize nominal per capita expenditure (Y_t), is defined as,

$$\ln P_t = \alpha_o + \Sigma\, \alpha_j \ln P_{jt} + ½\ \Sigma\, \Sigma\, \gamma_{ij} \ln P_{it} \ln P_{jt} \quad (2)$$

The Stone (1954) price index, $\ln P_t = \Sigma\, w_{it} \ln P_{it}$, is used to approximate (2). For the system to conform to consumer demand theory, the structural parameters are further constrained to satisfy the following conditions:

Adding-up condition, Engel Aggregation:	$\Sigma\, \alpha_i = 1,\ \Sigma\, \beta_i = 0,\ \Sigma\, \gamma_{ij} = 0;$	(3)
Homogeneity:	$\Sigma\, \gamma_{ij} = \theta_i = 0;$	(4)
Symmetry:	$\gamma_{ij} = \gamma_{ji}$	(5)

Condition (3) is the budget exhaustion condition for a given income which implies that the sum of the weighted income elasticities adds to unity. Thus, only n-1 of the income elasticities are independent. Condition (4) means that the demand functions are homogenous of degree zero in prices and income. That is, an equal proportional change in prices and income will leave commodity demands unchanged.

The AIDS specification has several advantages for analyzing the demand for food in developing countries. First, in contrast to other functional forms of demand systems, such as the Linear Expenditure System, the AIDS is flexible enough to closely approximate demand elasticities at particular data points. Also, the possibility of inferior commodities is allowed. The effects of urbanization on demand are tested by including the percentage of the population in urban cities in the Philippines, and by female labor force participation rate in Japan and the Republic of Korea.

Estimation Procedure

To estimate the parameters of the budget share equations, additive disturbances are postulated. The disturbances (U_t) for each equation are assumed to satisfy the standard assumptions of normality, zero mean, and constant variance. Because of possible interactions of expenditures on commodities within the system, the error terms across equations are assumed to be contemporaneously correlated. Since the budget shares sum to one and the disturbances must sum to zero across commodities for each observation, the covariance matrix for the original disturbances is singular. Hence, the budget share equation for "other goods" (other food and non-food commodities) is arbitrarily deleted and the non-linear Zellner estimation procedure is applied to the remaining budget share equations. The iterative Zellner estimation is invariant to whichever budget share equation is deleted and asymptotically equivalent to the maximum likelihood estimation.

The monotonicity condition is equivalent to requiring the budget share equations to be non-negative. The quasi-convexity condition is equivalent to requiring the NxN matrix of Slutsky price derivatives to be negative semi-definite. Neither one of these conditions is imposed directly in estimation, but they are verified by checking the estimated parameters at selected data points.

Chapter VI. Africa's Food Challenge

The food situation in most developing countries has improved dramatically since the early 1960s, but not for those in Sub-Saharan Africa. Daily calorie intake in Sub-Saharan Africa as a whole has remained at low levels and has stagnated or declined in most countries since the mid-1960s. Nearly one-half of the region's population suffer temporary or chronic food shortages. It is estimated that in 1989 some 235 million people in Sub-Saharan Africa lived in households suffering from food deprivation (Maxwell, 1992). Malnutrition has escalated quickly into famine in recent years when food availability has been disrupted by war or drought. More than 40 million Africans faced the threat of starvation during a severe drought in 1992.

Severe food emergencies in several countries such as Angola, Ethiopia, Liberia, Mozambique, and Somalia have dramatized the region's food problem in recent years. In Sudan, for instance, a continuing civil war and ruined economy have resulted in the worst food crisis since the 1984 drought. Southern Africa was hit by the worst drought of the century during 1992. But, beyond the transitory food crises due to wars and drought, there is the important issue of the cause of the apparent long-term inability of Africa to feed itself at a satisfactory level. Several factors are involved or are symptomatic of the problem--weak agricultural growth and productivity, slow demographic transition, poor policies and governance, and resource constraints.

The challenge facing African countries in gaining food security in the 1990s and beyond is a serious one. The task involves increasing agricultural productive capacity, raising incomes of a rapidly growing population, competing in rapidly changing world markets, and earning foreign exchange to fuel economic growth. Africa must accomplish all these while at the same time reversing its environmental degradation. For some countries, the most immediate and important actions are outside agriculture--reducing civil unrest, achieving political stability, and improving macro-economic policy.

The task is complex and difficult. Recognizing this, there have been many studies into how Africa could reverse its long-term decline. Recent performance, however, provides reason for hope. In fact, several countries are showing improvements, and some have achieved impressive turnarounds through the successful adjustments of economic policies since the mid-1980s. We review recent trends and highlight several important difficulties facing Africa in meeting its food challenge.

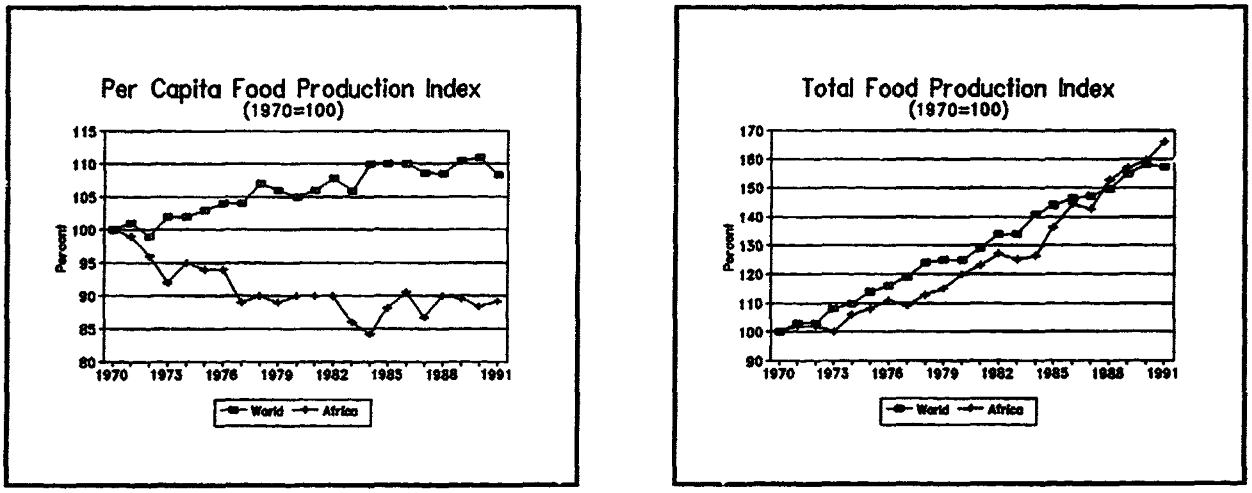
Achieving agricultural transformation and productivity growth are central. Agriculture is a significant segment of nearly all economies in the region while farmers and other rural dwellers constitute most of the food-insecure. Growth in agriculture during 1965-73 accounted for more than 40% of the growth in GDP during that period; while the decline in the agricultural sector in the 1980s reduced aggregate economic growth by 17% (Block and Timmer, 1992). The World Bank (1989) estimated that attaining food security objectives will require a doubling of the long-term rate of growth in agriculture. However, without reducing population growth, a sustained 4% annual growth in agriculture and food production would represent less than 1% p.a. increase on a per capita basis. Assuming that present estimated levels of daily calorie intake (2027 per person per day) are maintained, total food import requirements are estimated to increase to nearly 20 million tons (maize equivalent) by the year 2010, compared to 10 million tons (maize equivalent) in 1990. To raise the average calorie intake to the minimum requirements (2,330 calories per person per day) would require even higher growth in food production than the present target set by the World Bank--unless population growth can be reduced sharply.

Agricultural and food production growth in Sub-Saharan Africa will depend heavily on expanding productivity and technological change, particularly in countries where area expansion comes at increasing cost. There is little technology-based agriculture in Africa. The 2% annual average growth in food production during the last 30 years has depended more on increases in crop area and much less on yield increases or use of modern inputs compared with other parts of the developing world. During 1980-91, the agricultural growth rate declined slightly to 1.8% p.a. for Sub-Saharan Africa as a whole. This compares with 4.2% in low- and middle-income countries in East Asia and the Pacific, 3.6% p.a. in the Middle East and North Africa, 3.3% p.a. in South Asia, and 1.9% p.a. in Latin America and the Caribbean. However, there are wide variations in agricultural performance within Sub-Saharan Africa. About one-third of the countries in the region had impressive annual average growth rates (3.5% p.a. or more) in recent years, with ten countries surpassing the World Bank's target in 1986-89. The latter include Benin (5% p.a.), Chad (6% p.a.), Comoros (4.5% p.a.), Guinea-Bissau (6.4% p.a.), Kenya (4.3% p.a.), Nigeria (4.3% p.a.), Tanzania (4.5% p.a.), and Uganda (6% p.a.). Several of these countries had poor performances in the 1960s and 1970s; the change provides some evidence of the potential for reversing the agricultural decline. Those that have continued to be poor performers are mainly those countries that are drought prone; those that have continued to experience political instability and civil wars; and those that failed to persist in implementing appropriate policy reforms.

The performance in agriculture is mirrored in the food situation. On average for the region, daily calorie intake in the late 1980s is estimated to be only 91% of minimum requirements (Table 6.1). This is despite significant growth in cereal imports since the mid-1970s. However, recent food situation statistics indicate a wide diversity in performance across countries. Per capita daily calorie supplies has exceeded minimum requirements (estimated at 2,330 calories per capita per day) in 11 countries in 1987-90. The latter include Congo (2,519), Cote d'Ivoire (2,405), Gabon (2,398), the Gambia (2,339), Liberia (2,344), Mauritania (2,465), Mauritius (2,690), Sao Tome and Principe (2,530) and Swaziland (2,554). Burundi and Niger came close to reaching the minimum level in recent years. However, 12 countries experienced sharp deterioration in daily calorie supplies despite significant expansion in cereal imports. Most are countries that have been affected by drought (Botswana, Malawi, Zambia, and Zimbabwe) and extreme civil disturbances (Somalia, Sudan, and Mozambique).

Africa's food situation takes on a different complexion depending on whether we consider total or per capita food production. Figure 6.1 shows the FAO indexes of total and per capita food production for Africa and for the world. Total food production in Sub-Saharan Africa as a whole has grown as fast as in the rest of the world since 1970, and at an even faster rate during recent years (1987-91). However, unlike most of the rest of the world, population has risen more quickly than food production. Population growth has increased from about 2.7% p.a. during 1965-80 to about 3.1% p.a. since 1980. According to FAO statistics, food production has grown by 2.0% p.a. during this period. Hence, Africa's food production per person declined by 7% during the 1960s, and by an additional 15% during the 1970s. With improvements in farm performance in the 1980s, per capita food production held about constant in the 1980-89 period. Thus, the generalization of continuing decline over the past twenty years is inaccurate. In fact, between 1984 and 1991 there was a 6% increase in per capita food production. The improvement in Africa's food situation since 1983-84 is extremely important. It is in part due to better weather conditions, but more importantly it demonstrates significant latent productivity in African agriculture and the importance of appropriate policy reforms.

Figure 6.1 Food production in Africa and the world, 1970-91



Source: Based on FAO data.

The extent of Africa's food problem may not be as serious as portrayed in national production statistics. The data reported by African governments and in turn by international organizations (e.g., FAO) are based on reports of market purchases of agricultural commodities by official marketing agencies and on estimates made through government-sponsored census and market surveys. Government regulations such as price controls, taxes, and state marketing schemes have provoked widespread evasion by producers and traders, resulting in an increasing volume of commodities being marketed outside official marketing channels (Lele and Candler, 1981). Under-reporting may also occur due to the increasing inability of surveyors to get to fields because of severe cuts in budgets for crop reporting. In addition, crop interplanting and year-round crop rotation make crop estimation difficult. Roots crops are particularly hard to estimate because they are grown underground and very little find its way to markets. For these

Table 6.1 Food supply in Sub-Saharan Africa

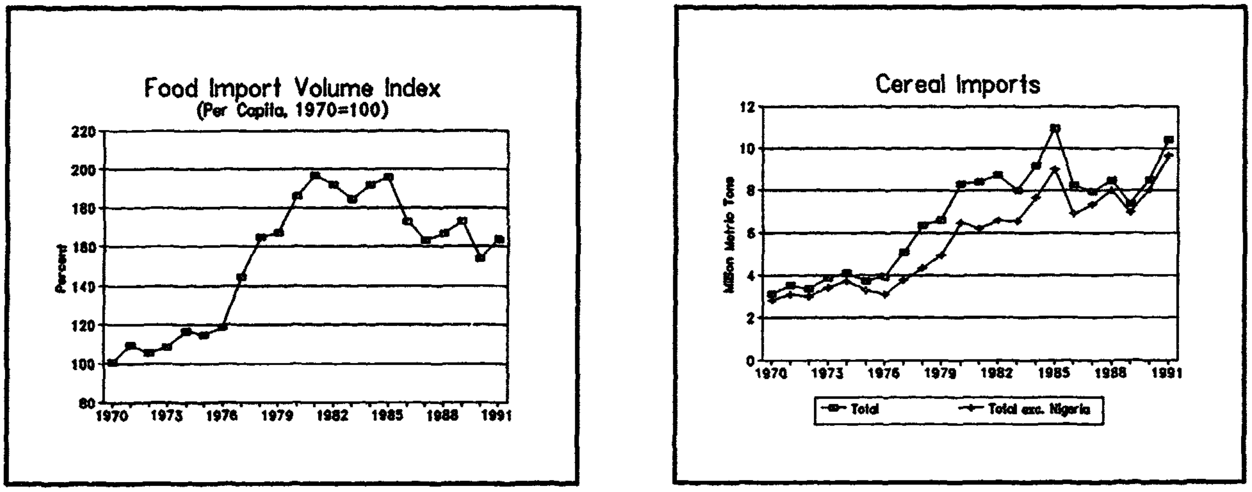
	Per capita daily calorie supply (calories) Average		Supply as percentage of minimum requirements		Average annual cereal imports		Index of per capita food production
	1965	1987-89	1987-89	1974	1990	1964-66	1988-90
Sub-Saharan Africa	2,074	2,121	91	4,209	7,838	..	94
Angola	1,907	1,742	74	149	272	127	81
Benin	2,019	2,115	92	8	126	94	112
Botswana	2,025	2,251	97	21	87	134	113
Burkina Faso	1,882	2,002	84	99	145	113	114
Burundi	2,131	2,320	100	7	17	100	92
Cameroon	2,011	2,142	92	81	398	89	89
Central African Rep.	2,055	1,965	87	7	37	94	91
Chad	2,395	1,821	76	37	36	124	85
Congo	2,260	2,519	114	34	94	110	94
Cote d'Ivoire	2,352	2,405	104	172	502	73	101
Ethiopia	1,853	1,684	72	118	687	111	84
Gabon	1,955	2,398	103	24	57	110	84
Gambia, The	..	2,339	98	..	..	152	..
Ghana	1,937	2,167	94	177	337	120	97
Guinea	2,187	2,007	87	63	210	106	87
Guinea-Bissau	..	2,437	106	..	..	140	..
Kenya	2,208	2,016	87	15	188	119	106
Lesotho	2,049	2,275	100	48	97	120	86
Liberia	2,158	2,344	101	42	70	95	84
Madagascar	2,447	2,174	95	114	183	105	88
Malawi	2,259	2,057	89	17	115	87	83
Mali	1,938	2,114	90	281	61	100	97
Mauritania	1,903	2,465	107	116	85	143	86
Mauritius	2,269	2,690	118	160	210	111	100
Mozambique	1,712	1,604	68	62	416	132	81
Niger	1,996	2,321	98	155	86	105	71
Nigeria	2,185	2,083	88	389	502	125	106
Rwanda	1,856	1,817	78	3	21	78	77
Senegal	2,372	2,162	91	341	534	156	102
Sierra Leone	2,014	1,813	79	72	146	99	89
Somalia	1,718	1,781	77	42	194	144	94
Sudan	1,938	1,981	84	125	186	89	71
Swaziland	..	2,554	110	..	..	68	..
Tanzania	1,831	2,186	94	431	73	87	88
Togo	2,454	2,110	92	6	111	118	88
Uganda	2,361	2,034	88	36	7	110	95
Zaire	2,187	2,079	93	343	336	110	97
Zambia	2,072	2,028	87	93	100	98	103
Zimbabwe	2,075	2,193	92	56	83	96	94

Source: FAO Supply and Utilization Database, 1991.

reasons, and given the high level of subsistence production, the degree of food inadequacy in Africa may be considerably overstated. A more detailed description of data problems in Africa are discussed in Berry (1984) and, more recently, in Jaeger (1992).

Regardless of what the production data measure, food imports[1] doubled in the late 1970s and have remained high in the 1980s (Figure 6.2). However, the doubling of food imports was almost entirely due to the quadrupling of Nigeria's food imports during the oil boom--from 1 million metric tons per year to around 4 million metric tons per year. Cereal imports[2] (excluding food aid) by sub-Saharan Africa rose by about 186 percent (4% p.a.) between 1974 and 1990 (from 4.2 million tons to 7.8 million tons, FAO data), and cereal food aid rose more than 290 percent (7% p.a.) over the same period (from 0.9 to 2.7 million tons). Despite the increase in food imports, calorie intake per person has been estimated to be only 87% of minimum requirements during the 1980s.

Figure 6.2 Africa's food and cereal imports, 1970-91



Source: Based on FAO data.

[1] Index numbers of food products include all commodities that are considered edible and contain nutrients, except animal feed products and alcoholic beverages. Coffee and tea are also excluded because, although edible, they have no nutritive value. Volume indexes represent the changes in the price-weighted sum of quantities and of the quantity-weighted unit values of products traded between countries. The weights are respectively the unit values and quantity averages of 1979-81, which is the base reference period used for all the index number series currently computed by the FAO.

[2] Wheat flour is included in terms of wheat equivalent, based on an extraction rate of 72 percent for all countries. Flour of cereals other than wheat is not included.

Challenges and Constraints

Concern for Africa's food situation and agricultural development has led to a significant body of literature dealing with strategies and needed interventions. The prevailing view of Africa's food problem has changed in recent decades along with the evolution of thought about economic development and the role of policy. Earlier perspectives on Africa were influenced by the "growth-with-modernization" era of the 1960s, when development was defined largely in terms of average per capita output. During this period, the food problem was perceived mostly in terms of deteriorating per capita food production. Many, especially within Africa, argued that priority should be given to increasing food production and attaining self-sufficiency at the national level. Since the 1970s, the "growth-with-equity" paradigm has broadened the coverage of development issues to include the role of income distribution, employment, nutrition, and poverty. It was recognized that solving the food problem not only required increasing production but also improving people's access to food (Sen, 1981; Mellor and Desai, 1985; World Bank, 1986a). Factors which limit peoples' purchasing power and their ability to acquire food were considered to be the major causes of chronic food crises rather than an absolute lack of supply.

Assessments of African economies by international agencies during the 1970s and 1980s portrayed a deepening economic crisis centered on the problem of deteriorating per capita food supplies. The crisis was attributed to declining or stagnant agricultural production due to government policies which discouraged or inhibited growth. Some studies identified adverse price incentives and excessive government interventions as critical constraints (World Bank 1981, 1984, 1986a). Other studies have argued that among the non-price factors, technological constraints are the most binding (Mellor, 1984b). Inadequate institutional capacity, human capital, and physical infrastructure (Eicher, 1984; Lele, 1988) have also been blamed, along with a bias against agriculture in the structural strategies pursued by many African governments (Johnston and Kilby, 1975).

The 1990s bring new challenges as concerns about increasing environmental degradation are combined with problems of poverty and very rapid population growth. The challenge to agriculture will be to continue, or improve on, recent positive trends in agricultural production. Several recent studies in the World Bank address some of these concerns, including the work of Carr (1989), Cleaver and Schreiber (1992), and Cleaver (1993). Many factors have been identified which constrain agricultural and food production, including physical constraints, inadequate land-tenure systems, constraints on the role of women, and neglect of infrastructure--all exacerbated by poor economic and agricultural policies as well as political instability. If Sub-saharan Africa is to increase per capita food production, agriculture will have to perform better--never mind that it has performed at about the world average in the past. This is a tall challenge for any region.

Transforming Agriculture

Agriculture remains the largest productive sector in Africa, accounting for 31% of GDP in 1991. Agriculture is the main supplier of raw materials to industry and farmers constitute the majority of consumers. While Africa has enormous physical potential to feed itself, a diverse set of supply bottlenecks has limited agricultural growth. These include slow adoption of yield-increasing technology; underdeveloped infrastructure; inadequate land tenure systems; and heavy government intervention and control in farm support systems including mandated low prices and high costs of transportation, marketing services, and farm input supplies.

The success of high-yielding crop varieties introduced to Sub-Saharan Africa has been limited. In contrast to other developing regions, Sub-Saharan Africa has been characterized by low and more or less stagnating yields per unit area of many subsistence food crops. The yields of cereals in Asia and Latin America are twice as high as they are in most African countries (Table 6.2). Worse still, in many countries yields of traditional foodgrains have declined, sometimes to a marked degree and over a long period of time. Studies have shown a picture of low or even negative per capita productivity change in the agricultural sector in many countries (Paulino, 1987). On average, productivity of agricultural labor seems to be significantly higher in Asia than in Africa despite a much more acute land scarcity (Delgado and Ranade, 1987).

The causes lie in the absence of any significant dynamics of technical change in African agriculture. Trends in the use of agricultural inputs provide clues to the relatively low productivity of agriculture in Sub-Saharan Africa. Compared to other countries, most of the region has little cropped area under irrigation and little use of fertilizer (Table 6.3). For the region as a whole, only 4% of arable and permanent crop land are under irrigation, compared to about 44% in China and 26% in India during 1985-87. On average, fertilizer consumption was only 3 kg per hectare during the early 1970s, compared to about 14 kg in India and 41 kg in China during the same period. While it increased to about 9 kg per hectare in 1989-90, it remains much lower than in other developing areas. At that time, fertilizer use in India and China had increased to 69 and 262 kg per hectare, respectively.

The reasons for the slow adoption of new technologies and low investment in irrigation are complex and poor data prevent strong analyses. The modern technologies introduced to farmers are based on higher-yielding varieties requiring additional labor and a higher level of fertilizer and other inputs. However, in most countries in Sub-Saharan Africa, agriculture is characterized by large cultivable areas, but with labor and capital scarcity. Resource-poor farmers had generally little capital and labor, but could develop new land. The traditional system of shifting cultivation, which was well adapted in many areas due to the low population density, did not require intensification and African farmers did not demand the new technology. People shifted to a different location when soil fertility declined. As long as land remained available, additional people were accomodated by developing new land. In addition, the high input costs combined with policies that keep producer prices at low levels (government price controls, heavy taxation, and overvalued exchange rates) has probably made new technologies no more profitable than existing technologies. Government controls on marketing and input supply may also have made new technologies more risky, thus adversely affecting adoption of "improved" varieties. Using a farm management framework, Anderson (1992) explains how low profitability and high risk may account for the disappointing performance of new technologies in Africa.

Research on Africa's irrigation potential during the 1980s indicates that the potential is quite limited--in any case much more limited than in Asia--and that rainfed agriculture will remain the most important and most economical way to increase foodcrop production in most African countries (Eicher and Baker, 1982; Lele, 1984; FAO, 1986; Matlon, 1987). However, more recent studies make a strong case for the important role of irrigation in Sub-Saharan Africa's agricultural development, with emphasis on prospects for small scale private irrigation systems where the best results have been achieved (Barghouti and Le Moigne, 1990). The potential differs considerably by country, but recent World Bank studies conclude that, for the region as a whole, the 5 million hectares presently under irrigation could be expanded to about 20-25 million hectares. While this potential is considerably less per capita than in Asia or Latin America, it nevertheless represents a substantial potential increase in output, since yields on irrigated land average 3.5 times those of rainfed areas. According to the FAO (1986) and World Bank studies (1990), the countries with the largest potential for expansion of irrigation are Angola, the Central African Republic, Chad, Mozambique, Nigeria, Sudan, Tanzania, and Zaire; although the studies also conclude that irrigation could also play a subsidiary role in many other Sub-Saharan countries.

The major problems encountered in past irrigation projects include cost overruns, deteriorating maintenance of large scale systems, and technical factors such as improper choices of location or design. Previous studies indicate that installation costs per hectare are higher in Sub-Saharan Africa than in other areas of the world. Access to water is considered much costlier and more problematical in Africa than in Asia. The unit cost of water is between two and three times higher in Africa than in India (FAO, 1986). This is considered the basic reason why most irrigated lands are devoted to export crops (cotton, sugar cane, and sugar beets) and to "superior" food crops (wheat in North Africa and rice in Sub-Saharan Africa). A number of technical reasons tend to make irrigation much more costly and problematic in Africa than in Asia including: a) the high unit cost of imported capital and intermediate goods resulting from long distances and poor roads, particularly in land-locked countries; b) African rivers, except those having their source in the mountains of East Africa, carry fewer sedimental matter than rivers in other regions of the world. This accounts for the decline in the fertility of irrigated fields a few years after the completion of irrigation projects (Mathieu, 1985). Asia is in a much more favorable position since its great rivers get much of their waters and alluvium from head-waters outside the tropics and carry a richer load of nutrient-bearing silt. More recent World Bank studies in several African countries indicate that with adequate planning and careful design, costs could be reduced to levels no higher than in other regions (Olivares, 1990). The studies conclude that privately owned pumps and small scale tank irrigation systems show the greatest potential in several countries (Seckler, 1990; Vrugt, 1990; Darghouth, 1990; Campbell, 1990).

Table 6.2 Crop yields in Sub-saharan Africa and selected Asian countries

	Cereals		Roots & Tubers	
	Mt/ha 1985-86	Percent Change from 1965-66	Mt/ha 1985-86	Percent Change from 1965-66
Angola	.46	-47	14.10	22
Benin	.82	54	8.24	34
Botswana	.18	-52	5.39	35
Burkina Faso	.69	33	6.57	96
Burundi	1.10	12	7.54	-3
Burundi	1.10	12	7.54	-3
Cameroon	.94	18	2.45	10
Cape Verde	.55	-11	3.01	-27
Central African Rep.	.51	-31	3.89	10
Chad	.53	-13	5.18	14
Comoros	1.16	-15	3.26	-4
Congo	.62	-43	6.46	31
Cote d'Ivoire	.98	23	6.28	70
Equatorial Guinea			2.40	-33
Ethiopia	1.08	39	2.83	-7
Gabon	1.48	-6	6.39	0
Gambia, The	1.21	15	3.00	-32
Ghana	.96	7	8.64	5
Guinea	.73	-10	7.09	-5
Guinea-Bissa	.85	19	6.15	0
Kenya	1.61	31	8.93	21
Lesotho	.68	-12	15.00	3
Liberia	1.30	107	4.01	-3
Madagascar	1.73	1	5.93	-7
Malawi	1.16	24	4.23	-13
Mali	.81	3	9.24	12
Mauritania	.43	20	1.90	-24
Mauritius	3.20	59	25.94	108
Mozambique	.66	-29	5.78	20
Niger	.37	-30	8.88	10
Nigeria	1.12	67	11.26	43
Rwanda	1.29	2	7.78	42
Senegal	.71	24	4.23	2
Sierra Leone	1.43	8	3.42	-6
Somalia	.72	47	10.79	8
Sudan	.51	-27	3.41	-1
Swaziland	1.53	225	1.82	-53
Tanzania	1.11	41	11.08	109
Togo	.87	83	10.50	-12
Uganda	.95	5	6.43	64
Zaire	.85	24	7.02	4
Zambia	1.75	106	3.69	13
Zimbabwe	1.46	63	4.91	22
India	1.59	76	14.27	61
China	3.89	122	15.61	81

Source: Based on FAO data.

Table 6.3 Input use in Sub-Saharan Africa and selected Asian countries

	Percent of land under irrigation a/	Fertilizer Consumption (100g/ha) b/	
	1985-87	1970-71	1989-90
Sub-Saharan Africa	4	33	89
Angola	0	33	74
Benin	0	36	18
Botswana	0	15	7
Burkina Faso	0	3	58
Burundi	5	5	35
Cameroon	0	34	41
Central African Rep.		12	4
Chad	0	7	15
Congo	1	525	32
Cote d'Ivoire	2	74	113
Ethiopia	1	4	70
Gabon			27
Ghana	0	11	31
Guinea	4	44	11
Kenya	2	238	481
Liberia	1	63	107
Madagascar	28	61	36
Malawi	1	52	227
Mali	9	31	54
Mauritania	6	11	116
Mauritius	16	2095	3302
Mozambique	3	22	8
Niger	1	1	8
Nigeria	3	2	121
Rwanda	0	3	14
Senegal	3	17	55
Sierra Leone	2	17	3
Somalia	12	27	26
Sudan	15	28	39
Swaziland	38		
Tanzania	3	31	93
Togo	0	3	83
Uganda	0	14	1
Zaire	0	6	10
Zambia	0	73	166
Zimbabwe	7	446	604
Asia			
India	26	137	687
China	44	410	2619

a/ Irrigated land as percentage of arable and permanent crop land (FAO, World Resources Institute).

b/ Fertilizer use in terms of hundreds of grams of plant nutrients per hectare of arable land (FAO, World Bank, World Development Indicators, 1992).

Improved farming packages geared towards the needs of small farmers have been limited. The only "success" story is that of maize for which East and Southern Africa had accumulated a backlog of advanced technology from the colonial period. In Kenya, research on hybrid maize started in the mid-1950s and the Kitale (Kenyan variety) was released about ten years later (Eicher, 1985; Lipton, 1985). However, these hybrid maize varieties have only benefited a few countries (Kenya, Malawi, Tanzania, Zambia, and Zimbabwe). "Under actual farming conditions, traditional seed varieties remain superior to the new varieties, both in yields and in pest resistance" (Eicher, 1986). With regard to staple foods, such as sorghum and millet, research programs undertaken by ICRISAT during the mid-1970s were unsuccessful in the transfer of hybrid varieties from India to West Africa (FAO, 1986; Spencer, 1986). Causes of this failure were located in "unforeseen problems with disease, variability in rainfall, and poor soils" (Eicher, 1984) and in the difficulty of transferring, crossing, or adapting exotic varieties so that they suit local conditions (Lipton, 1985). The situation of staple foods--cassava, yams, and other root crops--is similar to staple cereals in that local varieties remain superior to the "improved varieties" because the former tend to be more resistant to local diseases (Leonard, 1986).

With respect to agricultural technology development and diffusion, due to the "location-specific" characteristics of technology, direct "material" transfer does not succeed (Hayami and Ruttan, 1985). The development and rapid diffusion since the Second World War of high-yielding varieties of rice, wheat and maize in Asia and Latin America involved the adaptation of prototype high-yielding varieties (gradually replaced by crosses of the international center varieties with local varieties developed by national research units to suit local environmental conditions) which required institutional innovations in the organization, management, and financing of agricultural research. More than the direct transfer of materials and designs, it implied the international migration of scientific manpower and the development of indigenous research capability (Hayami and Ruttan, 1985; Johnston, 1986). The success of the green revolution in Asia owed much to access to a large backlog of scientific and technical knowledge in advanced countries through the mediation of international research centers and to a considerable strengthening in the receiving countries of capabilities for research, experimentation, and administration of agricultural programs. There was also a marked increase in the supply of well-trained scientists, engineers and administrators.

Lagging agricultural development in Africa was seen primarily as the consequence of a failure to make effective use of available technology due to various reasons, among which lack of knowledge and motivation among farmers stood foremost. There is a clear contrast between Asia and Africa. While in Asia foreign aid was used to strengthen indigenous scientific capacity to carry out research and field experiments and to generate new technologies adapted to local circumstances, in Africa it went mostly into direct assistance projects, thus preventing Africans from developing their own expertise and skills. Africa has remained a big builder and receiver of agricultural extension programs "which have generally been quite ineffective because they have had so little to extend" (Johnston, 1986); and of complex integrated rural development projects which cannot be properly handled due to an evident lack of trained manpower. Also telling and typical of many countries is the case of Senegal where the National School of Agriculture was not created until 19 years after national independence (Eicher, 1984).

Writers have also criticized the "extension" or "technological dependence bias" in the human capital model grounded on "overseas training and the provision of expatriate experts to Africa" (Eicher, 1986) and the heavy investment in the establishment of international research centers without the building of indigenous scientific capacity or local generation of new technologies and development of local materials relevant to the targeted areas (Spencer, 1986). Also criticized is the heavy commitment to applied research at the expense of basic scientific research such as soil science, plant physiology and pathology (Lipton, 1985; Mellor and Delgado, 1987). In addition, African agricultural research centers have been seriously handicapped by numerous inefficiencies originating in poor personnel management and work discipline, lack of performance incentives and professional advancement, and inadequate operating funds (Spencer, 1986). While many Asian countries benefited from significant foreign assistance with a high priority on the long-term objectives of institution building and development of graduate training in science and agriculture, Africa had programs of more limited size and shorter duration (Johnston, 1986).

Traditional land tenure systems are often regarded as a major impediment to growth of food production in Africa. The main thrust of the argument is that there is a conflict between existing land arrangements and the requirements of intensive agriculture. Communal control over land and the absence of active rural land markets discourage investments in land improvements and careful soil husbandry practices. This thesis is solidly based in the literature on contractual choice, property rights, and transactions costs (Williamson, 1985; Rosenzweig and Binswanger, 1986). However, Migot-Adholla et al (1991) suggest that customary land rights are robust enough not to inhibit investment and productivity growth as the structure evolves from communal control to individual control in response to population pressure and commercialization.

Reducing Population Growth

Africa is the only large region where population growth accelerated during the 1970s and 1980s (Table 6.4). The annual population growth rate was 2.1% in the mid-1950s, 2.6% in the late 1970s, and as much as 3% during 1980-85 (compared to 2.2% in Asia and 2.3% in Latin America). Africa lags behind other regions in terms of its demographic transition. The total fertility rate[3] for Sub-Saharan Africa has remained at about 6.5 for the past two decades (Table 6.4), while the average for all developing countries has declined to about 4. As life expectancy in Sub-Saharan Africa has risen from an average of 44 years in mid-1960s to 51 years in 1990, population growth has accelerated from an average of 2.6% p.a. during 1965-80 to about 3.1% p.a. in 1990.

Moreover, Africa's population growth rate is projected to continue to increase at nearly 3% p.a. throughout the 1990s before declining to about 2% p.a. by 2010-15. The situation is most desperate for countries where population is expected to grow at rates of more than 3.5% p.a. during the years 1990-2000 (e.g., Botswana, Kenya, Liberia, Nigeria, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe). Some countries are expected to experience a rate of population growth of around 4% p.a..

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[3] The number of children an average woman has in her lifetime.

The rapid population growth, combined with traditional systems of production, is creating increasing pressure on the land resources, with the result that increasingly marginal lands are being brought into cultivation and the fertility of existing lands reduced due to environmental degradation (Cleaver and Schreiber, 1992). The traditional system of shifting cultivation and extensive farming methods were appropriate when population grew slowly and land was abundant. People shifted to different areas when soil fertility declined. Until recently, more land could be gradually brought into farming to accomodate the slowly growing population. Due to the rapid population growth, more rural people are increasingly compelled to remain on the same land and new land for cultivation has become increasingly scarce, with further expansion becoming limited.

Enabling Policy Environment

The most important constraint facing agriculture in Sub-Saharan Africa is the widespread and continued inadequacy of macroeconomic and agricultural policies. A policy environment that increases efficiency, profitability, and private investment in African agriculture is necessary if food security objectives are to be met. In fact, the good performers in recent years have instituted economic policy reforms that have began to encourage improvements in these areas to some degree. Notable examples in the late 1980s and early 1990s include Benin, Burkina Faso, Guinea-Bissau, Nigeria, Uganda, and Tanzania. Agricultural output growth in countries[4] successfully embarking on economic policy reforms has attained growth rates of more than 3.5% p.a. in the 1987-90 period, compared to only 0.5% annual growth for non-reformers[5] (Cleaver, 1993; World Bank, 1993). However, much remains to be done in many countries where food and agriculture has suffered from poor or inappropriate macroeconomic and agricultural policies.

The nature and extent of policy inadequacy differs among countries, but the main areas include overvaluation of real effective exchange rates; government control over prices, marketing, and processing--areas in which government involvement leads to notoriously poor results; and poor public expenditure programs. Pricing and marketing policies at the sector level and fiscal and exchange rate policies at the economy-wide level have reduced the profitability of agriculture. This results in very low levels of private investment in agricultural production, agricultural marketing, and input supply. This has slowed or prevented gains in productivity and contributed to the persistence of rural poverty. The combined effects of currency overvaluation, high export taxes, fixed pricing policies, and inefficient marketing arrangements have reduced the real incomes of agricultural producers to less than half of the value of production as measured at world market prices (Lele, 1984; Oyejide, 1987; World Bank, 1981; 1986; 1989). Others studies have compared official producer prices measured in real terms with prices in local parallel markets and found that in countries such as Mali and Tanzania unofficial market prices

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[4] These countries include Cote d'Ivoire, Ghana, Guinea-Bissau, Kenya, Madagascar, Malawi, Mauritania, Mauritius, Nigeria, Senegal, Tanzania, Togo, and Zambia.

[5] These countries include those which did not receive adjustment lending, namely, Botwana, Ethiopia, Lesotho, Liberia, and Rwanda.

Table 6.4 Sub-Saharan Africa population growth rates and fertility rates, 1965-1990

Country	Average Annual Growth of Population (percent) 1965-80	1980-90	Total Fertility Rate 2/ 1965	1990
Sub-Saharan Africa	2.7	3.1	6.6	6.5
Angola	2.8	2.5	6.4	6.5
Benin	2.7	3.2	6.8	6.3
Botswana	3.5	3.4	6.9	4.7
Burkina Faso	2.1	2.6	6.4	6.5
Burundi	1.9	2.8	6.4	6.8
Cameroon	2.7	3.2	5.2	6.3
Cape Verde	1.6	2.4	-	-
Central African Rep.	1.9	2.7	4.5	5.8
Chad	2.0	2.4	6.0	6.0
Comoros	2.2	3.5	-	-
Congo	2.8	3.5	5.7	6.6
Cote d'Ivoire	4.1	4.0	7.4	6.7
Equatorial Guinea	1.7	1.9	-	-
Ethiopia	2.7	2.9	5.8	7.5
Gabon	3.6	3.9	4.1	5.7
Gambia, The	3.0	3.3	-	-
Ghana	2.2	3.4	6.8	6.2
Guinea	1.5	2.4	5.9	6.5
Guinea-Bissau	2.9	1.9	-	-
Kenya	3.6	3.8	8.0	6.5
Lesotho	2.3	2.7	5.8	5.6
Liberia	3.0	3.2	-	-
Madagascar	2.5	2.8	6.6	6.3
Malawi	2.9	3.4	7.8	7.6
Mali	2.1	2.4	6.5	7.1
Mauritania	2.3	2.6	6.5	6.8
Mauritius	1.6	1.0	4.8	1.9
Mozambique	2.5	2.7	6.8	6.4
Niger	2.6	3.5	7.1	7.2
Nigeria	2.5	3.3	6.9	6.0
Rwanda	3.3	3.3	7.5	8.3
Senegal	2.9	3.0	6.4	6.5
Sierra Leone	2.0	2.4	6.4	6.5
Somalia	2.7	3.0	6.7	6.8
Sudan	2.8	3.1	6.7	6.3
Swaziland	2.8	3.3	-	-
Tanzania	3.3	3.5	6.6	6.6
Togo	3.0	3.5	6.5	6.6
Uganda	2.9	3.2	7.0	7.3
Zaire	2.8	3.1	6.0	6.2
Zambia	3.0	3.9	6.6	6.7
Zimbabwe	3.1	3.7	8.0	4.9

Source: IEC, World Bank.

for millet, sorghum, maize, and rice were three to five times as high as official prices in the late 1970s (World Bank, 1986; 1989).

Improving Resource Management

Skilled management of African soils is required to ensure sustainability. African soils are often shallow and depleted of plants nutrients, and rainfed agriculture is only possible on a limited portion of the total land area. Soils also have very low water-holding capacity and with the low level of organic material they are severely damaged when exposed to the prolonged periods of drought and torrential rain (Kamarck, 1976; World Bank, 1989).

In the humid areas the sandy soils of the tropical lowlands predominate with their associated problems of acidity, low nutrient retention capacity, aluminum toxicity, and low initial phosphate and potassium content. In the more fertile soils of the tropical highlands, weed growth is often more critical than nutrient constraints. As for the dark clay soils, they are difficult to cultivate because they are hard when dry, sticky when wet, and prone to waterlogging. Their tendency to compact and harden during the dry season results in high early season runoff and severely restricts preseason and postseason cultivation (FAO, 1986; Collinson, 1987). Other physical limitations of African soils include very low structural porosity, reducing root penetration and water circulation; and generally poor infiltration (Matlon, 1987). Although Africa possesses considerable reserves of uncultivated lands which are often of high fertility, these land reserves are very unequally distributed between countries and they are often largely inaccessible due to serious animal, plant, and human diseases. Of the total land reserves of Africa (estimated at 603 million ha), three-quarters are located in the humid Central Africa and sub-humid, semi-arid Southern Africa. Only one-third of the region can be classified as land-abundant (Angola, Cameroon, Guinea, Mozambique, Sierra Leone, Sudan, Zaire, and Zambia).

The exceptional diversity of agroclimatic conditions further complicates the task of developing better soil management practices. Progressive intensification of land use does not appear to be a viable strategy until highly differentiated management techniques are developed. In contrast to Asia and Latin America, most of the output gains in Africa have resulted from increases in agricultural land used for crops rather than from increased yields. However, there is growing evidence that the agricultural frontier has been reached in many countries and, in those cases, it will be more costly to bring new lands into cultivation than to intensify production on land already in use (Binswanger and Pingali, 1988).

Summary

When people discuss world hunger today, they are almost invariably referring to Africa. The continent has been the site of most of the recent severe famines. Indeed, Africa is the last vestige of the severe hunger problems which faced most developing countries during the 1960s. It is the only region in the world where per capita food production has declined significantly during the past 30 years, although the decline is probably less drastic than government statistics indicate.

While there has been much pessimism expressed about Africa's future, we can be encouraged by remembering the similar prognoses during the 1960s that most Asians would face starvation in the 1970s, although the roots of the Green Revolution had already begun to flourish. The recent turnarounds of agriculture in several countries in the region offers hope that Africa may be closer than is commonly believed to where Asia stood then. This chapter reviews recent trends in the African food situation relative to other developing countries and highlights a number of important constraints and challenges. The list is naturally partial and selective; and given the vast amount of economic and agricultural literature, the intent is only to review the central factors explaining the region's poor performance relative to other developing countries. We leave to experts the discussion of specific strategies to achieve food security in Africa.

The relatively poor performance of African agriculture in recent decades has been primarily due to: (1) political instability and civil unrest; (2) drought; (3) the physical difficulties of farming in parts of the region; and (4) poor macro-economic and agricultural sector policies. None of these problems is ultimately beyond the control of Africa's people. The countries experiencing the worst food crisis in recent years are those experiencing armed conflict and political instability. In most countries, the most severe problems have resulted from poor policies--low mandated prices; state control of farm support systems including marketing, processing, and input supply; overvalued exchange rates; and mandated high costs of transportation, marketing services, and farm inputs. Weak agricultural growth and productivity has been due directly to the slow rate of technological developments for adoption by African farmers. Irrigated areas are below potential in most areas, and where developed they are poorly managed. Inherent soil constraints to expanded production using modern technology have not been tackled adequately in most countries. Underdeveloped infrastructure has resulted in high transport and marketing costs, while governments tend to set food prices well below world prices. This is exacerbated by maintaining overvalued exchange rates which effectively reduce the price of agricultural exports and products which compete with imports. The end result has been the inability of food production to keep up with population growth.

African farmers have already demonstrated that they can increase production with present resources when there are incentives to do so. Food production in many African countries rose significantly due to the stimulus of higher prices after the drought in 1983-84. In addition, agricultural growth in countries successfully adjusting economic policies has reached more than 3.5% p.a. in 1987-90, compared to less than 0.5% p.a. in countries that maintained poor policies.

Despite the myriad of contraints, there are several reasons why higher agricultural and food production growth rates should be expected in Sub-Saharan Africa. There is large potential for increasing productivity--fertilizer use is currently at very low levels relative to other developing countries; crop area under irrigation is estimated to be only one-fifth of potential; and infrastructure development lags far behind other developing countries. Improved farming systems, such as alley cropping, ridge tillage, mulch cropping, and wet rice production have demonstrated they can raise yields of most crops in Africa. However, most of these systems require major changes in traditional systems including adopting animal traction and using fertilizer. Many of Africa's farmers could grow more food than they presently do, if the region can generate lower-cost farming systems, improve rural infrastructure, and earn higher per capita incomes to invest in capital and other farm inputs. Large growth potential exists both through changes in agricultural policy to improve the efficiency in factor and output markets, raise the incentives of private smallholder food producers, and improve technology generation and dissemination, and through institutional reform to improve the provision of marketing and processing services. The underdeveloped infrastructure minimizes the potential growth linkages between the enclave estate sector and the smallholders. How to efficiently expand the provision of marketing, processing, and credit to private smallholder producers is a major challenge for public investment and agricultural research.

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Chapter VII. Simulating The Future

An econometric model of the world cereals markets is simulated to the year 2010 to evaluate the conditions under which the dramatic changes experienced since the 1960s are likely to continue. An initial set of assumptions for key variables is presented in this chapter which basically defines our "best estimate" of the future. These assumptions are used to produce the Baseline Simulation which is discussed in the next chapter. Alternative assumptions are introduced in Chapter IX to test the sensitivity of the world food situation to changes in these assumptions.

The most important variables have already been discussed, but to restate them in their perceived order of importance, they are:

Population - The world population growth rate is projected to slow over the next 20 years from about 1.74% p.a. in 1992 to about 1.4% p.a. by 2010. If this occurs, it will assist in the task of feeding the world. If population grows at a faster rate a greater contribution would be required from research to increase crop yields and cropland area may have to be expanded.

Cereals Yields - Yields have accounted for 90% of the increase in cereals production since 1950. If yields continue to grow at about the rate of the past decade--2% p.a.--then meeting projected food demand increases will be achieved comfortably. Even slower yield growth may be adequate if population growth slows as projected.

Reforms in the Former CPEs - The former centrally planned economies (CPEs) of Eastern Europe and the former USSR could represent a safety valve for the world food system. Because of distorted prices and centrally controlled decision making, food production in those countries stagnated during the 1970s and 1980s while consumption accelerated. This made the region a large food importer. If their economic reforms are successful the region could emerge as a much smaller importer or even a major exporter.

Income Growth in Developing Countries - If developing countries are able to achieve rapid income growth it will mean higher food demand, but it would also mean consumers can afford to import what they do not produce to allow greater diversification in diets. However, rapid income growth may mean that higher prices could be especially onerous for developing countries which do not achieve rapid income growth.

Energy Prices - Energy prices are important to agriculture because they directly affect the cost of irrigation and farm machinery use and they indirectly affect fertilizer prices as petroleum products are used in the manufacture of chemical nitrogen fertilizers. A rise in energy prices would cause food prices to rise.

Policy Reforms - Policy reforms in agriculture (other than those of the former CPEs) are possibly as important as some of the factors listed above but they do not appear as important in a global context as some of the factors such as income and population growth in developing countries. A country may undertake reforms of its exchange rate, food prices, producer prices, input subsidies or credit policies, all of which could be important, but determining the net impact of such reforms for one country is very difficult, let alone doing it for many countries. Thus global reforms in agriculture are not a focus of our analysis. If a country successfully reforms its agricultural policies, it may perform better than is suggested by past trends and vice-versa. If a group of countries reform their agricultural policies--as would appear to be desirable for a large number of developing countries--this could have significant global implications.

Reform of agricultural policy is included in the current GATT talks, and continues to present an obstacle to concluding an agreement. The difficulty largely centers on EC policies which support domestic prices at higher levels than world market prices. EC farmers strongly oppose such reforms and seem capable of diluting or barring significant reforms. Japan faces similar objections to agricultural reform--especially of the rice sector--from its farmers. These domestic political pressures indicate the difficulty of removing agricultural support policies and call into question the prospects of significant reforms. Since other studies have focused exclusively on this topic, we will not. We refer the reader to these other studies.

The Model

Most of our discussion has been about the world food situation, but we limit our analysis to the world cereals (grains) market because of the difficulty of modeling the global food market. Data limitations on many food items and the sheer number of commodities involved put it beyond the scope of our resources. However, the large share of grains in world food production, consumption and trade make grains a good proxy for the world food situation. For example, in developing countries, grains accounted for 61% of all calories consumed during 1986-88 (FAO, 1991). In that period, nearly 50% of all cropland was used to grow grains.

In this chapter we simulate the Baseline or "most likely" future for the world grains market from 1991 to 2010 using an econometric model. From this simulation, we draw conclusions which apply not only to the grains market but also to the broader topic of the world food situation over the next two decades. The model used for the simulations includes the major grains--wheat, rice, and coarse grains (maize, oats, barley, sorghum, rye, millet and mixed grains). The model is comprised of individual country models for 15 of the largest countries, with remaining countries grouped into nine regions. The model simulates production, consumption, net trade and stocks for each major grain. The econometric model is briefly described in this chapter and more fully described in the Annex Chapter.

While this simulation can provide a sense of the future trends in the world grains markets and the outlook for individual countries and regions, we should not forget that the results depend on the accuracy of the assumptions and on the integrity of the model. A simulation model allows the future to be projected based on the explicit assumptions for key variables and on the implicit assumptions which are part of the model. Since the model is estimated from historical data, the implicit assumptions should reflect the historical behavior of producers, consumers and markets. A model should be expected to translate the assumptions made about exogenous variables into reasonable projections which are consistent with historical results.

Econometric models have sometimes been associated with absurd forecasts because the model logic was flawed or because the assumptions made were unrealistic. To reduce the chances of making an absurd forecast we argue the merits of the forecasts not based on the claim that "the model projects...," but rather on the reasonableness of the forecast within the historical context and on our ability to integrate information which was presented in earlier chapters. For example, we know that consumption patterns are changing dramatically, with increased wheat consumption and slower growth in rice consumption in Asian countries. Therefore, we expect the model to project these trends to continue, and we expect these trends to follow similar patterns observed in other countries. Japan and the Republic of Korea, for example, may provide a measuring stick for other Asian countries such as Thailand. As Thailand's per capita income level increases, its consumption pattern may well follow a pattern similar to Japan and the Republic of Korea at the same income levels. However, we must also consider the capacity of the model to surprise us with insights; insights that we were unable to develop due to the sheer complexity of the interactions involved.

The simulation results must be scrutinized for internal consistency as a way of understanding and validating the forecasts. The projections should be logical extensions of past trends rather than abrupt changes which cannot be reasonably understood and which have no basis in the assumptions. This does not preclude forecasts of significant changes, but simply argues that these changes must fit the assumptions imposed on the model and the historical patterns of change.

Model Description

The world grains model used in this analysis was developed at the World Bank for use in projecting grains prices, production consumption, trade, and stocks (Mitchell, 1985 and 1988). It has been in use for nearly ten years and has been revised and updated several times. Individual models are estimated for each commodity and country or region with price linkages between commodities.

Production of each commodity is determined as the product of separately estimated harvested area and yield equations. Harvested area is determined by a two-stage process wherein total area harvested is determined first and then allocated among competing crops on the basis of per hectare revenues in the previous year. Yields are estimated as a function of crop prices in the previous year, fertilizer prices, the proportion of area planted to high yielding varieties and a linear trend representing adoption of innovations.

Grain imports are obtained from estimated per capita imports of each commodity multiplied by population. Per capita imports are estimated directly for importing countries as a function of income, domestic supply, and border prices in real terms. Year-ending stocks are estimated as a share of consumption and prices. Total consumption is obtained as an identity from production, net imports and stock changes. The designation of consumption as determined by domestic production, stock changes and net trade reflects the situation in most developing countries. Net imports are used to supplement domestic production.

Net exports of exporting countries are estimated as a function of the supply of each commodity available for export and world prices. Production and available stock levels are combined to reflect domestic supply and then domestic consumption is estimated and removed from domestic supply to obtain the supply available for export. This specification allows domestic consumers priority over exports and assures that their demand is satisfied. Per capita consumption in exporting countries is estimated as a function of incomes and prices, and total consumption is obtained by multiplying by population.

Grains prices are modeled as single world prices and are expressed as border prices in real terms by converting to domestic currency and deflating by each countries' CPI. The model is estimated on annual data from 1960 to 1988 using primarily ordinary least squares.

The model is solved simultaneously for world prices which equate net imports and net exports. A trade hierarchy is assumed which allows smaller exporters to export as much as they desire and forcing the United States to be the residual supplier. This specification conforms to market behavior in the world grains market, where the United States has traditionally been the largest grain exporter (see Mitchell and Duncan, 1987).

The model does not contain detailed information on government agricultural policies in individual countries because of the difficulty of obtaining and maintaining such data on a large number of countries. This limits the capacity of the model for policy analysis to determine the impact of changes in policies such as tariff rates, support prices, or fertilizer subsidies. However, it does not limit the model for projecting the effects of changes in variables such as yield growth, population, income, and world prices. For long-term projections, the absence of policy variables--which usually place a wedge between international and domestic prices--is not a serious problem. As Mundlak and Larson (1990) have shown, individual country prices follow world market prices even if with a substantial lag.

The Annex contains a more detailed discussion of the model. The countries which are individually modeled and the countries contained in each region are shown in the Annex, together with a listing of data sources for the variables.

Assumptions

Assumptions for the period to 2010 are made for population growth, income growth, consumer prices, and exchange rates for each country or region. The discussion of the population and income growth rates are presented in this section. The consumer price and exchange rate assumptions are presented for each country as part of the simulation output in the next chapter. Global petroleum and fertilizer price assumptions are discussed in this section. Crop yield assumptions are included in this section because their projected growth is largely based on historical trends which are assumed to continue.

GDP Assumptions

Real GDP growth rate assumptions are shown in Table 7.1. These are based on a number of sources including the World Bank (1992) and The WEFA Group (WEFA, 1992), as well as information from other forecasting groups. Ultimately the assumptions are those of this study and cannot be directly attributed to others. The assumptions are for moderate economic growth in the developed countries during 1990-2010, slow growth in Eastern Europe and the FSU, and rapid growth during the whole of the projection period for developing countries--most notably the developing countries of the Asian region.

The developed countries are generally projected to have slower economic growth during the next two decades than during recent past decades. This can be linked to slow population growth, an aging population, high consumer debt (especially in the United States) and excess capacity in a number of basic industries. The slow income growth is reflected in the grains simulation as slow growth in domestic grain consumption due to both the slow income growth and to the generally low income elasticities for grains for countries in this group.

Eastern Europe and the FSU are assumed to have negative real GDP growth during the next decade because of the changes in their economic and political systems and the effects of their past policies. The FSU is assumed to have real GDP declines of -3.4% p.a. during the 1990s followed by modest growth of 1.7% p.a. during the following decade. Eastern Europe is projected to have declining GDP of -.1% p.a. during the 1990s followed by 3.3% p.a. growth during the decade from 2000-2010. Eastern Europe grew at less than 0.5% p.a. during the 1980s, and since it underwent more significant changes and reforms during the 1980s than did the FSU, it may be expected to recover sooner. The importance of the assumed income growth rates for Eastern Europe and the FSU projections to the world grains markets are large, because this region has traditionally been a large importer of grains. If, as assumed, these countries have slow or negative growth for the next decade or more, then this reduces world grain import demand and should result in generally lower grain prices.

The developing countries are assumed to have rapid growth during the next two decades. For many, this follows rapid growth during the 1980s. India, for example, had real GDP growth of 5.7% p.a. during the 1980s and is assumed to grow at more than 6.5% p.a. during the next two decades. China grew at an even more rapid 8.9% p.a. during the 1980s and is assumed to grow by 8% p.a. during the next two decades. Latin America is also projected to grow rapidly--especially Mexico, due to its economic reforms and incorporation in the North American free trade area. If these growth rates are achieved, the demand for grain imports by the developing countries will very likely increase. For example, Mexico, which had real GDP growth of 6.6% p.a. during the 1970s, shifted from a small net grain exporter in 1970 to importing 8.5 million tons in 1980.

Table 7.1 Real GDP growth rates for Baseline Simulation

	1960-70	1970-80	1980-90	1990-2000	2000-2010
			(% p.a.)		
Developed					
Australia	5.2	3.1	3.3	2.8	2.8
Canada	5.1	4.6	2.9	2.2	1.8
EC-10	4.5	2.8	2.4	2.5	2.6
Japan	10.5	4.6	4.2	4.0	3.6
Other	8.2	2.9	2.3	2.7	2.6
United States	3.8	2.7	2.7	2.5	2.3
Former CPEs					
Eastern Europe	4.0	5.1	0.5	-.1	3.3
FSU	5.2	4.9	2.5	-3.4	1.7
Developing					
Argentina	4.4	2.6	-0.8	3.2	3.2
Brazil	6.1	8.7	1.8	2.4	3.5
Central Africa	4.2	4.4	2.2	3.0	3.1
China	4.1	5.6	8.9	8.4	8.4
East Asia	7.0	8.2	6.6	7.0	5.4
Egypt	5.4	6.6	4.4	4.1	3.1
India	4.0	3.2	5.7	6.5	6.6
Indonesia	4.5	7.7	4.6	7.0	6.5
Latin America	4.6	4.3	1.2	2.7	2.4
Mexico	7.1	6.6	1.5	6.1	6.3
Nigeria	3.7	4.3	0.0	3.9	4.3
North Africa	7.3	9.2	0.9	3.9	4.2
Pakistan	7.2	4.7	6.3	6.0	6.5
South Africa	6.0	3.3	1.7	2.8	3.2
South Asia	3.9	2.7	4.2	4.7	4.4
Thailand	8.2	6.8	7.4	9.0	7.4

Source: Based on World Bank and WEFA projections.

Population Assumptions

Population is the most important determinant of total food consumption in most countries. In recent decades, world population growth has slowed steadily from 2% p.a. during the 1960s to about 1.74% p.a. during the 1980s. The growth rate is expected to slow further with declining birth rates and as the fall in mortality rates begins to level off. As population growth slows, the demand for food will grow more slowly. The impact will be most dramatic in the developing countries where population growth rates still exceed 2.5% p.a. in many countries. In Pakistan, for example, the growth of population was 3.1% p.a. during the 1980s. Assumptions for population growth rates are shown in Table 7.2 for the countries and regions specified in the model. Historical averages for the 1960s, 1970s, and 1980s are also shown for comparison. The growth rates are from the medium variant of the United Nations population projections.

World population growth rates are projected to decline to 1.6% p.a. during the 1990s and to 1.4% during the period from 2000 to 2010. In the developing countries, which accounted for about 78% of world population in 1990, the growth rate is projected to slow from 2.1% during the 1980s to 2.0% during the 1990s and to 1.6% during the decade from 2000 to 2010. Growth rates in the developed countries, and in Eastern Europe and the FSU are projected to remain low at 0.4% to 0.5% p.a.

The most dramatic population growth changes are projected for the developing countries and these changes have important implications for the world grains market and for world food demand. In Brazil, for example, the rate of population growth is projected to drop from 2.1% p.a. during the 1980s to 1.5% during the period from 2000 to 2010. By the 2000-2010 period, few countries are projected to be growing faster than 2.0% p.a. compared with the 1980s when most developing countries grew at more than 2.0% p.a. Countries in Central Africa are projected to have the fastest growth during the 2000-2010 period at slightly more than 3% p.a. They will be followed by Pakistan at 2.4% p.a. The most populous countries, China and India, are projected to grow at 0.7% and 1.6% p.a., respectively, during the period 2000-2010.

Grain Yields Projections/Assumptions

Yields are projected individually for each of the grains--wheat, rice and coarse grains--and for each of the model countries and regions. The projections are derived from equations which included crop and fertilizer prices as well as a trend variable. Although the yield projections are based on estimated equations, they should be treated as model assumptions because the trend of yields is assumed to continue along the path of past growth.

The historical (1960-90) and projected (1991-2010) yields for the world and the three major regions are shown in Figure 7.1. Historically, yields have grown along a linear trend from 1960 to 1990, and they are projected to continue along this path. The growth rate per annum slows as the trend continues because of the increase in the base. The projected total cereals yield, which is aggregated from the individual cereals forecasts, is shown for each region

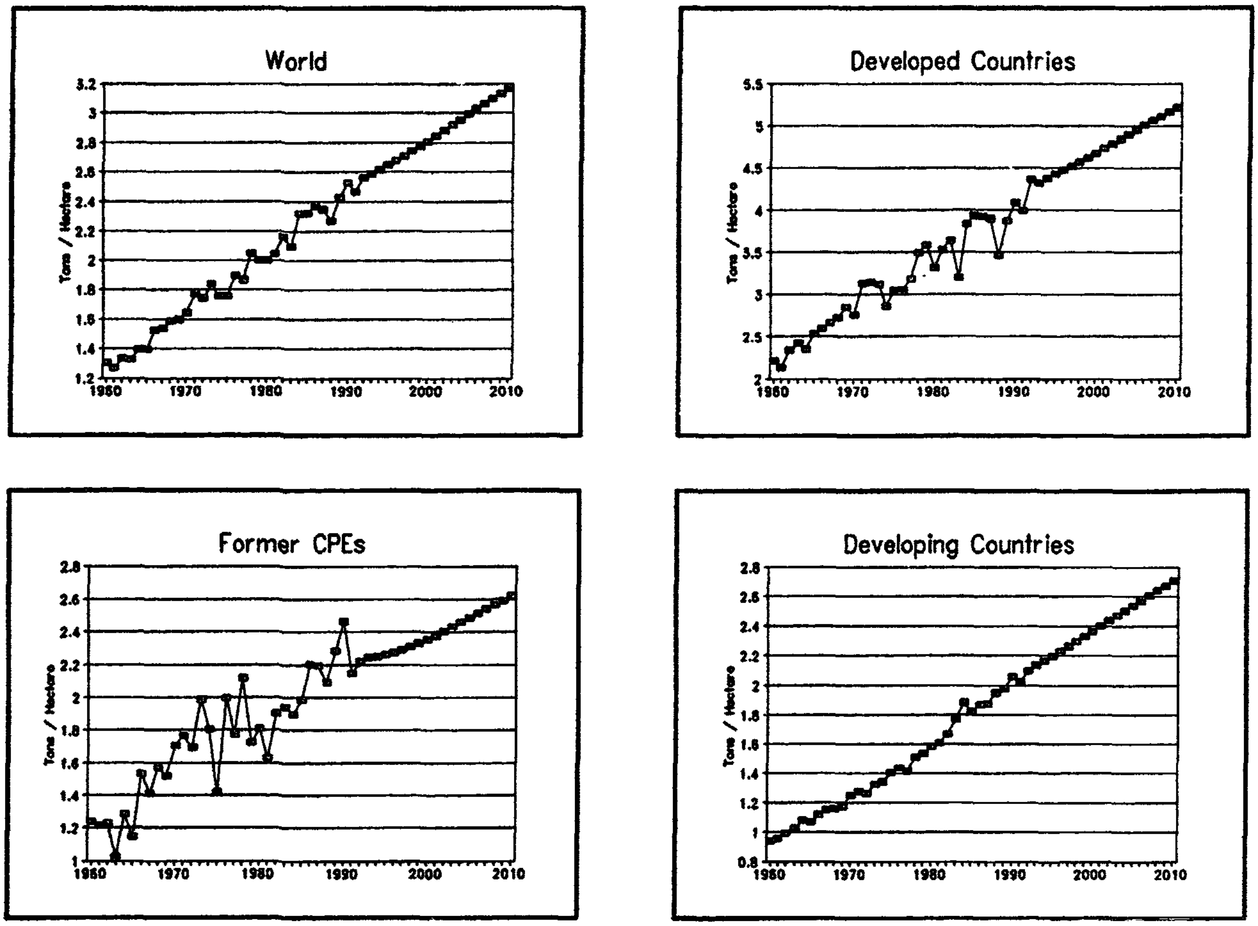
Table 7.2 Population growth rates for the Baseline Simulation

	1960-70	1970-80	1980-90	1990-2000	2000-2010
			(% p.a.)		
World	2.0	1.9	1.7	1.6	1.4
Developed	1.0	0.8	0.6	0.4	0.3
Australia	2.0	1.6	1.4	1.1	0.9
Canada	1.8	1.2	1.0	0.7	0.6
EC-10	0.8	0.4	0.2	0.2	C.0
Japan	1.0	1.1	0.6	0.4	0.2
Other	0.9	0.8	0.6	0.5	0.4
United States	1.3	1.1	0.9	0.7	0.5
Former CPEs	1.1	0.8	0.7	0.5	0.5
Eastern Europe	0.7	0.6	0.4	0.3	0.3
FSU	1.3	0.9	0.8	0.6	0.6
Developing	2.4	2.3	2.1	2.0	1.6
Argentina	1.5	1.7	1.3	1.2	1.0
Brazil	2.8	2.4	2.1	1.8	1.5
Central Africa	2.5	2.9	3.1	3.1	3.1
China	2.1	1.8	1.3	1.3	0.7
East Asia	2.8	2.3	2.2	1.8	1.4
Egypt	2.5	2.3	2.5	1.9	1.7
India	2.3	2.3	2.2	2.1	1.6
Indonesia	2.3	2.4	2.1	1.8	1.2
Latin America	2.7	2.3	2.1	1.8	1.6
Mexico	3.3	2.9	2.2	2.1	1.6
Nigeria	2.5	2.5	3.0	2.7	3.0
North Africa	2.9	3.0	2.8	2.4	2.0
Pakistan	2.8	3.1	3.1	2.9	2.4
South Africa	2.6	2.3	2.2	2.1	1.9
South Asia	2.5	2.6	2.5	2.2	1.8
Thailand	3.1	2.7	1.8	1.3	1.2

Source: World Population Prospects 1990, Department of International Economic and Social Affairs, United Nations, New York, 1991.

in Table 7.3. For comparison, the trend yields for the world and major regions are computed[1] and give forecasts which are similar to the more detailed country forecasts.

Figure 7.1 Historical and projected cereal yields, 1960-2010



Source: Historical data from 1960 to 1990 are from the USDA and projected data from 1991 to 2010 are from the simulation.

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[1] The forecasts of total cereal yields based on a 1960-90 linear trend are as follows:

	Yields (tons/hectare)			Growth Rates (% p.a.)	
	1990	2000	2010	1990-2000	2000-2010
World	2.469	2.878	3.287	1.54	1.34
Industrial	4.021	4.618	5.216	1.39	1.23
Former CPEs	2.270	2.631	2.992	1.49	1.29
Developing	1.987	2.356	2.725	1.72	1.47

The forecasts based on a 1970-90 linear trend are as follows:

	1990	2000	2010	1990-2000	2000-2010
World	2.473	2.888	3.302	1.56	1.35
Industrial	3.978	4.525	5.073	1.30	1.15
Former CPEs	2.026	2.442	2.859	1.89	1.59
Developing	2.211	2.497	2.783	1.22	1.09

Table 7.3 Cereal yield levels and growth rates for Baseline Simulation

	Yields						Growth Rates				
	1960	1970	1980	1990	2000	2010	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010
	(tons/hectare)						(% p.a.)				
World	1.30	1.65	2.00	2.57	2.81	3.17	2.37	1.97	2.52	.92	1.20
Developed	2.21	2.76	3.31	4.08	4.67	5.21	2.26	1.83	2.12	1.35	1.10
Australia	1.30	1.26	1.06	1.69	1.78	2.00	-.31	-1.75	4.83	.48	1.21
Canada	1.51	2.12	2.17	2.63	2.67	2.95	3.40	.25	1.96	.13	1.02
EC-10	2.55	3.21	4.40	5.49	6.28	7.23	2.30	3.21	2.24	1.34	1.42
Japan	3.23	3.71	3.66	4.44	4.80	5.18	1.41	-.15	1.97	.77	.78
Other	1.55	2.01	2.96	3.20	3.99	4.59	2.66	3.94	.79	2.21	1.42
United States	2.44	3.14	3.75	4.73	5.50	6.07	2.55	1.79	2.35	1.52	.99
Former CPEs	1.24	1.70	1.81	2.46	2.35	2.62	3.24	.61	3.14	-.45	1.08
Eastern Europe	1.78	2.25	3.29	3.62	3.60	3.92	2.36	3.87	.95	-.05	.86
FSU	1.10	1.58	1.50	2.19	2.05	2.31	3.68	-.50	3.83	-.64	1.20
Developing	.94	1.25	1.59	2.07	2.37	2.71	2.92	2.41	2.71	1.34	1.35
Argentina	1.34	1.85	2.52	2.42	2.90	3.24	3.27	3.14	-.39	1.83	1.11
Brazil	1.22	1.14	1.42	1.59	1.95	2.23	-.72	2.21	1.16	2.09	1.32
Central Africa	.79	.81	.84	.89	1.03	1.17	.22	.34	.58	1.55	1.30
China	1.00	1.77	2.48	3.78	4.58	5.40	5.85	3.45	4.28	1.94	1.67
East Asia	1.19	1.40	1.66	2.02	2.44	2.81	1.62	1.71	2.01	1.91	1.40
Egypt	2.59	3.47	3.73	5.24	5.68	6.20	2.95	.73	3.47	.81	.87
India	.74	.92	1.10	1.54	1.70	1.99	2.23	1.73	3.44	1.01	1.58
Indonesia	1.27	1.44	2.06	2.69	3.21	3.69	1.26	3.62	2.71	1.80	1.40
Latin America	1.05	1.29	1.63	1.93	2.33	2.65	2.09	2.36	1.70	1.91	1.30
Mexico	1.06	1.38	1.69	2.43	2.60	3.05	2.64	2.05	3.71	.68	1.62
Nigeria	.76	.72	.68	.69	.91	1.05	-.63	-.52	.10	2.87	1.36
North Africa	.75	.89	1.23	1.37	1.64	1.89	1.77	3.26	1.13	1.80	1.40
Pakistan	.76	1.12	1.47	1.62	1.91	2.18	3.98	2.76	1.00	1.67	1.32
South Africa	1.01	1.45	2.54	1.87	2.61	2.99	3.63	5.76	-2.99	3.36	1.37
South Asia	1.12	1.16	1.37	1.66	1.64	1.81	.38	1.66	1.93	-.10	.96
Thailand	1.15	1.42	1.38	1.38	1.58	1.72	2.16	-.32	.02	1.37	.82

Source: Historical data from 1960 to 1990 are from the USDA and projected data for 2000 and 2010 are from the simulation.

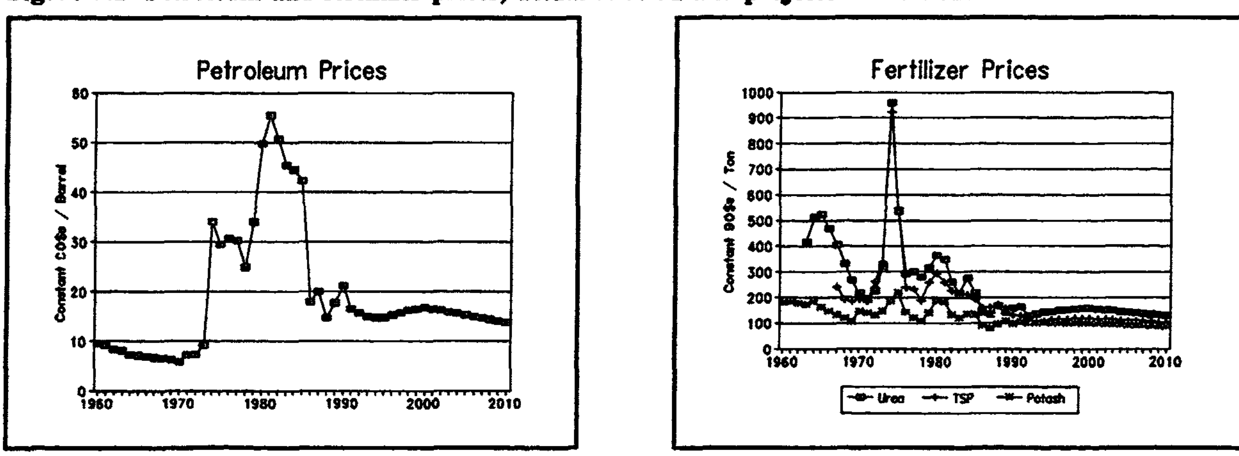
Energy and Fertilizer Price Assumptions

Energy and fertilizer prices are important determinants of the cost of agricultural production. The rapid increase in fertilizer prices during the mid-1970s was a major factor contributing to the world food crisis of that period. Since then, prices of both crude oil and fertilizer have declined by about one-half in real terms. As agricultural production becomes even more intensive, increased fertilizer and energy use will be essential and the price of fertilizer and energy will become more important.

The historical and projected prices of crude oil and fertilizers are shown in Figure 7.2 and Table 7.4 for the Baseline Simulation. The projections are for a decline in real prices for crude oil and fertilizer prices during the period to 2010. The forecast, provided by the International Trade Division of the World Bank, reflects the view that petroleum consumption will grow at 1.3% p.a. through the period, compared to only 0.9% p.a. from 1970 to 1990.

Three-fourths of the incremental demand for petroleum will come from developing countries as consumers in these countries increasingly rely on motorized transportation. Overall petroleum demand in these countries is projected to grow by 2.2% from the early 1990s to 2010. Consumption in the FSU is expected to decline until the mid- to late-1990s due to reduced domestic production and higher prices which will both lower energy demand and increase the efficiency of use. Demand for the entire period from 1990 to 2010 should grow only slightly at about .2% p.a. as demand first declines and then increases. Demand in the industrial countries is projected to grow only .6% p.a. due to more efficient transport vehicles, higher gasoline taxes and tighter regulations (World Bank, 1992).

Figure 7.2 Petroleum and fertilizer prices, actual 1960-92 and projected 1993-2010



Source: International Economics Department, World Bank.

Energy supplies increased during the 1980s by 1.1% p.a. due largely to the increase in non-OPEC supplies. Supply from these sources is projected to grow more slowly while OPEC supply is expected to increase. The role of the FSU and Eastern Europe in oil production is very uncertain as significant capital is needed to revitalize the sector. Without such investments, output will likely continue to decline in this region.

World fertilizer consumption increased by 2.45% p.a. during the 1980s and is projected to grow at a slower rate in the future (World Bank, 1992). The most rapid growth has been in the developing countries where both land cropped and the application rates per hectare have been increasing. Over the decade of the 1980s, the developing countries' consumption grew at near 6% p.a. and growth rates near this level are likely to be maintained for

Table 7.4 Petroleum and fertilizer price assumptions for Baseline Simulation

	1960	1970	1980	1990	2000	2010
			(current $s)			
Petroleum						
Opec Crude	1.5	1.3	30.5	21.2	24.7	29.1
Fertilizer						
Urea		48	222	157	232	271.6
TSP		43	180	132	172	218.8
Potash	29	32	116	98	147	183.0
			(constant 1990 $s)			
Petroleum						
Opec Crude	9.4	5.9	49.7	21.2	16.8	13.8
Fertilizer						
Urea		217.1	362.0	157.0	158.1	128.6
TSP		194.5	293.5	132.0	117.2	102.8
Potash	182.0	144.7	189.2	98.0	100.2	87.1

Source: International Economics Department, World Bank.
Prices for 1960-90 are actual and prices for 2000 and 2010 are projected.
Constant 1990 $ prices are deflated by the G7-CPI index, 1990=100.
Commodity Definitions:
Opec crude oil prices are $/barrel, for the period 1960-73 they refer to Saudi Arabian light, 34-34.9 API, f.o.b. Ras. Tanura; for the following years they are average OPEC spot prices weighted by their respective export volumes.
Urea prices are $/ton, varying origins, bagged, spot, f.o.b. West Europe.
TSP (triple superphosphate) is $/ton, bulk, spot, f.o.b. US Gulf.
Potash (muriate of Potash) is $/ton, standard grade, spot, f.o.b. Vancouver.

the next decade. In the developed countries, fertilizer use declined during the 1980s as land was idled in many countries and prices for crops declined. In the former CPEs, consumption increased during the 1980s by about 2% p.a. because of government policies which largely ignored world agricultural market prices and fertilizer prices. Both the developed countries and the former CPEs are expected to see slow or no growth in fertilizer consumption as area planted to crops remains nearly constant and applications rate are unchanged. Application rates will probably even decline in the former CPEs as these countries begin to charge world market prices for fertilizers.

World fertilizer production capacity is currently in surplus and the industry has restructured during the mid- to late-1980s following large investments during the 1970s and early 1980s. Production continues to shift to the developing countries where demand growth is the most rapid and to the sources of the natural resources such as the Middle East where abundant natural gas supplies are available. Production capacity is expected to grow by about 2% to 2.5% p.a. during the 1990s in response to increasing demand.

Reforms in the Former CPEs

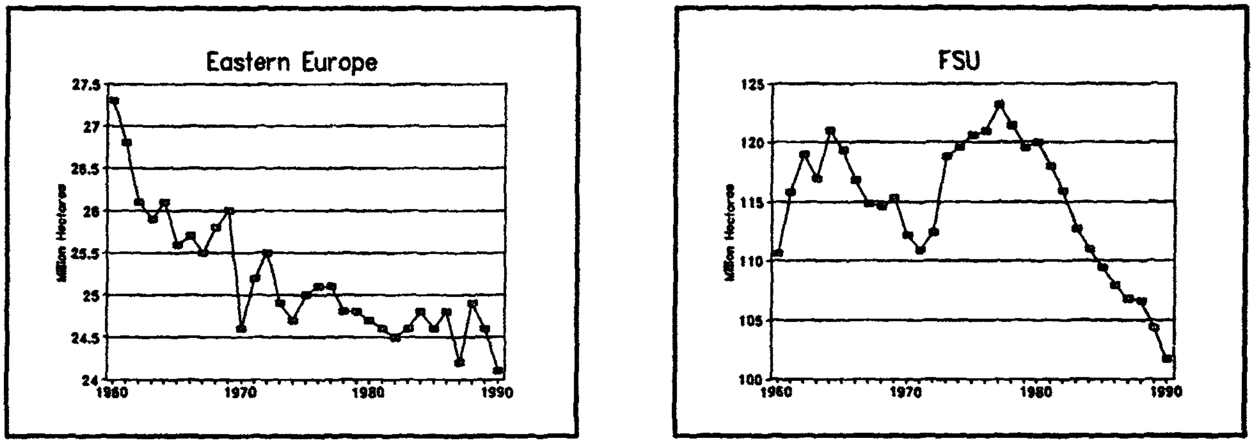
The former CPEs of Eastern Europe and the FSU are currently reforming their economies after decades of central planning. The outcomes of these reforms are uncertain, but they are also very important to the future of the world food situation. During 1970-90, these countries had average net grain imports of 30.8 million tons--equivalent to 16% of the world trade in grains. If the economic reforms in agriculture are successful, it seems very likely that the level of imports will decline as domestic production replaces imports. If the reforms are not successful, the incomes and the foreign exchange needed to maintain such large imports may not be available. Either way, grain imports would decline.

Simulating the agricultural performance of these countries is very difficult because their agricultural systems are changing in ways which make historical relationships poor indicators of the future. Consequently, our projections rely partly on assumptions about the behavior of important variables rather than only on the historically-based econometric estimates. The assumptions for real GDP, population and crop yields for the Baseline Simulation are as specified in previous sections of this chapter.

Grain yields are assumed to grow more slowly than the long term trend as shown in Table 7.3. This growth reflects a difficult transition to a market economy and only moderately successful reforms in agricultural production. It was implemented by estimating the yield trend over the 1970-90 period rather than for the 1960-90 period which was used for other countries. A very successful reform of the agricultural sector could be expected to lead to much more rapid yield increases. Since yields in the former CPEs are not high relative to those in Western Europe or in other developed countries such growth seems modest.

The area of grains harvested has been declining rapidly in the FSU and moderately in Eastern Europe (see Figure 7.3). Since 1977, when the FSU's cropped area reached a peak, the area harvested has declined 17.5% in the FSU. In Eastern Europe, the decline was greater during the 1960s than during the 1970s or 1980s. According to a recent World Bank report (World Bank, 1992, page 79) much of the decline in the FSU's area was due to marginal land being removed from production; according to this report it would be difficult to return this land to production. Therefore, we assume for the Baseline Simulation that the FSU grain area remains near current levels at 105 million hectares and Eastern Europe's area remains near 25 million hectares. However, the potential for much greater area under crops is clear and could occur if reforms are successful.

Figure 7.3 Harvested grain area in the former CPEs, 1960-90



Source: Based on USDA Data

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Chapter VIII. Baseline Simulation Results

The world can feed itself, this seems clear. The question is: At what price? Will we need to plow every hillside and dam every stream or have we plowed and dammed enough? Will it become increasingly difficult to meet the world's demand for food or will it become increasingly easy? We try to answer these questions in this chapter.

We use the world grain market model to simulate future grain demand, supply, net trade and prices. The assumptions about key variables such as population growth, income growth, energy prices and grain yields are taken from the previous chapter. The results from the simulation are very specific, but they should be viewed in more general terms. Our objective is to gain an overall view of where the world grain markets are heading from now to 2010 and from this to put together a view of the world food outlook. If major unforeseen changes occur in the world's economies or environment then the future must be reconsidered, but our objective is to say where were we are heading knowing what we know at this time.

Overview

The simulation results strongly suggest that the outlook for the world food situation is good, despite regional problems. Most consumers can expect to have increased food supplies and a greater variety of food at lower prices. The prices of basic staples such as grains will continue to decline relative to other consumer prices and relative to incomes. These changes suggest further improvements in diets of poor people, as has been the case during the past 30 years. Such gains will be possible because of higher crop yields and modest increases in cropland area. Major increases in resources devoted to crop production should not be required unless crop yields succumb to yet-unforeseen problems.

The simulation results suggest only gradual increases in world grain consumption, production and trade. In the absence of a major shock, that is all that is required to continue the gains of recent years. The large increases in consumption are probably past for most consumers despite large differences which remain in the levels of consumption. For example, consumers in the highest income Asian countries such as Japan, the Republic of Korea and Singapore consume only about one-half as much grain per capita as consumers in North America, but it doesn't appear that this gap will be reduced quickly.

Many consumers in developing countries increased consumption significantly during the 1960s and 1970s, but since then the increases have slowed. In China, for example, per capita grain consumption increased about 70% during the 1960s and 1970s, but by less than 10% during the 1980s. The slower growth during the 1980s took place despite abundant grain supplies and rapidly accelerating real per capita income growth. Future increases are also expected to occur slowly--more in line with changes during the 1980s than with increases in earlier years.

The most dramatic change now envisaged is for the former CPEs to shift from grain importers to exporters. These countries imported about 22% of world grain trade in 1980 but imports are likely to decline sharply for three reasons. First, in the short run the lower per capita incomes, shortages of foreign exchange and limits on credit will depress imports. Second, in the longer run consumption levels will decline due to the reduction of subsidies as food prices are brought up to international levels. Third, the longer-term restructuring of the agricultural sector will lead to increased production in the opinion of most experts. Estimates of future levels of consumption, production and trade cannot be very certain but the direction of change is clear.

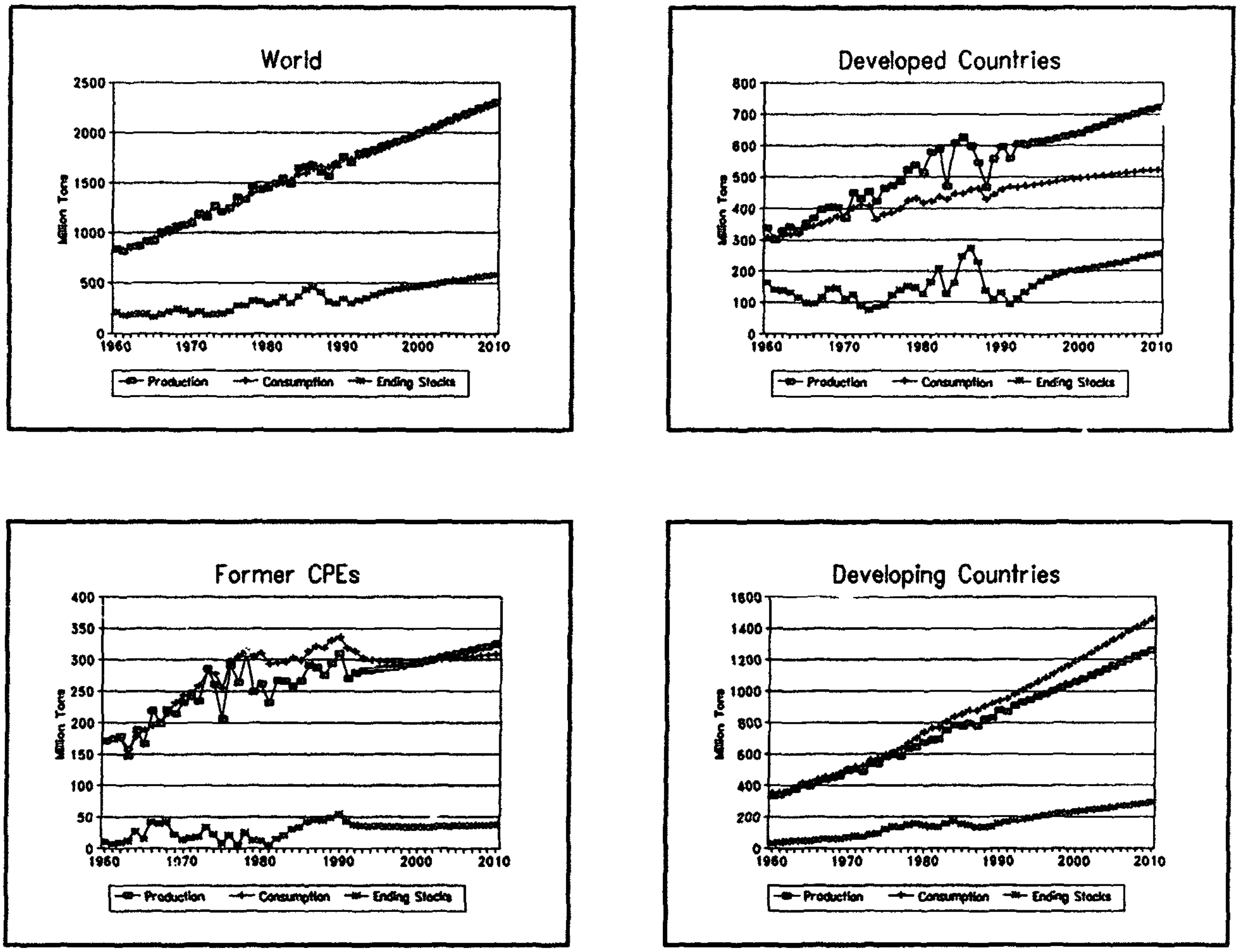
Based on the grain model simulations, world grain consumption is projected to grow by about 1.4% p.a. from 1990 to 2010 compared to 1.7% p.a. during the 1980s. The slower growth will be due in large part to declining consumption in the former CPEs as they restructure. Consumption in the developing countries is projected to increase by 2.2% p.a. during 1990 to 2010 compared to 2.4% p.a. from 1980 to 1990 due to a slowing of the rate of population growth. Thus, per capita consumption in the developing countries is projected to increase by about the same rate as during the 1980s. The developed countries are expected to continue the slow growth of consumption of the 1980s, increasing consumption by 0.6% p.a. during 1990-2010.

Regional problems will remain. Africa is projected to face severe food problems because of rapid population growth and slow income growth. Under such conditions farmers are unlikely to have adequate incentives to increase production at even the rate of population growth. The abundance of grain at low prices in the world market will further weaken farm prices and Africa's ability to produce. The situation could become critical with massive food aid required. Some South Asian countries may also face food problems, but these should be of much smaller magnitude than in Africa. The high population growth projected for Pakistan (2.9% p.a.) during the 1990s, for example, will probably exceed the rate of growth of grain production. However, rapid income growth should allow imports to avert the kind of food crises which Africa may face.

Expanded grain trade is essential to improved levels of consumption in the developing countries and especially to increased dietary diversity. Many countries are constrained by their ability to expand cropland area and by the types of crops which can be grown. Yet, because of rapidly rising incomes they are demanding greater variety in their diets. In many cases, this demand can be met at lower cost by importing, rather than from expanding domestic production. In total, grain imports by the developing countries are expected to more than double from 1990 to 2010. This may seem a major achievement, but, the previous 20 years saw a quadrupling of imports.

Grain balances, past and projected, for the world and the three major economic regions are shown in Figure 8.1.[1] Developing country imports are projected to continue to increase, as seen by the widening gap between production and consumption. This gap began to increase in the mid-1970s as incomes rose. Imports increased even while production grew rapidly, as consumers diversified their diets to include more wheat and meat.

Figure 8.1 Grain balances for the world and major regions, 1960-2010



Source: Historical data from 1960 to 1990 are from the USDA and projected data from 1991 to 2010 are from the simulation.

The former CPEs are projected to reduce sharply their grain imports from the levels of the 1980s, and by the end of the forecast period become significant exporters. Production in

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[1] Detailed simulation results are presented in the Annex to this chapter. Results for each country and region in the model are presented along with results for the world and for the three major aggregated regions--the developed economies, the former CPEs and the developing countries.

the former CPEs is assumed to regain its former growth path following the stagnation of the 1980s. This growth will result from the restructuring of farms, modernization of farming methods and improved technology.

The developed countries have historically exported larger and larger quantities of grain to the other regions. This trend was interrupted during the 1980s with exports declining and stocks increasing. The trend is expected to resume during the 1990s, but the loss of the former CPEs as a major export market will dampen growth. Production in the developed countries should grow at slower rates than during the 1960-80 period while still meeting the growing import demand of the developing countries and maintaining moderate to high stock levels. Despite rapid growth in exports to the developing countries, production is projected to grow by only 1% p.a. and even this modest growth will lead to increases in stocks. The area under grain production in the developed countries will decline by an estimated 5.1% from 1990 to 2010 and by 10.8% relative to 1980.

Land devoted to world grain production is projected to rise by 4.8% from 1990 to 2010. This increase is expected to occur in the developing countries while there will be decreases in cropland under grains in the developed countries and in the former CPEs. The largest increase in land use is projected to occur in the Central Africa region as very rapid population growth pressures food demand.

Real grain prices are projected to decline throughout the period as productivity increases exceed the demand growth that would occur at constant prices. By 2010, real wheat prices are projected to decline by 33% from 1992 levels, compared to a decline of 42% during the 1980s (Figure 8.2). Rice and maize prices are projected to decline by 31% and 21%, respectively, compared to declines of 48% and 37% during the 1980s. (See Annex Table A-1 for historical and projected prices for wheat, rice and maize.)

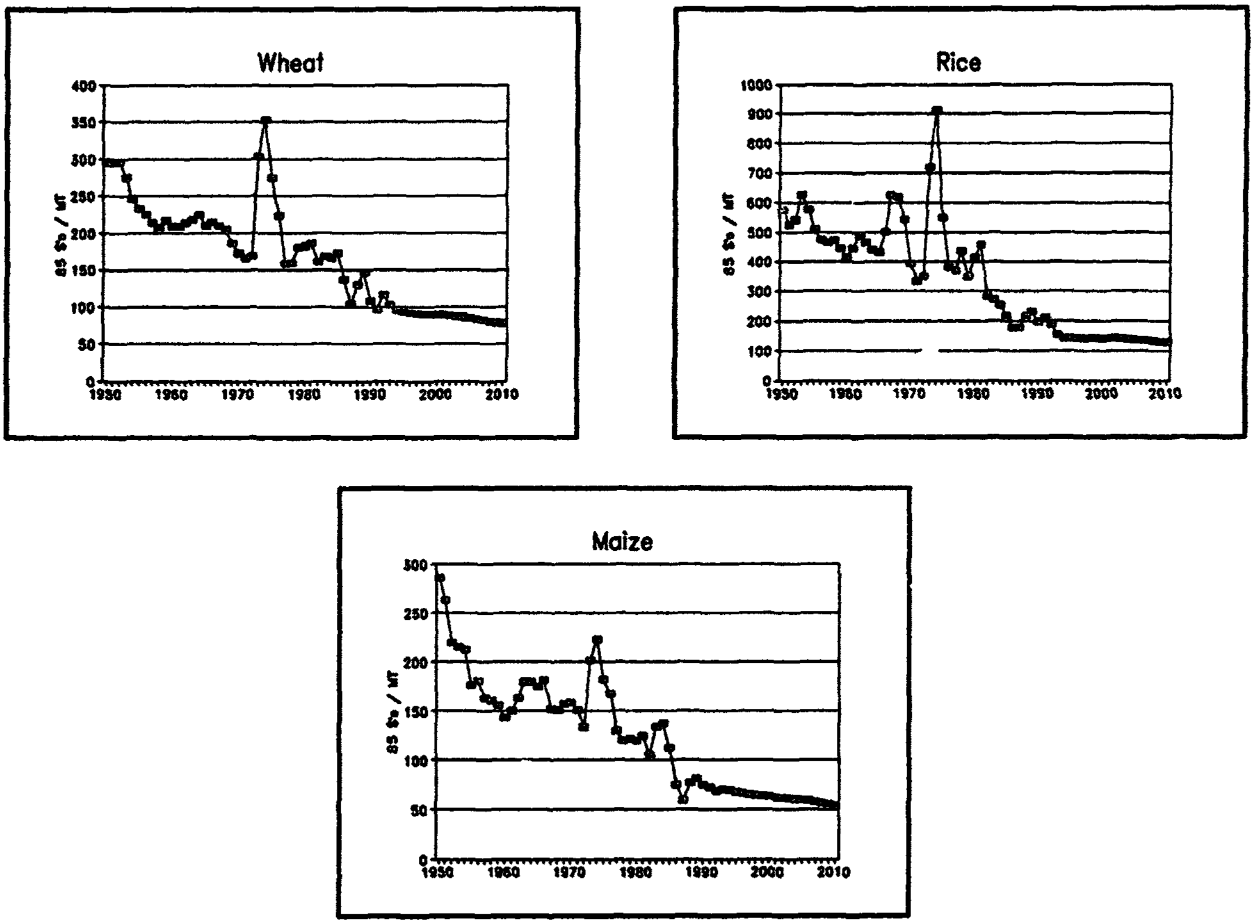
The Details

The devil is in the details, or so they say, and so we consider the details.

Consumption and Production

The rate of growth of world grain consumption was about halved during the past 20 years--from 3.1% during the 1960s to 1.7% during the 1980s. We don't expect it to be halved again during the next 20 years, but neither do we expect it to rise. Production was slow to adjust to slower consumption growth, but falling prices and rising surpluses eventually cut grain production growth to 2.1% p.a. during 1980-90 from 2.8% p.a. during the 1970s. The details are in Table 8.1. Figure 8.3 shows annual grain consumption data for selected countries for 1960-2010.

Figure 8.2 World grain prices, 1950-2010



Source: Historical data from 1960 to 1992 are from the USDA and World Bank and projections from 1993 to 2010 are from the simulation.

World grain production increases will need to slow further if huge stock accumulations are to be avoided. The adjustment will likely come in the developed countries. World production will only need to grow by an estimated 1.4% p.a. during the period from 1990 to 2010 to keep pace with world demand. This would still allow consumption in developing countries to increase by 2.2% p.a. during 1990-2010 compared to 2.4% p.a. during the 1980s.

The rapid growth of consumption for many developing countries during the 1960s and 1970s seems to reflect a catching-up period where rising incomes allowed consumers to increase grain consumption significantly. In China, for example, consumption increased by 4.3% p.a. during the 1960s, by 5.2% during the 1970s and by 2.3% during the 1980s (see Table 8.1 and Figure 8.3). The same pattern is seen in Brazil, Indonesia and North Africa. In North Africa, consumption grew by 5% p.a. during the 1970s but by only 2.9% p.a. during the 1980s. The slower growth during the 1980s reflected not only the slower income growth in some countries but also the attainment of an adequate diet by many consumers. Japan experienced a similar pattern at an earlier period, as grain consumption grew by 3.1% p.a. during the 1960s, by 2.4% p.a. during the 1970s and by 0.6% p.a. during the 1980s. Some countries such as India and Pakistan are currently going through a period of rapid increases; however most Asian, Latin American and North African countries are probably already past their period of most rapid growth. If so, further declines in the rate of consumption growth can be expected from them and for the developing countries in aggregate.

A similar consumption pattern can be seen in the former CPEs. Rapid growth occurred in Eastern Europe during the 1960s and in the F[illegible] during the 1970s followed by much slower growth during the 1980s. The slowdown in growth has been accelerated by the economic collapse in these countries in recent years. The high levels of per capita grain consumption reached in these countries as compared to other countries with similar cultural heritage and incomes makes increases unlikely. For example, Eastern Europeans consumed 834 kg of grain per capita in 1988 compared to 427 kg in Western Europe. These high consumption levels were probably due partly to high wastage rates as well as to inefficient practices due to the highly subsidized consumer prices.

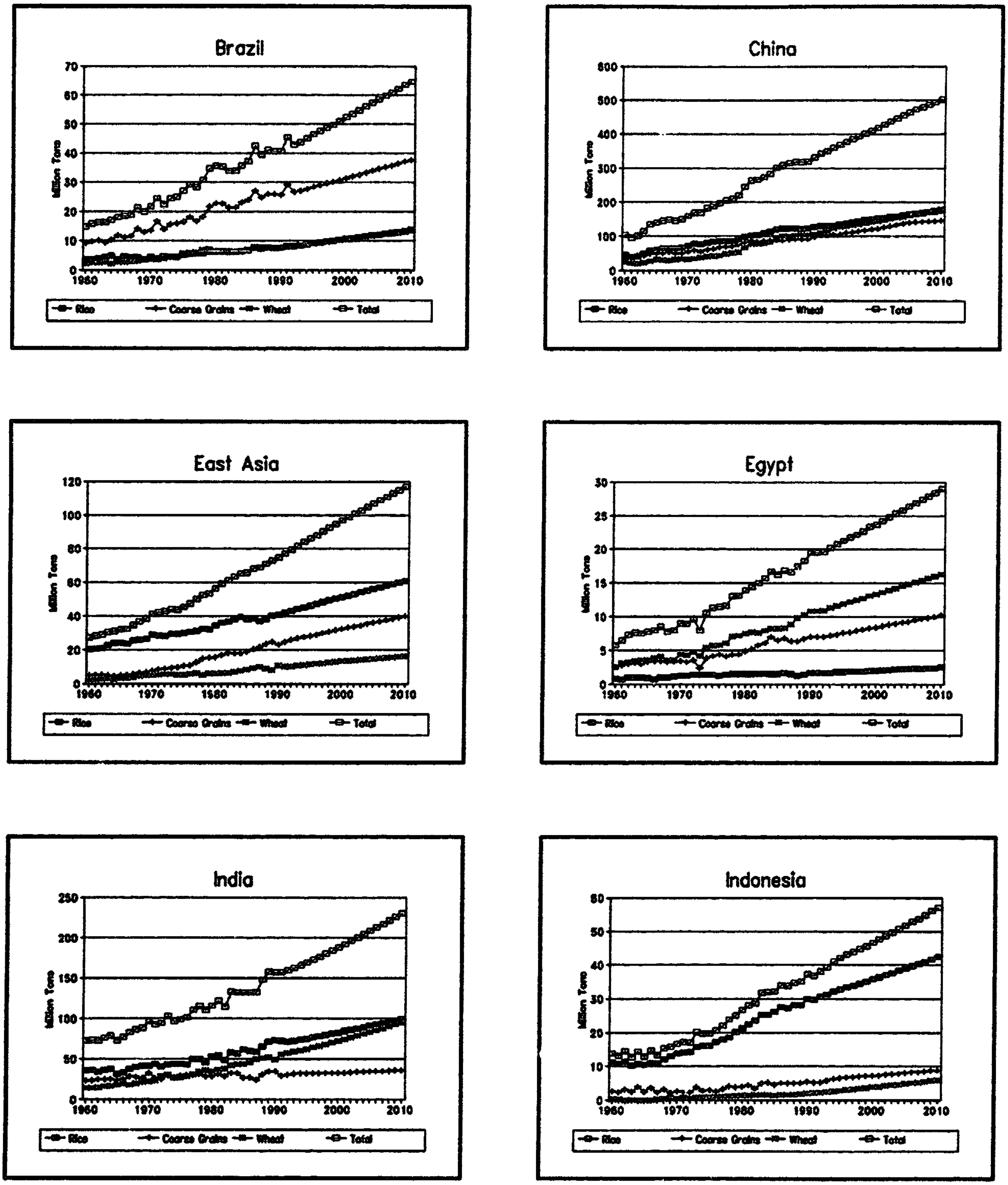
Most developed countries have increased grain consumption at slightly more than the rate of population growth during the past 20 years--about 1% p.a. since 1970--and this trend is expected to continue. Slower overall growth is projected as population growth rates are projected to decline from 0.6% p.a. during the 1980s to 0.4% p.a. during the 1990s and to 0.3% during the 2000-2010 period.

Table 8.1 Historical and projected grain production and consumption growth rates, 1960-2010

	Production					Consumption				
	1960-1970	1970-1980	1980-1990 (% p.a.)	1990-2000	2000-2010	1960-1970	1970-1980	1980-1990 (% p.a.)	1990-2000	2000-2010
World	2.7	2.8	2.1	1.1	1.4	3.1	2.7	1.7	1.4	1.4
Developed	1.0	3.4	1.5	.8	1.2	2.1	1.0	1.0	.8	.5
Australia	2.3	2.0	3.2	.2	1.6	2.5	2.9	2.8	.9	1.9
Canada	.7	3.8	3.6	-.3	1.3	3.0	.7	1.5	.4	.6
EC-10	2.4	3.1	1.1	1.4	.8	2.1	.6	-.5	.9	.3
Japan	-2.2	-2.5	1.0	.0	.8	3.1	2.4	.6	1.0	.4
Other	2.3	3.6	.2	1.5	.6	2.8	2.9	-1.0	1.8	.6
United States	.3	3.7	1.5	.6	1.4	1.7	.4	2.5	.4	.5
Former CPEs	3.2	1.2	1.7	-.5	1.0	3.7	2.5	.8	-1.2	.4
Eastern Europe	1.3	3.9	.7	.0	.5	1.8	3.8	-.3	-.6	.3
FSU	3.8	.2	2.1	-.7	1.1	4.5	1.9	1.3	-1.4	.4
Developing	4.1	3.1	2.7	1.9	1.7	3.6	3.9	2.4	2.4	2.1
Argentina	5.2	3.4	-2.8	2.0	1.3	.8	.4	-.5	3.2	1.2
Brazil	4.2	4.8	.5	3.3	1.9	3.9	5.1	1.3	2.5	2.2
Central Africa	3.8	2.5	1.5	4.2	2.5	4.1	3.2	2.3	3.4	2.7
China	5.9	3.7	4.1	1.6	1.6	4.3	5.2	2.3	2.4	1.8
East Asia	2.6	2.2	2.5	2.0	1.8	4.3	3.1	2.9	2.6	1.9
Egypt	2.9	1.1	4.5	1.9	1.1	4.4	4.4	3.5	2.0	2.0
India	3.1	2.1	3.3	1.4	1.8	2.8	1.9	3.1	1.8	2.1
Indonesia	2.4	4.2	4.1	1.5	1.7	2.1	4.7	3.4	2.3	2.0
Latin America	4.5	2.4	2.6	2.3	1.6	5.8	3.8	1.7	2.8	2.1
Mexico	6.8	2.4	2.5	1.7	1.8	5.9	5.5	2.0	2.5	3.1
Nigeria	1.3	.5	-2.6	4.7	1.5	1.6	2.0	-3.5	5.2	2.2
North Africa	2.0	3.8	2.0	2.1	2.0	3.1	5.0	2.9	2.7	2.4
Pakistan	6.2	3.5	2.2	2.2	2.0	4.6	2.2	3.0	2.8	2.7
South Africa	5.1	4.6	-5.3	5.8	1.5	4.4	3.7	1.5	2.4	2.9
South Asia	1.3	2.5	2.1	.2	1.4	1.2	2.6	2.4	2.0	1.9
Thailand	4.9	3.2	.3	2.7	1.6	5.3	1.6	2.3	.9	1.2

Source: Historical growth rates from 1960 to 1990 are based on USDA data and projected growth rates from 1991 to 2010 are from the simulation.

Figure 8.3 Grain consumption for selected countries, 1960-2010



Source: Historical data from 1960 to 1990 are from USDA and projections from 1991 to 2010 are from the simulation.

Grain Trade

Trade has provided an increasingly large share of grain consumption for the developing countries since the 1970s. On balance, the developing countries imported about 3% of total grain consumption during the 1960-75 period. This share steadily increased to 9% in 1990. It is projected to continue increasing, but not at a faster rate. By 2010, the developing countries are projected to import 14.8% of total consumption (see Figure 8.4).

The developed countries are expected to provide the bulk of world grain exports as has been the case during recent decades. Projected net import levels and growth rates are shown in Table 8.2. Net exports from the developed countries (shown as negative net imports) increase from about 117 million tons in 1990 to 194 million tons by 2010. This implies an average growth rate of 2.6% p.a. Net imports by the developing countries are projected to increase from 87 million tons in 1990 to 210 million tons by 2010. The former CPEs are projected to shift from net grain imports of 27 million tons in 1990 to 16 million tons of net exports by 2010.

Large increases in grain net imports are projected to occur in North Africa, Mexico, Indonesia, India, and China, among others. The increases primarily reflect rapid real GDP growth. Imports will be mainly in the form of wheat and coarse grains, while rice imports should remain low as consumption is satisfied largely by domestic production.

Per Capita Consumption

World average per capita grain consumption grew by about 20% during the 18 years from 1960 to 1978, but it has not increased appreciably since 1978. During the 1960s, per capita consumption grew by 1.1% p.a., followed by 0.8% p.a. growth during the 1970s. Per capita consumption actually declined from 1980 to 1990 due to the increasing share of world population in developing countries which lowered the average (see Figure 8.5 and Table 8.3).

The 1990s will most likely see declining world per capita grain consumption levels. In developing countries, per capita grain consumption is projected to grow by 0.4% p.a. during the 1990-2010 period, compared to 0.3% p.a. during the 1980s. Per capita consumption levels are projected to decline in the former CPEs for the reasons already noted, and this will largely account for the decline in world per capita consumption. Per capita consumption in the developed countries is projected to increase by 0.2% to 0.3% p.a., consistent with trends of the past 20 years.

Regional differences in per capita grain consumption reflect many factors including economic, demographic and cultural differences and these differences are largely expected to remain. Asian consumers are expected to maintain lower per capita consumption levels than consumers in the Americas or Europe despite more rapid income growth. This reflects historical dietary preferences as well as economic factors. Japan, for example, has the highest per capita grain consumption levels among Asian consumers but the lowest among developed countries.

Its level was only 58% of the average for all developed countries in 1990. Further, the level of consumption had not grown appreciably since 1980 despite rapid income growth and rising consumer spending. The differences between many Asian countries, including Japan, is now small.

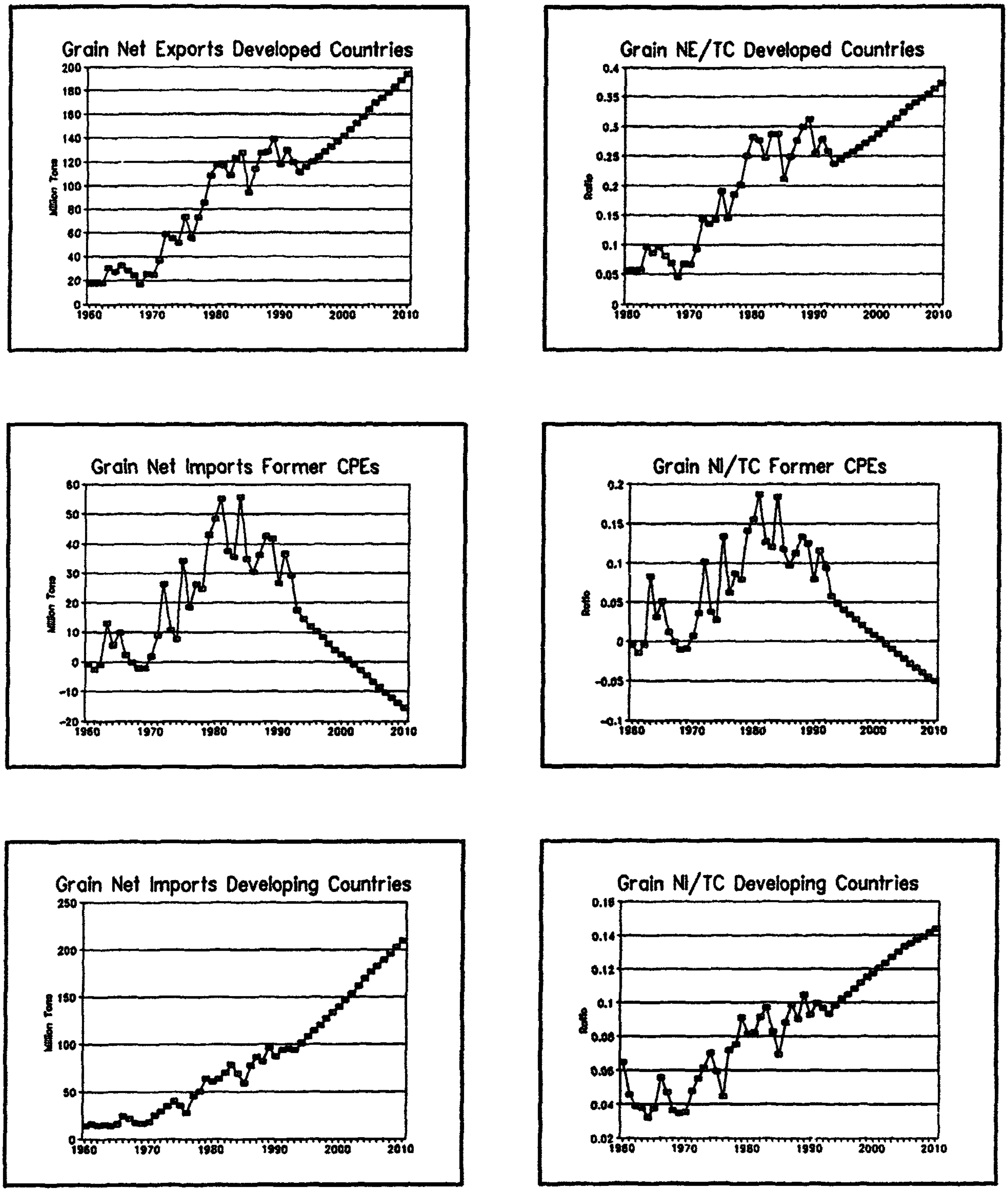
In the Asian region, Japan, which has the highest per capita consumption level among the Asian countries examined, consumed 306 kg per capita in 1990. Countries which had much lower incomes such as China consumed 298 kg per capita and countries in the East Asia region consumed 262 kg. Indonesia and Thailand consumed 204 and 211 kg per capita, respectively, in 1990. The projections are for a gradual increase in these levels with Japan increasing per capita consumption to 331 kg per capita by 2010, China increasing to 371 kg per capita to surpass Japan, and the East Asian region increasing average consumption to 297 kg per capita. Indonesia increases per capita consumption to 231 kg and Thailand is projected to decrease consumption as it has done since the 1970s as their diets diversify and cereals become a smaller share of consumption.

India, Pakistan and other South Asian countries have low per capita grain consumption levels compared to East Asian consumers with similar incomes. This may be due to the largely vegetarian diets of these countries compared to an increasing level of meat consumption in the East Asian countries. The growth of per capita grain consumption in the South Asian countries has been slow and it is projected to remain slow in the future.

Comparisons of per capita grain consumption across other countries and regions show some interesting general trends. Per capita consumption in Latin American countries shows the same clustering characteristic as in the Asian countries. Argentina, Brazil, and Mexico had similar consumption levels in 1990--311 kg per capita in Argentina, 272 kg per capita in Brazil, and 311 kg per capita in Mexico. However, the other countries of Latin America had much lower consumption on average at 162 kg per capita. This large gap suggests that the region should expect significant increases in consumption with increases in incomes.

The Sub-Saharan African countries have the lowest levels of per capita grain consumption and these levels are projected to decline further. Nigeria consumed only 69 kg of grain per capita in 1990 compared with 151 kg in 1960. Further decline is predicted largely because population growth, which currently exceeds 3% p.a, is projected to remain high during the period to 2010. The other countries of Sub-Saharan Africa, which are included in the Central Africa region in the model, have fared somewhat better with per capita consumption of 121 kg p.a. However, with population also growing at near 3% p.a. it will be difficult to keep per capita consumption from declining, and the simulation projects a decline to 119 kg per capita by 2010.

Figure 8.4 Grain net trade and trade-to-use ratios, 1960-2010



Source: Historical data from 1960 to 1990 are from the USDA and projected data from 1991 to 2010 are from the simulation.

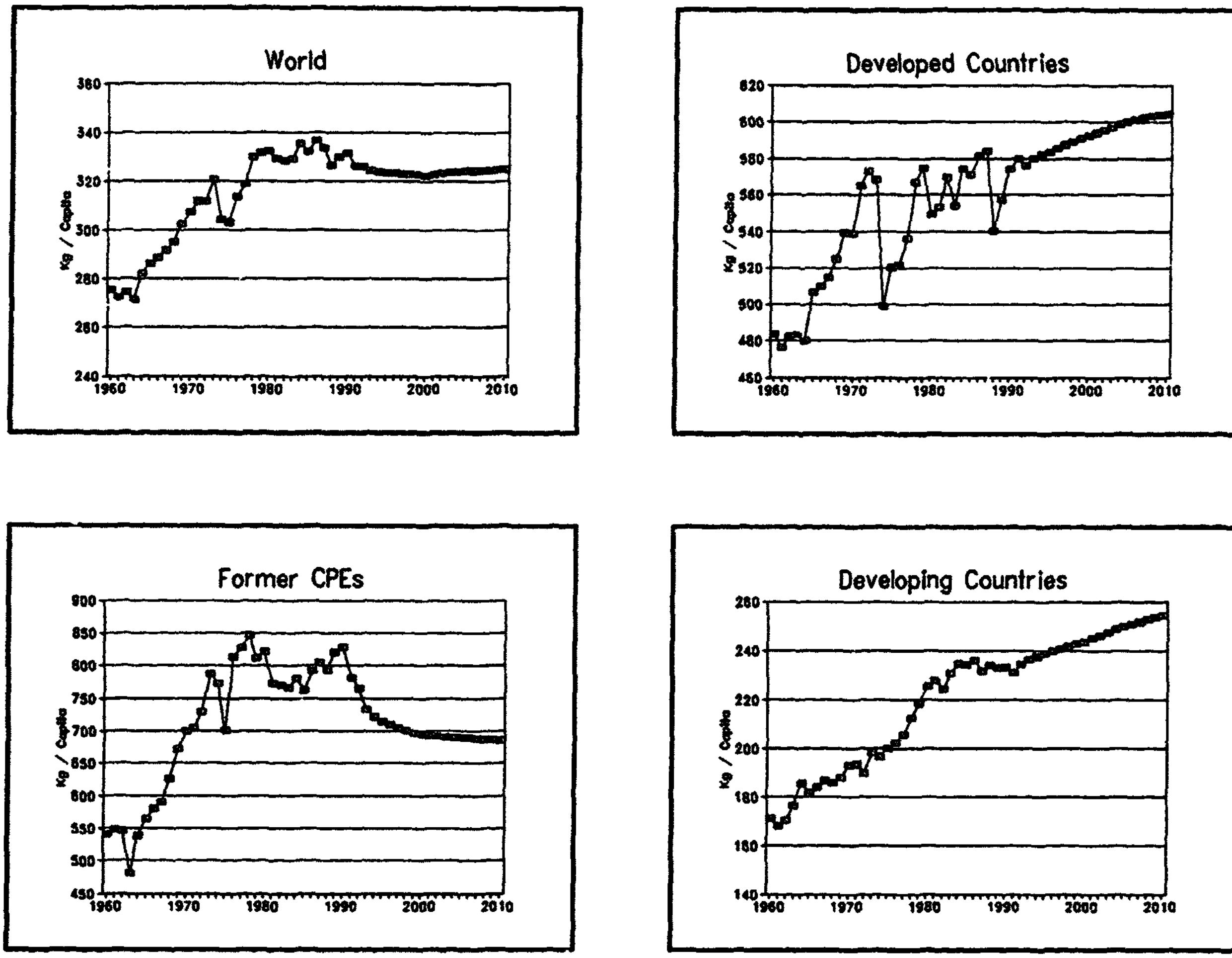
Table 8.2 Historical and projected grain net imports, 1960-2010

	Net Imports						Growth Rates				
	1960	1970	1980	1990	2000	2010	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010
	(million tons)						(% p.a.)				
Developed	-17.1	-24.8	-117.9	-117.4	-142.1	-194.4	3.7	16.9	0.0	1.9	3.2
Australia	-7.9	-12.2	-12.4	-14.9	-13.6	-15.4	4.5	.1	1.8	-.9	1.3
Canada	-10.1	-15.8	-19.5	-26.4	-28.5	-34.8	4.6	2.1	3.1	.8	2.0
EC-10	21.3	22.3	-3.6	-23.9	-35.7	-45.3	.5	na	20.8	4.1	2.4
Japan	4.8	14.4	23.7	26.7	30.9	31.5	11.6	5.1	1.2	1.5	.2
Other	4.0	6.4	8.4	1.1	1.8	1.7	4.7	2.8	-18.5	5.1	-.6
United States	-29.3	-39.8	-114.5	-79.9	-96.9	-132.1	3.1	11.1	-3.5	2.0	3.1
Former CPEs	-.7	1.8	48.4	26.5	2.3	-15.6	na	39.0	-5.8	-21.5	na
Eastern Europe	5.5	9.1	13.7	.6	-1.6	-3.6	5.1	4.2	-27.3	na	8.3
FSU	-6.2	-7.3	34.7	26.0	3.9	-12.1	1.6	na	-2.9	-17.2	na
Developing[2]	13.4	17.7	60.4	87.0	139.8	210.0	2.8	13.1	3.7	4.9	4.2
Argentina	-3.6	-10.1	-18.3	-11.0	-12.9	-14.6	10.9	6.1	- 4.9	1.5	1.3
Brazil	1.8	.7	4.0	5.9	6.4	9.3	-9.3	19.4	4.1	.7	3.8
Central Africa	.4	1.5	5.2	7.0	7.3	10.6	14.0	13.0	3.0	.4	3.9
China	2.2	2.3	14.0	3.7	11.3	21.6	.7	19.5	-12.5	11.8	6.7
East Asia	1.0	7.7	15.3	21.9	31.4	39.0	23.1	7.1	3.7	3.7	2.2
Egypt	.8	2.4	6.3	8.0	9.9	13.7	11.0	10.1	2.4	2.2	3.2
India	4.9	3.2	-.8	-1.1	6.9	14.1	-4.2	na	2.5	na	7.1
Indonesia	1.1	1.1	3.5	2.1	5.7	7.6	.7	12.1	5.2	9.3	4.3
Latin America	2.1	5.0	9.8	10.2	14.1	18.5	9.2	7.0	.5	3.3	2.8
Mexico	.1	-.3	8.5	5.4	8.3	15.3	na	na	-4.5	4.4	6.4
Nigeria	.1	.4	2.1	.6	1.9	3.3	13.8	18.1	-11.7	12.1	5.7
North Africa	4.1	7.6	19.6	30.8	43.6	59.0	6.2	10.0	4.6	3.6	3.1
Pakistan	1.0	.9	-.8	-.3	2.1	4.5	-1.0	na	-11.1	na	8.4
South Africa	-1.6	-2.6	-4.6	1.0	-2.5	-.4	5.1	5.6	na	na	-16.2
South Asia	1.1	1.3	2.1	2.9	9.2	12.8	.9	5.2	3.3	12.3	3.4
Thailand	-2.1	-3.3	-5.3	-5.1	-7.2	- 9.1	4.7	5.0	-.3	3.5	2.3

Source: Historical data and growth rates from 1960 to 1990 are based on USDA data and projected data and growth rates from 1991 to 2010 are from the simulation.

[2] The sum of net imports for the developing countries and regions does not equal the total for the region because of imports which go to unknown destinations. These imports are estimated and included in the regional totals, but are not included in the imports of a specific country or region.

Figure 8.5 Per capita grain consumption, 1960-2010



Note: There appears to be an anomaly in the historical data with per capita consumption rising faster in every region than for the world. This is not an error, it is caused by the large population in the developing countries (78% of world population) and the rapid population growth in this region which causes the world average to decline. This anomaly has been observed by others and it is called Simpson's Paradox (Simpson, 1951).
Source: Historical data from 1960 to 1990 are from the USDA and projected data from 1991 to 2010 are from the simulation.

Table 8.3 Historical and projected per capita grain consumption levels, 1960-2010

	1960	1970	1980	1990	2000	2010	Growth Rates 1960-1970	1970-1980	1980-1990	1990-2000	2000-2010
	(kilograms per capita)						(% p.a.)				
World	275	307	332	331	322	325	1.1	.8	.0	-.3	.1
Developed	484	539	549	574	593	604	1.1	.2	.5	.3	.2
Australia	385	406	457	526	513	565	.5	1.2	1.4	-.2	1.0
Canada	912	1,024	972	1028	991	997	1.2	-.5	.6	-.4	.1
EC-10	385	439	446	415	445	460	1.3	.2	-.7	.7	.3
Japan	219	268	303	306	325	331	2.1	1.2	.1	.6	.2
Other	379	456	563	484	551	561	1.9	2.1	-1.5	1.3	.2
United States	767	800	751	879	859	856	.4	-.6	1.6	-.2	.0
Former CPEs	541	700	822	829	695	686	2.6	1.6	.1	-1.7	-.1
Eastern Europe	555	622	849	788	716	720	1.1	3.2	-.7	-1.0	.1
FSU	535	734	810	845	687	673	3.2	1.0	.4	-2.0	-.2
Developing	171	193	225	233	244	255	1.2	1.6	.3	.4	.4
Argentina	453	423	373	311	380	388	-.7	-1.2	-1.8	2.0	.2
Brazil	204	227	294	272	292	313	1.1	2.6	-.8	.7	.7
Central Africa	108	127	131	121	124	119	1.6	.3	-.8	.2	-.4
China	157	195	270	298	333	371	2.2	3.3	1.0	1.1	1.1
East Asia	197	228	245	262	283	297	1.5	.7	.7	.8	.5
Egypt	224	271	332	367	374	386	1.9	2.0	1.0	.2	.3
India	168	176	169	185	180	188	.5	-.4	.9	-.2	.5
Indonesia	146	143	180	204	213	231	-.2	2.3	1.3	.4	.8
Latin America	108	145	168	162	178	187	3.1	1.4	-.3	.9	.5
Mexico	195	248	319	311	324	375	2.5	2.5	-.2	.4	1.5
Nigeria	151	139	132	69	87	81	-.9	-.5	-6.3	2.4	-.8
North Africa	275	281	342	346	353	367	.2	2.0	.1	.2	.4
Pakistan	164	195	178	176	174	179	1.7	-.9	-.1	-.1	.3
South Africa	257	306	351	325	335	370	1.8	1.4	-.8	.3	1.0
South Asia	214	189	189	187	183	184	-1.3	.0	-.1	-.2	.1
Thailand	180	223	200	211	202	202	2.2	-1.1	.5	-.4	.0

Source: Historical data and growth rates from 1960 to 1990 are based on USDA data and projected data and growth rates from 1991 to 2010 are from the simulation.

Grain Shares

The level of per capita grain consumption depends largely on incomes and prices; however, the preference of consumers for wheat, rice or coarse grains depends on the cultural background and availability of specific grains as well as on economic factors. Asia, for example, is traditionally a rice-consuming region, while Latin American and African countries depend more on coarse grains such as maize, sorghum and millet as staples. Pakistan, Egypt and North Africa are traditionally wheat-consuming countries. Table 8.4, shows the historical and projected shares of wheat, coarse grains and rice of total grain consumption for major regions and selected countries.

The share of coarse grains of total world grains consumption has been declining since 1960, while wheat and rice have been increasing. This trend is most pronounced in developing countries where grains are primarily used for direct human consumption and where coarse grains are an inferior good to rice and wheat in this use. In India, for example, the share of coarse grains has declined from 32% in 1960 to 22.3% in 1990. Other countries such as Thailand have increased their consumption of coarse grains for livestock and poultry feed, but overall the world's share of coarse grains continues to decline. At some stage, this trend will be reversed as the increase in coarse grains for feed increases fast enough to offset the decline in direct human consumption. However, such a trend is not yet clear in the world figures nor for developing countries as a group. We therefore project that coarse grains consumption will continue to decline as a share of total grains during the forecast period to 2010. The share of coarse grains in the developed countries and in the former CPEs has remained relatively constant since 1960 at about 72% in the developed countries and 52% in the former CPEs. This high share in total consumption reflects the use of coarse grains for feed.

The share of wheat in total grain consumption has increased since 1960 and it is projected to continue increasing throughout the forecast period because of increases in the developing countries. Wheat is displacing coarse grains in direct human consumption in nearly all regions, and it is also displacing rice in many Asian countries. In China, wheat has increased from 22.9% of total cereals in 1960 to 32% in 1990 while coarse grains and rice have both declined. A similar trend is seen in many other Asian countries--in India the wheat share increased from 19.4% to 31.3% over the same period and in Indonesia the share increased from 1.2% to 5.2%. In Africa and Latin America, the wheat share is increasing while the coarse grains share is decreasing. The changes in Latin America are occurring more slowly than in Asia, with Brazil, for example, increasing its wheat consumption share from 15.1% in 1960 to 18.4% in 1990. In Nigeria, the wheat share increased from nil to 12.8% of total cereals by 1980, but has since declined to 5.1% as economic problems have affected consumption.

Rice consumption as a share of total consumption has changed significantly since 1960 in many countries and, for the most part, these changes are projected to continue. The share of rice has declined substantially in many Asian countries, while it has increased in many other countries as consumers demand increased variety in their diets. In Asia, many countries had diets centered around rice as the basic cereal in the 1960s. Thailand, for example consumed

Table 8.4 Share of wheat, coarse grains and rice of total cereals consumption, 1960-2010 (percent)

	Wheat 1960	Wheat 1970	Wheat 1980	Wheat 1990	Wheat 2000	Wheat 2010	Coarse Grains 1960	Coarse Grains 1970	Coarse Grains 1980	Coarse Grains 1990	Coarse Grains 2000	Coarse Grains 2010	Rice 1960	Rice 1970	Rice 1980	Rice 1990	Rice 2000	Rice 2010
									(percent)									
World	28.2	29.9	30.7	32.7	32.5	33.1	53.0	51.4	50.4	47.3	47.0	46.0	18.8	18.7	18.8	20.0	20.5	20.9
Developed	25.4	23.9	22.8	27.1	25.0	25.2	70.0	72.2	73.9	69.7	71.9	71.4	4.6	3.8	3.3	3.2	3.1	3.4
Australia	50.1	51.7	52.1	46.4	41.3	40.8	49.0	46.8	46.9	51.7	56.7	57.2	.8	1.4	1.0	1.9	2.0	2.0
Canada	26.1	21.3	22.4	24.6	23.4	23.2	73.6	78.5	77.1	74.8	76.0	76.2	.3	.3	.4	.5	.6	.6
EC-10	40.6	37.3	36.3	47.1	46.6	46.0	58.6	62.0	62.9	51.9	52.5	53.0	.8	.7	.7	1.0	.9	1.0
Japan	20.3	18.5	17.2	16.2	16.4	16.1	21.9	39.7	54.3	58.4	60.0	59.3	57.8	41.8	28.5	25.4	23.5	24.6
Other	40.2	32.3	25.4	30.9	26.1	25.0	58.6	66.6	73.6	67.8	72.7	73.8	1.2	1.1	1.0	1.3	1.1	1.2
United States	11.6	12.8	12.5	17.1	13.9	15.3	87.7	86.4	86.3	81.5	84.5	82.7	.7	.8	1.2	1.4	1.6	1.6
Former CPEs	45.1	51.9	46.9	46.6	43.3	42.3	54.6	47.5	52.0	52.7	55.7	57.5	.3	.6	1.1	.6	1.0	1.1
Eastern Europe	32.1	38.8	34.5	41.4	39.4	39.3	67.2	60.6	65.1	58.2	60.0	60.1	.7	.6	.4	.4	.5	.6
FSU	51.4	56.7	52.4	48.6	44.8	42.2	48.5	42.7	46.3	50.7	54.0	56.5	.0	.6	1.4	.7	1.2	1.3
Developing	22.5	23.6	28.4	30.4	33.0	34.2	37.4	37.8	36.6	34.3	34.4	34.5	40.0	38.6	35.0	35.2	32.6	31.3
Argentina	35.3	40.0	37.5	47.8	40.8	37.9	63.7	58.5	61.6	50.7	58.0	60.9	1.0	1.5	.9	1.5	1.2	1.2
Brazil	15.1	16.9	18.5	18.4	19.7	20.6	61.2	62.2	64.0	63.2	60.0	58.3	23.8	20.9	17.5	18.3	20.3	21.1
Central Africa	8.2	11.0	10.6	14.5	12.2	12.6	78.9	75.7	75.6	71.3	75.4	75.2	12.9	13.3	13.8	14.2	12.4	12.3
China	22.9	20.3	28.7	32.0	34.5	35.8	32.8	34.4	32.9	29.5	29.2	29.3	44.4	45.3	38.4	38.5	36.3	36.3
East Asia	7.5	12.1	10.9	14.3	13.8	13.9	17.8	17.9	27.8	30.9	33.4	34.2	74.7	70.0	61.3	54.8	52.8	51.9
Egypt	42.8	48.5	54.2	55.5	56.0	56.3	43.5	37.7	35.2	35.9	35.4	35.2	13.6	13.7	10.7	8.6	8.5	8.6
India	19.4	22.8	29.6	31.3	38.4	41.2	32.0	34.2	24.5	22.3	17.5	15.6	48.5	43.0	45.9	46.5	44.1	43.1
Indonesia	1.2	2.4	5.2	5.2	8.1	10.3	18.0	15.1	15.0	14.5	15.4	15.4	80.8	82.5	79.7	80.3	76.5	74.3
Latin America	29.1	35.4	32.7	32.1	32.8	32.3	54.2	50.5	49.4	51.1	51.8	53.0	16.7	14.1	17.9	16.9	15.5	14.7
Mexico	16.9	16.0	15.6	16.2	19.7	20.7	80.1	82.0	82.8	82.9	78.6	77.7	2.9	2.0	1.6	1.7	1.7	1.6
Nigeria	.1	4.4	12.8	5.1	10.6	14.5	95.9	92.5	79.6	84.6	79.4	74.4	3.1	3.1	7.6	10.3	10.0	11.1
North Africa	58.4	60.4	60.1	57.9	55.4	55.3	38.0	35.5	35.5	37.4	40.4	40.7	3.6	4.1	4.4	4.7	4.1	4.0
Pakistan	72.3	70.8	76.2	80.2	84.5	84.6	14.7	12.1	10.3	9.1	7.1	5.6	13.0	17.1	13.5	10.6	8.4	9.8
South Africa	18.8	18.6	20.1	20.0	24.0	22.9	80.0	80.6	78.6	75.0	73.5	74.5	1.1	.8	1.3	3.0	2.5	2.6
South Asia	16.0	15.8	23.9	21.1	36.5	40.2	11.8	10.5	8.2	8.1	5.9	5.3	72.2	73.7	67.9	70.9	57.6	54.5
Thailand	.1	.8	2.0	3.4	3.9	4.9	.0	2.9	12.8	26.1	29.4	37.6	99.1	96.3	85.1	70.5	66.7	57.4

99.1% of its grains as rice in 1960. This is slowly changing, however. In 1990, rice accounted for 70.5% of Thailand's total grain consumption. If these trends continue as projected, the share of rice will decline further and by 2010 it will account for about 57% of total cereals in Thailand. Japan underwent a similar change beginning in the 1950s, when the share of rice was 61% in 1951 and by 1990 rice only accounted for 25% of total grains consumption, while coarse grains accounted for 58%--primarily as feed. In India and Pakistan, the rice share is declining while wheat's is increasing. Coarse grains consumption is still declining in these countries as the feed use of coarse grains is only about 10% of total consumption.

Rice consumption is increasing in most developed countries and in the former CPEs, but the share is small except for Japan. In the United States, the share of rice doubled from 0.7% to 1.4% from 1960 to 1990 as the popularity of Chinese food increased. Other developed countries show similar trends as diets diversify. However, it is unlikely that rice will ever be a major staple in these countries.

The trends in grain shares at the global, regional and country level show a consistent pattern of change as diets diversify and consumers shift among grains for direct consumption and to increased coarse grains use for feeding. These trends are carried forward in the forecast. Several trends are important. First, the share of wheat continues to increase as consumers in developing countries continue to consume a larger share of their total grains as wheat. Secondly, the overall trends do not indicate an increase in the share of coarse grains in the developing countries, although the decline is projected to end. This projection suggests that the increased livestock feeding which is evident in many countries such as Thailand will be offset by declines in human consumption of coarse grains. Overall, the world demand for cereals will continue to favor wheat while coarse grains remains a declining share of total cereals demand.

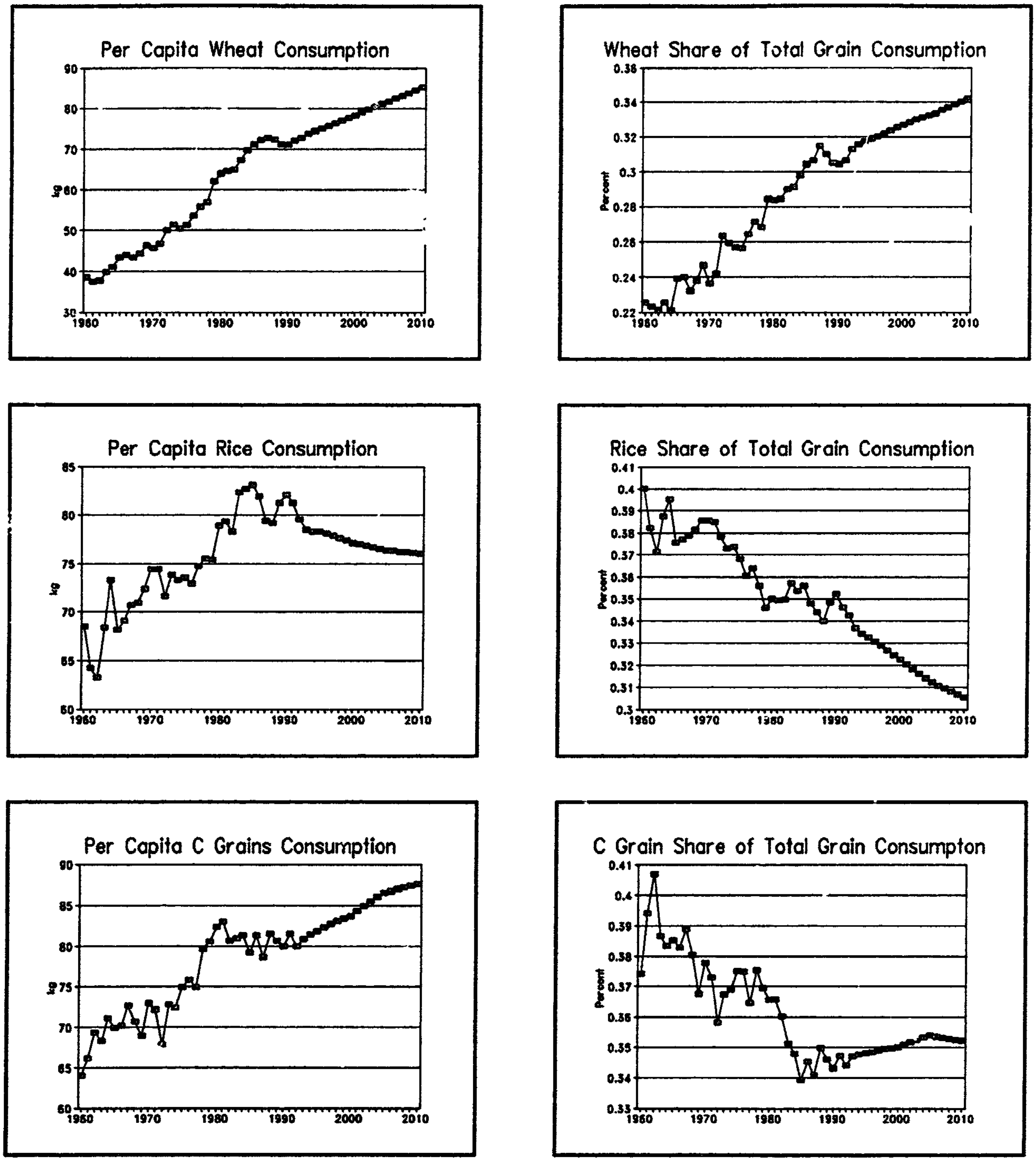
Per capita rice consumption is projected to decline in the developing countries during the forecast period while per capita wheat and rice consumption will continue to increase (see Figure 8.6). This suggests that rice has become an inferior good in the developing countries, and this conclusion is supported by the consumer demand studies presented in chapter 5.

In Defense of the Simulation Results

The simulation results present a picture of slow growth in world grain consumption and surplus production capacity. This leads to declining real grain prices. Despite this global picture, regional problems are expected to remain in Sub-Saharan Africa and to a lesser degree in South Asia.

World grain consumption is projected to grow by only 1.4% p.a. during the period to 2010. This appears to present a relatively modest challenge for world production, which grew by 2.1% p.a. during the 1980s and by about 2.7% p.a. during the 1960s and 1970s. If yields were to grow at 2% p.a. during the period to 2010--not unreasonable in our view--then an additional 11% of world cropland would need to be removed from production. Yields may actually grow more rapidly than in the recent past because of the genetic improvements which

Figure 8.6 Per capita wheat, rice and coarse grains consumption and shares in developing countries, 1960-2010



Source: Historical data from 1960 to 1990 are from the USDA and projected growth rates from 1991 to 2010 are from the simulation.

are becoming available through biotechnology and genetic engineering. If this occurs, then pressure to reduce cropland used for grain production would intensify and the pressure would most likely fall on the exporting countries.

An aspect of the simulation results which is critical to this conclusion is that world grain consumption will grow slowly during the period to 2010. This is consistent with the past 15 years and with the assumption of slower population growth. It depends on an additional factor and that is slow per capita consumption growth. As shown in the detailed results, most of the developing countries went through their period of rapid increase in per capita grain consumption during the 1960s and 1970s. Since about 1980, their per capita grain consumption has been nearly constant. The simulation results are for only modest growth, not for a resumption of the growth rates of the 1960s or 1970s.

Further support to the emerging picture of surplus capacity is the prospect for grain surpluses in Eastern Europe and the FSU. If production increases, as projected, due to improved price incentives, imported technology, better machinery, and improved storage and transportation facilities, this region will become an exporter. This would further pressure grain prices and cause an even larger reduction in production capacity in the exporting countries.

Is this an economically and politically viable scenario? With the former CPEs switching from net importers to net exporters, attempts to increase export shares could lead to increased trade tension among the high-income exporters. Trade tensions may also arise between the former CPEs and the high-income exporters as some former CPEs move into grain exports.

Larger grain imports by developing countries could well face opposition from domestic producers. However, imports rose very rapidly during the 1970s to levels which seemed impossible from the perspective of the 1960s. For example, Mexico increased imports of grains from 0.1 million tons in 1960 to 8.5 million tons in 1980 (38% of total consumption). Real GDP grew about 7% p.a. during this period and was a major factor causing imports to increase. Mexico was not alone as many developing countries saw large increases in grain imports. This slowed during the 1980s because of the sharp increase in their foreign debt and slow economic growth; however, the prospects for economic growth in developing countries have improved and larger grain imports seem likely.

Comparisons with Other Studies

Many studies of the world food outlook have been carried out. Here we review several and compare results with the conclusions of our Baseline Simulation. Among recent studies, World Agriculture: Toward 2000 published by the FAO in 1988 and Towards Free Trade in Agriculture, published by the International Institute for Applied Systems Analysis (IIASA) in 1988 are among the most complete. Both studies looked at the prospects for world agriculture over the period from the early-to-mid 1980s to 2000. Both are multicommodity and both consider a range of issues from production, consumption and trade to hunger in developing countries. Both are somewhat outdated in their treatment of agriculture in the former CPEs because they were prepared before the dramatic changes of recent years. Another study of more limited scope is Food in the Third World: Past Trends and Projections to 2000, published by the International Food Policy Research Institute (IFPRI) in 1986.

World Agriculture: Toward 2000 examines likely developments in 94 developing countries and 34 developed countries to present a global assessment of future world and country-group production, consumption, trade and nutrition. The analysis covers 33 individual crops and 6 livestock products. Projections are made using a model which combines aspects of a formal model with expert judgement. A world balance is obtained through successive rounds of inspection and adjustment of preliminary projections by country and commodity specialists. Prices are assumed constant and are not used explicitly to bring world or country demand and supply into balance.

The outlook for world agriculture to the year 2000, according to this study is for continued improvements in food demand and consumption. Average per capita food availability for direct human consumption is projected to rise from 2420 calories in 1983/85 to 2620 calories in 2000. The gains made by major low-income countries (e.g., China and India) are expected to be extended. Increases in food consumption in the middle-income countries (e.g., Near East/North Africa, Latin America) are expected to be much less pronounced than during the 1970s, mostly because of slower growth of incomes and reduced import capacity, but also because some of these countries already have attained high consumption levels. Many countries in Sub-Saharan Africa are projected to have food availability levels in 2000 which are not much above the levels of the early 1980s. Total consumption growth for all food and agricultural commodities in developing countries is projected to slow from 3.5% per year during 1961-85 to 3.1% p.a. for the period from 1983-85 to 2000, resulting in growth in per capita consumption of 1.2% p.a. in both periods.

Total agricultural production in the developing countries is projected to rise by 3% p.a. over the period from 1983-85 to 2000. This is lower than the 3.3% growth rate of the preceding 15-year period, but fast enough to keep per capita growth constant at 1.1% p.a. in both the historical and projected periods. The production of livestock products is expected to grow the fastest. Sub-Saharan Africa, the Near East/N. Africa and Asia would all have greater than 3% p.a. growth according to the projection (see Table 8.5). The net cereal deficits of the developing countries are expected to rise from 70 million tons in 1983-85 to 110 million tons in 2000.

Table 8.5: FAO projected growth rates of total and per capita production

	Total Production 1970-85	Total Production 1983/5-2000	Per Capita Production 1970-85	Per Capita Production 1983/5-2000
		(% p.a.)		
Africa (Sub-Sahara)	1.7	3.4 (3.1)*	-1.3	0.1
Near East/N.Africa	2.9	3.1	0.2	0.5
Asia	3.7	3.0	1.7	1.5
Latin America	3.1	2.7	0.7	0.6
All Developing Countries	3.3	3.0	1.1	1.1

*Growth rate in parenthesis is from post-drought 1985 production level.
Source: FAO, World Agriculture: Toward 2000, 1988, page 8.

The production increase in the developing countries is projected to come from higher yields (63%), increased arable areas (22%) and higher cropping intensities (15%). Wheat yields are projected to increase by 35% from 1982-84 to 2000, while rice and maize yields increase by 25% and 44%, respectively, over the same period. Arable land in agricultural use is projected to increase 80 million hectares between 1985 and 2000 (equivalent to the current area of arable land in Western Europe). Overall, the projection for the developing countries is for continuing development of their agricultural sectors but with significant problems including: an unfavorable economic environment which constrains demand growth; export opportunities which are limited by protectionism; only minimal improvement in the food situation in Sub-Saharan Africa; and no decrease in the total number of undernourished people.

Projections for the former European centrally planned countries are for moderate improvement in agricultural performance together with relatively slow growth of food demand. The already high level of calorie consumption, together with the effects of higher food prices following a reduction in food subsidies, and the slow growth of population combine to hold demand growth down. Moderate growth of 1.3% a year in cereal production could be achieved, resulting in cereal imports for the region remaining at about 35 million tons per year.

The developed market economies are faced with slow domestic and export demand growth and would need to hold production increases under 1% p.a. in order to avoid large stock increases. Net cereal import requirements of the rest of the world are projected to increase by some 35-40 million tons from the average of 1983-85--less than half of the increase of the previous 15 years. By 2000, net cereal exports of the developed market economies will reach 147 million tons, compared to 110 million in 1979-81. Price projections are not made but the implications of the scenario would be for declining prices of major crops, including cereals.

Towards Free Trade in Agriculture is primarily a trade policy study of world agriculture. It produces a reference scenario for 1980-2000 which provides a comparator to the other studies reported in this section and to our Baseline Simulation. The analysis is based on a system of empirically estimated national agricultural policy analysis models which are linked through trade and capital transfers. The system consists of 18 national models, 2 regional models--the EC and the Council of Mutual Economic Aid (CMEA)--and 15 models of groups of countries. Together these models cover all nations. The model has a general equilibrium approach at the national and international level. Since it is used for trade policy analysis, the model includes many policy instruments such as taxes, tariffs, and quotas.

Ten commodities are traded among the national models. These include wheat, rice, coarse grains, bovine and ovine meats, dairy products, other animal products, protein food, other food, nonfood agriculture and a non-agricultural group. Greater detail and commodity coverage may be included in the national models but they are aggregated to the ten commodities for trade.

While the authors stress that the reference run does not constitute a forecast, it provides a comparator for our purposes. The study concludes that although food demand grows substantially, due to higher incomes and populations, the world food system meets this additional demand with generally very modest increases in agricultural prices, while prices of basic staples decline. The proportion of the population of poor countries that is hungy decreases significantly from 23% of the population in developing countries in 1980 to 11% by 2000 (these estimates exclude China). The developed countries export nearly 165 million tons of cereals by 2000. The relative prices of wheat and coarse grains fall about one-half of a percentage point per year with most of this decline concentrated in the 1990s. This is due to the rate of technical progress in cereals production in major producing countries being more rapid than the rate of demand increase due to population and income growth. Rice prices do not fall, however, as technical progress in rice is smaller than in wheat and coarse grains.

Global demand for total grains increases 1.83% p.a. from 1980 to 2000 to reach 2,124 million tons by 2000. The demand for rice, wheat and coarse grains grow by 2.1%, 1.9% and 1.7% p.a. respectively. World trade in cereals almost doubles, increasing from 169 million tons in 1980 to 328 million tons in 2000.

Developing countries are projected to see an increase in rate of growth in their value added in agriculture from 2.6% p.a. during 1960-70 to 3% p.a. during 1980-2000. This fast growth is not enough to meet demand, causing net cereal imports to rise from 37 million tons in 1980 to 120 million tons in 2000. The CMEA countries are expected to increase the rate of growth of agricultural value added from -0.9% p.a. during the 1970s to 2.4% p.a. during the 1980s and 2.8% p.a. during the 1990s. Such rapid growth in the developing countries and the CMEA countries is expected to slow the exports of OECD countries and cause agricultural value added to increase about 1% p.a. during 1980-2000.

Food in the Third World: Past Trends and Projections to 2000, projects food production, consumption and trade for 105 developing countries to 2000. The projections are based on past trends in output and income and attempt to determine the overall size of future food problems in the Third World. The study also tries to identify the geographical areas and country groups most likely to face serious food deficiencies.

The study focuses on the major food crops: cereals, roots and tubers, pulses, groundnuts, and bananas and plantains. Projections of production to the year 2000 are in general simple extrapolations of country trends in aggregate output from 1961 to 1980. Demand is composed of the sum of separate projections of each country's use of the basic food staples for direct human consumption, animal feed, and other purposes such as seeds, nonfood uses, and waste. Demands for direct human consumption and for animal feed are each projected on the basis of constant 1980 per capita use and on the trend growth rate of per capita incomes during 1966-80. These projections assume unchanged relative prices.

Food production in developing countries grew by 3.1% p.a. during 1961-80 according to the study and is projected to grow at 2.9% p.a. during 1980-2000[3]. This growth rate would suggest a yearly increase of per capita food production of nearly 1.0% p.a. Demand for food staples in developing countries is projected to increase at 2.7% p.a. during the 1980-2000 period. The growth in food demand is projected to outstrip production in all developing regions except Asia. In Sub-Saharan Africa, food demand is projected to grow 3.6% per year, substantially faster than the projected growth of production. The North Africa/Middle East region is projected to have demand growth of 3.8%.

Consumption in the developing countries is projected to expand at an annual rate of 2.7% during 1980-2000 based on trend growth of per capita incomes. This results in a 72% increase in consumption from 1980 to 2000 and an increase in the net food deficit from 52 million tons to 69 million tons. The increase in consumption in Sub-Saharan Africa is 104%--from 78.3 million tons in 1980 to 160 million tons in 2000--resulting in the food deficit increasing from 5.9 million tons to 47 million tons. The food deficit also increases sharply in North Africa/Middle East (from 18.9 to 64 million tons). Asia moves into food surplus over the period, shifting from a deficit of 18.9 million tons in 1980 to a surplus of 51 million tons by 2000. Since production and demand are independently projected, prices are not considered and a world balance is not achieved.

Comparison of the three studies with the results of our Baseline Simulation shows up some interesting contrasts and similarities. A comparison can only be made to 2000 since all of these projections only covered the period to 2000. Each of the studies has features which make comparison difficult, such as different commodity coverage and different regional aggregations. The IIASA study is based on the most complete model and its results are most nearly aligned with our Baseline Simulation. However, the IIASA study was primarily designed for trade policy analysis not commodity forecasting. The FAO study has detailed forecasts for individual countries and commodities but it assumes constant prices and relies on expert judgement to a greater extent than either the IIASA study or our Baseline. However, it provides a useful compilation of the views of the commodity and country specialists at the FAO. The IFPRI study is much less complete, considering only the developing countries. It also relies on

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[3] According to the FAO, the index of food production for developing countries increased 3.4% p.a. during 1979-81 to 1990. The State of Food and Agriculture, FAO, 1991, Annex Table 2.

relatively simple trend projections, without considering adjustments to prices or trade balances.

The two studies which consider global agriculture to 2000, the FAO study and the IIASA study, reach several broad conclusions which are supportive of the results of our Baseline Simulation. First, they project surplus production capacity in the developed market economies and falling real prices for cereals to 2000 (FAO does not project prices but the levels of surplus in developed market economies imply such a forecast). The two studies project a similar level of cereals net exports from the developed market economies. The FAO study projects 147 million tons of cereal exports by 2000, the IIASA study projects 165 million tons of exports, while our Baseline projects 142 million tons. However, our projection includes the lower exports to the former CPEs which were not expected when the other studies were prepared.

The IFPRI study's conclusions are somewhat consistent with the FAO and IIASA studies for the developing countries. Total per capita consumption in developing countries is projected to increase 1% p.a. during 1980-2000 compared to 1.2% p.a. in the FAO study. Specific aspects of the IFPRI forecast differ from the other studies and seem to reflect the difference in methodology. For example, in Sub-Saharan Africa food demand is projected to grow at 3.6% p.a. from 1980 to 2000, resulting in a doubling in the food deficit from 78 million to 160 million. However, the ability of this region to purchase or otherwise acquire this food is not considered. The FAO study, which does consider the ability to import or receive food aid, projects a more modest increase in food demand for this region.

Total agricultural production is projected to grow at high rates during the 1980s and 1990s in the FAO and IIASA studies, causing per capita output to increase. However, more detailed comparisons between the studies is difficult as some include all agricultural products measured in value terms and others use quantity measures. The IIASA study has global grain demand increasing 1.83% p.a. from 1980 to 2000, compared to 1.52% p.a. growth in our Baseline Simulation for the same period. (These estimates become nearly identical when slower growth for the former CPEs are included in the IIASA simulation.)

All of the studies indicate continued improvement in the level of per capita consumption in developing countries--with the exception of Sub-Saharan Africa. The FAO study projects 1.2% p.a. growth in per capita total food demand in all developing countries, with the smallest increase in Sub-Saharan Africa. Per capita food availability for direct human consumption is projected by the FAO study to rise from 2,420 calories per day to 2,620 calories per day. They also project that the major problem of undernutrition would shift from the Asia region to Sub-Saharan Africa. The IIASA study finds that per capita calorie intake improves in all developing countries. This causes the proportion of the population left hungry to decline from 23% of developing country population in 1980 to 11% in 2000.

Overall, the studies are in broad agreement. They conclude that global food production will continue to increase faster than consumption, that the developing countries will significantly increase imports and that the levels of consumption in developing countries will continue to increase. The developed countries are expected to remain in surplus as domestic demand increases slowly and export growth is not sufficient to absorb production. There is less agreement on the prospects for the former CPEs, and events in recent years have largely overtaken these earlier studies.

Summary

It should become increasingly easy to meet the world's demand for grain if past trends in production and consumption continue. World grain consumption increased by 1.7% p.a. during the 1980s and we project slower growth during 1990-2010 partly because of reduced consumption in the former CPEs, partly because of slower consumption growth in the developing countries, and partly because of slower population growth in all regions. Even if consumption were to grow more rapidly for a period, the potential for increasing production far exceeds the expected increase. World grain production increased by 2.1% p.a. during the 1980s and our simulation suggests that growth of 1.4% p.a. during 1990-2010 would be sufficient to meet demand. Overall, the trend is for lower prices and increased per capita consumption for most consumers. The probability of significant surplus grain production capacity and price decreases appears far greater than the probability of shortages and price increases.

The two most important issues for the world grain market outlook are developments in former CPEs and in the developing countries. The former CPEs of Eastern Europe and the FSU are expected to become grain exporters of significance over the next two decades due to a combination of lower consumption and higher production. Their per capita grain consumption levels are nearly 50% higher than in the developed countries and will most likely decline as subsidized domestic prices rise to international levels. Production has been stagnant since 1980 and has great potential to increase with the adoption of market incentives and modern technology.

Developing country imports are expected to more than offset declines in imports by Eastern Europe and the FSU. By 2010, developing country grain imports are projected to increase to 210 million tons, compared to the current level of 87 million tons. The increase will primarily go to countries with rapidly growing incomes and rising levels of grain consumption for both direct human consumption and as livestock and poultry feed. A combination of slower population growth and more rapid income growth in the developing countries would allow per capita consumption levels to increase, sourced partly from larger grain imports and partly from larger domestic production--in contrast to the 1960s, which saw grain imports by the developing countries rise due to food shortages and inadequate diets.

The most important conclusion to come from our analysis is that the world food system has many options to meet future demand. If demand grows more rapidly than we project, then increased production can come from the developed countries which have surplus capacity or from the former CPEs which have great potential to increase yields. Production can be increased by higher yields or expanded cropland--both possible. If the grains markets are in surplus at current low world prices then higher prices would almost certainly stimulate production.

Not all countries will share in the surplus. Many countries in Sub-Saharan Africa will most likely face severe food problems in the future. Rapid population growth, often exceeding 3% p.a., combined with poor incentives to farmers have led to declining per capita grain consumption levels. Incomes are not rising fast enough to allow market imports to offset the decline which means that food aid must be offered as a temporary solution. The problems of Africa are much greater than just food production and the solutions require much more than higher food production. The long-term solution can only come from better domestic policies which result in higher food production, higher economic growth, and lower population growth.

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Annex Tables

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[a] Denotes a regional aggregate which is obtained by totaling the results of individual countries and regions.

[*] Denotes a region which has an estimated model.

Table A-1. Wheat, rice and maize prices, actual 1950-92 and projected 1993-2010, nominal and deflated

Year	Wheat	Rice	Maize	MUV	Wheat	Rice	Maize
	----Nominal $/Ton----			Deflator	----1985 $/Ton----		
1950	70.0	137.0	68.0	23.8	294.0	575.4	285.6
1955	65.0	142.0	49.0	27.9	233.3	509.7	175.9
1960	63.0	125.0	43.0	30.2	208.7	414.2	142.5
1965	66.0	136.0	55.0	31.5	209.7	432.2	174.8
1970	63.0	144.0	58.0	36.6	172.3	393.9	158.6
1971	64.0	129.0	58.0	38.5	166.1	334.7	150.5
1972	71.0	147.0	56.0	42.0	169.1	350.1	133.4
1973	147.0	350.0	98.0	48.7	302.2	719.4	201.4
1974	209.0	542.0	132.0	59.3	352.6	914.5	222.7
1975	181.0	363.0	120.0	65.9	274.7	550.8	182.1
1976	149.0	255.0	112.0	66.8	223.0	381.7	167.6
1977	116.0	272.0	95.0	73.4	158.1	370.6	129.4
1978	135.0	368.0	101.0	84.5	159.8	435.7	119.6
1979	172.0	334.0	116.0	95.7	179.8	349.2	121.3
1980	191.0	434.0	125.0	104.9	182.1	413.7	119.1
1981	196.0	483.0	131.0	105.3	186.1	458.5	124.4
1982	167.0	293.0	109.0	103.7	161.0	282.5	105.1
1983	170.0	277.0	136.0	101.4	167.7	273.3	134.2
1984	165.0	252.0	136.0	99.2	166.3	254.0	137.1
1985	173.0	216.0	112.0	100.0	173.0	216.0	112.0
1986	161.0	210.0	88.0	117.9	136.5	178.1	74.6
1987	134.0	230.0	76.0	129.5	103.5	177.6	58.7
1988	180.0	301.4	106.9	138.9	129.6	216.9	76.9
1989	201.0	320.2	111.5	138.0	145.7	232.1	80.8
1990	156.2	287.2	109.3	145.8	107.1	197.0	75.0
1991	142.9	314.4	107.4	148.7	96.1	211.4	72.2
1992	177.0	287.4	104.2	152.9	115.8	188.0	68.1
1993	162.7	244.5	111.6	158.9	102.4	153.9	70.2
1994	152.8	233.2	114.5	165.1	92.5	141.2	69.4
1995	158.1	244.1	116.0	171.3	92.3	142.5	67.7
2000	185.1	294.7	129.7	206.5	89.6	142.7	62.8
2005	209.5	340.7	148.4	248.2	84.4	137.3	59.8
2010	232.2	384.7	161.0	298.4	77.8	128.9	54.0

Source: Actual prices to 1992 from USDA, MUV from World Bank. Projected prices from 1993 to 2010 are from the simulation and the MUV projection is from the World Bank.

Definitions:

Wheat prices are calendar year averages for Canadian Western Red Spring export prices, in store, ST. Lawrence.

Rice prices are calendar year average prices for Thai 5% broken, Board of Trade posted price, f.o.b. Bangkok.

Maize prices are calendar year average prices for US No. 2, Yellow, f.o.b. Gulf Ports.

MUV is the G-5 Manufacturing Unit Value Index.

Table A2 World

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	836,067.0	1,096,158.1	1,446,042.1	1,781,995.8	1,997,683.8	2,305,217.0	2.7	2.8	2.1	1.1	1.4
AREA	641,807.0	665,916.0	722,669.0	694,544.0	710,773.0	727,716.4	.4	.8	-.6	.2	.2
YIELD	1.3	1.6	2.0	2.6	2.8	3.2	2.4	2.0	2.5	.9	1.2
CONSUMPTION	828,008.0	1,125,676.1	1,465,473.1	1,733,589.0	1,982,889.8	2,288,892.0	3.1	2.7	1.7	1.6	1.4
PER CAPITA	275.3	307.4	331.8	331.4	322.4	324.8	1.1	.8	.0	-.3	.1
NET IMPORTS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
ENDING STOCKS	203,082.0	192,955.0	286,642.0	340,946.0	470,464.2	581,216.3	-.5	4.0	1.8	3.3	2.1
WHEAT											
PRODUCTION	238,406.0	313,666.0	442,949.0	593,463.3	649,644.4	762,775.8	2.8	3.5	3.0	.9	1.6
AREA	202,192.0	206,994.0	236,685.0	231,591.0	231,085.1	237,787.5	.2	1.3	-.2	.0	.3
YIELD	1.2	1.5	1.9	2.6	2.8	3.2	2.5	2.1	3.2	.9	1.3
CONSUMPTION	233,572.0	336,061.0	450,269.0	566,765.0	644,595.0	757,701.5	3.7	3.0	2.3	1.3	1.6
PER CAPITA	77.6	91.8	102.0	108.4	104.8	107.5	1.7	1.1	.6	-.3	.3
NET IMPORTS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
ENDING STOCKS	82,849.0	80,551.0	112,857.0	143,719.0	187,261.4	210,643.1	-.3	3.4	2.4	2.7	1.2
COARSE GRAINS											
PRODUCTION	446,894.0	568,885.0	732,179.0	835,062.8	939,574.2	1,062,128.1	2.4	2.6	1.3	1.2	1.2
AREA	319,627.0	326,425.0	341,950.0	316,441.0	328,548.7	333,689.1	.2	.5	-.8	.4	.2
YIELD	1.4	1.7	2.1	2.6	2.9	3.2	2.2	2.1	2.1	.8	1.1
CONSUMPTION	438,530.0	579,076.0	739,097.0	819,464.0	931,583.7	1,052,990.6	2.8	2.5	1.0	1.3	1.2
PER CAPITA	145.8	158.1	167.4	156.7	151.5	149.4	.8	.6	-.7	-.3	-.1
NET IMPORTS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
ENDING STOCKS	109,773.0	83,611.0	125,810.0	139,057.0	209,680.4	279,610.6	-2.7	4.2	1.0	4.2	2.9
RICE											
PRODUCTION, PADDY	220,530.0	313,393.0	398,600.0	519,382.6	600,440.3	706,076.3	3.6	2.4	2.7	1.5	1.6
AREA	119,988.0	132,497.0	144,034.0	146,512.0	151,139.1	156,239.9	1.0	.8	.2	.3	.3
YIELD	1.8	2.4	2.8	3.5	4.0	4.5	2.6	1.6	2.5	1.1	1.3
PRODUCTION, RICE	150,767.0	213,607.0	270,914.0	353,469.7	408,465.2	480,313.3	3.5	2.4	2.7	1.5	1.6
CONSUMPTION	155,906.0	210,539.0	276,107.0	347,360.0	406,742.7	478,207.4	3.0	2.7	2.3	1.6	1.6
PER CAPITA	51.8	57.5	62.5	66.4	66.1	67.9	1.0	.8	.6	.0	.3
NET IMPORTS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
ENDING STOCKS	10,460.0	28,793.0	47,975.0	58,170.0	73,506.4	90,952.7	10.7	5.2	1.9	2.4	2.2
MACRO VARIABLES											
POPULATION (MIL)	3,008.2	3,662.4	4,416.3	5,230.8	6,150.8	7,047.5	2.0	1.9	1.7	1.6	1.4
GDP, REAL 1985	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
EXCHANGE RATE	1.0	1.0	1.0	N.A.	N.A.	N.A.	.0	.0	N.A.	N.A.	N.A.
CPI	1.0	1.0	1.0	N.A.	N.A.	N.A.	.0	.0	N.A.	N.A.	N.A.
XRI/CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table A3 Developed Countries Region

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	335,401.0	368,960.0	512,964.0	594,881.0	641,875.2	720,132.2	1.0	3.4	1.5	.8	1.2
AREA	151,870.0	133,609.0	154,873.0	165,646.0	137,426.5	138,190.8	-1.3	1.5	-.6	-.6	.1
YIELD	2.2	2.8	3.3	4.1	4.7	5.2	2.3	1.8	2.1	1.4	1.1
CONSUMPTION	305,678.0	377,382.0	416,162.0	460,029.0	495,740.5	520,995.1	2.1	1.0	1.0	.8	.5
PER CAPITA	483.6	538.9	548.8	574.1	592.5	604.4	1.1	.2	.5	.3	.2
NET IMPORTS	-17,161.0	-24,768.0	-117,938.0	-117,406.0	-142,141.4	-194,421.3	3.7	16.9	.0	1.9	3.2
ENDING STOCKS	162,496.0	111,272.0	124,705.0	130,602.0	203,320.1	254,387.4	-3.7	1.1	.5	4.5	2.3
WHEAT											
PRODUCTION	99,795.0	102,097.0	165,678.0	215,882.9	217,505.8	249,380.3	.2	5.0	2.7	.1	1.4
AREA	57,892.0	48,426.0	69,343.0	70,111.0	65,846.6	68,735.3	-1.8	3.7	.1	-.6	.4
YIELD	1.7	2.1	2.4	3.1	3.3	3.6	2.0	1.3	2.6	.7	.9
CONSUMPTION	77,608.0	90,370.0	94,961.0	124,697.0	123,748.7	131,037.6	1.5	.5	2.8	-.1	.6
PER CAPITA	122.8	129.0	125.2	155.6	147.9	152.0	.5	-.3	2.2	-.5	.3
NET IMPORTS	-19,294.0	-28,056.0	-70,516.0	-73,864.1	-94,200.9	-119,625.7	3.8	9.7	.5	2.5	2.4
ENDING STOCKS	69,978.0	55,129.0	53,263.0	56,143.0	79,813.0	80,518.0	-2.4	-.3	.5	3.6	.1
COARSE GRAINS											
PRODUCTION	221,187.0	251,214.0	331,877.0	362,200.1	406,767.1	447,816.6	1.3	2.8	.9	1.2	1.0
AREA	89,721.0	81,163.0	81,397.0	71,853.0	67,994.9	65,099.8	-1.0	.0	-1.2	-.6	-.4
YIELD	2.5	3.1	4.1	5.0	6.0	6.9	4.3	2.8	2.1	1.7	1.4
CONSUMPTION	214,033.0	272,615.0	307,335.0	320,596.0	356,396.4	372,236.4	2.6	1.2	.4	1.1	.4
PER CAPITA	338.6	389.3	405.3	400.1	425.9	431.8	1.4	.4	-.1	.6	.1
NET IMPORTS	2,663.0	5,521.0	-43,567.0	-37,487.5	-45,615.7	-69,326.9	7.6	N.A.	-1.5	2.0	4.3
ENDING STOCKS	90,547.0	49,085.0	66,323.0	71,764.0	120,550.1	171,145.8	-5.9	3.1	.8	5.3	3.6
RICE											
PRODUCTION, PADDY	19,976.0	21,555.0	21,256.0	23,344.2	24,447.9	31,865.4	.8	-.1	.9	.5	2.7
AREA	4,257.0	4,019.0	4,133.0	3,682.0	3,583.0	4,355.7	-.6	.3	-1.1	-.3	2.0
YIELD	4.7	5.4	5.1	6.3	6.8	7.3	1.3	-.6	2.1	.7	.7
PRODUCTION, RICE	16,419.0	15,649.0	15,409.[illegible]	16,798.0	17,602.2	22,935.2	.8	-.2	.9	.5	2.7
CONSUMPTION	16,037.0	14,397.0	13,846.0	14,736.0	15,599.1	17,720.6	.3	-.4	.6	.6	1.3
PER CAPITA	22.2	20.6	18.3	18.4	18.6	20.6	-.8	-1.2	.1	.1	1.0
NET IMPORTS	-510.0	-2,233.0	-3,855.0	-2,498.5	-2,324.9	-5,468.6	15.9	5.6	-4.2	-.7	8.9
ENDING STOCKS	1,971.0	7,058.0	5,119.0	2,695.0	2,956.9	2,725.6	13.6	-3.2	-6.2	.9	-.8
MACRO VARIABLES											
POPULATION (MIL)	632.1	700.3	758.2	801.4	836.7	862.0	1.0	.8	.6	.4	.3
GDP, REAL 1985	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
EXCHANGE RATE	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
XRT/CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table A4 Australia

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	10,815.0	13,628.0	16,600.0	22,815.8	23,200.7	27,089.7	2.3	2.0	3.2	.2	1.6
AREA	8,309.0	10,798.0	15,694.0	13,464.0	13,057.2	13,516.4	2.7	3.8	-1.5	-.3	.3
YIELD	1.3	1.3	1.1	1.7	1.8	2.0	-.3	-1.8	4.8	.5	1.2
CONSUMPTION	3,953.0	5,073.0	6,720.0	8,843.0	9,640.1	11,617.5	2.5	2.9	2.8	.9	1.9
PER CAPITA	384.7	405.6	457.4	525.6	513.3	565.0	.5	1.2	1.4	-.2	1.0
NET IMPORTS	-7,854.0	-12,231.0	-12,401.0	-14,880.0	-13,575.4	-15,439.3	4.5	.1	1.8	-.9	1.3
ENDING STOCKS	1,056.0	5,341.0	2,828.0	2,847.0	5,180.4	5,487.1	17.6	-6.2	.1	6.2	.6
WHEAT											
PRODUCTION	7,450.0	7,890.0	10,856.0	15,390.7	14,108.5	16,538.9	.6	3.2	3.6	-.9	1.6
AREA	5,439.0	6,479.0	11,283.0	9,216.0	8,127.0	8,446.0	1.8	5.7	-2.0	-1.2	.4
YIELD	1.4	1.2	1.0	1.7	1.7	2.0	-1.2	-2.3	5.7	.4	1.2
CONSUMPTION	1,982.0	2,625.0	3,503.0	4,100.0	3,978.5	4,742.2	2.8	2.9	1.6	-.3	1.8
PER CAPITA	192.9	209.9	238.4	243.7	211.8	230.6	.8	1.3	.2	-1.4	.9
NET IMPORTS	-6,456.0	-9,145.0	-9,577.0	-12,100.0	-10,162.4	-11,785.5	3.5	.5	2.4	-1.7	1.5
ENDING STOCKS	989.0	3,665.0	2,044.0	2,237.0	4,076.1	4,161.6	14.0	-5.7	.9	6.2	.2
COARSE GRAINS											
PRODUCTION	3,283.0	5,524.0	5,223.0	6,862.4	8,207.9	9,330.5	5.3	-.6	2.8	1.8	1.3
AREA	2,851.0	4,281.0	4,307.0	4,159.0	4,764.3	4,855.2	4.1	.1	-.3	1.4	.2
YIELD	1.2	1.3	1.2	1.7	1.7	1.9	1.1	-.6	3.1	.4	1.1
CONSUMPTION	1,936.0	2,376.0	3,152.0	4,575.0	5,467.8	6,642.3	2.1	2.9	3.8	1.8	2.0
PER CAPITA	188.4	190.0	214.5	271.9	291.1	323.0	.1	1.2	2.4	.7	1.0
NET IMPORTS	-1,347.0	-2,915.0	-2,357.0	-2,320.0	-2,742.2	-2,690.6	8.0	-2.1	-.2	1.7	-.2
ENDING STOCKS	35.0	1,617.0	558.0	303.0	565.8	551.3	46.7	-10.1	-5.9	6.4	-.3
RICE											
PRODUCTION, PADDY	114.0	299.0	729.0	786.8	1,236.4	1,706.3	10.1	9.3	.8	4.6	3.3
AREA	19.0	38.0	104.0	89.0	165.8	215.2	7.2	10.6	-1.5	6.4	2.6
YIELD	6.0	7.9	7.0	8.8	7.5	7.9	2.7	-1.1	2.3	-1.7	.6
PRODUCTION, RICE	82.0	214.0	521.0	562.7	884.3	1,220.4	10.1	9.3	.8	4.6	3.3
CONSUMPTION	35.0	72.0	65.0	168.0	193.7	232.9	7.5	-1.0	10.0	1.4	1.9
PER CAPITA	3.4	5.8	4.4	9.7	10.3	11.3	5.4	-2.6	8.1	.7	.9
NET IMPORTS	-51.0	-171.0	-467.0	-460.0	-670.8	-963.3	12.9	10.6	-.2	3.8	3.7
ENDING STOCKS	32.0	59.0	226.0	307.0	540.5	774.2	6.3	14.4	3.1	5.8	3.7
MACRO VARIABLES											
POPULATION (MIL)	10.3	12.5	14.7	16.8	18.8	20.6	2.0	1.6	1.4	1.1	.9
GDP, REAL 1985	57.4	95.7	129.6	178.5	236.4	312.8	5.2	3.1	3.3	2.8	2.8
EXCHANGE RATE	.9	.9	.9	1.3	1.6	2.0	.0	-.1	3.8	2.3	2.0
CPI	19.6	24.9	67.1	146.5	220.4	331.3	2.5	10.4	8.1	4.2	4.2
XRT/CPI	4.5	3.6	1.3	.9	.7	.6	-2.4	-9.5	-4.0	-1.7	-2.1

Table A5 Canada

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	26,592.0	28,498.0	41,428.0	58,735.5	56,857.5	64,790.9	.7	3.8	3.6	-.3	1.3
AREA	17,563.0	13,470.0	19,094.0	22,291.0	21,300.1	21,929.8	-2.6	3.6	1.6	-.5	.3
YIELD	1.5	2.1	2.2	2.6	2.7	3.0	3.4	.3	2.0	.1	1.0
CONSUMPTION	16,333.0	21,844.0	23,358.0	27,213.0	28,183.4	30,018.0	3.0	.7	1.5	.4	.6
PER CAPITA	912.0	1,026.4	971.5	1,028.3	990.8	997.0	1.2	-.5	.6	-.4	.1
NET IMPORTS	-10,078.0	-15,807.0	-19,512.0	-26,426.0	-28,542.7	-34,776.4	4.6	2.1	3.1	.8	2.0
ENDING STOCKS	21,079.0	25,439.0	13,968.0	15,821.0	19,569.7	20,059.0	1.9	-5.8	1.3	2.1	.2
WHEAT											
PRODUCTION	14,108.0	9,024.0	19,291.0	32,672.1	31,785.2	37,165.1	-4.4	7.9	5.4	-.3	1.6
AREA	9,930.0	5,752.0	11,098.0	14,393.0	14,439.8	15,335.8	-6.5	8.2	2.6	.0	.6
YIELD	1.4	1.8	1.7	2.3	2.2	2.4	2.3	-.3	2.7	-.3	1.0
CONSUMPTION	4,256.0	4,650.0	5,240.0	6,705.0	6,597.1	7,043.1	.9	1.2	2.5	-.2	.7
PER CAPITA	237.6	218.1	217.9	253.4	231.9	233.9	-.9	.0	1.5	.9	.1
NET IMPORTS	-9,614.0	-11,946.0	-16,262.0	-22,109.0	[illegible]	-30,132.5	2.1	3.2	3.1	1.3	1.8
ENDING STOCKS	16,556.0	19,980.0	8,510.0	10,300.0	[illegible]	12,895.0	1.9	-8.2	1.9	2.3	.0
COARSE GRAINS											
PRODUCTION	12,484.0	19,474.0	22,137.0	26,063.4	25,072.3	27,625.8	4.5	1.3	1.6	-.4	1.0
AREA	7,633.0	8,418.0	7,996.0	7,898.0	6,860.3	6,594.0	1.0	-.5	-.1	-1.4	-.4
YIELD	1.6	2.3	2.8	3.3	3.7	4.2	3.5	1.8	1.8	1.0	1.4
CONSUMPTION	12,029.0	17,146.0	18,019.0	20,348.0	21,421.0	22,786.2	3.6	.5	1.2	.5	.6
PER CAPITA	671.7	804.1	749.4	768.9	753.0	756.8	1.8	-.7	.3	-.2	.0
NET IMPORTS	-512.0	-4,009.0	-3,349.0	-4,475.0	-3,554.1	-4,832.5	22.9	-1.8	2.9	-2.3	3.1
ENDING STOCKS	4,523.0	5,459.0	5,458.0	5,521.0	6,680.2	7,163.9	1.9	.0	.1	1.9	.7
RICE											
PRODUCTION, PADDY	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
AREA	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
YIELD	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
PRODUCTION, RICE	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
CONSUMPTION	48.0	48.0	99.0	160.0	165.4	188.7	.0	7.5	4.9	.3	1.3
PER CAPITA	2.7	2.3	4.1	6.0	5.8	6.3	-1.7	6.2	3.9	-.4	.8
NET IMPORTS	48.0	48.0	99.0	160.0	165.4	188.7	.0	7.5	4.9	.3	1.3
ENDING STOCKS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
MACRO VARIABLES											
POPULATION (MIL)	17.9	21.3	24.0	26.5	28.4	30.1	1.8	1.2	1.0	.7	.6
GDP, REAL 1985	119.9	198.1	309.9	412.1	511.0	613.2	5.1	4.6	2.9	2.2	1.8
EXCHANGE RATE	1.0	1.0	1.2	1.2	1.3	1.4	.8	1.1	-.1	1.2	.5
CPI	24.7	32.3	69.9	124.5	162.9	198.9	2.7	8.0	5.9	2.7	2.0
XRT/CPI	3.9	3.2	1.7	.9	.8	.7	-1.9	-6.4	-5.7	-1.5	-1.5

Table A6 EC-10

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	72,565.0	92,056.0	125,510.0	139,376.4	160,513.7	173,884.8	2.4	3.1	1.1	1.4	.8
AREA	28,414.0	28,708.0	28,526.0	25,375.0	25,574.6	24,066.4	.1	-.1	-1.2	.1	-.6
YIELD	2.6	3.2	4.4	5.5	6.3	7.2	2.3	3.2	2.2	1.3	1.4
CONSUMPTION	92,599.0	114,255.0	120,776.0	114,479.0	124,683.5	128,721.0	2.1	.6	-.5	.9	.3
PER CAPITA	385.0	438.9	446.4	414.7	444.8	459.6	1.3	.2	-.7	.7	.3
NET IMPORTS	21,270.0	22,308.0	-3,605.0	-23,929.0	-35,723.2	-45,278.9	.5	N.A.	20.8	4.1	2.4
ENDING STOCKS	14,159.0	12,032.0	15,713.0	25,107.0	27,763.9	27,828.8	-1.6	2.7	4.8	1.0	.0
WHEAT											
PRODUCTION	29,696.0	36,677.0	55,072.0	75,615.9	82,579.2	87,779.0	2.1	4.1	3.2	.9	.6
AREA	12,886.0	11,911.0	12,567.0	13,527.0	13,254.9	12,238.8	-.8	.5	.7	-.2	-.8
YIELD	2.3	3.1	4.4	5.6	6.2	7.2	2.9	3.6	2.5	1.1	1.4
CONSUMPTION	37,586.0	42,650.0	43,870.0	53,914.0	58,062.8	59,252.1	1.3	.3	2.1	.7	.2
PER CAPITA	156.3	163.9	162.1	195.3	207.1	211.6	.5	-.1	1.9	.6	.2
NET IMPORTS	9,107.0	6,456.0	-10,382.0	-19,290.0	-24,629.4	-28,777.4	-3.4	N.A.	6.4	2.5	1.6
ENDING STOCKS	7,662.0	5,694.0	8,823.0	15,180.0	18,043.0	16,266.7	-2.9	4.5	5.6	1.7	-1.0
COARSE GRAINS											
PRODUCTION	42,330.0	54,697.0	69,690.0	62,634.6	72,926.8	85,004.6	2.6	2.5	-1.1	2.1	1.0
AREA	15,352.0	16,587.0	15,759.0	11,599.0	12,092.2	11,605.0	.8	-.5	-3.0	.4	-.4
YIELD	2.8	3.3	4.4	5.4	6.4	7.3	1.8	3.0	2.0	1.7	1.4
CONSUMPTION	54,261.0	70,817.0	76,002.0	59,423.0	65,477.3	68,239.1	2.7	.7	-2.4	1.0	.4
PER CAPITA	225.6	272.1	280.9	215.3	233.6	243.7	1.9	.3	-2.6	.8	.4
NET IMPORTS	11,949.0	15,726.0	6,559.0	-4,714.0	-11,228.7	-16,629.4	2.8	-8.4	N.A.	9.1	4.0
ENDING STOCKS	6,380.0	6,094.0	6,723.0	9,533.0	9,514.2	11,357.3	-.5	1.0	3.6	.0	1.8
RICE											
PRODUCTION, PADDY	779.0	985.0	1,080.0	1,645.9	1,476.0	1,610.3	2.4	.9	4.3	-1.1	.9
AREA	176.0	210.0	200.0	249.0	227.5	222.5	1.8	-.5	2.2	-.9	-.2
YIELD	4.4	4.7	5.4	6.6	6.5	7.2	.6	1.4	2.0	-.2	1.1
PRODUCTION, RICE	539.0	682.0	748.0	1,125.8	1,009.6	1,101.5	2.4	.9	4.2	-1.1	.9
CONSUMPTION	752.0	788.0	904.0	1,142.0	1,144.9	1,229.6	.5	1.4	2.4	.0	[illegible]
PER CAPITA	3.1	3.0	3.3	4.1	4.1	4.4	-.3	1.0	2.2	-.1	.7
NET IMPORTS	214.0	126.0	218.0	75.0	134.9	127.9	-5.2	5.6	-10.1	6.0	-.5
ENDING STOCKS	117.0	244.0	167.0	394.0	206.7	204.9	7.6	-3.7	9.0	-6.2	-.1
MACRO VARIABLES											
POPULATION (MIL)	240.5	260.3	270.6	276.0	280.3	280.1	.8	.4	.2	.2	.0
GDP, REAL 1985	1,008.7	1,569.6	2,065.6	2,627.0	3,375.5	4,363.2	4.5	2.8	2.4	2.5	2.6
EXCHANGE RATE	1.3	1.2	.8	1.1	1.4	1.9	-.5	-3.9	2.5	3.0	3.0
CPI	13.2	19.6	70.7	122.3	181.0	267.9	4.1	13.7	5.6	4.0	4.0
XRT/CPI	9.8	6.3	1.2	.9	.8	.7	-4.4	-15.4	-3.0	-1.0	-1.0

Table A7 Japan

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	15,888.0	12,698.0	9,847.0	10,865.4	10,849.9	11,790.3	-2.2	-2.5	1.0	.0	.8
AREA	4,923.0	3,422.0	2,694.0	2,445.0	2,262.1	2,275.5	-3.6	-2.4	-1.0	-.8	.1
YIELD	3.2	3.7	3.7	4.4	4.8	5.2	1.4	-.2	2.0	.8	.8
CONSUMPTION	20,600.0	27,988.0	35,427.0	37,755.0	41,730.6	43,449.2	3.1	2.4	.6	1.0	.4
PER CAPITA	218.9	268.2	303.4	305.6	324.5	331.2	2.1	1.2	.1	.6	.2
NET IMPORTS	4,799.0	14,375.0	23,731.0	26,653.0	30,871.3	31,539.6	11.6	5.1	1.2	1.5	.2
ENDING STOCKS	2,715.0	8,049.0	8,236.0	5,459.0	5,405.8	5,158.4	11.5	.2	-4.0	-.1	-.5
WHEAT											
PRODUCTION	1,531.0	474.0	583.0	951.6	1,067.8	1,359.3	-11.1	2.1	5.0	1.2	2.4
AREA	602.0	229.0	191.0	260.0	267.3	303.5	-9.2	-1.8	3.1	.3	1.3
YIELD	2.5	2.1	3.1	3.7	4.0	4.5	-2.0	4.0	1.8	.9	1.1
CONSUMPTION	4,187.0	5,183.0	6,095.0	6,100.0	6,853.9	6,984.3	2.2	1.6	.0	1.2	.2
PER CAPITA	44.5	49.7	52.2	49.4	53.3	53.2	1.1	.5	-.6	.8	.0
NET IMPORTS	2,781.0	4,799.0	5,702.0	5,235.0	5,792.1	5,625.9	5.6	1.7	-.9	1.0	-.3
ENDING STOCKS	775.0	950.0	1,690.0	1,754.0	1,675.0	1,709.3	2.1	5.9	.4	-.5	.2
COARSE GRAINS											
PRODUCTION	2,657.0	677.0	391.0	356.3	166.0	89.5	-12.8	-5.3	-.9	-7.4	-6.0
AREA	1,013.0	270.0	126.0	111.0	44.8	22.0	-12.4	-7.3	-1.3	-8.7	-6.9
YIELD	2.6	2.5	3.1	3.2	3.7	4.1	-.4	2.2	.3	1.4	.9
CONSUMPTION	4,513.0	11,115.0	19,232.0	22,055.0	25,057.8	25,780.9	9.4	5.6	1.4	1.3	.3
PER CAPITA	48.0	106.5	164.7	178.5	194.9	196.5	8.3	4.5	.8	.9	.1
NET IMPORTS	1,878.0	10,476.0	18,863.0	21,600.0	24,901.8	25,688.6	18.8	6.1	1.3	1.5	.3
ENDING STOCKS	514.0	1,042.0	2,546.0	2,679.0	2,566.8	2,596.1	7.3	9.3	.5	-.4	.1
RICE											
PRODUCTION, PADDY	16,072.0	15,861.0	12,188.0	13,128.4	13,208.9	14,205.5	-.1	-2.6	.7	.1	.7
AREA	3,308.0	2,923.0	2,377.0	2,074.0	1,950.0	1,950.0	-1.2	-2.0	-1.4	-.6	.0
YIELD	4.9	5.4	5.1	6.3	6.8	7.3	1.1	-.6	2.1	.7	.7
PRODUCTION, RICE	11,700.0	11,547.0	8,873.0	9,557.5	9,616.1	10,341.6	-.1	-2.6	.7	.1	.7
CONSUMPTION	11,900.0	11,690.0	10,100.0	9,600.0	9,819.0	10,683.9	-.2	-1.5	-.5	.2	.8
PER CAPITA	126.5	112.0	86.5	78.0	76.4	81.4	-1.2	-2.6	-1.0	-.2	.6
NET IMPORTS	140.0	-900.0	-834.0	18.0	177.4	225.2	N.A.	-.8	N.A.	25.7	2.4
ENDING STOCKS	1,426.0	6,057.0	4,000.0	1,026.0	1,163.9	853.0	15.6	-4.1	-12.7	1.3	-3.1
MACRO VARIABLES											
POPULATION (MIL)	94.1	104.4	116.8	123.6	128.6	131.2	1.0	1.1	.6	.4	.2
GDP, REAL 1985	56,458.0	152,580.0	240,180.0	362,003.0	534,765.8	760,187.5	10.5	4.6	4.2	4.0	3.6
EXCHANGE RATE	360.0	360.0	226.7	144.8	118.8	104.2	.0	-4.5	-4.6	-2.0	-1.3
CPI	21.1	36.9	87.2	106.6	141.8	189.4	[illegible]	9.0	2.0	2.9	2.9
XRT/CPI	1,702.4	974.5	259.9	135.8	83.8	55.0	-5.4	-12.4	-6.3	-4.7	-6.1

Table A8 Other Developed Countries

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	28,997.0	36,383.0	51,653.0	52,868.9	61,573.2	65,472.7	2.3	3.6	.2	1.5	.6
AREA	18,737.0	18,090.0	17,446.0	16,508.0	15,444.8	14,264.3	-.4	-.4	-.6	-.7	-.8
YIELD	1.5	2.0	3.0	3.2	4.0	4.6	2.7	3.9	.8	2.2	1.4
CONSUMPTION	33,602.0	44,116.0	58,764.0	53,044.0	63,279.4	67,093.6	2.8	2.9	-1.0	1.8	.6
PER CAPITA	379.3	455.9	562.7	484.2	550.9	561.3	1.9	2.1	-1.5	1.3	.2
NET IMPORTS	4,042.0	6,389.0	8,386.0	1,082.0	1,772.0	1,663.4	4.7	2.8	-18.5	5.1	-.6
ENDING STOCKS	4,856.0	5,237.0	12,175.0	8,601.0	10,493.9	11,051.3	.8	8.8	-3.4	2.0	.5
WHEAT											
PRODUCTION	10,133.0	11,237.0	15,077.0	16,596.9	15,784.3	16,066.5	1.0	3.0	1.0	-.5	.2
AREA	8,023.0	7,104.0	5,420.0	4,649.0	3,882.1	3,359.3	-1.2	-2.7	-1.5	-1.8	-1.4
YIELD	1.3	1.6	2.8	3.6	4.1	4.8	2.3	5.8	2.5	1.3	1.6
CONSUMPTION	13,515.0	14,253.0	14,943.0	16,383.0	16,547.4	16,797.3	.5	.5	.9	.1	.2
PER CAPITA	152.6	147.3	143.1	149.6	144.1	140.5	-.4	-.3	.4	-.4	-.2
NET IMPORTS	2,472.0	1,820.0	1,125.0	260.0	765.3	719.2	-3.0	-4.7	-13.6	11.4	-.6
ENDING STOCKS	3,118.0	2,442.0	5,280.0	3,109.0	3,119.7	3,041.0	-2.4	8.0	-5.2	.0	-.3
COARSE GRAINS											
PRODUCTION	18,522.0	24,736.0	36,147.0	35,767.3	45,352.4	48,948.9	2.9	3.9	-.1	2.4	.8
AREA	10,605.0	10,872.0	11,914.0	11,727.0	11,442.9	10,780.6	.2	.9	-.2	-.2	-.6
YIELD	1.7	2.3	3.0	3.1	4.0	4.5	2.7	2.9	.1	2.7	1.4
CONSUMPTION	19,696.0	29,372.0	43,256.0	35,985.0	46,015.2	49,506.4	4.1	3.9	-1.8	2.5	.7
PER CAPITA	222.4	303.5	414.2	328.5	400.6	414.2	3.2	3.2	-2.3	2.0	.3
NET IMPORTS	1,521.0	4,492.0	7,111.0	677.0	725.5	609.5	11.4	4.7	-21.0	.7	-1.7
ENDING STOCKS	1,672.0	2,708.0	6,714.0	5,335.0	7,163.6	7,778.1	4.9	9.5	-2.3	3.0	.8
RICE											
PRODUCTION, PADDY	534.0	609.0	630.0	761.6	658.8	690.3	1.3	.3	1.9	-1.4	.5
AREA	109.0	114.0	112.0	132.0	119.8	124.4	.4	-.2	1.7	-1.0	.4
YIELD	4.9	5.3	5.6	5.8	5.5	5.5	.9	.5	.3	-.5	.1
PRODUCTION, RICE	342.0	410.0	429.0	504.6	436.4	457.3	1.8	.5	1.6	-1.4	.5
CONSUMPTION	391.0	491.0	565.0	676.0	717.0	789.8	2.3	1.4	1.8	.6	1.0
PER CAPITA	4.4	5.1	5.4	6.2	6.2	6.6	1.4	.6	1.3	.1	.6
NET IMPORTS	49.0	77.0	150.0	145.0	281.2	334.7	4.6	6.9	-.3	6.8	1.8
ENDING STOCKS	66.0	87.0	181.0	157.8	210.5	232.2	2.8	7.6	-1.4	3.0	1.0
MACRO VARIABLES											
POPULATION (MIL)	88.6	96.8	104.4	109.5	114.9	119.5	.9	.8	.5	.5	.4
GDP, REAL 1985	162.4	356.4	476.1	600.2	782.6	1,011.6	8.2	2.9	2.3	2.7	2.6
EXCHANGE RATE	2.0	2.0	1.0	1.0	1.1	1.2	.0	-7.1	.6	1.0	1.0
CPI	36.0	49.9	81.1	112.0	161.0	231.5	3.3	5.0	3.3	3.7	3.7
XRT/CPI	5.6	4.0	1.2	.9	.7	.5	-3.2	-11.5	-2.6	-2.6	-2.6

Table A9 United States

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	180,544.0	185,697.0	267,926.0	310,219.0	328,880.2	377,103.5	.3	3.7	1.5	.6	1.4
AREA	73,924.0	59,120.0	71,419.0	65,563.0	59,785.7	62,138.4	-2.2	1.9	-.9	-.9	.4
YIELD	2.4	3.1	3.8	4.7	5.5	6.1	2.5	1.8	2.3	1.5	1.0
CONSUMPTION	138,591.0	164,106.0	171,097.0	218,695.0	228,223.5	240,095.8	1.7	.4	2.5	.4	.5
PER CAPITA	767.1	800.3	751.4	878.6	858.9	855.8	.4	-.6	1.6	-.2	.0
NET IMPORTS	-29,320.0	-39,802.0	-114,537.0	-79,908.0	-96,943.4	-132,129.6	3.1	11.1	-3.5	2.0	3.1
ENDING STOCKS	118,631.0	55,174.0	71,785.0	72,767.0	134,906.3	184,802.8	-7.4	2.7	.1	6.4	3.2
WHEAT											
PRODUCTION	36,877.0	36,795.0	64,799.0	74,655.6	72,180.7	90,471.6	.0	5.8	1.4	-.3	2.[illegible]
AREA	21,012.0	17,651.0	28,784.0	28,066.0	25,875.5	29,051.8	-1.7	5.0	-.3	-.8	1.2
YIELD	1.8	2.1	2.3	2.7	2.8	3.1	1.7	.8	1.7	.5	1.1
CONSUMPTION	16,082.0	21,009.0	21,310.0	37,495.0	31,709.1	36,218.6	2.7	.1	5.8	-1.7	1.3
PER CAPITA	89.0	102.5	93.6	150.6	119.3	129.1	1.4	-.9	4.9	-2.3	.8
NET IMPORTS	-17,584.0	-20,140.0	-41,122.0	-28,074.0	-40,812.5	-55,275.3	1.6	7.4	-3.7	3.8	3.1
ENDING STOCKS	40,878.0	22,398.0	26,916.0	23,563.0	40,011.6	42,444.4	-5.8	1.9	-1.3	5.4	.6
COARSE GRAINS											
PRODUCTION	141,911.0	146,106.0	198,289.0	230,516.1	251,043.7	276,817.5	.3	3.1	1.5	.9	1.0
AREA	52,267.0	40,735.0	41,295.0	36,359.0	32,790.4	31,243.0	-2.5	.1	-1.3	-1.0	-.5
YIELD	2.7	3.6	4.8	6.3	7.7	8.9	2.8	3.0	2.8	1.9	1.5
CONSUMPTION	121,598.0	141,789.0	147,674.0	178,210.0	192,957.4	199,281.4	1.5	.4	1.9	.8	.3
PER CAPITA	673.0	691.5	648.5	715.9	726.2	710.3	.3	-.6	1.0	.1	-.2
NET IMPORTS	-10,826.0	-18,249.0	-70,394.0	-49,635.0	-53,717.9	-71,472.4	5.4	14.5	-3.4	.8	2.9
ENDING STOCKS	77,423.0	32,165.0	44,324.0	48,393.0	94,059.3	141,699.1	-8.4	3.3	.9	6.9	4.2
RICE											
PRODUCTION, PADDY	2,477.0	3,801.0	6,629.0	7,021.5	7,867.8	13,653.1	4.4	5.7	.6	1.1	5.7
AREA	645.0	734.0	1,340.0	1,138.0	1,119.9	1,843.6	1.3	6.2	-1.6	-.2	5.1
YIELD	3.8	5.2	4.9	6.2	7.0	7.4	3.0	-.5	2.2	1.3	.5
PRODUCTION, RICE	1,756.0	2,796.0	4,838.0	5,047.4	5,655.8	9,814.5	4.8	5.6	.4	1.1	5.7
CONSUMPTION	911.0	1,308.0	2,113.0	2,990.0	3,559.2	4,595.6	3.7	4.9	3.5	1.8	2.6
PER CAPITA	5.0	6.4	9.3	10.7	13.4	16.4	2.4	3.8	1.4	2.3	2.0
NET IMPORTS	-910.0	-1,413.0	-3,021.0	-2,199.0	-2,413.0	-5,381.9	4.5	7.9	-3.1	.9	8.4
ENDING STOCKS	330.0	611.0	545.0	811.0	835.4	659.3	6.4	-1.1	4.1	.3	-2.3
MACRO VARIABLES											
POPULATION (MIL)	180.7	205.1	227.7	248.9	265.7	280.6	1.3	1.1	.9	.7	.5
GDP, REAL 1985	1,417.5	2,055.9	2,684.4	3,519.3	4,519.7	5,662.6	3.8	2.7	2.7	2.5	2.3
EXCHANGE RATE	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	.0	.0
CPI	27.5	36.1	76.6	121.4	173.4	251.8	2.8	7.8	4.7	3.6	3.8
XRT/CPI	3.6	2.8	1.3	.8	.6	.4	-2.7	-7.2	-4.5	-3.5	-3.7

Table A10 Former CPEs

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	170,473.0	232,768.0	261,856.0	310,039.3	295,100.0	324,408.3	3.2	1.2	1.7	-.5	1.0
AREA	137,839.0	136,772.0	144,722.0	125,837.0	125,348.7	123,813.5	-.1	.6	-1.4	.0	-.1
YIELD	1.2	1.7	1.8	2.5	2.4	2.6	3.2	.6	3.1	-.5	1.1
CONSUMPTION	169,186.0	243,550.0	310,284.0	335,647.0	297,619.5	308,3[illegible]8.1	3.7	2.5	.8	-1.2	.4
PER CAPITA	541.1	700.1	821.8	828.6	695.3	[illegible].6	2.6	1.6	.1	-1.7	-.1
NET IMPORTS	-711.0	1,800.0	48,405.0	26,520.0	2,349.9	-15,6[illegible]9.1	N.A.	39.0	-5.8	-21.5	N.A.
ENDING STOCKS	9,946.0	13,941.0	12,079.0	53,875.0	34,530.8	37,525.0	3.4	-1.4	16.1	-4.4	.8
WHEAT											
PRODUCTION	77,232.0	118,984.0	127,693.0	146,916.6	125,186.7	132,553.2	4.4	.7	1.4	-1.6	.6
AREA	68,058.0	73,650.0	69,676.0	57,195.0	54,919.3	52,012.5	.8	-.6	-2.0	-.4	-.5
YIELD	1.1	1.6	1.8	2.6	2.3	2.5	3.6	1.3	3.4	-1.2	1.1
CONSUMPTION	76,369.0	126,378.0	145,466.0	156,491.0	128,651.3	127,574.5	5.2	1.4	.7	-1.9	-.1
PER CAPITA	244.3	363.3	385.3	386.3	300.8	283.6	4.0	.6	.0	-2.5	-.6
NET IMPORTS	-143.0	-606.0	18,836.0	13,700.0	3,511.5	-4,762.2	15.5	N.A.	-3.1	-12.7	N.A.
ENDING STOCKS	3,648.0	7,400.0	8,397.0	35,332.0	21,894.1	23,914.7	7.3	1.3	15.5	-4.7	.9
COARSE GRAINS											
PRODUCTION	93,039.0	112,839.0	132,265.0	161,442.8	167,388.1	188,783.2	1.9	1.6	2.0	.4	1.2
AREA	69,627.0	62,704.0	74,328.0	67,974.0	69,646.3	70,959.9	-1.0	1.7	-.9	.2	.2
YIELD	1.3	1.8	1.8	2.4	2.4	2.7	3.0	-.1	2.9	.1	1.0
CONSUMPTION	92,298.0	115,710.0	161,452.0	176,959.0	165,797.8	177,406.1	2.3	3.4	.9	-.6	.7
PER CAPITA	295.2	332.6	427.6	436.8	387.6	394.4	1.2	2.5	.2	-1.2	.2
NET IMPORTS	-885.0	1,894.0	28,122.0	12,300.0	-1,606.3	-11,194.4	N.A.	31.0	-7.9	N.A.	21.6
ENDING STOCKS	6,290.0	6,523.0	3,677.0	18,532.0	12,592.9	13,554.7	.4	-5.6	17.6	-3.8	.7
RICE											
PRODUCTION, PADDY	312.0	1,455.0	2,920.0	2,585.0	3,885.2	4,726.5	16.6	7.2	-1.2	4.2	2.0
AREA	154.0	418.0	718.0	668.0	783.1	841.0	10.5	5.6	-.7	1.6	.7
YIELD	2.0	3.5	4.1	3.9	5.0	5.6	5.6	1.6	-.5	2.5	1.3
PRODUCTION, RICE	202.0	945.0	1,898.0	1,680.1	2,525.1	3,071.9	16.7	7.2	-1.2	4.2	2.0
CONSUMPTION	519.0	1,462.0	3,[illegible]66.0	2,197.0	2,969.0	3,418.6	10.9	8.7	-4.2	3.1	1.4
PER CAPITA	1.7	4.2	8.9	5.4	6.9	7.6	9.7	7.8	-4.8	2.5	.9
NET IMPORTS	317.0	512.0	1,447.0	520.0	444.7	347.6	4.9	10.9	-9.7	-1.6	-2.4
ENDING STOCKS	8.0	18.0	5.0	11.0	45.1	54.7	8.4	-12.0	8.2	15.2	1.9
MACRO VARIABLES											
POPULATION (MIL)	312.6	347.9	377.6	405.1	427.8	449.8	1.1	.8	.7	.5	.5
GDP, REAL 1985	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
EXCHANGE RATE	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
XRT/CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table A11 Eastern Europe

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	48,623.0	55,328.0	81,334.0	87,305.0	87,714.8	92,617.0	1.3	3.9	.7	.0	.5
AREA	27,264.0	24,581.0	24,708.0	24,137.0	24,380.1	23,628.5	-1.0	.1	-.2	.1	-.3
YIELD	1.8	2.3	3.3	3.6	3.6	3.9	2.4	3.9	.9	-.1	.9
CONSUMPTION	54,560.0	65,380.0	95,105.0	91,837.0	86,093.7	89,004.2	1.8	3.8	-.3	-.6	.3
PER CAPITA	554.9	621.9	849.0	788.1	716.3	720.1	1.1	3.2	-.7	-1.0	.1
NET IMPORTS	5,513.0	9,070.0	13,748.0	570.0	-1,599.1	-3,557.0	5.1	4.2	-27.3	N.A.	8.3
ENDING STOCKS	1,946.0	1,941.0	1,079.0	7,110.0	5,272.5	5,749.8	.0	-5.7	20.7	-2.9	.9
WHEAT											
PRODUCTION	12,933.0	19,250.0	29,511.0	38,948.3	33,275.8	35,047.7	4.1	4.4	2.8	-1.6	.5
AREA	7,665.0	8,420.0	8,201.0	8,995.0	8,843.0	8,633.3	.9	-.3	.9	-.2	-.2
YIELD	1.7	2.3	3.6	4.3	3.8	4.1	3.1	4.6	1.9	-1.4	.8
CONSUMPTION	17,505.0	25,363.0	32,784.0	37,991.0	33,961.6	35,014.5	3.8	2.6	1.5	-1.1	.3
PER CAPITA	178.0	241.2	292.7	326.0	282.6	283.3	3.1	2.0	1.1	-1.4	.0
NET IMPORTS	4,292.0	6,113.0	3,336.0	-800.0	687.5	-19.0	3.6	-5.9	N.A.	N.A.	N.A.
ENDING STOCKS	648.0	1,400.0	397.0	2,320.0	1,834.1	1,950.5	8.0	-11.8	19.3	-2.3	.6
COARSE GRAINS											
PRODUCTION	35,609.0	35,964.0	51,739.0	48,236.8	54,239.2	57,328.9	.1	3.7	-.7	1.2	.6
AREA	19,540.0	16,093.0	16,455.0	15,074.0	15,459.5	14,911.5	-1.9	.2	-.9	.3	-.4
YIELD	1.8	2.2	3.1	3.2	3.5	3.8	2.1	3.5	.2	.9	.9
CONSUMPTION	36,676.0	39,644.0	61,926.0	53,459.0	51,665.0	53,468.9	.8	4.6	-1.5	-.3	.3
PER CAPITA	373.0	377.1	552.8	458.8	429.9	432.6	.1	3.9	-1.8	-.6	.1
NET IMPORTS	923.0	2,703.0	10,122.0	1,100.0	-2,554.6	-3,819.3	11.3	14.1	-19.9	N.A.	4.1
ENDING STOCKS	1,290.0	523.0	677.0	4,779.0	3,393.4	3,744.7	-8.6	2.6	21.6	-3.4	1.0
RICE											
PRODUCTION, PADDY	126.0	177.0	129.0	185.0	308.4	370.9	3.5	-3.1	3.7	5.2	1.9
AREA	59.0	68.0	52.0	68.0	77.6	83.7	1.4	-2.6	2.7	1.3	.8
YIELD	2.1	2.6	2.5	2.7	4.0	4.4	2.0	-.5	.9	3.9	1.1
PRODUCTION, RICE	81.0	114.0	84.0	119.9	199.9	240.4	3.5	-3.0	3.6	5.2	1.9
CONSUMPTION	379.0	373.0	395.0	387.0	467.1	520.8	-.2	.6	-.2	1.9	1.1
PER CAPITA	3.9	3.5	3.5	3.3	3.9	4.2	-.8	-.1	-.6	1.6	.8
NET IMPORTS	298.0	254.0	290.0	270.0	268.1	281.3	-1.6	1.3	-.7	-.1	.5
ENDING STOCKS	8.0	18.0	5.0	11.0	45.1	54.7	8.4	-12.0	8.2	15.2	1.9
MACRO VARIABLES											
POPULATION (MIL)	98.3	105.1	112.0	116.5	120.2	123.6	.7	.6	.4	.3	.3
GDP, REAL 1985	216.9	322.1	531.4	560.9	557.4	768.2	4.0	5.1	.5	-.1	3.3
EXCHANGE RATE	1.0	1.8	1.0	1.0	1.0	1.0	.0	.0	.0	.0	.0
CPI	1.0	1.6	1.0	1.0	1.0	1.0	.0	.0	.0	.0	.0
XRT/CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table Ai2 FSU

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	121,850.0	177,440.0	180,522.0	222,734.3	207,385.1	231,791.3	3.8	.2	2.1	-.7	1.1
AREA	110,575.0	112,191.0	120,014.0	101,700.0	100,968.6	100,185.0	.1	.7	-1.6	-.1	-.1
YIELD	1.1	1.6	1.5	2.2	2.1	2.3	3.7	-.5	3.8	-.6	1.2
CONSUMPTION	114,626.0	178,170.0	215,179.0	243,810.0	211,325.8	219,394.0	4.5	1.9	1.3	-1.4	.4
PER CAPITA	534.8	733.9	810.3	844.9	687.1	672.5	3.2	1.0	.4	-2.0	-.2
NET IMPORTS	-6,224.0	-7,270.0	34,657.0	25,950.0	3,949.0	-12,052.1	1.6	N.A.	-2.9	-17.2	N.A.
ENDING STOCKS	8,000.0	12,000.0	11,000.0	46,765.0	29,258.3	31,775.2	4.1	-.9	15.6	-4.6	.8
WHEAT											
PRODUCTION	64,299.0	99,734.0	98,182.0	107,968.0	91,910.9	97,505.5	4.5	-.2	1.0	-1.6	.6
AREA	60,393.0	65,230.0	61,475.0	48,200.0	46,076.3	43,379.2	.8	-.6	-2.6	-.4	-.6
YIELD	1.1	1.5	1.6	2.2	2.0	2.2	3.7	.4	3.4	-1.2	1.2
CONSUMPTION	58,864.0	101,015.0	112,682.0	118,500.0	94,689.7	92,560.1	5.5	1.1	.5	-2.2	-.2
PER CAPITA	274.6	416.1	424.4	410.6	307.9	283.7	4.2	.2	-.3	-2.8	-.8
NET IMPORTS	-4,435.0	-6,719.0	15,500.0	14,500.0	2,824.0	-4,743.2	4.2	N.A.	-.7	-15.1	N.A.
ENDING STOCKS	3,000.0	6,000.0	8,000.0	33,012.0	20,060.1	21,964.2	7.2	2.9	15.2	-4.9	.9
COARSE GRAINS											
PRODUCTION	57,430.0	76,875.0	80,524.0	113,206.0	113,149.0	131,454.2	3.0	.5	3.5	.0	1.5
AREA	50,087.0	46,611.0	57,873.0	52,900.0	54,186.8	56,048.4	-.7	2.2	-.9	.2	.3
YIELD	1.1	1.6	1.4	2.1	2.1	2.3	3.7	-1.7	4.4	-.2	1.2
CONSUMPTION	55,622.0	76,066.0	99,526.0	123,500.9	114,132.8	123,937.2	3.2	2.7	2.2	-.8	.8
PER CAPITA	259.5	313.3	374.8	428.0	371.1	379.9	1.9	1.8	1.3	-1.4	.2
NET IMPORTS	-1,808.0	-809.0	18,000.0	11,200.0	948.3	-7,375.1	-7.7	N.A.	-4.6	-21.9	N.A.
ENDING STOCKS	5,000.0	6,000.0	3,000.0	13,753.0	9,199.5	9,810.0	1.8	-6.7	16.4	-3.9	.6
RICE											
PRODUCTION, PADDY	186.0	1,278.0	2,791.0	2,400.0	3,576.8	4,355.5	21.3	8.1	-1.5	4.1	2.0
AREA	95.0	350.0	666.0	600.0	705.5	757.3	13.9	6.6	-1.0	1.6	.7
YIELD	2.0	3.7	4.2	4.0	5.1	5.8	6.4	1.4	-.5	2.4	1.3
PRODUCTION, RICE	121.0	831.0	1,814.0	1,560.2	2,325.[illegible]	2,831.5	21.2	8.1	-1.5	4.1	2.0
CONSUMPTION	140.0	1,089.0	2,971.0	1,810.0	2,501.9	2,897.8	22.8	10.6	-4.8	3.3	1.5
PER CAPITA	.7	4.5	11.2	6.3	8.1	8.9	21.2	9.6	-5.6	2.6	.9
NET IMPORTS	19.0	258.0	1,157.0	250.0	176.7	66.2	29.8	16.2	-14.2	-3.4	-9.3
ENDING STOCKS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
MACRO VARIABLES											
POPULATION (MIL)	214.3	242.8	265.5	288.6	307.6	326.2	1.3	.9	.8	.6	.6
GDP, REAL 1985	495.0	821.7	1,322.1	1,685.5	1,192.3	1,411.2	5.2	4.9	2.5	-3.4	1.7
EXCHANGE RATE	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.9	.0	.0
CPI	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	.0	.0
XRT/CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table A13 Developing Countries Region

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	330,072.0	494,289.0	671,050.0	877,075.7	1,060,708.9	1,260,676.7	4.1	3.1	2.7	1.9	1.7
AREA	352,098.0	395,536.0	423,074.0	423,061.0	447,999.7	465,712.1	1.2	.7	.0	.6	.4
YIELD	.9	1.2	1.6	2.1	2.4	2.7	2.9	2.4	2.7	1.3	1.3
CONSUMPTION	352,981.0	504,505.0	738,761.0	937,913.1	1,189,727.9	1,459,498.9	3.6	3.9	2.4	2.4	2.1
PER CAPITA	171.1	193.0	225.2	233.1	243.5	254.5	1.2	1.6	.3	.4	.4
NET IMPORTS	13,411.0	17,652.0	60,396.0	87,031.5	139,791.6	210,030.3	2.8	13.1	3.7	4.9	4.2
ENDING STOCKS	30,630.0	67,718.0	149,834.0	156,469.0	232,613.3	289,303.9	8.3	8.3	.4	4.0	2.2
WHEAT											
PRODUCTION	61,379.0	92,585.0	149,578.0	230,664.2	306,952.0	380,842.4	4.2	4.9	4.4	2.9	2.2
AREA	76,242.0	84,918.0	97,666.0	104,285.0	110,319.2	117,039.6	1.1	1.4	.7	.6	.6
YIELD	.8	1.1	1.5	2.2	2.8	3.3	3.1	3.5	3.7	2.3	1.6
CONSUMPTION	79,565.0	119,263.0	209,777.0	285,577.0	392,196.9	499,089.4	4.1	5.8	3.1	3.2	2.4
PER CAPITA	38.6	45.6	63.9	71.0	80.3	87.0	1.7	3.4	1.0	1.2	.8
NET IMPORTS	17,166.0	27,999.0	51,040.0	60,164.1	90,689.4	124,387.9	5.0	6.2	1.7	4.2	3.2
ENDING STOCKS	9,223.0	18,006.0	51,185.0	[illegible],244.0	85,554.3	106,210.4	6.9	11.0	.2	5.1	2.2
COARSE GRAINS											
PRODUCTION	132,609.0	204,776.0	267,974.0	311,419.8	365,418.8	425,528.3	4.4	2.7	1.5	1.6	1.5
AREA	160,279.0	182,558.0	186,225.0	176,614.0	190,907.5	197,629.3	1.3	.2	-.5	.8	.3
YIELD	.8	1.1	1.4	1.8	1.9	2.2	3.1	2.5	2.1	.8	1.2
CONSUMPTION	132,133.0	190,670.0	270,206.0	321,909.0	409,389.4	503,348.2	3.7	3.5	1.8	2.4	2.1
PER CAPITA	64.0	72.9	82.4	80.0	83.8	87.8	1.3	1.2	-.3	.5	.5
NET IMPORTS	-3,254.0	-11,623.0	6,617.0	25,187.5	47,222.0	80,521.4	13.6	N.A.	14.3	6.5	5.5
ENDING STOCKS	12,934.0	28,003.0	55,810.0	48,761.0	76,537.4	94,910.1	8.0	7.1	-1.3	4.6	2.2
RICE											
PRODUCTION, PADDY	200,146.0	290,252.0	374,261.0	493,453.5	572,107.3	669,484.4	3.8	2.6	2.8	1.5	1.6
AREA	115,577.0	128,060.0	139,183.0	142,162.0	146,773.0	151,043.2	1.0	.8	.2	.3	.3
YIELD	1.7	2.3	2.7	3.5	3.9	4.4	2.7	1.7	2.6	1.2	1.3
PRODUCTION, RICE	136,084.0	196,928.0	253,498.0	334,991.7	388,337.9	454,306.2	3.8	2.6	2.8	1.5	1.6
CONSUMPTION	141,283.0	194,572.0	258,778.0	330,427.0	388,174.5	457,068.2	3.3	2.9	2.5	1.6	1.6
PER CAPITA	68.5	74.4	78.9	82.1	79.4	79.7	.8	.6	.4	-.3	.0
NET IMPORTS	-479.0	1,276.0	2,739.0	1,978.5	1,880.2	5,121.0	N.A.	7.9	-3.2	-.5	10.5
ENDING STOCKS	8,473.0	21,709.0	42,839.0	55,464.0	70,504.4	88,174.5	9.9	7.0	2.6	2.4	2.3
MACRO VARIABLES											
POPULATION (MIL)	2,063.5	2,614.2	3,280.5	4,024.3	4,886.3	5,735.7	2.4	2.3	2.1	2.0	1.6
GDP, REAL 1985	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
EXCHANGE RATE	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
XRT/CPI	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table A14 Argentina

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	12,541.0	20,788.0	29,009.0	21,942.6	26,622.9	30,205.9	5.2	3.4	-2.8	2.0	1.3
AREA	9,363.0	11,246.0	11,519.0	9,063.0	9,175.1	9,318.9	1.8	.2	-2.4	.1	.2
YIELD	1.3	1.8	2.5	2.4	2.9	3.2	3.3	3.1	-.4	1.8	1.1
CONSUMPTION	9,329.0	10,142.0	10,545.0	10,044.0	13,781.4	15,596.9	.8	.4	-.5	3.2	1.2
PER CAPITA	452.5	423.2	373.4	311.3	380.2	388.0	-.7	-1.2	-1.8	2.0	.2
NET IMPORTS	-3,603.0	-10,147.0	-18,285.0	-11,025.0	-12,851.4	-14,616.7	10.9	6.1	-4.9	1.5	1.3
ENDING STOCKS	1,348.0	1,591.0	775.0	1,376.0	606.3	536.2	1.7	-6.9	5.9	-7.9	-1.2
WHEAT											
PRODUCTION	3,960.0	6,920.0	7,780.0	10,488.0	11,896.1	14,178.6	2.2	4.7	3.0	1.3	1.8
AREA	3,599.0	3,701.0	5,023.0	5,700.0	5,184.2	5,418.6	.3	3.1	1.3	-.9	.4
YIELD	1.1	1.3	1.5	1.8	2.3	2.6	1.9	1.5	1.7	2.2	1.3
CONSUMPTION	3,294.0	4,056.0	3,950.0	4,800.0	5,625.8	5,912.2	2.1	-.3	2.0	1.6	.5
PER CAPITA	159.8	169.3	139.9	148.8	155.2	147.1	.6	-1.9	.6	.4	-.5
NET IMPORTS	-1,094.0	-969.0	-3,845.0	-5,300.0	-6,277.1	-8,271.9	-1.2	14.8	3.3	1.7	2.8
ENDING STOCKS	764.0	675.0	413.0	431.0	131.1	70.8	-1.2	-4.8	.4	-11.2	-6.0
COARSE GRAINS											
PRODUCTION	8,484.0	15,681.0	21,043.0	11,226.4	14,434.7	15,694.9	6.3	3.0	-6.1	2.5	.8
AREA	5,718.0	7,468.0	6,414.0	3,273.0	3,855.6	3,742.2	2.7	-1.5	-6.5	1.7	-.3
YIELD	1.5	2.1	3.3	3.4	3.7	4.2	3.5	4.6	.4	.9	1.1
CONSUMPTION	5,940.0	5,936.0	6,495.0	5,089.0	7,987.0	9,499.0	.0	.9	-2.4	4.6	1.7
PER CAPITA	288.1	247.7	230.0	157.7	200.0	200.0	-1.5	-.7	-3.7	2.4	.0
NET IMPORTS	-2,498.0	-9,096.0	-14,354.0	-5,650.0	-6,450.1	-6,197.9	13.8	4.7	-8.9	1.3	-.4
ENDING STOCKS	568.0	858.0	359.0	937.0	435.7	425.8	4.2	-8.3	10.1	-7.4	-.2
RICE											
PRODUCTION, PADDY	149.0	288.0	286.0	351.0	449.3	511.3	6.8	-.1	2.1	2.5	1.3
AREA	46.0	77.0	82.0	90.0	135.9	158.1	5.3	.6	.9	4.2	1.5
YIELD	3.2	3.7	3.5	3.9	3.3	3.2	1.4	-.7	1.1	-1.6	-.2
PRODUCTION, RICE	97.0	187.0	186.0	228.2	292.1	332.4	6.8	-.1	2.1	2.5	1.3
CONSUMPTION	95.0	150.0	100.0	155.0	168.0	185.4	4.7	-4.0	4.5	.8	1.0
PER CAPITA	4.6	6.3	3.5	4.1	4.6	4.6	3.1	-5.5	1.5	1.2	.0
NET IMPORTS	-11.0	-82.0	-86.0	-75.0	-124.2	-147.0	22.2	.5	-1.4	5.2	1.7
ENDING STOCKS	16.0	58.0	3.0	8.0	39.5	39.7	13.7	-25.6	10.3	17.3	.0
MACRO VARIABLES											
POPULATION (MIL)	20.6	24.0	28.2	32.3	36.2	40.2	1.5	1.7	1.3	1.2	1.0
GDP, REAL 1985	.0	.0	.0	.0	.0	.0	4.4	2.6	-.8	3.2	3.2
EXCHANGE RATE	.0	.0	.0	.0	4.7	6,054.3	14.9	104.0	206.6	104.6	104.6
CPI	.0	.0	.0	.9	1,432.8	2,389,966.8	21.3	119.4	220.9	110.0	110.0
XRT/CPI	2.4	1.4	.7	.4	.3	.3	-5.3	-7.0	-4.5	-2.6	-2.6

Table A15 Brazil

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	13,120.0	19,776.0	31,488.0	33,167.5	46,015.4	55,584.7	4.2	4.8	.5	3.3	1.9
AREA	10,716.0	17,368.0	22,227.0	20,868.0	23,551.9	24,947.0	4.9	2.5	-.6	1.2	.6
YIELD	1.2	1.1	1.4	1.6	2.0	2.2	-.7	2.2	1.2	2.1	1.3
CONSUMPTION	14,804.0	21,771.0	35,665.0	40,662.0	52,263.2	64,740.3	3.9	5.1	1.3	2.5	2.2
PER CAPITA	203.9	227.1	294.0	271.5	291.6	312.5	1.1	2.6	-.8	.7	.7
NET IMPORTS	1,784.0	675.0	3,979.0	5,938.0	6,351.7	9,256.5	-9.3	19.4	4.1	.7	3.8
ENDING STOCKS	2,614.0	2,349.0	2,670.0	1,846.0	6,009.5	6,935.6	-1.1	1.3	-3.6	12.5	1.4
WHEAT											
PRODUCTION	350.0	1,735.0	2,676.0	3,007.0	6,215.1	8,062.0	17.4	4.4	1.2	7.5	2.6
AREA	565.0	1,895.0	3,062.0	3,100.0	3,557.1	3,779.2	12.9	4.9	.1	1.4	.6
YIELD	.6	.9	.9	1.0	1.7	2.1	4.0	-.5	1.0	6.1	2.0
CONSUMPTION	2,235.0	3,689.0	6,600.0	7,500.0	10,314.0	13,332.6	5.1	6.0	1.3	3.2	2.6
PER CAPITA	30.8	38.5	54.4	50.1	57.6	64.4	2.3	3.5	-.8	1.6	1.1
NET IMPORTS	1,885.0	1,710.0	3,910.0	4,200.0	4,198.9	5,282.0	-1.0	8.6	.7	-.2	2.5
ENDING STOCKS	200.0	322.0	623.0	77.0	684.9	802.0	4.9	6.8	-18.9	24.4	1.6
COARSE GRAINS											
PRODUCTION	9,103.0	16,373.0	22,938.0	24,107.7	29,500.2	34,465.5	4.7	4.8	.5	2.0	1.6
AREA	6,977.0	10,709.0	13,065.0	13,468.0	13,741.2	14,461.5	4.4	2.0	.3	.2	.5
YIELD	1.3	1.5	1.8	1.8	2.1	2.4	.3	2.7	.2	1.8	1.1
CONSUMPTION	9,053.0	13,536.0	22,809.0	25,712.0	31,350.8	37,732.4	4.1	5.4	1.2	2.0	1.9
PER CAPITA	124.7	141.2	188.1	171.7	174.9	182.1	1.3	2.9	-.9	.2	.4
NET IMPORTS	50.0	-893.0	119.0	1,138.0	1,827.3	3,227.7	N.A.	N.A.	25.3	4.8	5.9
ENDING STOCKS	2,100.0	1,993.0	1,348.0	1,007.0	2,348.8	1,924.6	-.5	-3.8	-2.9	8.8	-2.0
RICE											
PRODUCTION, PADDY	5,392.0	5,394.0	8,638.0	8,901.0	15,147.0	19,201.6	.0	4.8	.3	5.5	2.4
AREA	3,174.0	4,764.0	6,100.0	4,300.0	6,253.7	6,706.4	4.1	2.5	-3.4	3.8	.7
YIELD	1.7	1.1	1.4	2.1	2.4	2.9	-4.0	2.3	3.9	1.6	1.7
PRODUCTION, RICE	3,667.0	3,668.0	5,874.0	6,052.8	10,300.1	13,057.3	.0	4.8	.3	5.5	2.4
CONSUMPTION	3,516.0	4,546.0	6,256.0	7,450.0	10,598.5	13,675.2	2.6	3.2	1.8	3.6	2.6
PER CAPITA	48.4	47.4	51.6	46.1	59.1	66.0	-.2	.8	-1.1	2.5	1.1
NET IMPORTS	-151.0	-142.0	-50.0	600.0	415.5	746.8	-.6	-9.9	N.A.	-3.6	6.0
ENDING STOCKS	314.0	34.0	699.0	762.0	2,975.8	4,209.1	-19.9	35.3	.9	14.6	3.5
MACRO VARIABLES											
POPULATION (MIL)	72.6	95.8	121.3	149.8	179.2	207.2	2.8	2.4	2.1	1.8	1.5
GDP, REAL 1985	3.0	5.5	12.6	15.1	19.2	27.1	6.1	8.7	1.8	2.4	3.5
EXCHANGE RATE	.0	.0	.0	.0	.1	62.6	37.5	27.6	167.7	95.0	95.0
CPI	.0	.0	.0	2.7	3,484.0	4,566,861.6	43.3	35.3	175.7	105.0	105.0
XRT/CPI	.0	.0	.0	.0	.0	.0	-4.1	-5.6	-2.9	-4.9	-4.9

Table A16 Central Africa

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	16,835.0	24,473.0	31,371.0	36,469.6	55,154.2	70,474.6	3.8	2.5	1.5	4.2	2.5
AREA	21,314.0	30,306.0	37,548.0	41,195.0	53,419.3	59,991.6	3.6	2.2	.9	2.6	1.2
YIELD	.8	.8	.8	.9	1.0	1.2	.2	.3	.6	1.5	1.3
CONSUMPTION	17,258.0	25,850.0	35,503.0	44,525.0	62,055.2	80,678.6	4.1	3.2	2.3	3.4	2.7
PER CAPITA	108.1	126.7	131.2	121.4	124.1	118.8	1.6	.3	-.8	.2	-.4
NET IMPORTS	413.0	1,529.0	5,204.0	6,966.0	7,257.4	10,614.9	14.0	13.0	3.0	.4	3.9
ENDING STOCKS	183.0	525.0	2,480.0	3,095.0	8,642.9	12,498.7	11.1	16.8	2.2	10.7	3.8
WHEAT											
PRODUCTION	865.0	1,404.0	1,296.0	1,991.2	2,777.0	3,620.4	5.0	-.8	4.4	3.4	2.7
AREA	1,128.0	1,517.0	963.0	1,310.0	1,780.0	2,080.2	3.0	-4.4	3.1	3.1	1.6
YIELD	.8	.9	1.3	1.5	1.6	1.7	1.9	3.8	1.2	.3	1.1
CONSUMPTION	1,417.0	2,841.0	3,780.0	6,454.0	7,592.0	10,132.4	7.2	2.9	5.5	1.6	2.9
PER CAPITA	8.9	13.9	14.0	17.6	15.2	14.9	4.6	.0	2.3	-1.5	-.2
NET IMPORTS	552.0	1,431.0	2,522.0	4,464.0	4,831.0	6,537.0	10.0	5.8	5.9	.8	3.1
ENDING STOCKS	.0	123.0	383.0	635.0	614.6	825.5	N.A.	12.0	5.2	-.3	3.0
COARSE GRAINS											
PRODUCTION	14,079.0	20,321.0	26,954.0	30,302.5	47,172.5	60,248.1	3.7	2.9	1.2	4.5	2.5
AREA	17,967.0	25,668.0	32,865.0	35,650.0	46,722.4	52,307.6	3.6	2.5	.8	2.7	1.1
YIELD	.8	.8	.8	.9	1.0	1.2	.1	.4	.4	1.7	1.3
CONSUMPTION	13,613.0	19,581.0	26,834.0	31,757.0	46,776.4	60,645.1	3.7	3.2	1.7	3.9	2.6
PER CAPITA	85.3	96.0	99.2	86.6	93.5	89.3	1.2	.3	-1.3	.8	-.5
NET IMPORTS	-476.0	-624.0	949.0	316.0	-93.5	741.6	2.7	N.A.	-10.4	N.A.	N.A.
ENDING STOCKS	108.0	285.0	1,871.0	2,024.0	7,184.7	10,435.4	10.2	20.7	.8	13.5	3.6
RICE											
PRODUCTION, PADDY	1,695.0	4,232.0	4,801.0	6,437.2	8,023.0	10,183.2	9.6	1.3	3.0	2.2	2.4
AREA	2,219.0	3,121.0	3,720.0	4,235.0	4,916.9	5,603.8	3.5	1.8	1.3	1.5	1.3
YIELD	.8	1.4	1.3	1.5	1.6	1.8	5.9	-.5	1.6	.7	1.1
PRODUCTION, RICE	1,891.0	2,748.0	3,121.0	4,175.9	5,204.7	6,606.1	3.8	1.3	3.0	2.2	2.4
CONSUMPTION	2,228.0	3,428.0	4,889.0	6,314.0	7,687.0	9,901.3	4.6	3.6	2.6	2.0	2.6
PER CAPITA	14.0	16.8	18.1	17.2	15.4	14.6	1.9	.7	-.5	-1.1	-.5
NET IMPORTS	337.0	722.0	1,733.0	2,186.0	2,519.9	3,336.3	7.9	9.2	2.3	1.4	2.8
ENDING STOCKS	75.0	117.0	226.0	436.0	843.6	1,237.8	4.5	6.8	6.8	6.8	3.9
MACRO VARIABLES											
POPULATION (MIL)	159.6	204.0	270.6	366.8	500.2	679.4	2.5	2.9	3.1	3.1	3.1
GDP, REAL 1985	19.9	30.0	46.3	57.5	77.6	105.5	4.2	4.4	2.2	3.0	3.1
EXCHANGE RATE	.6	.7	.5	1.2	2.5	5.2	.8	-2.0	8.1	7.8	7.8
CPI	19.0	24.1	49.8	169.0	463.3	1,269.9	2.4	7.5	13.0	10.6	10.6
XRT/CPI	3.2	2.7	1.1	.7	.5	.4	-1.5	-8.9	-4.3	-2.5	-2.5

Table A17 China

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	92,360.0	164,518.0	235,516.0	350,780.9	411,600.4	483,593.3	5.9	3.7	4.1	1.6	1.6
AREA	92,165.0	92,964.0	94,840.0	92,887.0	89,914.0	89,505.5	.1	.2	-.2	-.3	.0
YIELD	1.0	1.8	2.5	3.8	4.6	5.4	5.9	3.4	4.3	1.9	1.7
CONSUMPTION	104,540.0	159,360.0	264,486.0	331,465.0	419,652.5	501,758.7	4.3	5.2	2.3	2.4	1.8
PER CAPITA	156.7	194.7	269.5	298.3	333.1	370.9	2.2	3.3	1.0	1.1	1.1
NET IMPORTS	2,181.0	2,343.0	13,970.0	3,680.0	11,277.1	21,570.5	.7	19.5	-12.5	11.8	6.7
ENDING STOCKS	8,500.0	32,600.0	90,100.0	77,500.0	137,039.0	169,044.1	14.4	10.7	-1.5	5.9	2.1
WHEAT											
PRODUCTION	20,960.0	29,185.0	55,210.0	98,102.1	132,898.0	165,340.4	3.4	6.6	5.9	3.1	2.2
AREA	26,800.0	25,458.0	29,228.0	30,753.0	31,637.0	33,270.2	-.5	1.4	.5	.3	.5
YIELD	.8	1.1	1.9	3.2	4.2	5.0	3.9	5.1	5.4	2.8	1.7
CONSUMPTION	23,907.0	32,343.0	75,999.0	106,030.0	144,635.4	179,393.5	3.1	8.9	3.4	3.2	2.2
PER CAPITA	35.8	39.5	77.5	95.4	114.8	132.6	1.0	7.0	2.1	1.9	1.5
NET IMPORTS	1,947.0	3,656.0	13,789.0	9,500.0	12,707.1	15,067.5	6.5	14.2	-3.7	3.0	1.7
ENDING STOCKS	3,000.0	7,200.0	31,700.0	23,279.0	47,891.1	57,937.6	9.1	16.0	-3.0	7.5	1.9
COARSE GRAINS											
PRODUCTION	29,589.0	58,340.0	82,372.0	120,059.1	125,042.0	141,578.0	7.0	3.5	3.8	.4	1.2
AREA	33,865.0	35,148.0	31,734.0	29,070.0	26,110.3	26,865.4	.4	-1.0	-.9	-1.1	-.5
YIELD	.9	1.7	2.6	4.1	4.8	5.7	6.6	4.6	4.8	1.5	1.7
CONSUMPTION	34,250.0	54,808.0	87,023.0	97,835.0	122,715.6	146,793.4	4.8	4.7	1.2	2.3	1.8
PER CAPITA	51.3	67.0	88.7	88.1	97.4	108.5	2.7	2.8	-.1	1.0	1.1
NET IMPORTS	662.0	-31.0	651.0	-5,320.0	-920.4	6,878.7	N.A.	N.A.	N.A.	-16.1	N.A.
ENDING STOCKS	2,500.0	14,400.0	33,400.0	26,837.0	46,376.6	58,511.7	19.1	8.8	-2.2	5.6	2.4
RICE											
PRODUCTION, PADDY	59,730.0	109,990.0	139,906.0	189,456.7	219,514.9	252,778.3	6.3	2.4	3.1	1.5	1.4
AREA	31,500.0	32,358.0	33,878.0	33,064.0	32,166.8	31,369.9	.3	.5	-.2	-.3	-.3
YIELD	1.9	3.4	4.1	5.7	6.8	8.1	6.0	2.0	3.3	1.8	1.7
PRODUCTION, RICE	41,811.0	76,993.0	97,934.0	132,619.7	153,660.4	176,944.8	6.3	2.4	3.1	1.5	1.4
CONSUMPTION	46,383.0	72,209.0	101,464.0	127,600.0	152,330.8	175,577.3	4.5	3.5	2.3	1.8	1.4
PER CAPITA	69.5	88.2	103.4	114.8	120.9	129.8	2.4	1.6	1.1	.5	.7
NET IMPORTS	-428.0	-1,284.0	-470.0	-500.0	-509.5	-375.7	11.6	-9.6	.6	.2	-3.0
ENDING STOCKS	3,000.0	11,000.0	25,000.0	27,384.0	42,752.1	52,587.6	13.9	8.6	.9	4.6	2.1
MACRO VARIABLES											
POPULATION (MIL)	667.1	818.3	981.2	1,111.0	1,259.9	1,352.9	2.1	1.8	1.3	1.3	.7
GDP, REAL 1985	168.0	251.4	432.8	1,011.3	2,263.1	5,079.2	4.1	5.6	8.9	8.4	8.4
EXCHANGE RATE	2.5	2.5	1.5	4.8	11.3	28.5	.0	-4.8	12.3	8.9	9.7
CPI	N.A.	71.6	81.6	170.6	473.2	1,355.7	N.A.	1.3	7.7	10.7	11.1
XRT/CPI	N.A.	3.4	1.8	2.8	2.4	2.1	N.A.	-6.1	4.4	-1.6	-1.3

Table A18 East Asia

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	26,090.0	33,701.0	41,830.0	53,685.0	65,530.3	78,138.8	2.6	2.2	2.5	2.0	1.8
AREA	21,898.0	24,091.0	25,229.0	26,546.0	26,825.8	27,825.6	1.0	.5	.5	.1	.4
YIELD	1.2	1.4	1.7	2.0	2.4	2.8	1.6	1.7	2.0	1.9	1.4
CONSUMPTION	27,248.0	41,490.0	56,341.0	74,825.0	96,852.9	117,083.7	4.3	3.1	2.9	2.6	1.9
PER CAPITA	196.7	227.6	245.1	262.4	282.8	297.0	1.5	.7	.7	.8	.5
NET IMPORTS	961.0	7,659.0	15,263.0	21,872.0	31,396.7	39,039.4	23.1	7.1	3.7	3.7	2.2
ENDING STOCKS	1,139.0	3,384.0	6,470.0	8,305.0	7,082.3	8,771.3	11.5	6.7	2.5	-.5	1.1
WHEAT											
PRODUCTION	300.0	580.0	807.0	1,607.8	2,556.4	3,289.9	6.8	3.4	7.1	4.7	2.6
AREA	288.0	666.0	714.0	812.0	972.5	1,071.8	8.7	.7	1.3	1.8	1.0
YIELD	1.0	.9	1.1	2.0	2.6	3.1	-1.8	2.6	5.8	2.9	1.6
CONSUMPTION	2,040.0	5,040.0	6,136.0	10,695.0	13,349.1	16,242.8	9.5	2.0	5.7	2.2	2.0
PER CAPITA	14.7	27.7	26.7	37.5	39.0	41.2	6.5	-.4	3.5	.4	.6
NET IMPORTS	1,750.0	4,409.0	5,404.0	9,264.0	10,811.5	12,967.8	9.7	2.1	5.5	1.6	1.8
ENDING STOCKS	81.0	419.0	518.0	591.0	1,015.9	1,170.3	17.9	2.1	1.3	5.6	1.4
COARSE GRAINS											
PRODUCTION	4,660.0	5,792.0	7,597.0	10,659.6	12,430.4	14,646.9	2.2	2.7	3.4	1.5	1.7
AREA	4,046.0	4,341.0	5,253.0	5,922.0	6,167.5	6,564.6	.7	1.9	1.2	.4	.6
YIELD	1.2	1.3	1.4	1.8	2.0	2.2	1.5	.8	2.2	1.1	1.0
CONSUMPTION	4,857.0	7,408.0	15,655.0	23,126.0	32,333.4	40,032.6	4.3	7.8	4.0	3.4	2.2
PER CAPITA	35.1	40.6	68.1	81.1	94.4	101.6	1.5	5.3	1.8	1.5	.7
NET IMPORTS	161.0	1,639.0	7,906.0	12,435.0	19,941.8	25,426.5	26.1	17.0	4.6	4.8	2.5
ENDING STOCKS	115.0	1,649.0	1,707.0	1,525.0	2,391.4	2,779.2	30.5	.3	-1.1	4.6	1.5
RICE											
PRODUCTION, PADDY	32,019.0	41,450.0	51,348.0	63,002.2	76,883.9	91,575.9	2.6	2.2	2.1	2.0	1.8
AREA	17,564.0	19,084.0	19,262.0	19,812.0	19,685.8	20,189.3	.8	.1	.3	-.1	.3
YIELD	1.8	2.2	2.7	3.2	3.9	4.5	1.8	2.1	1.8	2.1	1.5
PRODUCTION, RICE	21,130.0	27,329.0	33,426.0	41,417.6	50,543.5	60,202.0	2.6	2.0	2.2	2.0	1.8
CONSUMPTION	20,351.0	29,042.0	34,550.0	41,004.0	51,170.5	60,808.3	3.6	1.8	1.7	2.2	1.7
PER CAPITA	146.9	159.3	150.3	143.8	149.4	154.3	.8	-.6	-.4	.4	.3
NET IMPORTS	-950.0	1,611.0	1,953.0	173.0	643.4	647.1	N.A.	1.9	-21.5	14.0	.1
ENDING STOCKS	943.0	1,316.0	4,245.0	6,189.0	4,475.0	4,821.9	3.4	12.4	3.8	-3.2	.7
MACRO VARIABLES											
POPULATION (MIL)	138.5	182.3	[illegible]	285.2	342.5	394.2	2.8	2.3	2.2	1.8	1.4
GDP, REAL 1985	31.7	62.6	[illegible]	260.8	512.9	871.2	7.0	8.2	6.6	7.0	5.4
EXCHANGE RATE	.5	.7	.8	1.1	1.7	2.8	3.4	1.3	3.5	4.7	4.7
CPI	5.8	10.0	39.4	130.6	261.4	522.9	5.6	14.7	12.7	7.2	7.2
XRT/CPI	8.4	6.8	2.0	.8	.7	.5	-2.1	-11.6	-8.2	-2.3	-2.3

Table A19 Egypt

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	4,972.0	6,619.0	7,374.0	11,459.6	13,898.7	15,448.2	2.9	1.1	4.5	1.9	1.1
AREA	1,917.0	1,909.0	1,978.0	2,186.0	2,446.0	2,492.3	.0	.4	1.0	1.1	.2
YIELD	2.6	3.5	3.7	5.2	5.7	6.2	2.9	.7	3.5	.8	.9
CONSUMPTION	5,813.0	8,969.0	13,789.0	19,443.0	23,808.1	29,028.5	4.4	4.4	3.5	2.0	2.0
PER CAPITA	224.2	271.4	332.1	367.3	373.7	386.3	1.9	2.0	1.0	.2	.3
NET IMPORTS	841.0	2,396.0	6,280.0	7,978.0	9,913.7	13,584.7	11.0	10.1	2.4	2.2	3.2
ENDING STOCKS	.0	46.0	2,187.0	883.0	1,580.0	1,624.0	N.A.	47.1	-8.7	6.0	.3
WHEAT											
PRODUCTION	1,499.0	1,519.0	1,796.0	4,284.6	5,654.6	6,100.2	.1	1.7	9.1	2.8	.8
AREA	612.0	551.0	557.0	740.0	891.3	885.2	-1.0	.1	2.9	1.9	-.1
YIELD	2.4	2.8	3.2	5.8	6.3	6.9	1.2	1.6	6.0	.9	.8
CONSUMPTION	2,490.0	4,354.0	7,469.0	10,786.0	13,339.2	16,330.4	5.7	5.5	3.7	2.1	2.0
PER CAPITA	96.1	131.7	179.9	203.8	209.4	217.3	3.2	3.2	1.3	.3	.4
NET IMPORTS	991.0	2,835.0	5,423.0	6,500.0	7,686.9	10,232.6	11.1	6.7	1.8	1.7	2.9
ENDING STOCKS	.0	.0	250.0	783.0	524.9	548.3	N.A.	N.A.	12.1	-3.9	.4
COARSE GRAINS											
PRODUCTION	2,477.0	3,355.0	3,981.0	5,381.9	6,209.8	7,118.6	3.1	1.7	3.1	1.4	1.4
AREA	1,008.0	878.0	1,013.0	1,033.0	1,081.8	1,124.2	-1.4	1.4	.2	.5	.4
YIELD	2.5	3.8	3.9	5.2	5.7	6.3	4.5	.3	2.9	1.0	1.0
CONSUMPTION	2,530.0	3,385.0	4,850.0	6,987.0	8,432.3	10,208.3	3.0	3.7	3.7	1.9	1.9
PER CAPITA	97.6	102.4	116.8	132.0	132.4	135.9	.5	1.3	1.2	.0	.3
NET IMPORTS	53.0	76.0	984.0	1,600.0	2,224.6	3,091.8	3.7	29.2	5.0	3.4	3.3
ENDING STOCKS	.0	46.0	1,937.0	100.0	1,055.1	1,075.7	N.A.	45.4	-25.6	26.6	.2
RICE											
PRODUCTION, PADDY	1,486.0	2,605.0	2,384.0	2,676.2	3,036.3	3,327.7	5.8	-.9	1.2	1.3	.9
AREA	297.0	480.0	408.0	413.0	473.0	482.9	4.9	-1.6	.1	1.4	.2
YIELD	5.0	5.4	5.8	6.5	6.4	6.9	.8	.7	1.0	-.1	.7
PRODUCTION, RICE	996.0	1,745.0	1,597.0	1,793.1	2,034.3	2,229.5	5.8	-.9	1.2	1.3	.9
CONSUMPTION	793.0	1,230.0	1,470.0	1,670.0	2,036.5	2,489.9	4.5	1.8	1.3	2.0	2.0
PER CAPITA	30.6	37.2	35.4	30.5	32.0	33.1	2.0	-.5	-1.5	.5	.4
NET IMPORTS	-203.0	-515.0	-127.0	-122.0	2.2	260.4	9.8	-13.1	-.4	N.A.	60.9
ENDING STOCKS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
MACRO VARIABLES											
POPULATION (MIL)	25.9	33.1	41.5	52.9	63.7	75.1	2.5	2.3	2.5	1.9	1.7
GDP, REAL 1985	5.1	8.7	16.5	25.6	37.9	51.6	5.4	6.6	4.4	4.1	3.1
EXCHANGE RATE	.4	.4	.7	.7	1.0	1.2	2.3	4.8	.5	2.7	2.7
CPI	15.6	21.2	51.8	247.2	765.4	2,077.3	3.1	9.4	16.9	12.0	10.5
XRT/CPI	2.2	2.1	1.4	.3	.1	.1	-.8	-4.2	-14.0	-8.3	-7.1

Table A20 India

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	68,675.0	92,797.0	113,934.0	157,555.5	181,675.7	218,074.0	3.1	2.1	3.3	1.4	1.8
AREA	92,644.0	100,377.0	103,775.0	102,348.0	106,746.9	109,595.7	.8	.3	-.1	.4	.3
YIELD	.7	.9	1.1	1.5	1.7	2.0	2.2	1.7	3.4	1.0	1.6
CONSUMPTION	73,106.0	96,513.0	116,044.0	157,076.0	187,761.3	230,750.4	2.8	1.9	3.1	1.8	2.1
PER CAPITA	168.1	176.3	168.8	184.6	180.1	188.3	.5	-.4	.9	-.2	.5
NET IMPORTS	4,923.0	3,216.0	-840.0	-1,075.0	6,855.7	13,666.4	-4.2	N.A.	2.5	N.A.	7.1
ENDING STOCKS	10,337.0	16,000.0	12,200.0	25,720.0	29,166.4	38,920.2	4.5	-2.7	7.7	1.3	2.9
WHEAT											
PRODUCTION	10,320.0	20,093.0	31,830.0	49,306.8	66,010.6	82,919.6	6.9	4.7	4.5	3.0	2.3
AREA	13,380.0	16,626.0	22,172.0	23,257.0	25,416.2	26,839.6	2.2	2.9	.5	.9	.5
YIELD	.8	1.2	1.4	2.1	2.6	3.1	4.6	1.7	4.0	2.1	1.8
CONSUMPTION	14,218.0	22,007.0	34,323.0	49,102.0	72,048.2	95,151.3	4.5	4.5	3.6	3.9	2.8
PER CAPITA	32.7	40.2	49.9	57.7	69.1	77.7	2.1	2.2	1.5	1.8	1.2
NET IMPORTS	4,398.0	2,914.0	-5.0	-550.0	6,482.8	12,769.9	-4.0	N.A.	60.0	N.A.	7.0
ENDING STOCKS	2,900.0	5,000.0	4,000.0	9,000.0	15,328.9	20,752.9	5.6	-2.2	8.4	5.5	3.1
COARSE GRAINS											
PRODUCTION	23,716.0	30,479.0	28,473.0	33,201.9	32,879.1	36,292.2	2.5	-.7	1.5	-.1	1.0
AREA	45,136.0	46,159.0	41,451.0	36,891.0	37,485.6	37,117.9	.2	-1.1	-1.2	.2	-.1
YIELD	.5	.7	.7	.9	.9	1.0	2.3	.4	2.7	-.3	1.1
CONSUMPTION	23,415.0	32,994.0	28,418.0	34,999.0	32,826.5	36,091.0	3.5	-1.5	2.1	-.6	1.0
PER CAPITA	53.8	60.3	41.3	41.1	31.5	29.5	1.1	-3.7	-.1	-2.6	-.7
NET IMPORTS	191.0	15.0	-5.0	.0	-94.7	-235.0	-22.5	N.A.	-100.0	N.A.	9.5
ENDING STOCKS	4,937.0	5,000.0	1,700.0	1,220.0	1,328.1	956.3	.1	-10.2	-3.3	.9	-3.2
RICE											
PRODUCTION, PADDY	52,011.0	63,401.0	80,527.0	112,674.0	124,290.1	148,426.1	2.0	2.4	3.4	1.0	1.8
AREA	34,128.0	37,592.0	40,152.0	42,200.0	43,845.1	45,638.2	1.0	.7	.5	.4	.4
YIELD	1.5	1.7	2.0	2.7	2.8	3.3	1.0	1.7	2.9	.6	1.4
PRODUCTION, RICE	34,639.0	42,225.0	53,631.0	75,048.8	82,785.9	98,862.1	2.0	2.4	3.4	1.0	1.8
CONSUMPTION	35,473.0	41,512.0	53,301.0	72,975.0	82,885.9	99,510.3	1.6	2.5	3.2	1.3	1.8
PER CAPITA	81.6	75.8	77.5	85.8	79.5	81.2	-.7	.2	1.0	-.8	.2
NET IMPORTS	334.0	287.0	-830.0	-525.0	467.6	1,131.5	-1.5	N.A.	-4.5	N.A.	9.2
ENDING STOCKS	2,500.0	6,000.0	6,500.0	15,500.0	12,511.5	17,209.2	9.1	.8	9.1	-2.1	3.2
MACRO VARIABLES											
POPULATION (MIL)	434.9	547.6	687.3	850.8	1,042.8	1,225.1	2.3	2.3	2.2	2.1	1.6
GDP, REAL 1985	667.1	988.9	1,358.1	2,369.9	4,454.6	8,426.9	4.0	3.2	5.7	6.5	6.6
EXCHANGE RATE	4.8	7.5	7.9	18.0	43.9	64.9	4.7	.5	8.6	9.3	4.0
CPI	16.5	30.6	64.1	155.5	352.3	712.7	6.4	7.7	9.3	8.5	7.3
XRT/CPI	28.8	24.5	12.3	11.6	12.5	9.1	-1.6	-6.7	-.6	.7	-3.1

Table A21 Indonesia

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	12,628.0	15,965.0	24,154.0	36,014.9	41,649.4	49,508.7	2.4	4.2	4.1	1.5	1.7
AREA	9,925.0	11,074.0	11,740.0	13,402.0	12,964.0	13,412.7	1.1	.6	1.3	-.3	.3
YIELD	1.3	1.4	2.1	2.7	3.2	3.7	1.3	3.6	2.7	1.8	1.4
CONSUMPTION	13,680.0	16,763.0	26,652.0	37,204.0	46,624.4	57,098.3	2.1	4.7	3.4	2.3	2.0
PER CAPITA	145.5	142.6	179.7	204.1	213.0	231.3	-.2	2.3	1.3	.4	.8
NET IMPORTS	1,052.0	1,125.0	3,519.0	2,070.0	5,031.1	7,645.8	.7	12.1	-5.2	9.3	4.3
ENDING STOCKS	53.0	763.0	2,033.0	2,074.0	3,069.9	3,631.3	30.6	10.3	.2	4.0	1.7
WHEAT											
PRODUCTION	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
AREA	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
YIELD	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
CONSUMPTION	161.0	396.0	1,388.0	1,920.0	3,778.9	5,873.8	9.4	13.4	3.3	7.0	4.5
PER CAPITA	1.7	3.4	9.4	10.5	17.3	23.8	7.0	10.8	1.2	5.1	3.3
NET IMPORTS	161.0	455.0	1,474.0	2,000.0	3,788.8	5,883.7	10.9	12.5	3.1	6.6	4.5
ENDING STOCKS	.0	233.0	283.0	330.0	414.1	512.9	N.A.	2.0	1.5	2.3	2.2
COARSE GRAINS											
PRODUCTION	2,460.0	2,825.0	3,991.0	5,307.0	7,014.9	8,448.3	1.4	3.5	2.9	2.8	1.9
AREA	2,640.0	2,939.0	2,735.0	2,900.0	3,007.4	3,050.5	1.1	-.7	.6	.4	.1
YIELD	.9	1.0	1.5	1.8	2.3	2.8	.3	4.3	2.3	2.5	1.7
CONSUMPTION	2,460.0	2,539.0	4,010.0	5,410.0	7,188.1	8,797.9	.3	4.7	3.0	2.9	2.0
PER CAPITA	26.2	21.6	27.0	29.7	32.8	35.6	-1.9	2.3	.9	1.0	.8
NET IMPORTS	.0	-286.0	19.0	60.0	193.2	369.6	N.A.	N.A.	12.2	12.4	6.7
ENDING STOCKS	.0	.0	.0	290.0	490.0	690.0	N.A.	N.A.	N.A.	5.4	3.5
RICE											
PRODUCTION, PADDY	14,953.0	19,324.0	29,651.0	45,158.6	50,933.2	60,383.0	2.6	4.4	4.3	1.2	1.7
AREA	7,285.0	8,135.0	9,005.0	10,502.0	9,956.0	10,362.2	1.1	1.0	1.5	-.5	.4
YIELD	2.1	2.4	3.3	4.3	5.1	5.8	1.5	3.3	2.7	1.8	1.3
PRODUCTION, RICE	10,168.0	13,140.0	20,163.0	30,707.9	34,634.6	41,060.4	2.6	4.4	4.3	1.2	1.7
CONSUMPTION	11,059.0	13,828.0	21,254.0	29,874.0	35,657.3	42,426.7	2.3	4.4	3.5	1.8	1.8
PER CAPITA	117.7	117.6	143.3	163.9	162.9	171.9	.0	2.0	1.3	-.1	.5
NET IMPORTS	891.0	956.0	2,026.0	10.0	1,049.0	1,392.5	.7	7.8	-41.2	59.2	2.9
ENDING STOCKS	53.0	530.0	1,750.0	1,454.0	2,165.8	2,628.3	25.9	12.7	-1.8	4.1	1.2
MACRO VARIABLES											
POPULATION (MIL)	94.0	117.5	148.3	182.3	218.9	246.8	2.3	2.4	2.1	1.8	1.2
GDP, REAL 1985	14,975.0	23,234.0	48,914.0	76,378.1	150,691.6	282,485.9	4.5	7.7	4.6	7.0	6.5
EXCHANGE RATE	.3	365.0	627.0	1,843.0	2,927.3	4,633.7	105.5	5.6	11.4	4.7	4.7
CPI	.0	12.9	62.9	145.7	276.7	516.6	80.9	17.2	8.8	6.6	6.4
XRT/CPI	796.3	2,840.2	996.3	1,265.0	1,057.8	900.5	13.6	-9.9	2.4	-1.8	-1.6

Table A22 Latin America

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	7,114.0	11,095.0	14,041.0	18,162.0	22,751.6	26,687.0	4.5	2.4	2.6	2.3	1.6
AREA	6,781.0	8,602.0	8,622.0	9,424.0	9,770.2	10,070.7	2.4	.0	.9	.4	.3
YIELD	1.0	1.3	1.6	1.9	2.3	2.6	2.1	2.4	1.7	1.9	1.3
CONSUMPTION	9,190.0	16,206.0	23,529.0	27,964.0	36,740.9	45,093.7	5.8	3.8	1.7	2.8	2.1
PER CAPITA	107.5	145.2	167.7	162.3	177.8	187.1	3.1	1.6	-.3	.9	.5
NET IMPORTS	2,070.0	4,977.0	9,761.0	10,218.0	14,075.3	18,498.1	9.2	7.0	.5	3.3	2.8
ENDING STOCKS	567.0	1,395.0	3,334.0	2,595.0	4,150.6	5,090.7	9.4	9.1	-2.5	4.8	2.1
WHEAT											
PRODUCTION	868.0	2,066.0	1,629.0	2,954.7	3,329.7	3,598.8	9.1	-2.3	6.1	1.2	.8
AREA	1,022.0	1,478.0	1,113.0	1,407.0	1,193.5	1,181.5	3.8	-2.8	2.6	-1.6	-.1
YIELD	.8	1.4	1.5	2.1	2.8	3.0	5.1	.5	3.7	2.9	.9
CONSUMPTION	2,677.0	5,743.0	7,689.0	8,965.0	12,043.8	14,548.9	7.9	3.0	1.5	3.0	1.9
PER CAPITA	31.3	51.4	54.8	52.0	58.3	60.4	5.1	.6	-.5	1.1	.3
NET IMPORTS	1,825.0	3,613.0	6,001.0	6,295.0	8,758.9	10,994.2	7.1	5.2	.5	3.4	2.3
ENDING STOCKS	40.0	506.0	899.0	896.0	1,611.0	2,062.5	28.9	5.9	.0	6.0	2.5
COARSE GRAINS											
PRODUCTION	4,850.0	6,912.0	8,590.0	11,105.5	13,887.1	16,673.1	3.6	2.2	2.6	2.3	1.8
AREA	4,733.0	5,872.0	5,785.0	6,346.0	6,612.4	6,821.2	2.2	-.1	.9	.4	.3
YIELD	1.0	1.2	1.5	1.8	2.1	2.4	1.4	2.3	1.7	1.8	1.5
CONSUMPTION	4,978.0	8,178.0	11,632.0	14,276.0	19,018.9	23,898.2	5.1	3.6	2.1	2.9	2.3
PER CAPITA	58.2	73.3	82.9	82.9	92.1	99.1	2.3	1.2	.0	1.1	.7
NET IMPORTS	94.0	1,174.0	3,510.0	3,401.0	5,151.2	7,247.4	28.7	11.6	-.3	4.2	3.5
ENDING STOCKS	223.0	377.0	1,521.0	1,130.0	1,309.0	1,544.5	5.4	15.0	-2.9	1.5	1.7
RICE											
PRODUCTION, PADDY	2,169.0	3,262.0	5,913.0	6,333.1	8,545.8	9,904.8	4.2	6.1	.7	3.0	1.5
AREA	1,026.0	1,252.0	1,724.0	1,671.0	1,964.3	2,067.9	2.0	3.3	-.3	1.6	.5
YIELD	2.1	2.6	3.4	3.8	4.4	4.8	2.1	2.8	1.0	1.4	1.0
PRODUCTION, RICE	1,396.0	2,117.0	3,822.0	4,101.8	5,534.9	6,415.0	4.3	6.1	.7	3.0	1.5
CONSUMPTION	1,535.0	2,285.0	4,208.0	4,723.0	5,678.2	6,646.5	4.1	6.3	1.2	1.9	1.6
PER CAPITA	18.0	20.5	30.0	27.4	27.5	27.6	1.3	3.9	-.9	.0	.0
NET IMPORTS	151.0	190.0	250.0	522.0	165.2	256.5	2.3	2.8	7.6	-10.9	4.5
ENDING STOCKS	304.0	512.0	914.0	569.0	1,230.7	1,483.6	5.4	6.0	-4.6	8.0	1.9
MACRO VARIABLES											
POPULATION (MIL)	85.5	111.6	140.3	172.3	206.6	241.1	2.7	2.3	2.1	1.8	1.6
GDP, REAL 19P$	20.0	31.5	48.2	54.1	70.4	89.3	4.6	4.3	1.2	2.7	2.4
EXCHANGE RATE	.0	.0	.0	.0	.1	.2	2.6	1.5	17.8	15.0	15.0
CPI	.2	.3	.6	2.6	13.5	71.0	1.0	8.4	15.9	18.0	18.0
XRT/CPI	.7	.8	.4	.5	.4	.3	1.7	-6.4	1.6	-2.6	-2.6

Table A23 Mexico

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	7,252.0	13,949.0	17,600.0	22,491.6	26,637.1	31,798.3	6.8	2.4	2.5	1.7	1.8
AREA	6,834.0	10,131.0	10,440.0	9,270.0	10,262.1	10,436.3	4.0	.3	-1.2	1.0	.2
YIELD	1.1	1.4	1.7	2.4	2.6	3.0	2.6	2.0	3.7	.7	1.6
CONSUMPTION	7,399.0	13,097.0	22,435.0	27,280.0	34,809.5	47,044.0	5.9	5.5	2.0	2.5	3.1
PER CAPITA	194.6	248.2	318.6	311.4	324.2	375.3	2.5	2.5	-.2	.4	1.5
NET IMPORTS	85.0	-337.0	8,489.0	5,370.0	8,264.3	15,327.4	N.A.	N.A.	-4.5	4.4	6.4
ENDING STOCKS	427.0	970.0	4,902.0	3,362.0	3,174.6	4,055.6	8.6	17.6	-3.7	-.6	2.5
WHEAT											
PRODUCTION	1,190.0	2,148.0	2,650.0	3,904.5	4,835.6	5,764.8	6.1	2.1	4.0	2.2	1.8
AREA	840.0	763.0	740.0	950.0	912.5	944.9	-1.0	-.3	2.5	-.4	.4
YIELD	1.4	2.8	3.6	4.1	5.3	6.1	7.1	2.4	1.4	2.6	1.4
CONSUMPTION	1,253.0	2,100.0	3,500.0	4,425.0	6,849.9	9,717.7	5.3	5.2	2.4	4.5	3.6
PER CAPITA	33.0	39.8	49.7	50.5	63.8	77.5	1.9	2.2	.2	2.4	2.0
NET IMPORTS	7.0	-35.0	1,225.0	490.0	2,037.3	3,979.1	N.A.	N.A.	-8.8	15.3	6.9
ENDING STOCKS	94.0	79.0	434.0	215.0	618.3	862.6	-1.7	18.6	-6.8	11.1	3.4
COARSE GRAINS											
PRODUCTION	5,843.0	11,531.0	14,690.0	18,386.4	21,301.0	25,438.3	7.0	2.5	2.3	1.5	1.8
AREA	5,851.0	9,218.0	9,570.0	8,245.0	9,196.6	9,336.7	4.7	.4	-1.5	1.1	.2
YIELD	1.0	1.3	1.5	2.2	2.3	2.7	2.3	2.1	3.8	.4	1.6
CONSUMPTION	5,930.0	10,734.0	18,565.0	22,395.0	27,375.1	36,551.0	6.1	5.6	1.9	2.0	2.9
PER CAPITA	156.0	203.4	263.6	255.6	254.9	291.6	2.7	2.6	-.3	.0	1.4
NET IMPORTS	81.0	-320.0	7,124.0	4,630.0	6,138.1	11,163.1	N.A.	N.A.	-4.2	2.9	6.2
ENDING STOCKS	293.0	861.0	4,385.0	3,036.0	2,376.5	2,962.4	11.4	17.7	-3.6	-2.4	2.2
RICE											
PRODUCTION, PADDY	328.0	405.0	390.0	300.0	747.8	889.4	2.1	-.4	-2.6	9.6	1.7
AREA	143.0	150.0	130.0	75.0	153.0	154.7	.5	-1.4	-5.4	7.4	.1
YIELD	2.3	2.7	3.0	4.0	4.9	5.8	1.6	1.1	2.9	2.0	1.6
PRODUCTION, RICE	219.0	270.0	260.0	200.8	500.5	595.2	2.1	-.4	-2.6	9.6	1.7
CONSUMPTION	216.0	263.0	370.0	460.0	584.5	775.3	2.0	3.5	2.2	2.4	2.9
PER CAPITA	5.7	5.0	5.3	5.3	5.4	6.2	-1.3	.5	.0	.4	1.3
NET IMPORTS	-3.0	18.0	140.0	250.0	89.0	185.2	N.A.	22.8	6.0	-9.8	7.6
ENDING STOCKS	40.0	30.0	83.0	111.0	179.8	230.7	-2.8	10.7	2.9	4.9	2.5
MACRO VARIABLES											
POPULATION (MIL)	38.0	52.8	70.4	87.6	107.4	125.6	3.3	2.9	2.2	2.1	1.6
GDP, REAL 1985	1,187.5	2,363.4	4,470.1	5,189.0	9,395.0	17,339.7	7.1	6.6	1.5	6.1	6.3
EXCHANGE RATE	12.5	12.5	23.0	2,807.0	5,223.1	10,274.6	.0	6.3	61.7	6.4	7.0
CPI	1.5	2.0	9.3	1,405.8	5,583.3	19,983.5	2.7	16.5	65.1	14.8	13.6
XRT/CPI	811.2	619.1	245.8	199.7	93.5	51.4	-2.7	-8.8	-2.1	-7.3	-5.8

Table A24 Nigeria

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	7,693.0	8,759.0	9,197.0	7,033.8	11,083.9	12,815.9	1.3	.5	-2.6	4.7	1.5
AREA	10,060.0	12,198.0	13,490.0	10,210.0	12,122.2	12,248.8	1.9	1.0	-2.7	1.7	.1
YIELD	.8	.7	.7	.7	.9	1.0	-.6	-.5	.1	2.9	1.4
CONSUMPTION	7,802.0	9,164.0	11,164.0	7,828.0	12,938.3	16,066.6	1.6	2.0	-3.5	5.2	2.2
PER CAPITA	151.2	138.5	131.8	68.9	87.4	80.7	-.9	-.5	-6.3	2.4	-.8
NET IMPORTS	109.0	396.0	2,089.0	600.0	1,875.6	3,273.7	13.8	18.1	-11.7	12.1	5.7
ENDING STOCKS	.0	67.0	514.0	3,167.0	779.8	988.0	N.A.	27.0	19.9	-13.1	2.4
WHEAT											
PRODUCTION	.0	6.0	24.0	50.0	259.7	425.9	N.A.	14.9	7.6	17.9	5.1
AREA	.0	3.0	10.0	50.0	100.0	150.0	N.A.	12.8	17.5	7.2	4.1
YIELD	.0	2.0	2.4	1.0	2.6	2.8	N.A.	1.8	-8.4	10.0	.9
CONSUMPTION	78.0	400.0	1,429.0	400.0	1,370.4	2,331.2	17.8	13.6	-12.0	13.1	5.5
PER CAPITA	1.5	6.0	16.9	3.5	9.3	11.7	14.9	10.8	-14.5	10.2	2.4
NET IMPORTS	78.0	385.0	1,400.0	350.0	1,112.6	1,909.0	17.3	13.8	-12.9	12.3	5.5
ENDING STOCKS	.0	27.0	102.0	20.0	77.7	105.7	N.A.	14.2	-15.0	14.5	3.1
COARSE GRAINS											
PRODUCTION	7,454.0	8,469.0	8,650.0	6,365.0	10,026.0	11,463.9	1.3	.2	-3.0	4.6	1.3
AREA	9,875.0	11,941.0	12,930.0	9,500.0	11,267.5	11,273.3	1.9	.8	-3.0	1.7	.0
YIELD	.8	.7	.7	.7	.9	1.0	-.6	-.6	.0	2.9	1.3
CONSUMPTION	7,484.0	8,479.0	8,885.0	6,620.0	10,269.8	11,958.2	1.3	.5	-2.9	4.5	1.5
PER CAPITA	145.0	128.1	104.9	58.3	69.4	60.1	-1.2	-2.0	-5.7	1.8	-1.4
NET IMPORTS	30.0	10.0	300.0	.0	262.3	514.6	-10.4	40.5	-100.0	N.A.	7.0
ENDING STOCKS	.0	20.0	240.0	3,036.0	669.3	855.8	N.A.	28.2	28.9	-14.0	2.5
RICE											
PRODUCTION, PADDY	360.0	427.0	786.0	930.6	1,200.3	1,392.8	1.7	6.3	1.7	2.6	1.5
AREA	185.0	254.0	550.0	660.0	754.6	825.5	3.2	8.0	1.8	1.3	.9
YIELD	1.9	1.7	1.4	1.4	1.6	1.7	-1.5	-1.6	-.1	1.2	.6
PRODUCTION, RICE	239.0	284.0	523.0	618.8	798.1	926.1	1.7	6.3	1.7	2.6	1.3
CONSUMPTION	240.0	285.0	850.0	808.0	1,298.3	1,776.8	1.7	11.5	-.5	4.9	3.2
PER CAPITA	4.7	4.3	10.0	7.1	8.8	8.9	-.8	8.8	-3.4	2.1	.2
NET IMPORTS	1.0	1.0	389.0	250.0	500.6	850.1	.0	81.5	-4.3	7.2	5.4
ENDING STOCKS	.0	.0	172.0	111.0	32.9	26.5	N.A.	N.A.	-4.3	-11.5	-2.1
MACRO VARIABLES											
POPULATION (MIL)	51.6	66.2	84.7	113.6	148.0	199.1	2.5	2.5	3.0	2.7	3.0
GDP, REAL 1985	25.8	37.1	56.5	56.7	83.0	126.1	3.7	4.3	.0	3.9	4.3
EXCHANGE RATE	.7	.7	.5	8.0	34.5	187.0	.0	-2.6	30.8	15.7	18.4
CPI	7.0	10.6	42.3	260.6	1,725.8	10,596.9	4.2	14.9	19.9	20.8	19.9
XRT/CPI	10.2	6.8	1.3	3.1	2.0	1.8	-4.0	-15.3	9.1	-4.2	-1.3

Table A25 North Africa

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	25,060.0	30,622.0	44,586.0	54,540.4	66,960.8	81,477.4	2.0	3.8	2.0	2.1	2.0
AREA	33,520.0	34,369.0	36,320.0	39,716.0	40,788.7	43,175.5	.3	.6	.9	.3	.6
YIELD	.7	.9	1.2	1.4	1.6	1.9	1.8	3.3	1.1	1.8	1.4
CONSUMPTION	28,561.0	38,911.0	63,314.0	84,625.0	109,967.5	139,823.8	3.1	5.0	2.9	2.7	2.4
PER CAPITA	274.7	281.3	342.1	345.6	353.7	367.2	.2	2.0	.1	.2	.4
NET IMPORTS	4,142.0	7,574.0	19,578.0	30,753.0	43,604.2	59,008.5	6.2	10.0	4.6	3.6	3.1
ENDING STOCKS	2,245.0	2,699.0	12,263.0	17,774.0	21,644.4	27,985.4	1.9	16.3	3.8	2.0	2.6
WHEAT											
PRODUCTION	13,956.0	17,786.0	27,233.0	34,545.1	41,736.0	51,368.1	2.5	4.4	2.4	1.9	2.1
AREA	19,461.0	21,579.0	22,354.0	23,661.0	24,398.0	25,692.1	1.0	.4	.6	.3	.5
YIELD	.7	.8	1.2	1.5	1.7	2.0	1.4	4.0	1.8	1.6	1.6
CONSUMPTION	16,672.0	23,488.0	38,062.0	48,990.0	60,949.3	77,381.0	3.5	4.9	2.6	2.2	2.4
PER CAPITA	160.4	169.8	205.7	200.1	196.1	203.2	.6	1.9	-.3	-.2	.4
NET IMPORTS	3,151.0	5,678.0	11,174.0	15,595.0	19,521.6	26,354.0	6.1	7.0	3.6	2.3	3.0
ENDING STOCKS	1,620.0	2,164.0	9,567.0	11,374.0	12,614.8	15,924.0	2.9	16.0	1.7	1.0	2.4
COARSE GRAINS											
PRODUCTION	10,422.0	11,786.0	16,251.0	18,869.7	23,864.9	28,632.9	1.2	3.3	1.5	2.4	1.8
AREA	13,617.0	12,367.0	13,543.0	15,467.0	15,963.4	17,037.2	-1.0	.9	1.3	.3	.7
YIELD	.8	1.0	1.2	1.2	1.5	1.7	2.2	2.3	.2	2.1	1.2
CONSUMPTION	10,856.0	13,829.0	22,459.0	31,669.0	44,472.0	56,841.4	2.5	5.0	3.5	3.5	2.5
PER CAPITA	104.4	100.0	121.4	129.3	143.1	149.3	-.4	2.0	.6	1.0	.4
NET IMPORTS	650.0	1,312.0	6,755.0	12,510.0	20,894.0	28,528.2	7.3	17.8	6.4	5.3	3.2
ENDING STOCKS	572.0	427.0	2,457.0	6,146.0	8,689.2	11,708.1	-2.9	19.1	9.6	3.5	3.0
RICE											
PRODUCTION, PADDY	1,027.0	1,582.0	1,672.0	1,699.3	2,053.1	2,228.8	4.4	.6	.2	1.9	.8
AREA	442.0	423.0	423.0	588.0	447.3	446.3	-.4	.0	3.3	-2.7	.0
YIELD	2.3	3.7	4.0	2.9	4.6	5.0	4.9	.6	-3.1	4.7	.8
PRODUCTION, RICE	682.0	1,050.0	1,102.0	1,125.6	1,359.9	1,476.3	4.4	.5	.2	1.9	.8
CONSUMPTION	1,033.0	1,594.0	2,793.0	3,966.0	4,546.7	5,601.2	4.4	5.8	3.6	1.4	2.1
PER CAPITA	9.9	11.5	15.1	16.2	14.6	14.7	1.5	2.7	.7	-1.0	.1
NET IMPORTS	341.0	584.0	1,649.0	2,648.0	3,188.7	4,126.2	5.5	10.9	4.9	1.9	2.6
ENDING STOCKS	53.0	108.0	239.0	254.0	340.3	353.4	7.4	8.3	.6	3.0	.4
MACRO VARIABLES											
POPULATION (MIL)	104.0	138.3	185.1	244.9	310.9	380.8	2.9	3.0	2.8	2.4	2.0
GDP, REAL 1985	312.7	633.6	1,528.5	1,675.3	2,466.8	3,708.0	7.3	9.2	.9	3.9	4.2
EXCHANGE RATE	.8	.8	.6	1.1	1.7	2.8	.0	-2.1	5.9	4.8	4.8
CPI	.2	.3	.6	1.8	5.4	16.2	2.1	8.7	11.5	11.7	11.7
XRT/CPI	363.3	295.5	103.1	61.6	32.5	17.2	-2.0	-10.0	-5.0	-6.2	-6.2

Table A26 Pakistan

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	6,043.0	11,005.0	15,488.0	19,311.2	24,122.5	29,451.6	6.2	3.5	2.2	2.2	2.0
AREA	7,990.0	9,848.0	10,559.0	11,916.0	12,607.6	13,496.0	2.1	.7	1.2	.6	.7
YIELD	.8	1.1	1.5	1.6	1.9	2.2	4.0	2.8	1.0	1.7	1.3
CONSUMPTION	7,540.0	11,804.0	14,689.0	19,746.0	26,137.0	33,953.7	4.6	2.2	3.0	2.8	2.7
PER CAPITA	164.4	194.8	177.9	175.9	174.4	179.0	1.7	-.9	-.1	-.1	.3
NET IMPORTS	978.0	888.0	-843.0	-260.0	2,035.2	4,543.2	-1.0	N.A.	-11.1	N.A.	8.4
ENDING STOCKS	996.0	1,202.0	1,204.0	4,175.0	1,695.6	2,019.7	1.9	.0	13.2	-8.6	1.8
WHEAT											
PRODUCTION	3,909.0	7,294.0	10,857.0	14,277.9	18,747.1	23,864.8	6.4	4.1	2.8	2.8	2.4
AREA	4,878.0	6,229.0	6,924.0	7,845.0	8,867.3	9,864.8	2.5	1.1	1.3	1.2	1.1
YIELD	.8	1.2	1.6	1.8	2.1	2.4	3.9	3.0	1.5	1.5	1.4
CONSUMPTION	5,454.0	8,356.0	11,200.0	15,845.0	22,098.4	28,720.7	4.4	3.0	3.5	3.4	2.7
PER CAPITA	119.0	137.9	135.6	141.2	147.4	151.4	1.5	-.2	.4	.4	.3
NET IMPORTS	1,026.0	1,075.0	320.0	920.0	3,369.4	6,874.0	.5	-11.4	11.1	13.9	3.8
ENDING STOCKS	524.0	650.0	975.0	3,019.0	1,395.9	1,577.4	2.2	4.1	12.0	-7.4	1.2
COARSE GRAINS											
PRODUCTION	1,104.0	1,511.0	1,508.0	1,780.9	1,890.2	2,009.0	3.2	.0	1.7	.6	.6
AREA	1,931.0	2,116.0	1,702.0	1,957.0	1,751.9	1,671.7	.9	-2.2	1.4	-1.1	-.5
YIELD	.6	.7	.9	.9	1.1	1.2	2.2	2.2	.3	1.7	1.1
CONSUMPTION	1,105.0	1,430.0	1,508.0	1,801.0	1,849.5	1,902.2	2.6	.5	1.8	.3	.3
PER CAPITA	24.1	23.6	18.3	16.0	12.3	10.0	-.2	-2.5	-1.3	-2.6	-2.0
NET IMPORTS	1.0	-5.0	.0	20.0	-40.8	-106.9	N.A.	-100.0	N.A.	N.A.	10.1
ENDING STOCKS	15.0	95.0	.0	.0	.0	.0	20.3	-100.0	N.A.	N.A.	N.A.
RICE											
PRODUCTION, PADDY	1,547.0	3,303.0	4,689.0	4,883.3	5,232.7	5,371.7	7.9	3.6	.4	.7	.3
AREA	1,181.0	1,503.0	1,933.0	2,114.0	1,988.3	1,959.4	2.4	2.5	.9	-.6	-.1
YIELD	1.3	2.2	2.4	2.3	2.6	2.7	5.3	1.0	-.5	1.3	.4
PRODUCTION, RICE	1,030.0	2,200.0	3,123.0	3,252.5	3,485.1	3,577.7	7.9	3.6	.4	.7	.3
CONSUMPTION	981.0	2,018.0	1,981.0	2,100.0	2,189.1	3,330.9	7.5	-.2	.6	.4	4.3
PER CAPITA	21.4	33.3	24.0	18.6	14.6	17.6	6.5	-3.2	-2.5	-2.4	1.9
NET IMPORTS	-49.0	-182.0	-1,163.0	-1,200.0	-1,293.4	-223.9	14.0	20.4	.3	.8	-16.1
ENDING STOCKS	457.0	457.0	229.0	1,156.0	299.7	442.4	.0	-6.7	17.6	-12.6	4.0
MACRO VARIABLES											
POPULATION (MIL)	45.9	60.6	82.6	112.2	149.9	189.6	2.8	3.1	3.1	2.9	2.4
GDP, REAL 1985	73.9	148.4	234.5	432.1	776.0	1,451.1	7.2	4.7	6.3	6.0	6.5
EXCHANGE RATE	4.8	4.8	9.9	21.4	41.2	78.1	.0	7.6	8.0	6.8	6.6
CPI	16.0	21.8	70.8	138.6	341.9	759.0	3.2	12.5	6.9	9.5	8.3
XRT/CPI	29.7	21.8	14.0	15.4	12.0	10.3	-3.1	-4.3	1.0	-2.5	-1.6

Table A27 South Africa

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
					TOTAL CEREALS						
PRODUCTION	6,521.0	10,698.0	16,773.0	9,724.0	17,091.2	19,781.0	5.1	4.6	-5.3	5.8	1.5
AREA	6,429.0	7,382.0	6,616.0	5,195.0	6,558.7	6,622.2	1.4	-1.1	-2.4	2.4	.1
YIELD	1.0	1.4	2.5	1.9	2.6	3.0	3.6	5.8	-3.0	3.4	1.4
CONSUMPTION	4,473.0	6,882.0	9,915.0	11,455.0	16,590.7	19,441.3	4.4	3.7	1.5	2.4	2.9
PER CAPITA	257.1	306.4	350.6	324.6	335.2	370.4	1.8	1.4	-.8	.3	1.0
NET IMPORTS	-1,610.0	-2,637.0	-4,562.0	1,040.0	-2,522.9	-431.2	5.1	5.6	N.A.	N.A.	-16.2
ENDING STOCKS	1,113.0	2,231.0	5,090.0	1,615.0	2,884.3	2,236.2	7.2	8.6	-10.8	6.0	-2.5
					WHEAT						
PRODUCTION	769.0	1,396.0	1,470.0	1,705.0	3,923.0	4,662.5	6.1	.5	1.5	8.7	1.7
AREA	1,253.0	1,930.0	1,623.0	1,550.0	1,845.1	1,945.6	4.4	-1.7	-.5	1.8	.5
YIELD	.6	.7	.9	1.1	2.1	2.4	1.7	2.3	2.0	6.8	1.2
CONSUMPTION	842.0	1,283.0	1,993.0	2,522.0	3,504.1	4,460.7	4.3	4.5	2.4	3.3	2.4
PER CAPITA	48.4	57.1	70.5	71.5	80.5	85.0	1.7	2.1	.1	1.2	.5
NET IMPORTS	73.0	157.0	242.0	730.0	-384.6	-187.7	8.0	4.4	11.7	N.A.	-6.9
ENDING STOCKS	.0	519.0	320.0	270.0	1,272.1	1,473.1	N.A.	-4.7	-1.7	16.8	1.5
					COARSE GRAINS						
PRODUCTION	5,752.0	9,302.0	15,303.0	8,019.0	13,168.2	15,118.5	4.9	5.1	-6.3	5.1	1.4
AREA	5,176.0	5,452.0	4,991.0	3,645.0	4,713.6	4,676.6	.5	-.9	-3.1	2.6	-.1
YIELD	1.1	1.7	3.1	2.2	2.8	3.2	4.4	6.0	-3.3	2.4	.5
CONSUMPTION	3,580.0	5,545.0	7,796.0	8,586.0	10,721.0	14,482.6	4.5	3.5	1.0	2.2	3.1
PER CAPITA	205.8	246.9	275.6	243.3	246.3	275.9	1.8	1.1	-1.2	.1	1.1
NET IMPORTS	-1,734.0	-2,848.0	-4,930.0	-40.0	-2,503.7	-741.7	5.1	5.6	-38.2	51.2	-11.5
ENDING STOCKS	1,113.0	1,719.0	4,770.0	1,345.0	1,612.2	763.2	4.4	10.7	-11.9	1.8	-7.2
					RICE						
PRODUCTION, PADDY	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
AREA	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
YIELD	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
PRODUCTION, RICE	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
CONSUMPTION	51.0	54.0	126.0	347.0	365.5	498.1	.6	8.8	10.7	.5	3.1
PER CAPITA	2.9	2.4	4.5	9.8	8.4	9.5	-2.0	6.4	8.2	-1.6	1.2
NET IMPORTS	51.0	54.0	126.0	350.0	365.5	498.1	.6	8.8	10.8	.4	3.1
ENDING STOCKS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
					MACRO VARIABLES						
POPULATION (MIL)	17.4	22.5	28.3	35.3	43.5	52.5	2.6	2.3	2.2	2.1	1.9
GDP, REAL 1985	24.9	44.6	62.0	73.3	96.2	131.9	6.0	3.3	1.7	2.8	3.2
EXCHANGE RATE	.7	.7	.8	2.6	4.9	11.6	.0	.9	12.7	6.6	9.0
CPI	14.5	19.0	52.0	203.9	646.9	1,853.4	2.8	10.6	14.7	12.2	11.1
XRT/CPI	4.9	3.8	1.5	1.3	.8	.6	-2.7	-8.8	-1.7	-5.0	-1.9

Table A28 South Asia

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	16,349.0	18,530.0	23,676.0	29,282.1	29,806.9	34,142.9	1.3	2.5	2.1	.2	1.4
AREA	14,614.0	15,950.0	17,289.0	17,655.0	18,148.8	18,898.1	.9	.8	.2	.3	.4
YIELD	1.1	1.2	1.4	1.7	1.6	1.8	.4	1.7	1.9	-.1	1.0
CONSUMPTION	17,497.0	19,620.0	25,347.0	32,006.0	38,926.8	46,931.9	1.2	2.6	2.4	2.0	1.9
PER CAPITA	214.4	188.7	189.2	186.5	182.6	184.2	-1.3	.0	-.1	-.2	.1
NET IMPORTS	1,148.0	1,251.0	2,080.0	2,865.0	9,160.0	12,822.5	.9	5.2	3.3	12.3	3.4
ENDING STOCKS	124.0	385.0	1,450.0	1,852.0	2,027.8	2,386.7	12.0	14.2	2.5	.9	1.6
WHEAT											
PRODUCTION	2,433.0	2,453.0	4,320.0	4,441.5	6,113.1	7,646.2	.1	5.8	.3	3.2	2.3
AREA	2,416.0	2,522.0	3,183.0	3,150.0	3,564.5	3,916.0	.4	2.4	-.1	1.2	.9
YIELD	1.0	1.0	1.4	1.4	1.7	2.0	-.3	3.4	.4	2.0	1.3
CONSUMPTION	2,795.0	3,103.0	6,067.0	6,748.0	14,192.9	18,850.1	1.1	6.9	1.1	7.7	2.9
PER CAPITA	34.3	29.8	45.3	39.3	66.6	74.0	-1.4	4.3	-1.4	5.4	1.1
NET IMPORTS	362.0	620.0	1,846.0	2,550.0	8,103.6	11,218.3	5.5	11.5	3.3	12.3	3.3
ENDING STOCKS	.0	70.0	651.0	662.0	1,234.3	1,404.7	N.A.	25.0	.2	6.4	1.3
COARSE GRAINS											
PRODUCTION	2,072.0	2,061.0	2,083.0	2,592.7	2,290.4	2,486.5	-.1	.1	2.2	-1.2	.8
AREA	1,454.0	1,415.0	1,490.0	1,717.0	1,616.5	1,664.9	-.3	.5	1.4	-.6	.3
YIELD	1.4	1.5	1.4	1.5	1.4	1.5	.2	-.4	.8	-.6	.5
CONSUMPTION	2,072.0	2,058.0	2,069.0	2,577.0	2,301.7	2,493.7	-.1	.1	2.2	-1.1	.8
PER CAPITA	25.4	19.8	15.4	15.0	10.8	9.8	-2.5	-2.5	-.3	-3.2	-1.0
NET IMPORTS	.0	-3.0	-14.0	.0	11.4	7.2	N.A.	16.7	-100.0	N.A.	-4.5
ENDING STOCKS	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
RICE											
PRODUCTION, PADDY	17,772.0	21,019.0	25,902.0	33,376.7	32,109.9	36,020.4	1.7	2.1	2.6	-.4	1.2
AREA	10,744.0	12,013.0	12,616.0	12,788.0	12,967.8	13,317.2	1.1	.5	.1	.1	.3
YIELD	1.7	1.7	2.1	2.6	2.5	2.7	.6	1.6	2.4	-.5	.9
PRODUCTION, RICE	11,844.0	14,016.0	17,273.0	22,247.9	21,403.5	24,010.1	1.7	2.1	2.6	-.4	1.2
CONSUMPTION	12,630.0	14,459.0	17,211.0	22,681.0	22,632.3	25,587.8	1.6	1.8	2.8	-.1	1.3
PER CAPITA	154.8	139.1	128.4	132.2	105.2	100.4	-1.1	-.8	.3	-2.3	-.5
NET IMPORTS	786.0	634.0	248.0	315.0	1,045.0	1,597.0	-2.1	-9.0	2.4	12.7	4.3
ENDING STOCKS	124.0	315.0	799.0	1,190.0	793.5	982.0	9.8	9.8	4.1	-4.0	[illegible]
MACRO VARIABLES											
POPULATION (MIL)	81.6	104.0	134.0	171.6	213.2	254.8	2.5	2.6	2.5	2.2	1.8
GDP, REAL 1985	6.7	9.8	12.7	19.2	30.3	46.7	3.9	2.7	4.2	4.7	4.4
EXCHANGE RATE	.2	.2	.5	1.2	3.2	8.6	1.1	11.5	9.3	10.3	10.3
CPI	18.4	24.6	56.7	160.5	417.0	1,083.6	2.9	8.7	11.0	10.0	10.0
XRT/CPI	.8	.7	.9	.8	.8	.8	-1.8	2.6	-1.5	.3	.3

Table A29 Thailand

	ACTUAL 1960	ACTUAL 1970	ACTUAL 1980	ACTUAL 1990	FORECAST 2000	FORECAST 2010	GROWTH 1960-70	GROWTH 1970-80	GROWTH 1980-90	GROWTH 1990-2000	GROWTH 2000-2010
TOTAL CEREALS											
PRODUCTION	6,819.0	10,994.0	15,013.0	15,455.0	20,107.5	23,494.6	4.9	3.2	.3	2.7	1.6
AREA	5,928.0	7,721.0	10,884.0	11,180.0	12,698.4	13,675.2	2.7	3.5	.3	1.3	.7
YIELD	1.2	1.4	1.4	1.4	1.6	1.7	2.2	-.3	.0	1.4	.8
CONSUMPTION	4,741.0	7,963.0	9,343.0	11,765.0	12,820.1	14,408.4	5.3	1.6	2.3	.9	1.2
PER CAPITA	179.6	222.8	208.1	211.1	201.9	201.8	2.2	-1.1	.5	-.4	.0
NET IMPORTS	-2,063.0	-3,256.0	-5,286.0	-5,115.0	-7,247.0	-9,053.2	4.7	5.0	-.3	3.5	2.3
ENDING STOCKS	984.0	1,524.0	2,162.0	1,130.0	2,259.9	2,580.1	4.5	3.6	-6.3	7.2	1.3
WHEAT											
PRODUCTION	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
AREA	.0	.0	.0	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.
YIELD	.0	.0	.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
CONSUMPTION	32.0	64.0	190.0	395.0	503.6	710.0	7.2	11.5	7.6	2.5	3.5
PER CAPITA	1.2	1.8	4.1	7.1	7.9	9.9	4.0	8.6	5.7	1.1	2.3
NET IMPORTS	32.0	63.0	160.0	385.0	508.9	715.8	7.0	9.8	9.2	2.8	3.5
ENDING STOCKS	.0	19.0	67.0	662.0	126.9	180.2	N.A.	13.4	25.7	-15.4	3.7
COARSE GRAINS											
PRODUCTION	544.0	2,038.0	3,550.0	4,054.5	4,307.3	5,493.6	14.1	5.7	1.3	.6	2.4
AREA	285.0	867.0	1,684.0	1,530.0	1,634.4	1,913.7	11.8	6.9	-1.0	.7	1.6
YIELD	1.9	2.4	2.1	2.7	2.6	2.9	2.1	-1.1	2.3	-.1	.8
CONSUMPTION	10.0	230.0	1,198.0	3,070.0	3,771.1	5,421.1	36.8	17.9	9.9	2.1	3.7
PER CAPITA	.4	6.4	25.7	55.1	59.4	75.9	32.7	14.8	7.9	.8	2.5
NET IMPORTS	-519.0	-1,743.0	-2,397.0	-1,300.0	-535.4	-61.9	12.9	3.2	-5.9	-8.5	-19.4
ENDING STOCKS	390.0	273.0	115.0	128.0	270.8	277.4	-3.5	-8.3	1.1	7.8	.2
RICE											
PRODUCTION, PADDY	9,508.0	13,570.0	17,368.0	17,273.5	23,939.7	27,289.5	3.6	2.5	-.1	3.3	1.3
AREA	5,643.0	6,854.0	9,200.0	9,650.0	11,064.0	11,761.4	2.0	3.0	.5	1.4	.6
YIELD	1.7	2.0	1.9	1.8	2.2	2.3	1.6	-.5	-.5	1.9	.7
PRODUCTION, RICE	6,275.0	8,956.0	11,463.0	11,400.5	15,800.2	18,011.0	3.6	2.5	-.1	3.3	1.3
CONSUMPTION	4,699.0	7,669.0	7,955.0	8,300.0	8,545.5	8,277.3	5.0	.6	.4	.3	-.3
PER CAPITA	178.0	214.5	170.3	157.3	134.6	115.9	1.9	-2.3	-.8	-1.5	-1.5
NET IMPORTS	-1,576.0	-1,576.0	-3,049.0	-4,200.0	-7,220.5	-9,707.0	.0	6.8	3.3	5.6	3.0
ENDING STOCKS	594.0	1,232.0	1,980.0	340.0	1,864.2	2,122.5	7.6	4.9	-16.2	18.6	1.3
MACRO VARIABLES											
POPULATION (MIL)	26.4	35.7	46.7	55.7	63.5	71.4	3.1	2.7	1.8	1.3	1.2
GDP, REAL 1985	155.8	342.3	658.5	1,341.9	3,175.4	6,508.0	8.2	6.8	7.4	9.0	7.4
EXCHANGE RATE	21.2	20.8	20.5	25.6	23.2	21.7	-.2	-.2	2.3	-1.0	-.7
CPI	24.8	31.0	78.7	121.1	192.5	285.0	2.3	9.7	4.4	4.7	4.0
XRT/CPI	85.4	67.0	[illegible]	21.1	12.1	7.6	-2.4	-9.0	-2.1	-5.5	-4.5

Chapter IX. Alternative Simulation Results

How easily could the surplus in the world's cereals markets be upset? Not easily, it appears, but several scenarios for such an event are considered in this chapter. First, minor variations to the assumptions for the Baseline Simulation are considered such as higher income and population growth rates. Second, major variations from the Baseline assumptions are considered such as zero-yield-growth after 1990 and sharply higher consumption levels in developing countries. The minor variations are intended to represent likely alternatives to the Baseline Simulation while the major variations are intended to represent extreme cases. Even though the major variations are considered unlikely, they are included to deepen our understanding of the world food outlook. The effects of each alternative are estimated separately.

The effects of the minor variations to the Baseline assumptions can be evaluated reasonably well with the econometric model. The major variations are more difficult to evaluate because they are outside the range of historical experience and they could well lead to policy as well as economic changes. The econometric model can still be useful in indicating the magnitude of the adjustment required, but it cannot project the types of government policy responses which are likely.

The minor variations considered are for 10% higher GDP growth, higher population growth as specified in the United Nations' high variant alternative and a temporary doubling of energy and fertilizer prices. The major variations considered are for zero-yield-growth after 1990 and a high consumption alternative for the developing countries. The zero-yield-growth alternative could be interpreted as being caused by severe environmental or biological constraints. It could also be viewed as the result of strict environmental legislative controls on fertilizers or agricultural chemicals. How long could the world continue to meet food demand without further growth in cereal yields?

The high consumption alternative for the developing countries implies future food consumption patterns which are greatly different from the past 15 years--a period in which consumption has grown slowly. Under this scenario of greatly improved diets in developing countries, cereals consumption for all consumers in developing countries is raised to the level of the country with the highest consumption in each region in 1990. This would more than double per capita cereals consumption in some countries.

Minor Variations to the Baseline Simulation

The first minor variation to the Baseline considered is the effect of more rapid population growth. Rather than a slowing of population growth rates, as most experts expect, population growth rates are assumed to increase. This is implemented in the model by simulating the high variant population growth from 1990 to 2010 from the United Nations' population projection.

All other assumptions are the same as for the Baseline Simulation. The high variant population growth rates are shown in Table 9.1 along with the medium variant assumptions used in the Baseline Simulation. World population grows to 7.38 billion by 2010 under the high variant assumption compared to 7.05 billion under the medium variant assumption--an increase of 4.7%. Population in the developing countries reaches 6.02 billion under the high variant compared to 5.74 billion under the medium variant. Population in the developed countries reaches 901 million in 2010 under the high variant compared to 862 million under the medium variant and in the former CPEs population increases to 462 million under the high variant alternative compared to 450 million under the medium variant. Since other assumptions are unchanged, the world has a larger population and reduced per capita incomes. This increases world food demand as the effect of the larger weight of population on consumption offsets the effect of the lower per capita incomes.

The second minor variation assumes 10% faster GDP growth over the projection period beginning in 1993 as compared with the Baseline Simulation growth rates. A 10% higher GDP growth rate over an extended period is a significant increase for most countries.

The third minor variation to the Baseline assumes the petroleum price doubles in real terms over the two-year period 1993-94 and then decline in equal increments to its Baseline level over the next four years. This variation is not so minor, but it is within the range of past experience and is much more likely than the major variations considered. This scenario could be consistent with any number of events such as a political disturbance in the Middle East which causes oil exports to be reduced and then rebuilt over several years. The rise in energy prices is assumed to cause nitrogen fertilizer prices to follow the same path since petroleum is a major input into chemical nitrogen fertilizer production. The scenario is implemented in the model through higher nitrogen fertilizer prices which are included in the estimated crop yield equations. As fertilizer prices rise, crop yields decline and production is reduced. This causes higher cereals prices which partly offset the higher fertilizer prices.

Simulation Results

Grains prices rise under each of the minor variations relative to the Baseline Simulation, but the world grains markets accommodate each alternative with relative ease. The high population growth alternative would cause real wheat prices to rise by an estimated 10.2% by the year 2010 (Figure 9.1). The high GDP alternative would cause real wheat prices to rise by an estimated 6.7% relative to the Baseline by 2010, and the higher energy/fertilizer price scenario would cause wheat prices to rise by an estimated 19.7% relative to the Baseline and then decline back to the Baseline over a 5-7 year period.

Prices remain higher throughout the simulation period for the high population and high GDP alternatives reflecting consistently greater demand. Prices rise more quickly under the high energy/fertilizer price scenario before falling back to the Baseline levels. The largest impact of the higher energy/fertilizer prices occurs in 1996--after the peak in energy/fertilizer prices. The

Table 9.1 Population growth rates for the Baseline Simulation and High Population Alternative

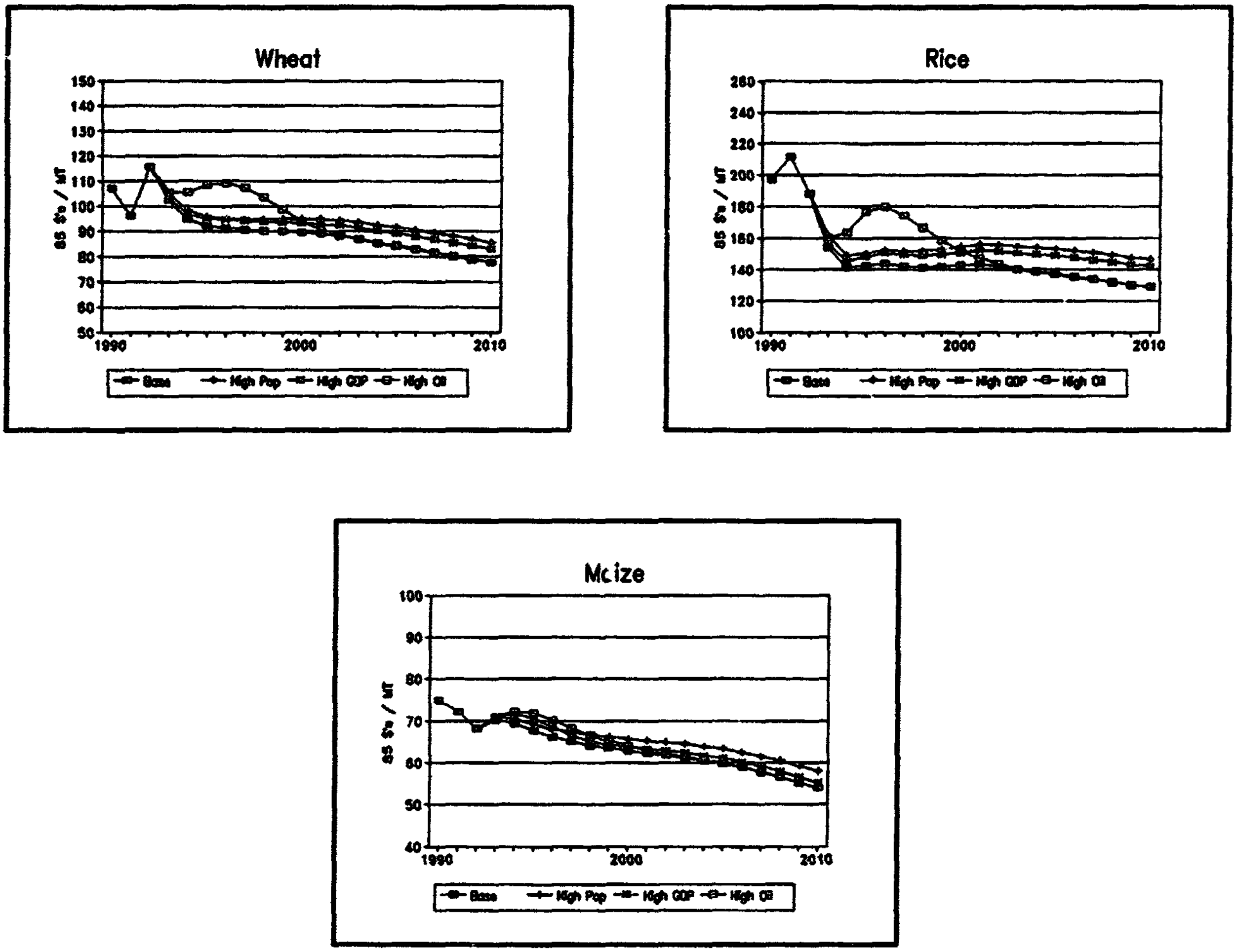
	1990-2000	2000-2010	1990-2000	2000-2010
	----Baseline Simulation----		--High Population Alternative--	
	(% p.a.)			
World	1.6	1.4	1.8	1.6
Industrial Countries	0.4	0.3	.6	.5
Australia	1.1	0.9	1.4	1.2
Canada	0.7	0.6	.9	.8
EC-10	0.2	0.0	.3	.2
Japan	0.4	0.2	.5	.4
Other	0.5	0.4	.6	.5
United States	0.7	0.5	.9	.9
Former CPEs	0.5	0.5	.6	.7
Eastern Europe	0.3	0.3	.4	.5
FSU	0.6	0.6	.7	.8
Developing Countries	2.0	1.6	2.2	1.8
Argentina	1.2	1.0	1.3	1.3
Brazil	1.8	1.5	2.1	1.8
Central Africa	3.1	3.1	3.2	3.3
China	1.3	0.7	1.6	.9
East Asia	1.8	1.4	2.1	1.7
Egypt	1.9	1.7	2.1	1.9
India	2.1	1.6	2.2	1.8
Indonesia	1.8	1.2	2.0	1.5
Latin America	1.8	1.6	2.0	1.8
Mexico	2.1	1.6	2.2	1.7
Nigeria	2.7	3.0	2.8	3.4
North Africa	2.4	2.0	2.6	2.3
Pakistan	2.9	2.4	3.3	2.8
South Africa	2.1	1.9	2.2	2.0
South Asia	2.2	1.8	2.4	2.1
Thailand	1.3	1.2	1.7	1.5

Source: World Population Prospects 1990, Department of International Economic and Social Affairs, United Nations, New York, 1991.

price of rice rises more than wheat and the maize price increases less than wheat reflecting the relative demand and supply elasticities and stock levels.

The increase in cereals prices due to the doubling of energy/fertilizer prices is much less than the increase experienced during the first oil price shock of the early 1970s. This difference is due to several factors. First, stocks of cereals were lower before the energy/fertilizer price increases in 1973/74 than in 1993. Secondly, other factors such as the crop production shortfall in the USSR in the early 1970s and the drought in the United States in 1974 are not assumed to be repeated. Thirdly, GDP effects are not included.

Figure 9.1 Grains prices for the Baseline Simulation and the Minor Variation Alternatives, 1990-2010



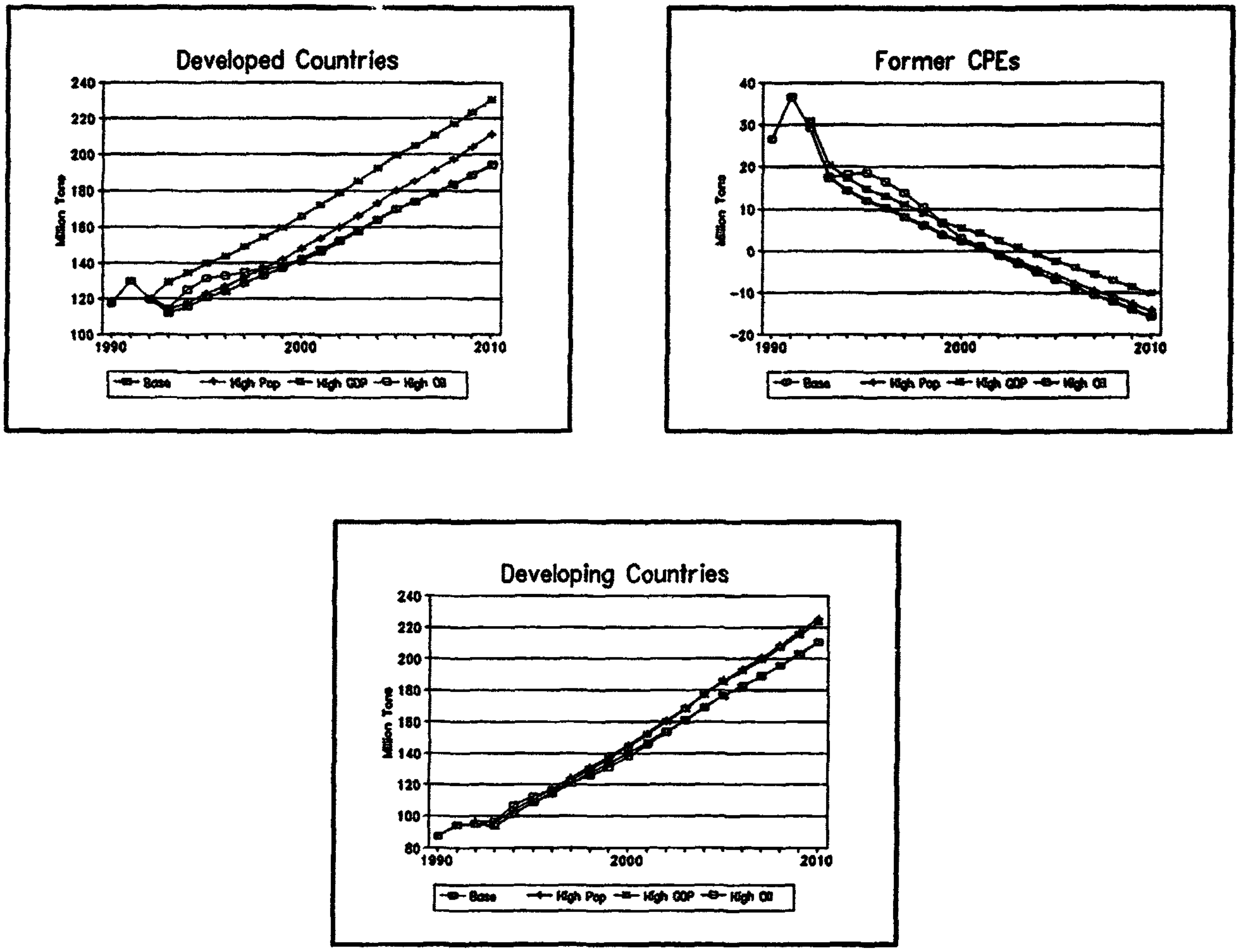
Source: Projected data from 1993 to 2010 are from the simulation.

Grain trade would expand under each of the alternative simulations as the developing countries and the former CPEs increase net imports. Under the high population alternative, the developing countries increase net imports from 210.0 million tons to 225.3 million tons by 2010 (Figure 9.2). The high GDP alternative causes imports by the developing countries to rise to 223.0 million tons by 2010. The high energy/fertilizer alternative causes imports to rise during the period of high prices and then return to the Baseline Simulation level over the longer term. The greatest increase in net imports under this alternative occurs in 1994 when imports increase 5.4 million tons relative to the Baseline.

Net exports by the former CPEs fall from 15.6 to 14.1 million tons by 2010 under the high population alternative and to 9.9 million tons under the high GDP alternative as domestic consumption increases. The rise in imports under the high energy/fertilizer price alternative causes imports to rise from 12.1 million tons under the Baseline Simulation to 18.6 million tons in 1995--the year of the greatest impact.

The developed countries increase grain exports by 16.8 million tons under the high population alternative and by about 36.1 million tons under the high GDP alternative. The high energy/fertilizer price alternative causes net grain exports to rise from 120.5 million tons to 131.1 million tons in 1995 and then exports return to the Baseline by about the year 2000.

Figure 9.2 Grain net trade for the Baseline Simulations and the Minor Variation Alternatives, 1990-2010

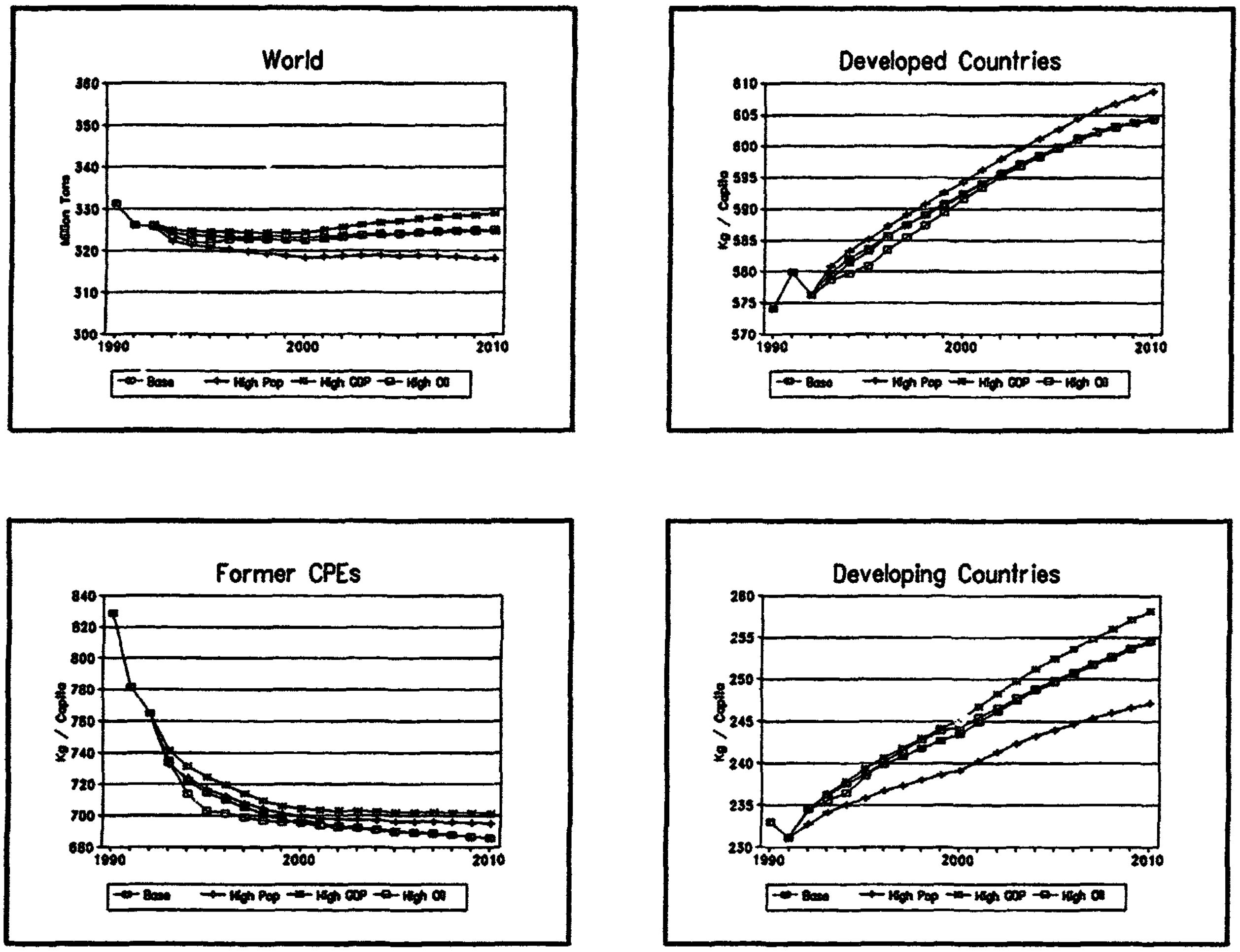


Source. ojected data from 1993 to 2010 are from the simulation.

World consumption of grains increases by 2.6% by 2010 under the high population alternative relative to the Baseline, this compares to a rise of 4.7% in world population. The less than proportionate increases in consumption is due to the combined effects of higher grain prices and lower per capita GDP levels. Under the high GDP alternative, world grain consumption rises by only 1.2% due to the relatively low estimated income elasticities and the offsetting effects of higher grains prices.

Per capita world grain consumption falls by 2.1% by 2010 under the high population alternative and rises by 1.2% by 2010 under the high GDP alternative (Figure 9.3). In the developing countries, per capita grain consumption falls by 2.9% by 2010 under the high population alternative and increases by 1.5% under the high GDP alternative.

Figure 9.3 Per Capita Grain Consumption for the Baseline Simulations and the Minor Variation Alternatives, 1990-2010



Source: Projected data from 1993 to 2010 are from the simulation.

Major Variations to the Baseline Simulation

The major variations to the Baseline Simulation are designed to stretch the limits of possible outcomes--to simulate the unlikely. The two alternatives considered are for zero-yield-growth after 1990 and for sharply higher consumption levels in developing countries. Both alternatives would severely press agriculture to produce. Formulation of the outcomes of each alternative can only be approached using a combination of past experience, economic reasoning and results from the simulation model because the events assumed differ so greatly from the past. However, it becomes clear that either variation would provide serious challenges to the world food system.

Zero-yield-growth Scenario

Increases in cereal yields have provided about 90% of the growth in world cereal production since 1950, with growth of 2.2% p.a. during 1950-90 and 2.5% p.a. during 1980-90 (USDA). Some are concerned that past rates of increase are not sustainable because of possible environmental degradation or because the high yield levels already attained in many countries may represent a biological limit (Brown, et al., 1990, page 75). We have presented arguments earlier that the evidence for this view is weak, but suppose we take things to an extreme and assume that grain yields will not increase from the 1990 levels. What could be the consequences?

Production could still rise by an estimated 15% over a decade's time by bringing land which could be used for cereals back into production and because of other adjustments which would increase production. If the cereal area harvested rose to the highest level achieved in each country during 1980-90, world production would rise by 10.3% from the 1990 levels without further yield increases. This is possible because many countries idled cropland during the 1980s due to low prices and weak demand. In the developed countries, cropland used for cereals could increase 14.9% relative to 1990, while in the former CPEs crop area could by 15.1%. The developing countries would have the smallest increase (5.5%) because they have generally been increasing the area planted to cereals during the 1980s. A return to the highest area harvested during the 1980s seems reasonable if yields were not increasing because import demand would be increasing and prices would be rising. Additional land would also likely be brought into production by land-surplus countries. Other production increasing activities such as expanding irrigated area and improved management practices would add additional output in response to higher prices. We approximate these increases at 5%, bringing the total world production increase to 15% by the year 2000.

According to the Baseline Simulation, world consumption rises by 14.4% from 1990 to 2000. However, without increasing yields, cereals prices would increase substantially and reduce this expansion in consumption somewhat. Based on these approximations, it appears that world production could keep pace with consumption for about a decade after yields stopped increasing. Beyond this, it would be essential for yield increases to again resume. The growth in consumption and production would not necessarily occur in the same countries and this would cause regional imbalances which would increase the level of trade.

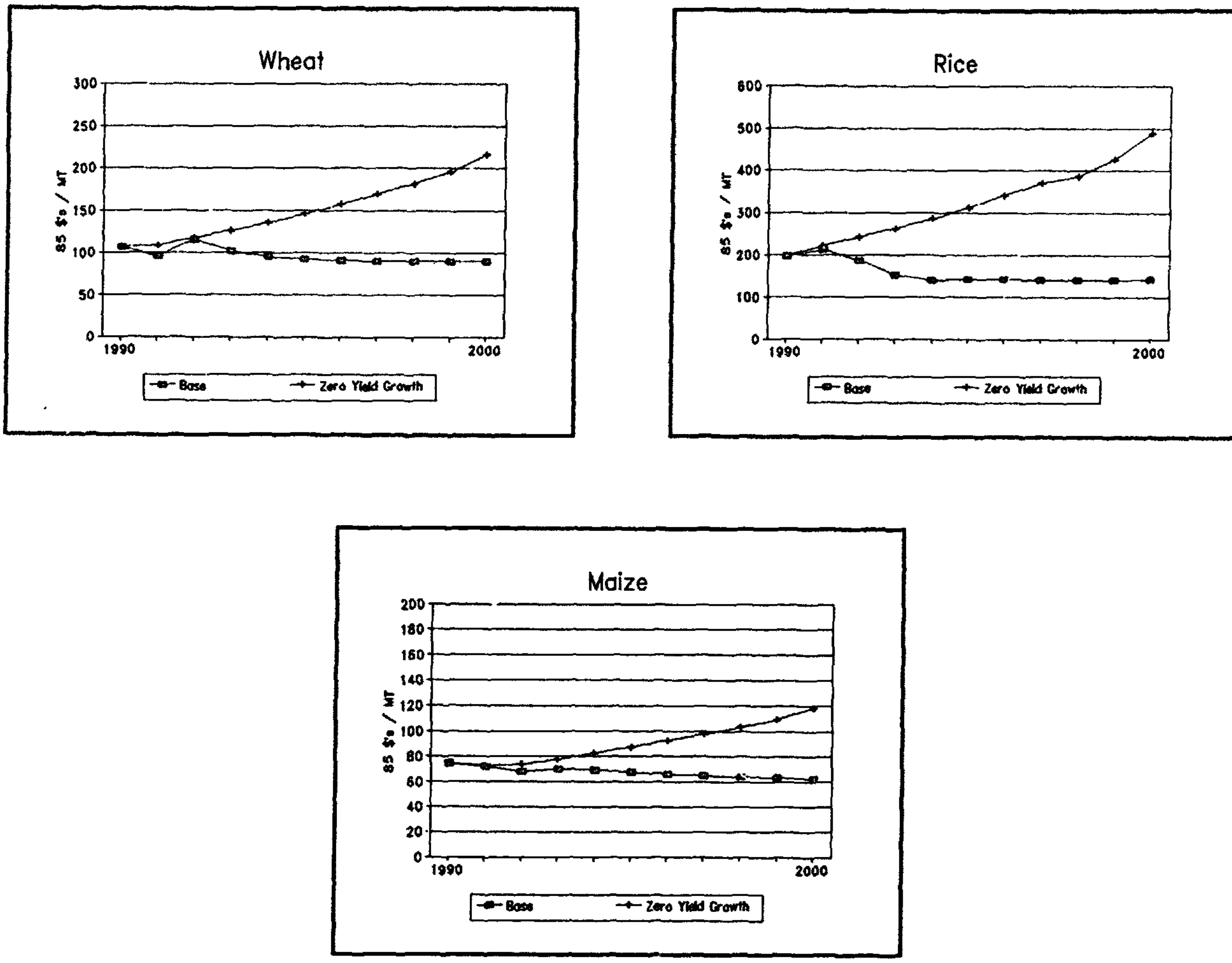
Zero-yield-growth would have a more severe impact on the developing countries than on the former CPEs or on the developed countries, and the impact would be felt more quickly. Higher population and income growth rates in the developing countries cause the demand for cereals to grow at more than double the rates in developed countries. And, because the developing countries have little idle cropland which could be brought into production, they have a smaller cushion than the developed countries or the former CPEs. Rising cereals prices would also adversely affect the developing countries, because on balance they are large cereal net importers.

We have simulated this scenario to test our reasoning against the model responses and to estimate the price increases needed to balance world demand and supply. Based on our simulated results, world grains prices in constant dollars would more than double the Baseline Simulation levels by the year 2000 (Figure 9.4). Wheat prices would rise by an estimated 141 percent, rice by 241 percent and maize by 88 percent. Grains prices would still be well below their 1974 peak levels in constant dollars. Wheat prices, for example, would rise to $216/ton by 2000 in constant 1985 dollars compare to the actual price of $353/ton in 1974.

The simulated increase in grain production in the developing countries from 1990 to 2000 is 8% (Figure 9.5). This is less than half of the increase of 20.9 percent under the Baseline Simulation which included trend yield growth. Production in the developed countries increases by an estimated 7% reflecting the relative ease with which cropland can be increased in these countries. The former CPEs decrease production under both the Baseline Simulation and the zero-yield-growth simulation because of restructuring which is taking place in agriculture. The zero-yield growth simulation reduced production in the former CPEs by 7.6% by 2000 relative to the Baseline Simulation. These changes may understate the actual production responses because they exclude any yield response to the higher prices as a result of increased irrigation, for example. A doubling of real grains prices would provide strong incentives for farmers to improve all aspects of the production process and could easily lead to an additional 5% of production.

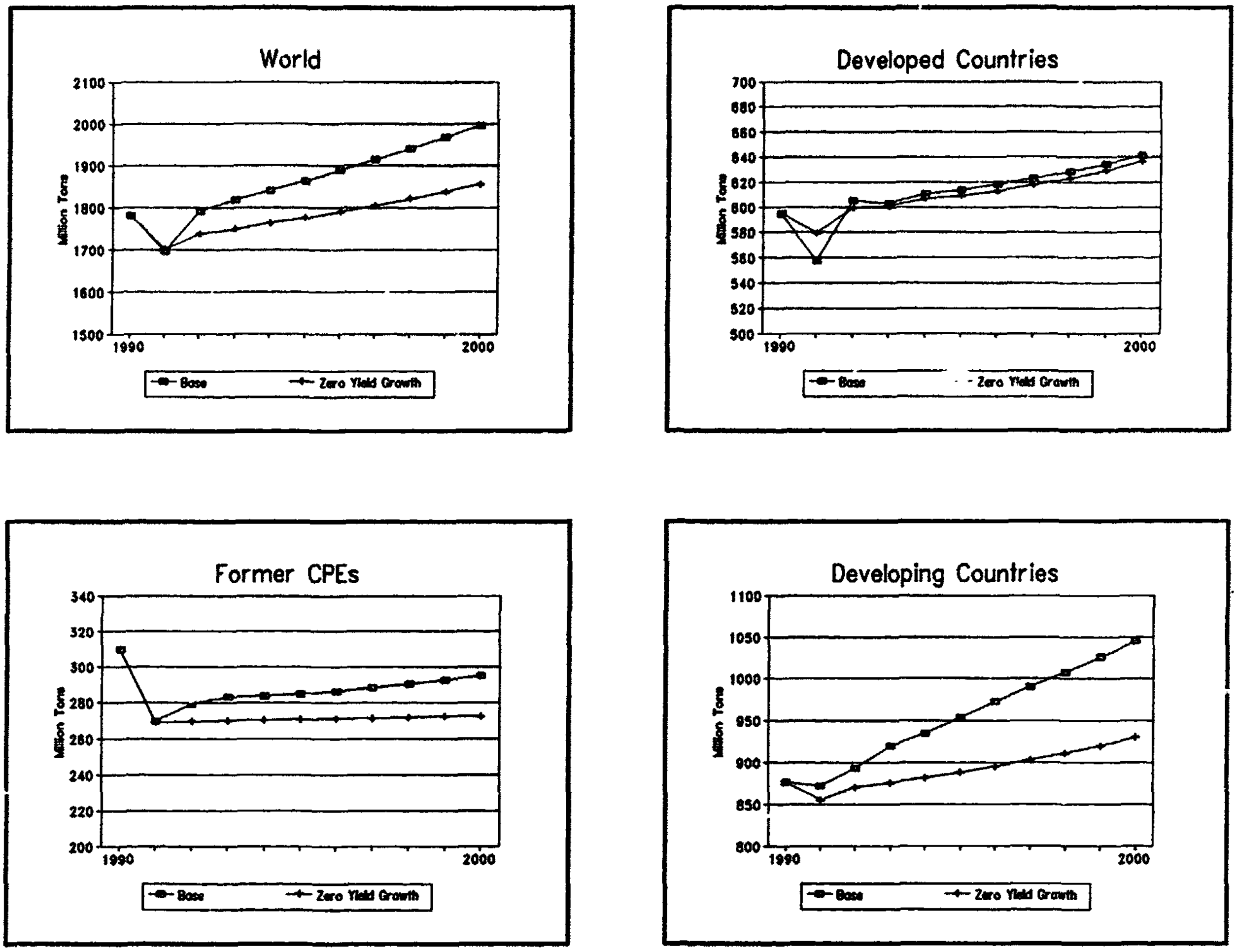
Net imports increase in the developing countries and former CPEs to partially offset the lower production (Figure 9.6). Together they would import about 30 million tons more grain than under the Baseline Simulation in the year 2000. The former CPEs would offset a greater proportion of the production shortfall through increased imports. However, this is largely based on past behavior and may not reflect recent political and economic changes in these countries. The developing countries are only able to offset 10% of their 114 million tons production shortfall by 2000 due to the impact of higher real grain prices on import demand. The higher imports would allow per capita consumption levels to be largely maintained in the former CPEs but not in the developing countries. By the year 2000, per capita consumption declines by about 5.8% in the developing countries relative to the Baseline Simulation (Figure 9.7).

Figure 9.4 Grains prices for Zero-Yield-Growth and Baseline Simulations, 1990-2000



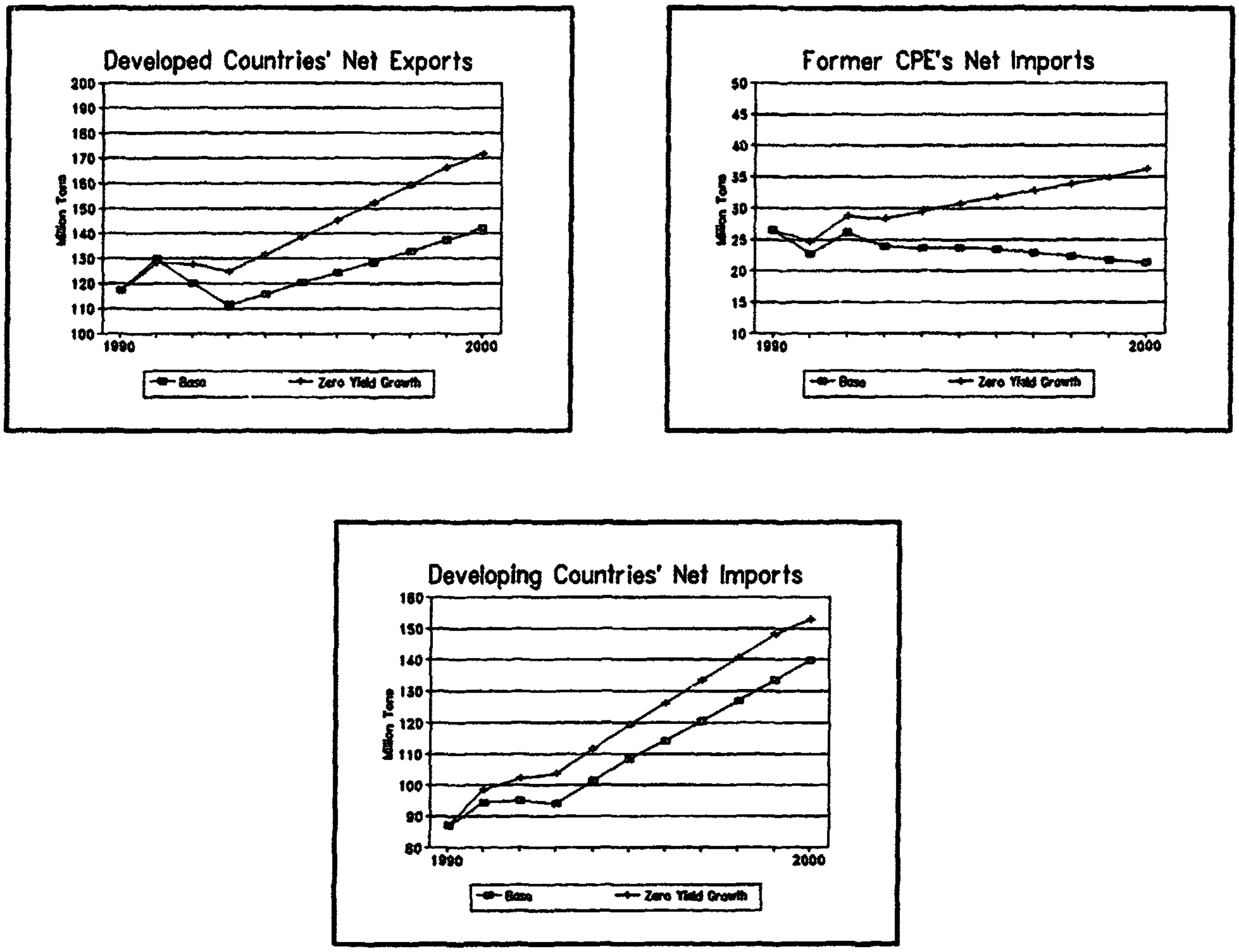
Source: Projected data from 1993 to 2000 are from the simulation.

Figure 9.5 Grain production for Zero-yield-growth and Baseline Simulations, 1990-2000



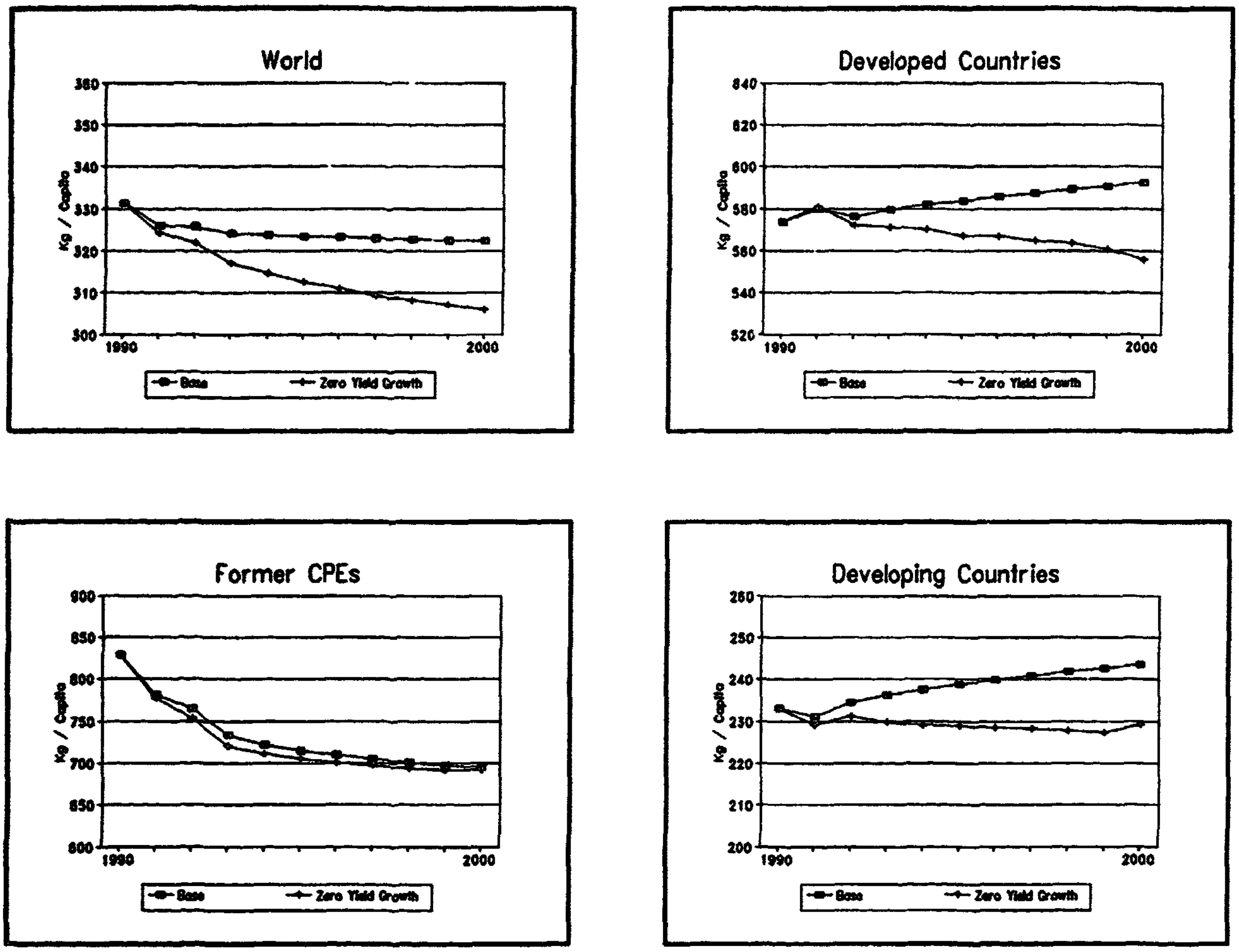
Source: Projected data from 1993 to 2000 are from the simulation.

Figure 9.6 Grain net trade for Zero-Yield-Growth and Baseline Simulation, 1990-2000



Source: Projected data from 1993 to 2000 are from the simulation.

Figure 9.7 Per capita grain consumption for Zero-Yield-Growth and Baseline Simulations, 1990-2000



Source: Projected data from 1993 to 2000 are from the simulation.

Changing Diets in Developing Countries

Demand studies show that diets in developing countries are diversifying to include less direct consumption of cereals and more meat, animal products, fruits and vegetables (see Chapter 5). As incomes rise further these changes are expected to continue. How rapidly diets in developing countries change in the future will be very important to the world food situation. We project modest changes in per capita cereals consumption in the Baseline Simulation, but what would be the consequences of more rapid change?

In defining the type of consumption alternatives which are possible, it is important to acknowledge the role of culture and demography in shaping diets. For example, it does not seem likely that Asian consumers will quickly adopt the diets of Western Europe or the United States. Rather, they will more likely follow the path of dietary change of other Asian countries which have had rapid economic development such as Japan, the Republic of Korea or Hong Kong. Likewise, the diets of Latin American consumers would probably differ greatly from those of Asia or Africa even after dietary improvements in all regions. Consequently, we consider benchmark diets for each region of developing countries and ask: What would be the consequence of achieving this diet?

The benchmark is taken to be the per capita grain consumption of the developing country in each region with the highest consumption in 1990. These are shown in Table 9.2 along with the average grain consumption level of the developing countries in each region. Achieving these benchmark levels would represent significant improvements in the diets of some consumers. The benchmark countries for each region are Senegal for Sub-saharan Africa, the Republic of Korea for Asia, Mexico for Latin America and the Caribbean, and Egypt for North Africa and the Middle East. The benchmark levels of consumption in Asia, Latin America & Caribbean, and North Africa & Middle East range from 321 to 376 kg per capita, while the benchmark for Sub-saharan Africa is much less at 201 kg. These figures compare with an average per capita grain consumption of 573 kg in the industrial countries.

Total consumption in the developing countries would need to increase by an estimated 44% from 1990 levels for all developing countries to reach the benchmark levels. The total grain required would be about 414 million tons, which is about 24% of 1990 world production and more than double the 195 million tons of grain traded in the world market in 1990. India accounts for about one-third of this total increase at 145 million tons. The other countries with the lowest consumption levels relative to the benchmark are Pakistan and Nigeria.

Such large increases in consumption would not be easily achieved, since the countries with the lowest consumption relative to the benchmark are also among the poorest. The required increases would probably need to come mostly from domestic

Table 9.2 Per capita and total grain consumption in Developing Countries, 1990

Country/ Region	Per Capita Consumption	Total Consumption	Increase to Achieve Benchmark	
	(kg per capita)	(mil tons)	(percent)	(mil tons)
All Developing	243.16	937.91	44.2	414.1
Africa, Sub-Saharan	122.57	63.81		
Central Africa	121.20	44.53	65.8	29.3
Nigeria	66.56	7.83	202.0	15.8
South Africa	321.57	11.46	-	-
Benchmark (Senegal)	201.00			
Asia	256.28	664.09		
China	297.30	331.46	19.7	65.4
East Asia	260.54	74.83	36.6	27.4
India	185.21	157.08	92.2	144.9
Indonesia	204.54	37.20	74.0	27.5
Pakistan	175.71	19.75	102.6	20.3
South Asia	185.56	32.01	91.9	29.4
Thailand	208.80	11.77	70.5	8.3
Benchmark (Rep of Korea)	356.00			
Latin America & Carrib	238.99	105.95		
Argentina	310.94	10.04	3.2	.3
Brazil	270.18	40.66	18.8	7.6
Latin America	161.30	27.96	99.0	27.7
Mexico	313.00	27.28	-	-
Benchmark (Mexico)	321.00			
North Africa & Middle East	344.62	104.07		
Egypt	358.83	19.44	4.8	.9
North Africa	341.51	84.63	10.1	9.3
Benchmark (Egypt)	376.00			

Note: The benchmark country is the developing country in each region with the highest per capita grain consumption in 1990.
Source: Grain consumption data are from USDA and population is from the International Financial Statistics, IMF.

production rather than imports. If the increase was to be provided solely by domestic production, an average increase in production of about 3.7% p.a. would be required for a decade. This is in addition to the increased production required to offset population growth. Overall, therefore, grain production in developing countries would need to increase by an average of about 6% p.a. for a decade to reach the benchmark consumption level in each region. This would be nearly double the 3.1% p.a. growth during the 1970s in the early phases of the green revolution and seems unattainable given current knowledge.

The simulation model cannot contribute much to furthering our understanding of this alternative. Sharply higher imports would cause prices to rise, but the model cannot respond with a tripling of grain trade (and probably the world can't either). The most likely outcome which would raise consumption levels to the benchmark in each region would seem to be for higher grain yields which might be part of a second generation green revolution. This is not impossible and may occur with the help of continued research and biotechnology; however, it would probably require longer than a decade. Without such a breakthrough, the only other alternative which would raise per capita consumption levels would be for sharply lower population growth rates than projected.

Summary

The alternative simulations show that moderately increased rates of growth in population, income or energy/fertilizer prices compared to the Baseline levels would only slow the decline of real cereal prices. Cereal prices still decline significantly over the forecast period. Only an extreme break with past trends in cereal production or consumption would reverse the trend of declining cereal prices over the next 15 to 20 years.

If population grew at the high variant of the United Nations projection to 2010, wheat prices would rise by an estimated 17.2% relative to the Baseline Simulation by the year 2010 for example. Wheat prices would still decline by an estimated 29% from 1990 levels, but this decline would be less than projected under the Baseline Simulation which assumes the medium population growth projection.

More rapid GDP growth would also cause real cereal prices to be higher than the Baseline. According to the simulation, 10% faster real GDP growth in all countries would cause real wheat prices to rise 6.7% relative to the Baseline 2010 level. Real prices would still decline by 23% from 1990 levels over the forecast period as the rise in world grain imports is not large enough to raise prices significantly.

A doubling of energy/fertilizer prices would raise wheat prices by an estimated 19.7% relative to the Baseline Simulation. However this rise would be temporary if energy prices subsequently fell. Cereals prices decline to the Baseline over several years if energy/fertilizer prices return to their Baseline levels.

The major variations considered show possible limits of outcomes for world cereals yield growth and cereals demand in developing countries. If cereal yields remained frozen at 1990 levels because of biological or environmental limits, cereal prices would about double in a decade, but world demand and supply would still balance. The estimated price increases are less than occurred during the early 1970s when energy prices rose sharply and cereals prices tripled. Beyond a decade, significant adjustments in diets and resource use would be required if yields did not increase. The second alternative, which considered sharply higher cereals consumption in developing countries, shows that most of the increases would need to come from increased domestic production. Increased imports can supplement domestic production increases and can provide variety to diets and increased consumption in years of domestic production shortfall, but they cannot lift consumption levels significantly for all developing countries.

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Chapter X. Summary and Conclusions

Since Malthus wrote his essay on population in 1798, many have been concerned that with growing population the world would be less and less able to feed itself. This hasn't occurred, but modern day Malthusians warn that Malthus will ultimately be right. The evidence to support this view is scant but the arguments are compelling: population keeps expanding; no new land is being created; crop yields have increased considerably and may have peaked; and the environment may not tolerate the pressure of more intensive agriculture. Yet the evidence to the contrary is also compelling: prices of agricultural commodities are at their lowest level in history; crop yields continue to rise faster than population; and world cereals yields grew more rapidly during the 1980s than during the 1960s or the 1970s.

Despite the concerns expressed, the food situation has improved dramatically for most of the world's consumers. World output of cereals, the main food source for most consumers, has increased by 2.7% per annum since 1950 while population has grown by about 1.9% per annum. Cereal yields alone have increased more rapidly than world population since 1950--at 2.24% per annum. This has allowed per capita calorie consumption in developing countries to increase by about 27% since the early-1960s. These gains offer the hope that access to food will cease to be a problem for most of the world's consumers.

This does not mean that all people have adequate diets, but rather that the diets for most of the world's consumers have improved dramatically in recent years and they should continue to improve. Moreover, food will likely be available at prices which are lower than today. The proportion of the population who lack the necessary income to purchase food should become smaller. Periodic food shortages caused by weather disturbances will still occur, but the problem of inadequate world food production over extended periods seems to be past.

Sub-Saharan Africa remains the primary exception to these general developments, with stagnant or even declining per capita consumption levels. Population growth in this region has increased to 3% p.a. while food production has grown by 2% p.a. Serious problems of hunger and malnutrition have developed in this region. The problems, however, extend well beyond agriculture and in many cases are economy-wide and the solutions require more than improved agricultural performance.

Future world food demand growth will probably be less than in the past and continued productivity gains appear likely. Population growth rates are slowing and diets have improved to levels which are adequate for most consumers. In contrast, during the early 1960s many consumers in the developing countries had inadequate diets. Having attained better dietary levels, the task ahead is to maintain the current consumption levels while providing sufficient increases in production to meet population growth and meet the diversity in diets that increasing incomes will demand.

Assessing the World Food Situation

Food is the largest expenditure item for most consumers in developing countries, accounting for more than one-half of total expenditures in many countries. In assessing the food situation, one important measure is the level of food prices relative to other consumer prices and relative to incomes. If per capita incomes are rising faster than food prices, consumers can spend a declining share of incomes on food and maintain the same level of consumption.

The World Bank's index of food commodity prices fell by 78 percent from 1950 to 1992 in constant 1990 prices. The period of rising prices during the 1970s was the exception in the general decline in food prices. It was caused by a combination of factors which included a sharp increase in crude oil prices, rising imports by the former Soviet Union as well as many developing countries, several years of poor harvests, and government policies which reduced stock levels during the late 1960s and early 1970s. Retail food prices have not declined as much as food commodity prices because of increased marketing costs and increased processing of food items; however, when measured relative to incomes, retail food prices have declined in most countries.

Real per capita GDP increased an average of 162% for consumers in developing countries from 1960 to 1990, while food costs remained relatively stable in most countries. This meant significantly reduced food costs in relative terms. In India, for example, real food prices rose at nearly the same rate as all consumer prices while real per capita GDP nearly doubled.

A second important measure of the food situation is the level of nutrition relative to dietary requirements. By this measure, the food situation has improved dramatically in developing countries, although hunger and malnutrition are still serious problems for many. The average per capita calorie supplies in developing countries has increased steadily since the early 1960s. The increase was especially rapid during the 1970s as production increased in many developing countries because of the release of the high-yielding wheat and rice varieties which raised yields. This increase in calorie supplies has meant that the proportion of the developing countries' population suffering from chronic undernutrition has declined significantly--from 36% during the late 1960s to 20% during the late 1980s according to the FAO. An estimated 60% of the world's population now live in countries which have average calorie supplies of 2,600/day or more, which is the level considered to be "relatively comfortable" by FAO.

The improvements in calorie supplies have not been shared equally. The East Asia and Pacific region has recorded the largest increase in calories from 1961-63 to 1987-89 (50.4%) and this is also the region with the largest population. The other developing regions had smaller increases, with Sub-Saharan Africa showing an increase of only 4.4% during the period. Latin America increased per capita calorie supplies by 15% and also reached the highest average level of calorie supplies of the developing country regions.

Diets vary greatly due to culture, income levels, prices, food availability and other factors. Diets of consumers in developing countries have a higher proportion of vegetable products than diets of consumers in developed countries and on average only 72% of the calories. Cereals are the largest source of calories in developing countries, accounting for 61% of total calorie supplies during 1986-88. The share of total calories supplied by cereals has remained nearly constant since the 1960s. However, the situation varies by country with consumers in many Sub-Saharan African countries relying more on starchy roots than do consumers in Asia or Latin America.

A third useful measure of the food situation is the level of per capita food production. This measure is particularly useful for most developing countries since domestic production provides the largest part of total food supplies. As income levels increase, domestic food production becomes less useful as a measure of the food situation since consumers can more easily turn to imports for increased quantities and varieties of food. Per capita total food production increased by 19.3% in the developing countries from the 1960s to the late 1980s.

Consumption

The focus of discussion of the world food situation often centers on the ability of production to maintain past trends, but it is equally as important to understand the trends in consumption. During the 1970s, world cereals consumption increased by an average of 2.7% p.a., despite increasing world cereals prices during most of the decade. During the 1980s, world cereals consumption growth slowed to an average of 1.7% p.a., despite a decline in deflated world cereal prices of more than 40%. Part of the slower growth during the 1980s can be credited to slower economic growth in many developing countries; however, consumption growth also slowed in many Asian countries which did not have slower income growth during that period. In China, for example, real GDP grew substantially faster during the 1980s than during the 1970s, yet consumption of cereals grew by an average of 2.3% p.a. during the 1980s compared to 5.2% p.a. during the 1970s.

There are strong indications that the stage of most rapid increase in total food demand is past because per capita consumption has risen to levels which are adequate for most consumers and population growth rates are declining. The world's average per capita cereals consumption for all uses has not increased appreciably since 1978, and in developing countries the average has not increased since 1984. Shifts from cereals consumption to other foods such as meats, vegetables and fruits will continue, but the rate of growth of total food demand is expected to decline.

Indeed, challenges to the world food situation appear to have changed considerably. Now that most consumers have achieved adequate quantities of food, they are demanding greater variety and more tasty foods. Consumers who a decade ago consumed most of their cereals as rice now demand wheat products such as bread and noodles as well as more meat, fruits and vegetables. In Thailand, for example, rice now comprises about 70% of total consumption of cereals compared to 99% in 1960. Further growth in per capita consumption of foodstuffs can be expected to be associated with a shift away from direct cereal consumption. In developed countries, the dietary emphasis is on less red meat and more fruits and vegetables for a healthier diet. These trends have important implications for the mix of food production.

Population growth is now the most important determinant of the growth of food demand in most countries. World population growth rates are projected to fall 40% by 2025 to less than 1% p.a. according to United Nations and World Bank estimates. The projected decline is the net result of rapidly declining birth rates and slowly declining death rates. The decline should substantially reduce demands on the world food system.

Production

World food production has more than kept pace with population growth and rates of growth of food production show few signs of slowing. Cereals yields continue to increase along a trend which extends back to the 1950s. During the 1980s, world cereals production increased by 2.1% p.a. while population grew by 1.7%. World cereals yields increased by about 2.5% from 1980 to 1990 while land used for cereals production declined by 4%. Since 1950 about 90% of the increase in cereals production has come from yield increases.

The pressure on the land resource to increase production is less in many countries than it was 10 years ago when high prices brought marginal land into production. Total land used for world cereals production rose sharply during the 1970s as cereals prices rose. During the 1980s, land used for cereals fell in the developed countries and the former CPEs and remained constant in the developing countries. This decline in cereals cropland from the peaks of the 1970s and early 1980s represents a large potential reserve which could be used for production, if required. Some of the land removed from cereals production went into less intensive agricultural uses such as pasture, some was left idle, and some went to other uses such as industrial or residential uses. The production potential of the land taken out of cereal production, relative to the peak, is about 125 million tons at trend 1990 yields. This compares with world trade in cereals of 200 million tons in 1990.

Whether past trends in productivity will be maintained in the future depends largely on higher crop yields. The impact of the first generation of high-yielding rice and wheat varieties, developed during the 1960s, has largely been realized and scientists are now working on the next generation of improved varieties. Higher crop yields originate in investments in research and in factors of agricultural production such as irrigation systems, as well as in education of the farm work force. Continued investments are essential to continued improvements in the food situation, especially in the developing countries.

Sustainability

The sustainability of agricultural production has become a major concern of many people during the past decade. This concern is often expressed in the form of doubts about whether agricultural production can continue to grow because of changes in the quality of the resource base. However, because the resource base can adjust to economic incentives, its production potential is difficult to measure. Under proper economic incentives, the land resource can be made more productive by clearing, contouring, leveling, and adding organic matter and chemical fertilizers. Water can be stored in irrigation dams, pumped from wells and transported to more fertile land areas. Both land and water are abundant according to most estimates and the primary issue concerns making the most efficient use of these resources. Only 11% of the world's land surface is currently used for agricultural crops, and by one commonly accepted estimate, the world's land and water used for agriculture could more than double--although the economic incentives do not justify such an effort.

Soil degradation is often cited as a major concern despite ever higher yields. However, the extent of soil erosion and degradation is very much disputed. According to some studies, as much as 15% of the world's cropland is degraded due to human-induced activities. Water erosion is estimated to account for 56% of the degradation, wind erosion is said to account for an additional 28%, and the remainder is due to chemical and physical degradation. However, the consequences of this degradation are judged to be either great or minor depending upon the study, which leaves the issue open.

Environmental changes such as global warming are also cited as a threat to the production potential of agriculture. The greatest concern is that these changes might occur quickly, before new crop varieties could be developed which would thrive in a warmer climate. Very gradual changes seem to pose less of a threat and may even increase agricultural production by extending the frost-free growing season in some regions. The effects of global warming on world agriculture are yet to be properly understood, but at this time they do not appear to constitute an immediate threat.

Recent Developments in the Former Centrally Planned Economies (CPEs)

Recent developments in the former Soviet Union and in Central and Eastern European countries should further ease any world food problem as these countries become more market-oriented. These countries were major cereals importers during the 1970s and 1980s and their imports contributed directly to the world food crisis of the 1970s. While the political and economic transition is these countries is still unfolding, it is very clear that major changes in food consumption will occur. These changes will almost certainly cause consumption and imports to decline. Production will also likely begin to recover from recent declines as privatization and modernization occur. Foreign exchange constraints will also encourage policy changes in agriculture as imports are curtailed and exports encouraged.

Food consumption levels in the former CPEs have been very high, relative to other countries with similar income levels, and are expected to decline as pricing reforms and economic adjustments are undertaken. Per capita grain consumption for all uses in these countries was nearly double that of Western European consumers--partly due to inefficient use and wastage. For example, in 1988 the level of cereals consumption reached 783 kg/capita in the FSU and 834 kg/capita in Eastern Europe compared to 426 kg/capita in the EC-10 countries. With consumption declines and production reforms, the region is expected to eventually become a net exporter.

The production potential of this region is considered by most experts to be great. Political and economic uncertainty has caused cereals production to stagnate since about 1980 while other regions have steadily increased agricultural productivity. However, reforms which allow greater private ownership of land, smaller production units and the importing of the best technologies would likely stimulate production sharply. Allowing farmers to receive world market prices for output and the opportunity to export would also stimulate greater efficiency at all levels of production.

Looking Ahead

What about the future? Based on simulations using an econometric model of the world cereals markets, most consumers can expect to have increased food supplies and a greater variety of food at lower prices. The prices of basic staples such as cereals are expected to decline relative to other consumer prices and relative to incomes. By 2010, real wheat prices are projected to decline by 33% from 1992 levels, real rice prices are projected to decline by 30% and real maize prices by 20%.

World cereals consumption is projected to grow by about 1.4% p.a. over the period 1990 to 2010 compared to 1.7% p.a. during the 1980s. Consumers in developing countries are projected to increase cereals consumption by 2.2% p.a. during 1990 to 2010 compared to 2.4% p.a. during the 1980s. This will allow per capita consumption to increase by about 0.4% p.a., which is slightly faster than during the 1980s. Consumption levels are projected to decline in the former CPEs as lower incomes and higher prices force more efficient use and lower consumption. By 2010, their per capita consumption of cereals for all uses is expected to decline 17% relative to 1990. However, even after this decline, their per capita consumption levels would still exceed the average of all developed countries by 13%.

Continued expansion of trade in food commodities such as cereals will be essential to further reducing the likelihood of a world food problem. Since for many countries it does not make economic sense to attempt to become self-sufficient, they will need to import. This is especially the case for many Asian countries. As long as countries are well integrated into the world economy, they will be able to purchase food with earnings from exports. The exceptions have been and may continue to be primarily Sub-Saharan African countries which have not been able to earn enough foreign exchange to import sufficient food for their needs and have therefore had to rely on domestic production and food aid.

Net cereals imports by the developing countries are projected to increase from 87 million tons in 1990 to 210 million tons by 2010. This would continue the trend towards increased imports as a share of consumption. On balance, the developing countries imported about 3%

of total cereal consumption during the 1960s and this share has steadily increased to 9% by 1990. It is projected to increase to 14.8% by 2010. The bulk of these imports will be supplied by the developed countries as has traditionally been the case. However, by the end of the projection period to 2010, the former CPEs are expected to emerge as significant exporters to supply part of this import demand.

Alternative simulations show that moderately faster rates of population growth, income growth or higher energy prices would only slow the decline of real cereal prices. Only an extreme break with past trends in cereal production or consumption would reverse the trend of declining cereal prices over the next 15 to 20 years. Such a break with past trends could be caused by stagnating yields or sharply higher demand. To consider the implications of other scenarios, several major variations from past trends were considered.

If cereal yields remained frozen at 1990 levels because of biological or environmental limits, cereal prices would more than double over a decade. The estimated price increases are less than occurred during the early 1970s when energy prices rose sharply and cereals prices tripled. Beyond a decade, significant adjustments in diets and resource use would be required if yields did not increase. A second scenario, which considered sharply higher cereals consumption in developing countries, shows that most of the increases would need to come from increased domestic production. Increased imports can supplement domestic production increases and provide variety to diets and increased consumption in years of domestic production shortfall, but they cannot lift consumption levels significantly for all developing countries.

The countries being left behind present the greatest challenge. But the challenge is not to the world food system. The challenge is to their own economic development. In most of these countries, and most of these countries are in Africa, problems are economy-wide--not just in agriculture. Africa remains vulnerable to the ravages of famine. In the decade just past, droughts in 1984-85 and 1988 depleted food production. A major drought affected southern Africa in 1992. Equally as important have been civil wars, such as in Somalia, which have often prevented delivery of emergency food aid and economic recovery--let alone allowing farming to flourish. Poor and often deteriorating economic conditions in Africa have also limited their capacity to produce. The net result has been a mismatch between agricultural production growth and population growth. The 1980s saw production increase by less than 2% per annum while population grew by more than 3% per annum--further increasing the continent's vulnerability to adverse weather and deteriorating economic and social circumstances.

The world food situation has improved dramatically during the past 30 years and the prospects are very good that the 20-year period from 1990 to 2010 will see further gains. However, these gains depend on continued increases in food production along the trends of the past. This will not occur automatically, rather it will require continued investments in research to increase crop yields and in other factors of production. If past crop yield trends continue and if population growth rates slow as projected, then the gains in the world food situation seen during the past 30 years should continue. If Malthus is ultimately to be correct in his warning that population will outstrip food production, then at least we can say: Malthus Must Wait.

Appendix: The Econometric Simulation Model [1]

The World Grains Model used for the simulation analysis is a non-spatial, partial equilibrium, net-trade model. It is global in scope with 15 countries modelled individually and the remaining countries grouped into nine regions. The commodities included in the model are wheat, rice, and coarse grains (maize, oats, barley, sorghum, rye, millet, and mixed grains) Individual models are estimated for each commodity and country or region with cross linkages between commodities.

Production for each country or region is determined as the product of separately estimated harvested area and yield equations. Harvested area is determined by a two-stage process wherein total area harvested is determined first and then allocated among competing crops on the basis of lagged per acre revenues. Yields are estimated as a function of lagged crop prices, fertilizer prices, the proportion of area planted to high yielding varieties and a linear trend.

Per capita imports of each commodity are estimated directly for importing countries as a function of population, income, domestic supply and prices. Ending stocks are estimated as a share of consumption and prices. Total consumption is obtained as an identity. Net exports are estimated for exporting countries as a function of the level of each commodity available for export and world prices. Consumption in the exporting countries is estimated as a function of population, income and prices. The model is solved simultaneously for the level of world prices which equates net imports and net exports.

Model Description

The general structure of the global model is shown in Figure 1. Each country model takes the price from the world linkage and returns the level of net trade. Table 1 contains the list of exogenous and endogenous variables used in the model, along with their sources and definitions. One difficulty with commodity data is the distinction between a calendar year and a crop year. Some agricultural data, such as stocks, are only available on a crop year basis. Other macroeconomic data, such as income, are available only for a calendar year. Regardless of the year definition selected, some incompatibilities will be encountered. If a calendar year is selected, consumption and trade for a single harvest fall in two years. If a crop year is selected, the macroeconomic definitions do not correspond. A crop year basis is used in this model in order to focus on the agricultural aspects of the model.

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[1] The World Grains Model was originally estimated during the early 1980s for use in forecasting and policy analysis by the Commodities Division of the World Bank. It has been revised and updated several times--most recently in 1990 using data through 1988.

Every model necessarily involves compromise and simplifications of the real world. This model does not consider a number of topics which are important, but which have not been modelled. Quality differences within each product are not considered; each commodity is treated as homogeneous and having a single world price. Trade flows between countries are also ignored; trade is assumed to take place in a world market yielding only net trade figures. Resource use for production is also largely ignored with the exception of land and fertilizer. Transportation costs are not considered. The model is constructed so that individual variables, such as yields, can be analyzed and modified by expert opinion. In this way the important variables which cannot be explicitly included, can be reflected in model variables.

The model has been estimated primarily with ordinary least squares, using annual data from 1960 to 1988. The equations are linear in the variables. The entire model contains approximately 500 equations and is solved using the Gauss-Siedel iterative procedure.

The countries and regions defined in the model are shown in Table 2. The selection of countries to model individually was made on the basis of three criteria: 1) similar economic and political structure; 2) geographical location; and 3) importance to global trade for the commodities.

Supply

The supply model consists of three separate components corresponding to the decision sequence of producers. First, a total cropland equation is estimated for each country or region to capture the quantity of cropland harvested for the three model commodities; second, the allocation of this land among the commodities is estimated; and third, a yield equation is estimated for each commodity. Production for each commodity is the product of the area harvested and yield equations.

The two-stage specification of the cropland harvested of each crop attempts to separate the short term and long term decisions faced by producers. The short term decision involves allocating cropland among closely competing crops. This decision can be made and implemented very rapidly and the decision can be reversed in a future year at very little cost. Rigidities are imposed on the decision by different machinery requirements for each crop and the competition for a scarce resource such as labor availability at peak load periods, but switching of land between crops is generally possible.

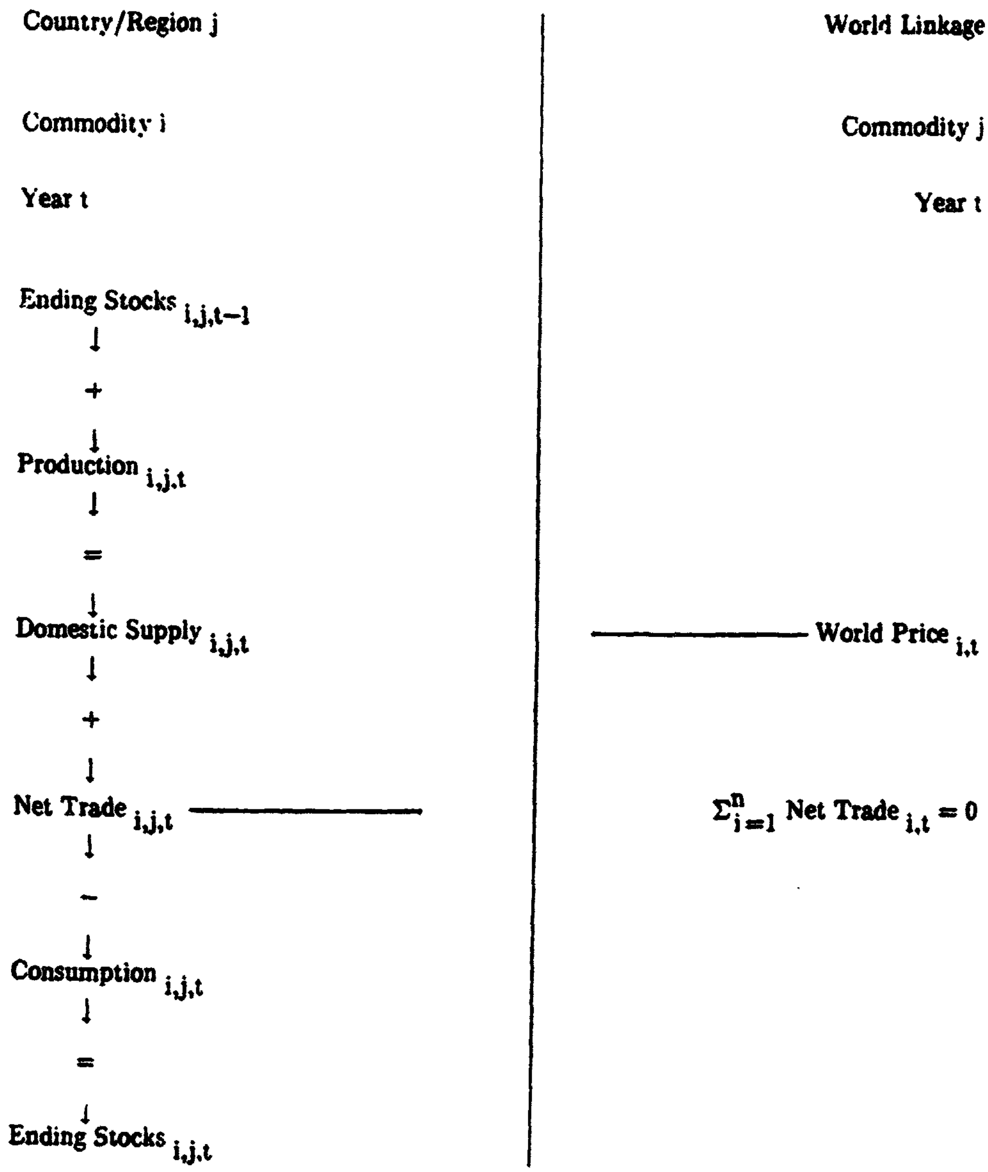

Figure 1. World Grains Model

Table 1: Agricultural Model Variable List*

Variable	Source	Definition	Years
EXOGENOUS VARIABLES			
Population	WB, UN	Million People Calendar Year	1960-88
Income - GDP	WB, IFS	Billion Local Currency Calendar Year	1960-88
Exchange Rate to $	WB, IFS	Local Currency/US $ Calendar Year	1960-88
Consumer Price Index	WB, IFS	Index, 1975=100 Calendar Year	1960-88
ENDOGENOUS VARIABLES			
World Crop Prices	USDA	$/MT, f.o.b. Gulf Simple Monthly Average Crop Year	1960-88
Production	USDA	Thousand Metric Tons Crop Year	1960-88
Harvested Area	USDA	Thousand Hectares Crop Year	1960-88
Crop Yields	USDA	Tons Per Hectare Crop Year	1960-88
Consumption	USDA	Thousand Metric Tons Crop Year	1960-88
Net Trade	USDA	Thousand Metric Tons Crop Year	1960-88
Beginning Stocks	USDA	Thousand Metric Tons Crop Year	1960-88

* Data sources are WB = World Bank; FAO = Food and Agricultural Organization; IFS = International Financial Statistics published by the International Monetary Fund; USDA = US Dept. of Agriculture.

Table 2: Model Regions

<u>Industrial Countries</u>	
Australia	Australia
Canada	Canada
EC-10	Belgium, France, Luxembourg, Netherlands, W. Germany, Ireland, United Kingdom, Denmark, Greece.
Japan	Japan
Other Industrial Countries	Austria, Finland, Iceland, Malta, Norway, Portugal, Spain, Sweden, Switzerland, New Zealand.
United States	United States
<u>Centrally Planned Economies</u>	
Eastern Europe	Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, Yugoslavia.
USSR	Union of Soviet Socialist Republics.
<u>Developing Countries</u>	
Argentina	Argentina
Brazil	Brazil
Central Africa	Botswana, Lesotho, Namibia, Kenya, Swaziland, Malagasy Republic, Malawi, Mozambique, Tanzania, Uganda, Zambia, Angola, Burundi, Cameroon, Central African Republic, Chad, Congo, Ethiopia, Djibouti, Benin, Gabon, Gambia, Ghana, Guinea, Equatorial Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Mauritius, Niger, Reunion, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Togo, Upper Volta, Zaire, Zimbabwe.

(Table 2 continued)

China	China
East Asia	Burma, Kampuchea, Laos, Vietnam, Hong Kong, Singapore, South Korea, Brunei, Malaysia, Philippines, North Korea, Mongolia, Pacific Islands, Papua New Guinea, Fiji Islands.
Egypt	Egypt
India	India
Indonesia	Indonesia
Latin America and Caribbean	Bahamas, Barbados, Bermuda, Belize, Other Caribbean Islands, Cuba, Dominica, Dominican Republic, Jamaica, Trinidad and Tobago, Honduras, Nicaragua, Panama, Costa Rica, El Salvador, Guatemala, Haiti, Bolivia, Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Surinam, Uruguay, Venezuela.
Mexico	Mexico
Nigeria	Nigeria
North Africa and Middle East	Algeria, Bahrain, Cyprus, Iran, Iraq, Israel, Kuwait, Libya, Oman, Qatar, Saudi Arabia, United Arab Emirates, Jordan, Lebanon, Morocco, Syria, Tunisia, Turkey, Yemen A.R., Yemen, D.M.
Pakistan	Pakistan
South Asia	Afghanistan, Bangladesh, Bhutan, Nepal, Sri Lanka.
Thailand	Thailand

The decision of how much total land to plant to crops is a long term decision because of the capital investment required to prepare land for planting. The decision to expand cropland requires that land be taken out of its alternative use (e.g., forestry) and cleared, ploughed and harrowed so that it can be planted. This process requires an investment of labor and capital. Once land is prepared for cropping, the subsequent investment required to keep the land under crop is small. Consequently, the decision to expand cropland involves an initial outlay plus the loss of revenue from the previous land use. The decision is often irreversible in the short run. Timber, for example, is not an annual crop and cannot be interchanged with an annual crop.

Total Cropland

The expansion of total cropland which a producer will undertake can be viewed as an optimal investment problem. It is assumed that the producer will attempt to maximize the following function:

$$\Pi_t = f(\textstyle\sum_1 \Delta P_i/(1+r)^i, C_t)$$

where $\Sigma_1 \Delta P_i/(1 + r)^i$ is the discounted incremental profit flow expected from planting the land to crops rather than its previous use. The one-time capital investment required to prepare the land for crops is denoted by C_t.

This investment function suggests that an estimated total cropland equation should contain variables to measure the profitability of alternative land uses, and the capital cost of land preparation. Based on these assumptions, the cropland equation is specified as follows:

$$TCHA_t = f(TCHA_{t-1}, DTCRV_{t-1}, TGES_{t-1}, TIME)$$

where

$TCHA_t$	is the harvested area in year t of the model commodities
$DTCRV_{t-1}$	is the weighted revenue per hectare based on world prices of the crops expressed in constant local currency in year t-1.
$TGES_{t-1}$	is the sum of wheat, coarse grain and rice ending stocks in year t-1.
TIME	is a linear trend with 1960 = 1, 1962 = 2, etc.

The lagged total cropland, $TCHA_{t-1}$, is included to reflect the partial adjustment of cropland toward the desired level. The arguments for this specification are well known and date back to Nerlove's work on agricultural supply response (Nerlove, 1958). The variable $DTCRV_{t-1}$ reflects the weighted revenue per hectare received from all grains in the previous year. The prices used to calculate this variable are the international prices. The yields are the actual country yields and the weights are based on the area harvested of each of the crops. This variable does not capture the profitability of crop production since no cost information is included, however, it is a superior specification to prices since it reflects yield increases over time. The lagged form of the variable is included to proxie farmers' expectations of future revenues. This variable may also be measuring capital availability which may be a factor in an investment decision. The variable is converted into local currency and deflated by the country consumer price index. A linear trend is included to capture unknown factors such as government land development programs which are independent of year-to-year changes in commodity prices of profitability.

A final variable, not suggested by the theoretical model, is also included in the estimated equation. This variable is total grain ending stocks (wheat, coarse grain and rice) in the previous year. It is included to measure local food stock conditions. It is significant in a number of countries. The negative sign indicates that low grain stocks in the previous year result in expanded total cropland in the next year. This result would be consistent with a subsistence type agriculture where low stocks increase the risk of lower food consumption. It is also consistent with an exporting country which attempts to maintain an inventory for exports.

The land preparation costs suggested by the theoretical model were not included because of lack of data. Interest rates were included in several preliminary specifications, but were consistently not found to be significant.

An alternative functional form of the total crop revenue which was used in some specifications was to include this variable in ratio form rather than separately. While not the preferred specification, this alternative has the advantage of eliminating the exchange rate and consumer price index from the equation. It worked better for countries which have had very high inflation rates and rapidly falling currency values. An undesirable characteristic of this functional form is the forced equality of the response of area to both total crop revenue and beef prices.

Harvested Area

The harvested area of each crop is estimated as a function of total cropland harvested and relative commodity revenues. This specification treats the determination of harvested area as a short run allocation decision given that the decision of how much cropland to plant has already been made. The specified equation is:

$$HA_{i,t} = f\,(TCHA_t,\ HA_{i,t-1},\ RV_{i,t-1},\ RV_{j,t-1},\ TIME)$$

where

$HA_{i,t}$	is the harvested area of commodity i in year t
$TCHA_t$	is the total cropland harvested in year t of wheat, coarse grains, rice
$RV_{i,t}$	is the revenue of commodity i in year

TIME	is a linear trend with 1960=1, 1961=2, etc.

The lagged dependent variable, $HA_{i,t-1}$, was included to represent the partial adjustment toward a desired area harvested. The inclusion of this variable is based on theoretical arguments offered by Nerlove and others. The lagged crop revenues are included to represent the relative profitability of competing crops. Revenues rather than prices are used to allow changing crop yields to be reflected in both the historical estimates and in projections. Finally a linear trend, TIME, is included to capture unknown factors or factors which are known to be important, but which cannot be included due to data limitations. One of these known but not included factors is production costs. Ideally, net profits should be used rather than revenues. By excluding production costs, the assumption is being made that costs are growing proportionately to revenues. This is not true. The costs of producing some crops such as those which require large amounts of fertilizers and chemicals, may be growing more rapidly than other crops. A linear trend allows some of these omitted variables to be captured but not identified.

Crop Yields

Crop yields are assumed to be influenced by seed quality, inputs such as fertilizers, land quality and weather. The estimated yield model necessarily simplifies these factors into variables which can be used to represent the various factors. The model is:

$$YD_{i,t} = f\ (TIME,\ RPF_{i,t-1},\ HA_{i,t},\ HYV_{i,t})$$

where

$YD_{i,t}$	is the yield per hectare in year t of commodity i
TIME	is a linear trend with 1960=1, 1961=2, etc.
$RPF_{i,t-1}$	is the lagged ratio of the price of the commodity i to the price of fertilizer
$HA_{i,t}$	is the area harvested of the commodity i in year t
$HYV_{i,t}$	is the percent of total area planted to the high-yielding varieties.

The linear trend, TIME, is included to measure the genetic improvement in seed over time. Doing so assumes that the contribution of plant breeding research to yields is growing at a constant amount per year. An alternative assumption which should be considered is that a yield limit exists and yields increase at a decreasing rate. If this is the case yields would increase along a nonlinear or perhaps log linear path. The selection of the appropriate yield model can be based on both empirical observation and agronomic research. Yield experiments conducted by plant breeders provide some evidence of whether leveling-off of yields is being observed. As reported by Menz and Pardey (1983), agronomic trials do not indicate any plateau in US corn yield gains, and the evidence suggests linear growth. A review of yield data in most countries does not show clear evidence of a slowing of yields.

For many countries data is very difficult to obtain on rates of fertilizer application. In order to capture the contribution of fertilizer to yields, the ratio of world crop price to world fertilizer price was used. This variable attempts to measure the incentives for farmers to apply fertilizer, considering both the price of fertilizer and the price of the crop.

Three different variables are used to measure the influence of fertilizer and crop prices on yields. In one form, the ratio of last year's crops to last year's fertilizer price is used. Secondly, last year's crop price is divided by the current fertilizer prices. The appropriate variable to use depends on two factors, the availability of information and the speed of adjustment. The first variable, last year's crop price divided by the current year's fertilizer price assumes that at the time of fertilizer application, farmers do not know the current crop price but they do know the current year's fertilizer price. The third form of the variable is only appropriate in Southern Hemisphere countries where crops are planted after the Northern Hemisphere crops are harvested. Consequently, farmers are able to estimate the current year price very well. This specification is applied to crops grown in Argentina, Australia, Brazil and South Africa.

The third factor influencing crop yields is the quality of land. In general, the quality of land should be inversely related to the quantity of land planted. As more and more land is planted, farmers will be using less productive land. Since not all countries have changed their crop area significantly over the last two decades, we would not expect yields to respond to this variable in all countries. Further, it is often statistically difficult to separate the negative influence of lower quality land from the positive influence of genetic yield gains.

The introduction of the high-yielding varieties (HYVs) represents a movement to a higher yield curve. In some cases the new varieties were able to produce twice the amount of the traditional varieties. In order to account for this shift, the HYV variable was included directly in the yield equation. When data was not available on the level of HYV use, a proxie variable was used to represent the adoption of the HYVs.

Import Demand

The demand for imports can be viewed in general as a function of income, prices and relevant demand shifters

$$M_{i,t} = f\,(Y_t, P_{i,t}, P_{j,t}, Z_t)$$

where $M_{i,t}$ is per capita imports of commodity i, Y_t is real per capita income, $P_{i,t}$ is the real import price of commodity i, $P_{j,t}$ is the real price of a related commodity j, and Z_t is a set of relevant demand shifters. This basic import demand model has been presented by Leamer and Stern (1970), Labys (1973) and others. The specific functional form, relevant variables and expected results are dependent upon characteristics of the commodity being imported, the nature of use of the imported commodity, the structure both of the international market and the domestic market and many other factors.

In this study the demand for grain imports is treated as the independent demand for each of the primary grain categories--wheat, rice and coarse grains. In many cases, an importing country both produces and imports the commodity, and in some cases a country will produce, import and export the commodity. This latter case can occur for several reasons. First, a large country may import in one geographic region while exporting from another. This kind of activity occurs between the United States and Canada, with the United States importing feed grains along the Canadian border and exporting through the Gulf. Seasonal supply availabilities may also cause an exporting country to import during certain periods of the year. Finally, differences in grain quality and varieties may cause a country to both import and export grain. The EC, for example, produces, consumes and exports soft wheat while importing hard wheat. The soft wheat is used primarily for noodles, pastries and quick bread while the hard wheats are used for yeast breads and hard rolls.

An explanation of the occurrence of both imports and exports within the same year will not be pursued here. In order to avoid these issues, other researchers have chosen instead to study the net import demand for grain. This approach has merit to the extent that imported and domestic goods are substitutes. If the imported good does not substitute for the domestically produced good, no change in domestic production will affect the demand for imports. Alternatively, if the imported and domestic good are identical, domestic and imported goods are perfect substitutes and a unit of imported grain will exactly offset a unit of domestically produced grain.

Because of the small size of their imports relative to total world demand, most importing countries can be assumed to face a perfectly elastic supply at a given price. If imports and domestic goods are regarded as perfect substitutes, import demand can be viewed as an excess demand schedule. Consider Figure 2. Domestic demand and supply are shown in Figure 2A as D and S, respectively. The difference between D and S below P_1 is the excess demand schedule, ED in Figure 2B, or equivalently the demand for imports. At a price below P_1, domestic demand exceeds domestic supply and ED shows the imports required to satisfy domestic demand. If the imported and domestically produced goods are perfect substitutes and if free trade prevails, then imports, M, will equal ED. Therefore, domestic supply will directly influence imports and the import demand function should include domestic supply variables directly (see Leamer and Stern, 1970, p.11 for a discussion of this specification).

With trade barriers the excess demand curve will be rotated to ED'. This situation can be written as

$$ED' = F\ (ED, G)$$

where the excess demand curve depends on the difference between domestic demand and supply and a set of government variables, G. Examples of such government variables could be import duties, foreign exchange constraints or a government budget constraint.

A dynamic specification of import demand is appropriate when demand in any period is assumed to adjust only partially toward desired or equilibrium demand. Government restrictions could also delay the adjustment of demand to changes in the underlying demand determinants. Partial adjustment to some desired level can be modeled using the Koyck lag specification of a lagged dependent variable as an explanatory variable. However, this specification may have another valid interpretation. That is, the use of an imported good as an input into a production process could cause the level of imports to depend on past levels of imports. This occurs when imports have contributed importantly to the size of an end-use industry and their continuation is necessary to maintain the industry. The feeding of livestock is an example.

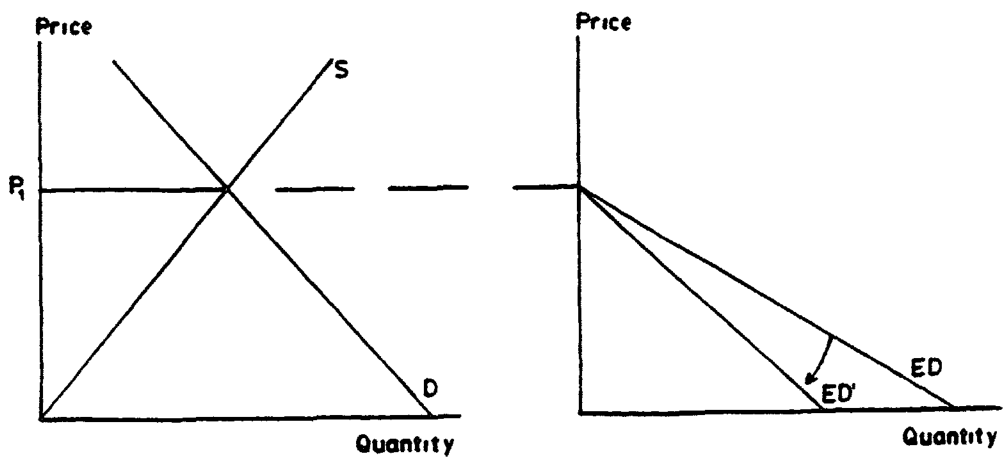

Figure 2a

Figure 2b

Figure 2. Import demand

Foreign exchange availability has been suggested as an important determinant by a number of authors including Leamer and Stern (1970), Hemphill (1974), Abbott (1979). The importance of foreign exchange as a constraint may have increased in recent years, at least among the developing countries, following the worsening in debt servicing ability by these countries.

Finally, a variable which may also influence grain import demand is the level of food aid. This variable is relevant for many developing countries and should act as a demand shifter causing imports to increase beyond the levels which would have been imported without food aid. One of the most significant food aid programs is the P.L. 480 program of the United States.

The framework of the import model can be stated as a reduced form of a standard residual trade model. Consider the following model:

$$PROD_t = \beta_0 + \beta_1 PF_{t-1} + \beta_2 PROD_{t-1} \quad (1)$$
$$STK_t = \alpha_0 + \alpha_1 PF_{t-1} \quad (2)$$
$$DD_t = \gamma_0 + \gamma_1 Y_t + \gamma_2 PR_t \quad (3)$$
$$PF_t = \Upsilon_2 + \Upsilon_2 PW_t \quad (4)$$
$$PR_t = \delta_1 + \delta_2 PW_t \quad (5)$$
$$M_t = \pi_0 + \pi_1 (DD_t - PROD_t - STK_t + STK_{t+1}) - \pi_2 G_t \quad (6)$$

where

$PROD_t$	is production in year t
PF_t	is the real farm price in year t
STK_t	is the level of beginning stocks in year t
DD_t	is the level of domestic demand in year t
Y_t	is real per capita income in year t
PR_t	is the real retail price in year t
M_t	is the level of imports in year t
PW_t	is the world price expressed in local currency and deflated by consumer price index in year t
G_t	is other factors which influence imports such as a country's balance of payments, in year t

All quantities are assumed to be expressed on a per capita basis and all prices are in real terms. Transportation costs are assumed to be zero. Equation (1) is a simple production model in which production depends on farm prices in the previous period and on last year's production. Equation (2) is a stock equation which specifies the level of stocks available in period t as dependent on prices in year t-1. Domestic demand, equation (3), is a function of income, population and retail price. Equations (4) and (5) reflect the relationship between farm and retail price and the world price. Finally, equation (6) expresses the level of imports as a function of the level of excess demand, the world price and other relevant variables such as the balance of payments. Assume that production and stocks are predetermined in any given year. Substituting equations (1)-(5) into (6) and rewriting, we have:

$$M_t = \pi_0 + \pi_1 (\gamma_0 + \gamma_1 Y_t + \gamma_2 (\delta_1 + \delta_2 PW_t)$$

$$+ (\overline{PROD_t} + \overline{STK_t}) + \pi_1 (\alpha_0 + \alpha_1 (\tau_1 + \tau_2 PW_t) - \pi_2 G_t \qquad (7)$$

or

$$M_t = \omega_0 + \omega_1 Y_t + \omega_2 PW_t + \omega_3 (\overline{PROD_t} + \overline{STK_t}) + \omega_4 G_t \qquad (8)$$

where

$$\omega_0 = \pi_0 + \pi_1\gamma_0 + \pi_1\gamma_2\delta_1 + \pi_1\alpha_0 + \pi_1\alpha_1\tau_1$$
$$\omega_1 = \pi_1\gamma_1$$
$$\omega_2 = \pi_1\gamma_2\delta_2 + \pi_1\alpha_1\tau_2$$
$$\omega_3 = \pi_1$$
$$\omega_4 = \pi_2$$

Equation (8) is a reduced form import demand equation which can be estimated directly. It is difficult to interpret the individual coefficients, however, we can infer the sign of most of the variables. Income should have a positive sign, production plus stock should have a negative sign as should current world price. The intercept term and the exogenous variable G_t may have either a positive or negative sign.

The direct estimate of an import equation is not without problems. However, in spite of these problems, this approach produces a useful model for forecasting imports of a country or region. Abbott (1979) has pointed out some of the advantages and disadvantages of using this approach. One of the advantages of the import demand approach is that the direct estimation of trading behavior requires little knowledge of individual country's policies. This is important when a large number of countries are being studied as is the case in building a world model. It is also essential when regions are being considered since the government policies of a region are nearly impossible to define.

A second advantage of the import demand model is that the government is treated endogenously in the determination of the level of imports. This corresponds to the decision making structure regarding the level of imports in the majority of countries. It also indicates that the coefficients of the import demand equation reflect the response of the government importing agency. Variables which would influence a government decision maker can also be explicitly included as explanatory variables. These types of variables cannot be easily included in the more traditional trade models.

The import demand approach does have limitations which need to be recognized. Since the estimated equation is a reduced form, interpretation of the parameters is difficult. The structural form model which yields the reduced form is unknown and incorrect conclusions about the contribution of a particular variable are more likely to occur Another problem occurs because the parameters also change. As a consequence, estimation of the import demand equation requires stable country policies. At the very least, this problem requires some attention and caution in the use of import equations under unstable policy conditions.

The elasticity of demand for imports taken from the excess demand curve is:

$$E_{ED} = \frac{\delta ED}{\delta P} \cdot \frac{\overline{P}}{\overline{Q_I}}$$

where $\overline{Q_I}$ is the mean quantity imported and $\overline{P}$ is the mean price. This can be stated in terms of domestic demand and supply elasticities as:

$$E_{ED} = E_D \frac{\overline{Q_D}}{\overline{Q_I}} - E_S \frac{\overline{Q_S}}{\overline{Q_I}}$$

Therefore, the elasticities of excess demand is equal to the elasticity of demand times the ratio of quantity demanded to the quantity imported minus the elasticity of domestic supply times the ratio of domestically produced to imported quantities.

The E_{ED} will equal E_D when $Q_s = 0$ or $E_S = 0$ and E_{ED} will be more elastic than E_D in all other cases. Suppose $E_S = 0$, domestic supply is perfectly inelastic--the situation which exists in the short run for production of an annual crop as wheat. The elasticity of excess demand is then given by

$$E_{ED} = E_D \cdot \frac{\overline{Q_D}}{\overline{Q_I}}$$

or it is equal to domestic demand times the ratio of quantity demanded to imports. If imports represent half of total quantity demanded, E_{ED} would be twice E_D.

The import equation (8) expresses imports as a function of income, domestic supply, the import price and a government variable. An expanded version of the model was estimated for each of the three grain types. The estimated equation allows for cross price effects and domestic substitution between grains and is estimated on net imports. The model is also specified as a dynamic model to allow for a partial adjustment to changes in the independent variables. The estimated model is:

$$NI_{i,t} = f(Y_t, DS_{i,t}, DS_{j,t}, P_{i,t}, P_{j,t}, NI_{i,t-1})$$

where

- $NI_{i,t}$ is per capita net imports of commodity i in year t
- Y_t is per capita real gross domestic product in year t
- $DS_{i,t}$ is per capita domestic supply (production plus beginning period of stocks) of commodity i in year t
- $DS_{j,t}$ is domestic supply of a substitute commodity j in year t
- $P_{i,t}$ is the world price of commodity in year t in US dollars expressed in the country currency and deflated by the country's consumer price index
- $P_{j,t}$ is the price of a substitute commodity j in year t

Export Supplies

The structure of the world grain export market has been described by various authors as oligopolistic with price leadership provided by one or several of the major exporting countries. McCalla (1967) described the world wheat market as a duopoly with price leadership provided by Canada. Alaouze, Watson and Sturgess (1977) described the wheat market as a triopoly involving the United States, Canada and Australia. Bredahl and Leonardo (1983) tested a US residual supplier model for coarse grain exports. Mitchell and Duncan (1987) analyzed the behavior of grain exporters and found evidence of oligopoly behavior.

Grain exports are dominated by a few countries. The five largest exporters provided 75% of the total rice exports, 89.9% of the total wheat exports, and 86.6% of the total grain exports over the 1987-91 period (USDA). The United States was the largest exporter, providing 62.4% of the coarse grain exports, 35.7% of the wheat exports, and 18.5% of the rice exports over the 1987-91 period.

Because of the small number of countries which supply the majority of exports, the oligopoly model provides a useful beginning point for analysis of exports. An oligopoly exists when more than one seller can influence the market. Because of the small number of sellers, each seller is expected to be aware of the actions of its rival and of their reactions to changes in policy. Many different marke. outcomes are possible from an oligopoly model ranging from competition to collusion.

Suppose the market consists of one dominant firm and a number of smaller firms. The dominant firm may or may not be the low cost producer in the market. For political or other reasons, the dominant firm may decide to set the market price and let the small firms sell all they wish at that price. The small firms will behave as perfectly competitive suppliers and regard their demand curve as perfectly elastic at the price set by the dominant firm. The problem facing the dominant firm is to determine the price so as to maximize profits while allowing the small firms to sell as much as they wish. Consider Figure 3. The market demand curve is D, and the marginal cost curve of the dominant firm is MC_d. The summation of the marginal cost curves of all small firms is MC_s. The dominant firm will maximize profits by equating its marginal cost with its marginal revenue curve, after allowing the small firms to sell their desired amounts. In Figure 3, this occurs by equating MC_d and MR_d to sell a total output of Q_1 at a price of P_1. The small firms will supply Q_2, while the dominant firm provides Q_1. Total sales will be $Q_1 + Q_2 = Q_3$.

This basic model provides a reasonable model of the world grain markets. Two basic tenants of this model are price leadership and the granting of market access by the dominant firm to the smaller firms. Consider how closely this conforms to the world grain markets. The United States is the dominant exporter and sets price bounds by its government program allowing price to fall as low as the loan rate after which grain is bid into the government storage programs. Other exporting countries can and do export as much as desired, with occasional pressure from the United States. Argentina, for example, increased coarse grain exports from 5.3 million tons in 1979/80 to 14.2 million tons in 1980/81 when the United States embargoed grain sales to the USSR.

In this form of oligopoly the behavior of the small firms is that of a price taker. The small firm accepts the world price as set by the dominant firm and maximizes profits by supplying the quantity where marginal cost equals world price. The application of this model to exports is shown in Figure 4.

Domestic supply is shown by S, and is fixed within a given marketing year. Domestic demand is given by D. At an export price above the level where domestic demand is equal to domestic supply, the country will export (ignoring differences between country and world prices). The excess supply curve, ES, is equal to S - D and shows the level of exports. At the world price P_W, domestic demand is given by Q_D, exports are equal to Q_E which is also $Q_S - Q_D$.

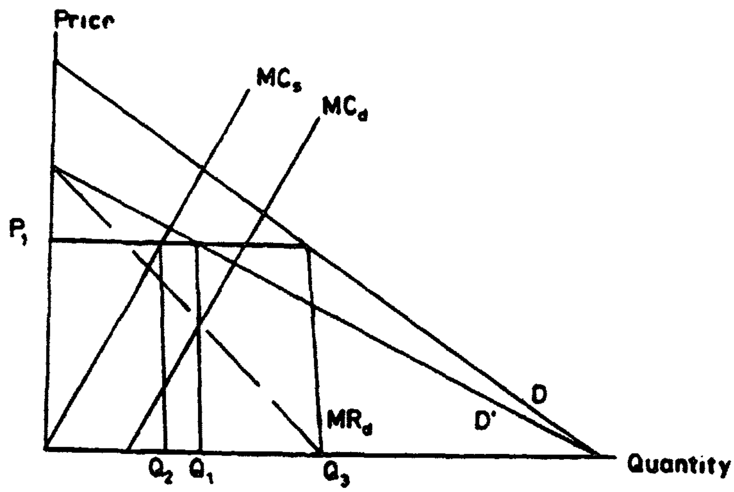

Figure 3. Dominant firm oligopoly model

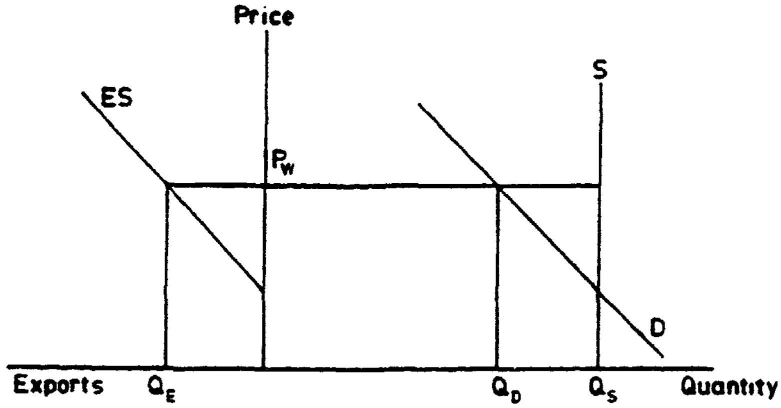

Figure 4. Small country exporter

Following the dominant firm oligopoly model of the world grains and soybean market, the export supply curves for the exporting countries is:

$$X_{i,t} = DS_{i,t} - DD_{i,t} - STK_{i,t+1}$$

where

X_{it}	is the exports of commodity i in year t
$DS_{i,t}$	is the domestic supply (production plus beginning of stocks) of commodity i in year t
$STK_{i,t+1}$	is the beginning stocks of commodity i in year t

The functional relationships can be described as

$$DS_{i,t} = PROD_{i,t} + STK_{it}$$
$$DD_{i,t} = f(Y_t, P_{i,t}, P_{j,t})$$
$$STK_{i,t} = f(Y_t, P_{i,t}, P_{j,t}, DD_{i,t-1})$$

where $DS_{i,t}$ is per capita domestic supply and is predetermined; domestic demand, $DD_{i,t}$, is defined as per capita demand which depends on real per capita income, Y_t, and real prices of commodity i and a related commodity j; per capita ending stocks, $STK_{i,t}$, are a function of real per capita income, relative prices and an inventory holding level which depends on domestic demand in the previous year.

All exporters of wheat, rice and coarse grains are treated as small country exporters, except for the United States. Exports from the United States are equal to the residual required to balance world net imports and exports. This configuration corresponds with actual market behavior since the early 1970s, although the United States has competed for exports with the EC in recent years.

Consumption

In the importing countries and regions, consumption is calculated as the residual with production, net imports and stocks being estimated. For the exporting countries, consumption is estimated directly. In these countries, consumption is disaggregated into two final uses: feed and all other. Per capita consumption is then estimated as a function of income and relevant prices:

$$CF_{i,t} = f(Y_t, P_{i,t}, P_{j,t})$$
$$CO_{i,t} = f(Y_t, P_{i,t}, P_{j,t})$$

where $CF_{i,t}$ and $CO_{i,t}$ are per capita food and all other consumption of commodity i respectively.

Y_t is real per capita income and $P_{i,t}$ and $P_{j,t}$ are the real prices of the commodity i and a related commodity j.

Stocks

In order to close each country model, the final component which must be estimated is the level of ending stocks (next year's beginning stocks). The ratio of ending stocks to domestic consumption in the previous year is estimated. The equation is:

$$\frac{STK_{i,t}}{DD_{i,t-1}} = f(P_{i,t})$$

where

$STK_{i,t}$ is the level of ending stocks of commodity i in year t
$P_{i,t}$ is the real price of commodity i in year t

Previous experience has shown that this type of model will perform reasonably well, but will not capture totally the volatilability which is frequently present in stock holdings.

Prices

A single world price, the US export price in dollars, is assumed to exist for each of the commodities. Each country's border price is then equal to the world price expressed in constant units of local currency.

$PW_{i,t}$ = US export price of commodity i in year t
$P^k_{i,t}$ = border price of country k for commodity i in year t
= $PW_{i,t} * XR_{k,t} / CPI_{k,t}$

where $XR_{k,t}$ is the exchange rate of country i relative to the US dollar, and $CPI_{k,t}$ is the consumer price index of country k in year t. The model is solved for the world price which equates net imports with net exports.

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Data Sources and Definitions

The primary historical data sources are the World Bank, International Monetary Fund, FAO and the US Department of Agriculture.

A single world rice, wheat and corn price is used in the model. The wheat price is the US No. 1 HRW, Ordinary Protein, FOB Gulf, July-June year. The rice price is the US No. 2 Long Grained, Milled, Bagged, FOB Houston, August-July year. The corn price (which is a proxy for all coarse grains) is US No. 2 Yellow, FOB Gulf, October-September year. The real border price for each country is then used for estimation and is defined as the world price multiplied by the exchange rate and deflated by the country's consumer price index.

The grains data is taken from the Foreign Agriculture Service of the US Department of Agriculture. All data are on a crop year basis and are measured in thousand metric tons or thousand hectares.

The macroeconomic and demographic data are taken from the World Bank data base and the International Financial Statistics (International Monetary Fund). Population is in millions, income is gross domestic product measured in billions of local currency. The exchange rate is measured in units of local currency per dollar, and the consumer prices are an index. All these data are taken from the IFS or from the World Bank data base. The trade balance is FOB Exports minus FOB imports in millions of US dollars and is from the IFS.

Finally, data for the USSR, Eastern Europe and China are defined differently from the data used for other countries. The exchange rate and consumer price indices were not used. Equations were estimated on real US commodity prices and real income based on World Bank data.

The regional data are obtained by aggregating country data for variables with common units, i.e., tons, hectares, persons. Regional GDP is obtained by converting local currency GDP to US dollars using a 1971-80 average exchange rate and then aggregating. Regional exchange rate and consumer price indices are constructed as a weighted average of the largest countries in each region. Because the exchange rate and consumer price index data are the most incomplete of the data series used in the model, this approach was the only alternative for regions comprised of many small countries.