

**Food Security Assessment: Why Countries Are At Risk.** By Shahla Shapouri and Stacey Rosen. Market and Trade Economics Division. Agriculture Information Bulletin No. 754.

### Abstract

Food insecurity in many low-income, developing countries is projected to intensify unless steps are taken to reverse the performance trend of key contributing factors: agricultural productivity, foreign exchange earnings, and population growth. For the poorest countries, an increase in agricultural productivity is the key to improving food security. In these countries, imports play a small role in the domestic food supply because of limited foreign exchange availability. This study evaluates availability and distribution of food and analyzes their trends through 2008 by projecting food gaps to maintain per capita consumption, meet nutritional needs, and fulfill requirements stemming from unequal food distribution.

**Keywords:** Food security, developing countries, productivity, foreign exchange availability, import capacity, income distribution, population growth, nutritional requirements, per capita consumption.

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## Summary

Food insecurity in many low-income, developing countries is projected to intensify unless steps are taken to reverse the performance trend of key factors. Agricultural productivity, foreign exchange earnings, and population growth all influence a country's food security. For the poorest countries, an increase in agricultural productivity is the key to improving food security. In these countries, imports play a small role in the domestic food supply because of limited foreign exchange availability.

In this study, two main food gaps are used to measure food insecurity: the status quo gap and the nutrition gap. The status quo gap is the difference between projected food supplies and base period (1995-97 average) per capita consumption. The nutrition gap is the difference between projected food supplies and the food needed to support minimum per capita nutritional standards. The requirements stemming from unequal food distribution among income levels are measured through the distribution gap. The food gap to maintain per capita consumption—status quo—at the base level for the 66 countries is estimated at 11 million tons for 1998 and is projected to be 18.8 million tons in 2008. Many countries that cannot maintain their per capita consumption are also consuming below their nutritional targets. The food supplies needed to meet their minimum nutritional requirements are projected to rise from less than 18 million tons in 1998 to more than 28 million in 2008.

Sub-Saharan Africa is the most vulnerable region with respect to food security. The region's per capita consumption is projected to decline 0.5 percent per year through the next decade. By 2008, Sub-Saharan Africa is projected to account for 61 percent of the total (all 66 countries) gap to maintain consumption and 79 percent of the nutritional gap even though the region's population constitutes only 25 percent of the total for the 66 countries. The main problem in the Sub-Saharan region is high population growth, which puts pressure on food supplies. While the region's production growth during 1980-97 exceeded that in Asia and Latin America, its population growth was also higher.

The Asian countries included in this study, despite having the second largest food gap, have made significant gains in increasing food availability over the past three decades. The ratio of food gaps to total consumption is very small (1-2 percent) and is projected to remain relatively constant for the next decade. The region, which will account for 63 percent of the population of all 66 countries in 2008, is projected to account for only 29 percent of the status quo food gap and 16.5 percent of the nutritional gap.

In Latin America and the Caribbean, the most difficult dimension of food security is the distribution of food within each country. Highly skewed distribution of income limits purchasing power and access to food for low-income households which, in turn, intensifies food security problems. As a result, 40 percent of the region's population is projected to be undernourished in 2008.

North Africa is the only study region with food supplies adequate to meet its nutritional needs.

Food consumption in the New Independent States (NIS, part of the former Soviet Union) is projected to increase because of economic recovery, improved export performance, and higher food production. This region is projected to

achieve the largest gains in per capita consumption—roughly 1 percent per year. Only the war-torn economy of Tajikistan, projected to have a significant food gap on a consistent basis, will likely remain vulnerable to food insecurity.

Among the factors contributing to food insecurity, the most crucial component is the performance of the food production sector. Domestic food production contributes to more than 90 percent of consumption in the most food-insecure countries. During the last decade, domestic production contributed 97 and 91 percent of consumption in the two lowest income groups in Asia and Sub-Saharan Africa. In North Africa, Latin America, and the NIS, domestic production contributed 50-60 percent. The volume of food production, in addition to its direct impact on consumption, has a strong link to population growth. Improvements in technology reduce the traditional reliance on human labor and affect human fertility decisions.

Although the main factors influencing food security are domestic food production, foreign exchange availability for food imports, and population growth, distribution of purchasing power within each country also plays a part in determining food security. Lower income groups have larger nutritional gaps than wealthier people. The distribution gap, which measures the amount of food required to raise food consumption of each income group to the nutritional requirement, is projected to increase 36 percent between 1998 and 2008. The growth of this gap far surpasses the growth in the number of people becoming food insecure. In fact, the number of people failing to meet their nutritional requirement is projected to grow only 3 percent during the next decade, reaching 1.13 billion by 2008. This means distribution-related nutritional problems will not necessarily spread to countries that are unaffected today, but instead problems will grow in countries that already suffer from food insecurity. Food-insecurity problems will intensify in those more than they will spread to other countries.

# Food Security Assessment

## Why Countries Are At Risk

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### Introduction

The world's resources are adequate to produce enough food for its population for at least the next few decades. The available food, however, is not distributed evenly. This means that many countries experience "food insecurity" when food supplies are not adequate to provide all people at all times with sufficient food for an active and healthy life. Although undernutrition is rarely viewed as an emergency, it reduces productivity and a society's long-term growth. Participants at the World Food Summit in November 1996 pledged "to reduce the number of undernourished people to half their present level no later than 2015." The success of the World Food Summit pledge depends on the current state of global food security and governments' commitment to implement policies that can improve the situation.

The principal focus of food security policies has been to increase food supplies; little attention has been paid to unequal distribution of food as the cause of food insecurity. A review of nutritional data, however, shows that undernutrition is prevalent even in middle-income countries with ample food supplies. In fact, if the objective of the World Food Summit is to be met, not only do food supplies need to expand, but strategies for reducing poverty and inequality of purchasing power need to be adopted.

In this study, we evaluate two aspects of food security—availability and distribution of food—and analyze their trends through 2008. The study includes 66 countries that have been or are potential food aid recipients (see box, p.2). We project food consumption at

the aggregate level, as well as by different income groups, through the next decade. To assess food security of countries, we project shortfalls in food availability from that needed to maintain per capita consumption, to meet national nutritional requirements, and to meet nutritional requirements for each income group within a particular country. We also examine the feasibility of achieving food security by evaluating the required growth for the principal factors affecting food security—agricultural productivity, foreign exchange earnings, and population.

We project that food insecurity in many of the study countries will intensify unless the performance trends of the key contributing factors are improved. For the poorest countries, an increase in agricultural productivity is the key to improving food security. In these countries, imports play a small role in the domestic food supply because foreign exchange availability is limited. Raising productivity is not an easy task, however. In Sub-Saharan Africa, the region most vulnerable to undernutrition, grain yields must grow at a rate 60 percent higher than the growth achieved during 1980-97 to satisfy nutritional requirements by 2008. Achieving this goal will require a substantial increase in investment. In other regions, although there are vulnerable countries, the overall picture is more promising. In Asia, food security will improve if yields or imports continue to grow as they did during 1980-97. The challenge, however, is to overcome Asia's recent slowdown in yield growth and external financial difficulties that may pose food-security problems in the long term.

## Food Insecurity Will Escalate

Projections indicate that food consumption will increase at a slower rate than population in many low-income countries during the next decade, leading to a decline in per capita consumption. Many countries will also be unable to meet the minimum nutritional requirements of their people. In some countries, although their national performance shows an increase in average consumption, low-income groups remain vulnerable to food insecurity because of internal distribution problems.

Forty-seven of the 66 countries will face a declining per capita consumption trend through 2008, which, in most cases, will lead to nutritional problems. By 2008,

**Table 1—Production, commercial imports, and food gaps\***

*The distribution gap is projected to be double the size of the status quo gap and 35 percent higher than the nutrition gap in 2008.*

Region	Pro-duction	Com-mercial imports	Food gaps		
			Status quo	Nutri-tion	Distri-bution
-----Million tons-----					
<b>North Africa</b>					
1998	38.0	19.2	0.0	0.0	0.1
2008	44.2	23.8	0.2	0.0	0.1
<b>Sub-Saharan Africa</b>					
1998	138.4	8.6	6.7	13.9	17.9
2008	173.2	9.8	12.1	22.4	27.0
<b>Asia</b>					
1998	418.1	16.6	3.8	2.7	8.4
2008	489.8	23.4	5.7	4.7	8.7
<b>LAC</b>					
1998	27.5	10.3	0.4	0.4	1.8
2008	32.7	13.8	0.7	0.6	1.7
<b>NIS</b>					
1998	6.1	1.5	0.1	0.7	0.8
2008	7.1	2.0	0.1	0.6	0.7
<b>Total 66 countries</b>					
1998	628.1	56.2	11.0	17.7	29.0
2008	747.0	72.8	18.8	28.3	38.2

\* in grain equivalent.

39 countries are projected to be unable to meet their nutritional food requirements.

In this study, two main food gaps are used to measure food insecurity: the status quo gap and the nutrition gap. The status quo gap is the difference between projected food supplies and base period (1995-97 average) per capita consumption (see box, p. 3). The nutrition gap is the difference between projected food supplies and the food needed to support minimum per capita nutritional standards. The food gap to maintain per capita consumption (status quo) at the 1995-97 base level for the 66 countries is estimated at 11 million tons for 1998 and is projected to be 18.8 million tons in 2008 (table 1). Many countries that cannot maintain their per capita consumption are also consuming below their nutritional targets. The food supplies needed to meet their minimum nutritional requirements are projected to rise from less than 18 million tons in 1998 to more than 28 million in 2008.

National-level analysis, however, masks the impact of unequal access to income on food security. People in

### Regions and Countries

**North Africa:** Algeria, Egypt, Morocco, Tunisia

**Sub-Saharan Africa:** Cameroon, Central Africa Republic, the Congo (formerly known as Zaire), Burundi, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda, Angola, Lesotho, Madagascar, Malawi, Mozambique, Swaziland, Zambia, Zimbabwe, Benin, Burkina Faso, Cape Verde, Chad, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo

**Asia:** Afghanistan, Bangladesh, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam

**Latin America and Caribbean (LAC):** Bolivia, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Peru

**NIS:** Armenia, Azerbaijan, Georgia, Kyrgyzstan, Tajikistan

lower income groups have larger nutrition gaps than wealthier people. The distribution gap is the amount of food required to increase food consumption for all income groups to the level to meet nutritional requirements (see box, p. 4). This gap is projected to increase 32 percent during the projection period to 38.2 million tons by 2008. The growth of this gap far surpasses the growth in the number of people becoming food insecure. In fact, the number of people failing to meet

their nutritional requirement is projected to grow by 3 percent—from roughly 1.1 billion in 1998 to 1.13 billion by 2008. This means distribution-related nutritional problems will intensify more than they will spread.

A study by the United Nations Food and Agriculture Organization projected a decline in the number of undernourished people between 1990 and 2010. This assessment was made despite the study's assumption

## Model Description and Definitions

The Food Security Assessment model used in this report was developed at USDA's Economic Research Service for use in projecting food consumption and access, and the food gap in 66 low-income countries—37 in Sub-Saharan Africa, 4 in North Africa, 11 in LAC, 9 in Asia, and 5 in the New Independent States (NIS) of the former Soviet Union. The projection period covered in this study is the 10-year period 1998 through 2008. The reference to food includes grains, root crops, and "other." The "other" category includes most other components of the diet. These three food commodity groups account for as much as 90 percent of all calories consumed in the study countries. Root crops are generally not traded, while the bulk of all food imports of these countries, commercial or food aid, is in the form of grains.

Food security of a country is evaluated based on the gap between projected domestic food consumption (produced domestically and imported commercially) and a consumption requirement. Although food aid is expected to be available during the projection period, it is not included in the projection of food consumption. It should be noted that while projection results will provide a baseline for the food security situation of the countries, they depend on assumptions and specifications of the model. Since the model is based on historical data, it implicitly assumes that the historical trend in key variables will continue in the future.

Projections of food gaps for the countries are based on differences between consumption targets and estimates of food availability, which are domestic supplies (production plus commercial imports) minus nonfood use. The estimated gaps are used to evaluate food security

of the countries. Food gaps are projected using two consumption criteria:

**Status quo target**, where the objective is to maintain average per capita consumption of the recent past. The most recent 3-year average (1995-97) is used for the per capita consumption target in order to eliminate short-term fluctuations.

**Nutrition-based target**, where the objective is to maintain the minimum daily caloric intake standards recommended by the UN's Food and Agriculture Organization (FAO). The caloric requirements (based on total share of grains, root crops, and "other") used in this assessment are those necessary to sustain life with minimum food-gathering activities. They are comparable to the activity level for a refugee—they do not allow for play, work, or any activity other than food gathering.

The status quo measure embodies a "safety-net" criterion by providing food consumption stability at recently achieved levels. The nutrition-based target assists in comparisons of relative well-being. Comparing the two consumption measures either for countries or regions provides an indicator of the need, depending on whether the objectives are to achieve consumption stability and/or to meet a nutritional standard. Large nutrition-based needs relative to status quo needs, for example, mean additional food must be provided if improved nutrition levels are the main objective. In cases where nutrition-based requirements are below status quo consumption needs, food availability could decline without risking nutritional adequacy, on average. Both methods, however, fail to address inequalities of food distribution within a country.

of a decline in the growth rate of agricultural output during the projection period compared with 1970-90. Lower population growth is projected, resulting in higher per capita food consumption and, therefore, less nutritional problems. The incidence of undernu-

### **Measuring a Distribution Gap**

In the estimation of nutritional deficits in developing countries, unequal distribution of food consumption is a major concern. We have estimated a distribution gap which measures the food needed to meet nutritional requirements under a targeted policy scenario. Under this scenario, consumption by each specified group (by income or any other category) is targeted to rise by the amount necessary to meet that particular group's nutritional requirements. The distribution food gap is projected to be more than 38 million tons in 2008, this is 33 percent higher than the projected gap to meet aggregate nutritional requirements.

trition is projected to decline in all regions except Sub-Saharan Africa (12).<sup>1</sup>

A recent FAO report indicates that the total number of chronically undernourished people in developing countries increased slightly between 1990-92 and 1994-96, from 822 million to 828 million (14).

The projections of food gaps in this study do not include external food assistance. In the past, food aid has played an important role in reducing food insecurity in low-income countries, but it remains inadequate to offset the full magnitude of needs. In fact, food aid shipments have declined in recent years, principally due to smaller budget outlays in donor countries. From the mid-1980's to the early 1990's, total food aid shipments exceeded 10 million tons annually. During the last 2 years, shipments have averaged around 5 million tons. Global food aid in 1997/98 was 5.3 million tons. At this level, food aid could fill about half the estimated food gap necessary to maintain consumption and roughly 30 percent of the nutrition gap for the 66 countries in 1998.

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<sup>1</sup> Italicized numbers in parentheses refer to sources listed in the References.



## Food Problems Vary Among Regions and Countries

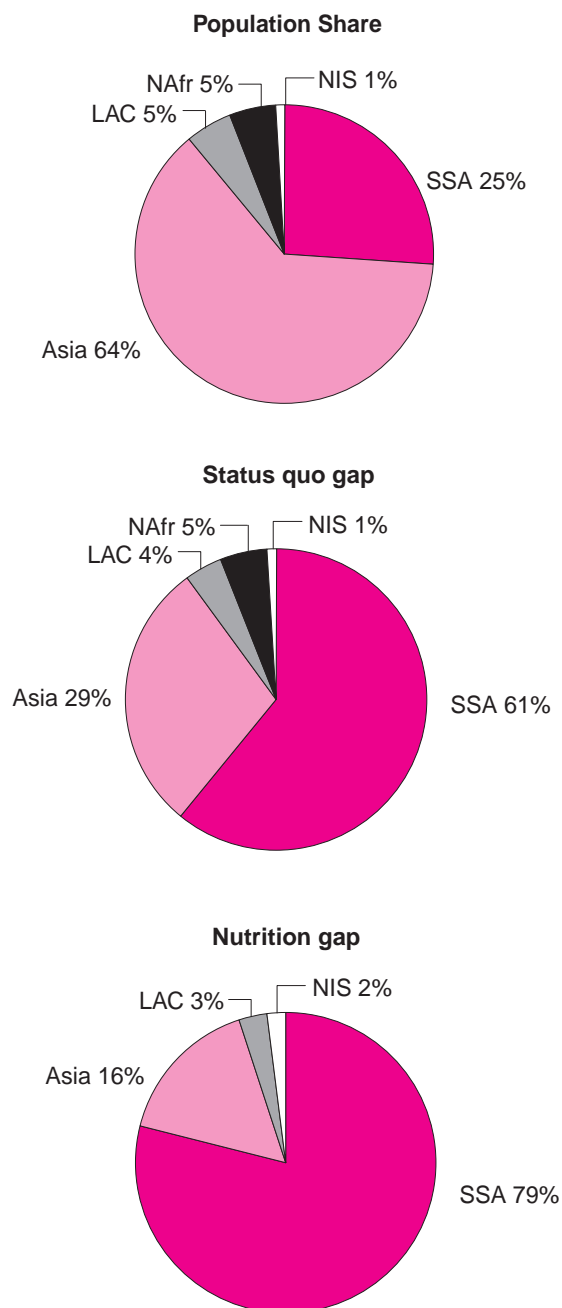
Regional comparisons of projections of food gaps reveal the intensity of the current as well as future food security problems of different regions. The results place Sub-Saharan Africa as the most food-insecure region. By 2008, this region is projected to account for 61 percent of the total (all 66 countries) gap to maintain consumption and 79 percent of the gap to meet nutritional needs even though the region's population constitutes only 25 percent of the 66-country total (fig. 1). The region's nutrition gap, as a share of consumption (total available food supplies), is projected to exceed 10 percent by 2008 (fig. 2). The main problem in the Sub-Saharan Africa region is high population growth, which puts pressure on food supplies; while the region's production growth during 1980-97 exceeded that in Asia and Latin America and the Caribbean (LAC), its population growth was also higher.

In addition to inadequate food availability, skewed distribution of purchasing power amplifies Sub-Saharan Africa's nutritional problems. The distribution gap for the region is projected to be 27 million tons in 2008. This is 21 percent higher than the region's aggregate nutrition gap. The number of people in Sub-Saharan Africa who cannot meet their nutritional requirements is projected to increase from 361 million during 1995-97 to 516 million by 2008 (fig. 3). This means that two-thirds of this region's population will be undernourished in 2008. Sub-Saharan Africa also suffers the greatest nutritional problems. It is the only region where consumption is projected to fall below the minimum nutritional requirement for 80 percent of the population during the next decade (table 2). In other regions, the problem is generally concentrated in the lowest income group (20 percent of the population).

The Asian countries included in this study, despite having the second largest nutrition gap, have made significant gains in increasing food availability over the past three decades. The ratio of food gaps to total consumption is very small (1-2 percent), and is projected to remain relatively constant for the next decade. Asia will account for 64 percent of the population of all the study countries in 2008, and is projected to account for only 29 percent of the

Figure 1  
**Population and food gaps in 2008**

*While Sub-Saharan Africa is projected to account for only 25 percent of the population of the 66 countries in 2008, the region is expected to account for 79 percent of the nutrition gap.*



LAC = Latin America and the Caribbean, NAfr = North Africa, NIS = New Independent States, SSA = Sub-Saharan Africa.

**Table 2—Ratio of consumption to nutritional requirements**

*Consumption is projected to fall short of the minimum nutritional requirement for all but the highest income group in the Sub-Saharan region.*

Region	Income quintiles				
	Lowest 20%	Second	Third	Fourth	Highest 20%
<b>North Africa</b>					
Base	0.99	1.08	1.14	1.19	1.30
2008	1.11	1.17	1.22	1.27	1.38
<b>Sub-Saharan Africa</b>					
Base	0.74	0.82	0.88	0.94	1.09
2008	0.70	0.78	0.83	0.89	1.03
<b>Asia</b>					
Base	0.89	0.97	1.03	1.08	1.20
2008	0.89	0.96	1.00	1.06	1.19
<b>LAC</b>					
Base	0.75	0.89	0.97	1.05	1.20
2008	0.85	0.95	1.03	1.11	1.31
<b>NIS<sup>1</sup></b>					
Base	0.74	0.83	0.88	0.93	1.01
2008	0.92	1.00	1.06	1.13	1.24

<sup>1</sup> Regional average income distribution was used for estimation.

status quo food gap and 16.5 percent of the nutrition gap. In fact, most Asian countries may be able to close their food gaps by increasing imports slightly above projected growth rates. The region's impressive gains, however, mask food problems of large segments of the population whose purchasing power is insufficient. When skewed purchasing power is taken into account, the region's distribution gap is projected at almost two times the average nutrition gap in 2008. Moreover, although the number of people who cannot meet their nutritional requirements is projected to decline over the next decade, still 40 percent of the region's population will be undernourished in 2008.

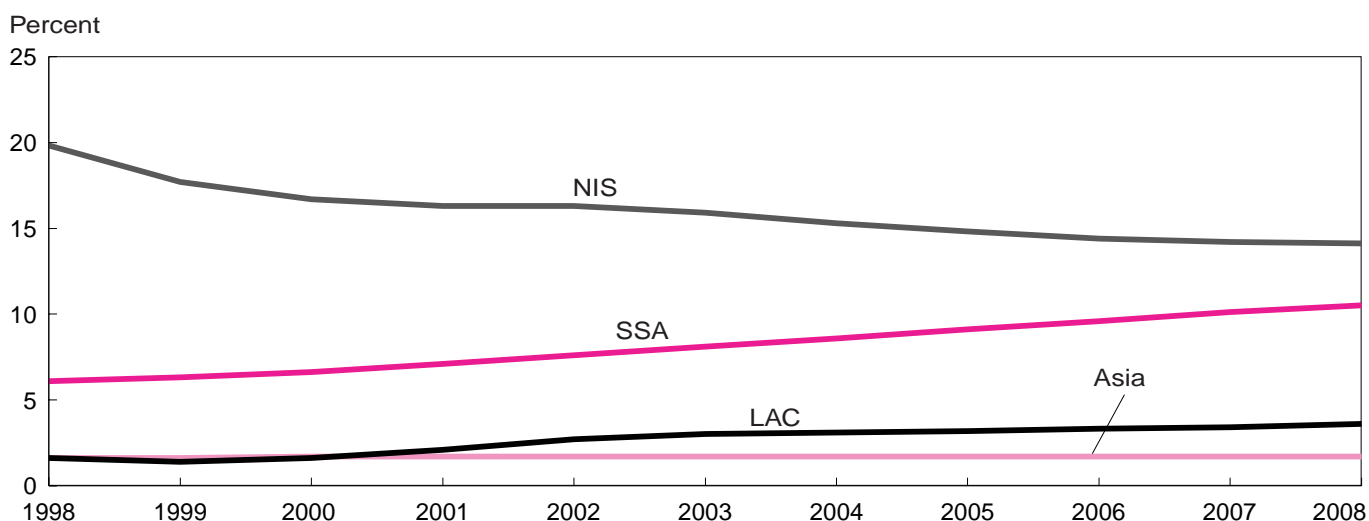
In LAC, the most difficult dimension of food security is the distribution of food within each country. The distribution gap is projected to be almost three times larger than the nutrition gap in 2008. The number of people who cannot meet their nutritional requirements is projected to decline slightly between the 1995-97 average levels and 2008. However, 40 percent of the LAC region's population is projected to be undernourished in 2008. Because the distribution of income is highly skewed, low-income households have limited purchasing power and access to food which, in turn, intensifies food-security problems.

North Africa is the only study region with adequate food supplies to meet its nutritional needs. However,

Figure 2

**Nutrition gap as a share of consumption**

*Asia's and LAC's nutrition gaps are projected to remain quite small relative to their consumption throughout the projection period.*



frequent droughts often affect a country's economic growth and welfare. The region's current level of food consumption is among the highest in the world, and consumption is projected to increase in Morocco and Tunisia, but decrease marginally in Algeria and Egypt. Political instability would be a major threat to food security in the region. The North African region, like the others, is faced with unequal food distribution. Therefore, while food consumption, on average, exceeds nutritional requirements, food consumption for 20 percent of the population (the lowest income group) in Algeria is projected to be less than the requirement by 2008.

Food consumption in the New Independent States is projected to increase because of economic recovery, improved export performance, and higher food production. Only the war-torn economy of Tajikistan, projected to have a significant food gap on a consistent

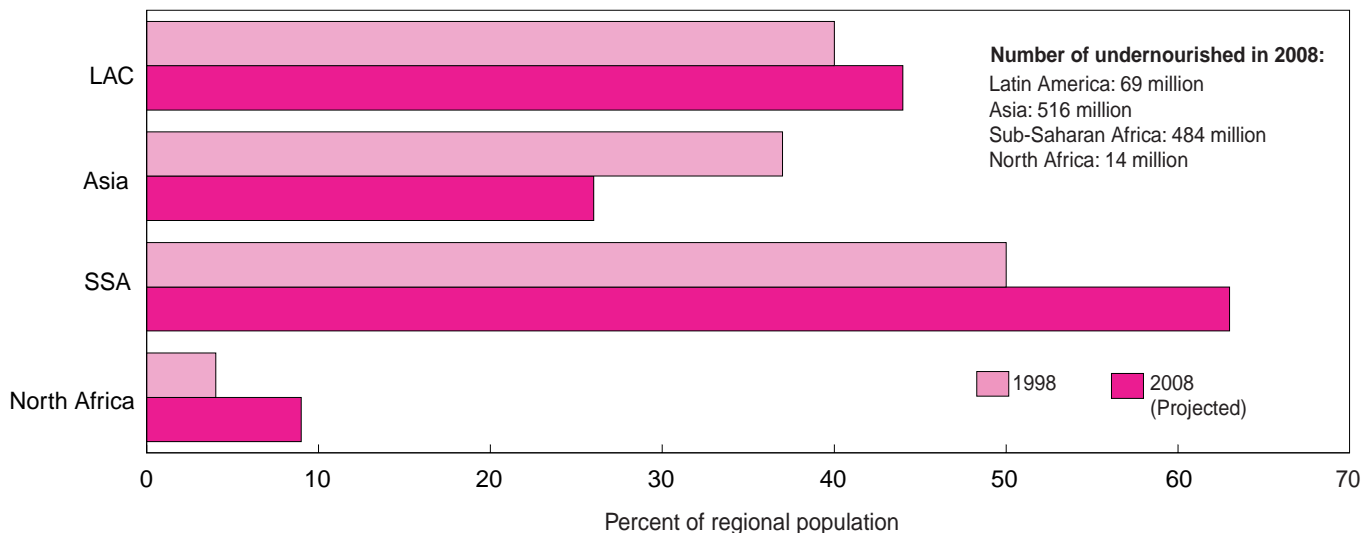
basis, will likely remain vulnerable to food insecurity. It should be noted that data for the NIS are weak, and because their economies are in a transition stage, the projection results should be used with caution.

Based on the projected results, countries covered in this report can be grouped into four different food-security categories: 1) countries that are projected, on the national level, to have adequate food in 2008, but because of inequality in purchasing power, segments of their population will face food insecurity; 2) countries that are moderately food insecure, where projected average food consumption falls in the range of 75 to 99 percent of the nutritional requirement; 3) countries with severe food-insecurity problems, where average food consumption is projected to fall to less than 75 percent of the nutritional requirement; and 4) countries where all income groups are projected to have adequate food (table 3).

Figure 3

**Share of population undernourished**

*The share of population undernourished increases most in Sub-Saharan Africa.*



**Table 3—Food insecurity in 2008**

*In 39 of the 66 countries, consumption is projected to fall short of the nutritional requirement on the national level, and in 12 countries the nutritional problem is due to large disparity in income distribution.*

	Nationally food secure <sup>1</sup>	Moderately food insecure <sup>2</sup>	Highly food insecure <sup>3</sup>
<b>N.Africa:</b>	Algeria		
<b>Sub-Saharan Africa:</b>	Benin, Cote d'Ivoire, Guinea-Bissau, Nigeria	Cameroon, Centr. Afr. Republic, D.R. of Congo, Ethiopia, Kenya, Sudan, Uganda, Tanzania, Lesotho, Madagascar, Malawi, Mozambique, Zambia, Zimbabwe, Burkina Faso, Guinea, Mali, Mauritania, Senegal, Togo	Burundi, Eritrea, Rwanda, Somalia, Angola, Cape Verde, Chad, Liberia, Sierra Leone
<b>Asia:</b>	India, Pakistan, Sri Lanka	Bangladesh, Nepal	Afghanistan
<b>LAC:</b>	El Salvador, Ecuador, Peru	Bolivia, Guatemala, Honduras, Nicaragua, Haiti	
<b>NIS:</b>	Azerbaijan		Tajikistan

In the remaining 26 countries, all income groups are projected to have adequate food.

<sup>1</sup> Adequate food but unequal distribution.

<sup>2</sup> Meet 75 percent or more of requirement.

<sup>3</sup> Meet less than 75 percent of requirement.

## Degree of Vulnerability

In the first category of insecure countries, skewed income distribution limits access of low-income groups to sufficient amounts of food despite adequate food supplies on the national level. Twenty-seven of the 66 countries have adequate aggregate food supplies, but in 12 of them, skewed income distribution limits purchasing power for lower income groups, thereby precluding adequate diets. In these countries, improved agricultural performance can reduce income inequality. Most poor live in rural areas with limited access to resources such as land or credit. In these countries, food insecurity in the low-income group is expected to continue unless programs to create employment and increase productivity of the poor are adopted. Increasing investment to improve market infrastructure will also help markets work, increasing returns to farming communities.

The second group includes 27 countries that are moderately food insecure, where projected food consumption represents 75 to 99 percent of nutritional requirements. Most of the countries in this group are in Sub-Saharan Africa, but factors contributing to their food insecurity vary. Some countries are experiencing civil unrest; others have shown progress in their agricultural performance and may be able to sustain the recent growth momentum. For example, the Congo's civil unrest during the last 2 years has displaced populations, adversely affecting food production and hindering marketing activities. This factor, plus flooding from El Niño in early 1998 that damaged houses, infrastructure, and crops, led to higher food prices and food insecurity in many parts of the country. On the other hand, Mozambique is reaping the benefits of sustained peace. Production has risen steadily for the last 6 years, and grain output in 1997 was roughly three times higher than the average output of the late 1980's.

The common characteristic of this group, however, is the large contribution of domestic food production to food consumption. Since these countries have been unable to adopt new technologies to increase productivity, labor remains the principal input in production, encouraging large families. With slow growth in domestic food production, these countries use commercial imports to fill food gaps. Historically, imports in these countries were supported by external assistance, which helped reduce the financial burden of food imports. With the decline in external assistance, a

larger share of foreign exchange availability must be allocated to food imports. However, any increase in spending on food imports will crowd out spending on essential raw materials and spare parts, raising concern over the long-term economic health of these countries.

The 12 countries in the third group are the most food insecure, and all but 2 are in Sub-Saharan Africa. For these countries, average food consumption is projected to fall to less than 75 percent of the nutritional requirement in 2008. A common characteristic among these countries is that they have been or are currently faced with political problems. While the projections of production and imports did not represent a decline from the historical period, population growth alone will severely deteriorate their food security situation because of their already weak position.

The political problems of these countries reinforce long-term trends in poverty, food insecurity, and a breakdown of social structure. Consequently, events such as drought, disease (human or livestock), or floods can easily trigger acute food shortages and famine. For these countries, political stability and better policies are essential for improving food security.

Fifteen of the study countries fall into the fourth group, projected to be food secure because their consumption, both on average and by individual income group, will be higher than the minimum nutritional requirements.

In summary, Asia and Sub-Saharan Africa are projected to face a deteriorating nutritional situation. In Asia, however, the deterioration is negligible, and the region's current consumption is higher than that of Sub-Saharan Africa. In Sub-Saharan Africa, the deterioration is measurable, and consumption has a lower base value. In this region, only the highest income group is projected to consume more than the minimum nutritional requirement, compared with the top three groups in Asia. The severity of the situation in Sub-Saharan Africa is confirmed by projected changes in the distribution gap. With the exception of Sub-Saharan Africa, for all the regions covered in this study, this gap declines or increases negligibly during the projection period. For Sub-Saharan Africa, however, the distribution gap jumps more than 50 percent over the next decade. This statistic alone is a strong indicator of the intensity of the region's food insecurity problem.

## Closing Food Gaps

A country will be faced with growing food insecurity when food supplies are nutritionally inadequate and/or do not keep pace with population growth. Projections are made assuming trends in the key factors affecting food security—agricultural productivity, foreign exchange availability, and population growth—continue. Any change in the performance of these factors could significantly alter the projection results (fig. 4). We used a projections model to simulate the effect of changes in these factors. For example, to estimate the feasibility of closing food gaps by increasing crop yields, we assumed fertilizer use to increase at a higher rate than that of the baseline projections; we then compared the effect on per capita consumption with the baseline results.

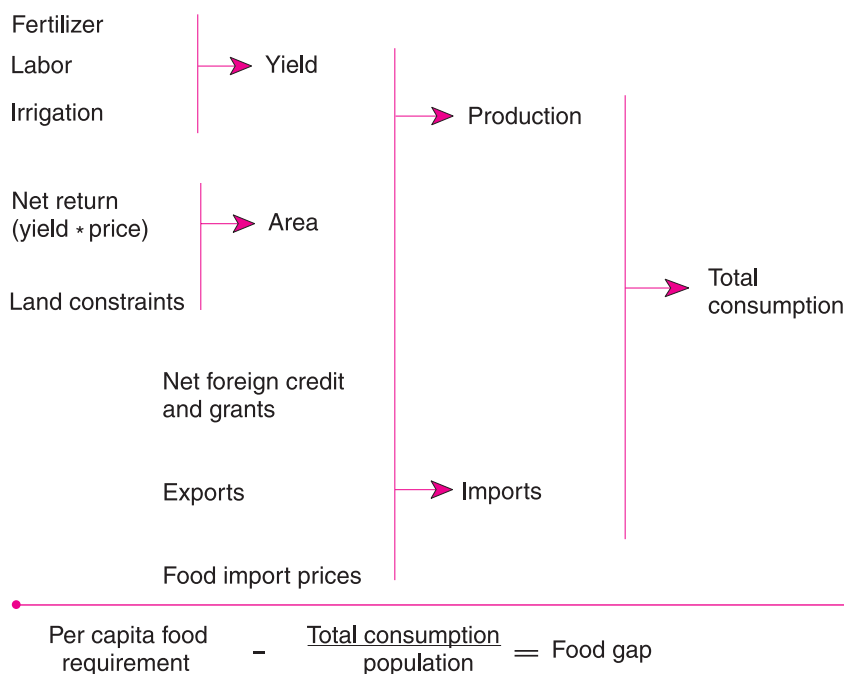
### Increasing Production

Agricultural productivity is, generally, the essential element of the food security equation. In food-insecure countries, growth in food production is usually low, and, in many cases, population growth is high,

putting additional pressure on food demand. The annual production growth rate required to close the average nutrition food gap by 2008 ranges from 3.4 percent in Sub-Saharan Africa to 1.4 percent in North Africa (fig. 5). The questions are: can past success be repeated or failures avoided? what would be the source of growth? Surprisingly, for the 66 countries studied, the average annual growth in food production was about 3 percent during 1980-97, more than their average population growth of 2.3 percent for the same period. Most of the food production growth, however, was concentrated in a handful of countries.

For example, Egypt showed an impressive production growth rate following the adoption of a new wheat variety that led to more than a 60-percent increase in grain yields between 1980 and 1997. In Nigeria, grain production increased nearly 7 percent annually, and production of root crops grew 10 percent per year during 1980-97. Nigeria's continued restrictions on food imports have increased domestic prices, thereby raising the incentives to produce. Nigerian farmers adopted a

Figure 4  
**Factors affecting food consumption and food gaps**



new variety of cassava, and increased their average yield threefold. Because of Nigeria's size relative to other countries in the region, its strong growth supported Sub-Saharan Africa's food output growth at 3.6 percent per year during 1980-97. In fact, if Nigeria is excluded from the Sub-Saharan statistics, the annual growth rate of food production in the region would have been only 2 percent per year, which is lower than the region's 3-percent-per-year increase in population.

In Asia, average food production grew 2.6 percent per year during 1980-97, which roughly translates into a 0.5-percent-per-year increase per capita. Food production growth in the LAC countries increased only 1.2 percent per year, considerably less than their 2.2-percent population growth. In the NIS countries, production has stagnated since 1987, the first year data were available.

Future production growth in the countries depends on expanding crop area, improving productivity of the existing lands, or both.

### Expanding Crop Area

Since many low-income countries, particularly in Sub-Saharan Africa and LAC, have not experienced improvements in technology, most increases in agricultural output have stemmed from area expansion (1,12). In Sub-Saharan Africa, area expansion measured more than 2 percent per year during 1980-97. However, the long-term prospects for acreage expansion are not bright, because, in most countries, a large part of land that could be used for farming is unfit to cultivate without major investment. In LAC and Sub-Saharan Africa, continued expansion of cropland means converting range and forest land to crop production, a process with high economic and environmental costs. According to FAO estimates, about half of the land that could be used to produce food in Sub-Saharan Africa has poor soil (12). Sub-Saharan Africa has a vast and diverse land area, but the region faces a number of resource constraints (such as lack of water) to sustainable agricultural growth (6). Some countries, such as Sudan and Zaire, have vast areas of rainfed land with crop potential, while others, such as Kenya and Madagascar, have already exhausted their high-potential land. In addition, relative to land currently in production, much of the potential cropland is distant from domestic and foreign markets. Moreover, the transport and communications infrastructure necessary

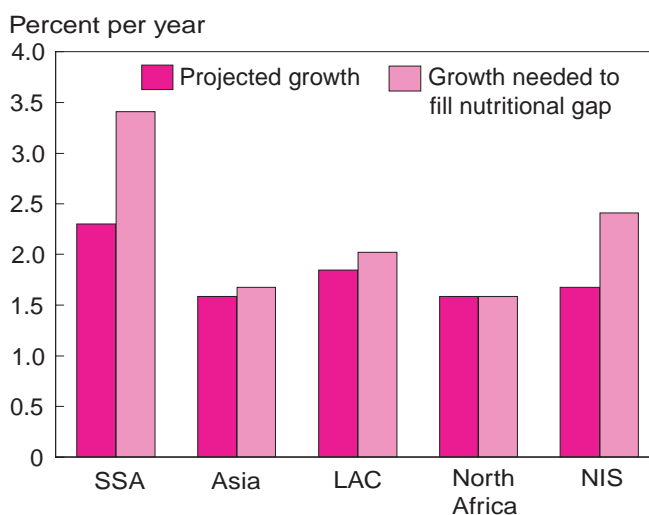
for trade between the areas of crop potential and markets is poorly developed.

Demographic changes are placing increasing pressure on land in Sub-Saharan Africa. More than 20 percent of all vegetative land is degraded due to human causes; however, water and wind erosion still account for a majority of the affected hectares. Much of this degraded area is in the Sahel, Sudan, Ethiopia, Somalia, Kenya, and southern Africa. Historically, farmers adjusted to resource constraints by following several years of planting with several fallow years. However, population pressures have reduced the practice of these sustainable agricultural techniques, and are leading to rapid declines in land productivity.

### Growth in Yields

The only option to sustain production growth is to increase yields. Growth in yields is projected to match or exceed 1980-97 levels in LAC, Sub-Saharan Africa, and the NIS. These optimistic trends are attributed to the improved government policies of recent years which are expected to increase returns and provide better incentives to producers. In North Africa, growth of grain yields is projected to be slower than during 1980-97 because no major technological shift, similar to the early 1990's adoption of high-yielding varieties in Egypt, is expected in the future (12). Grain yields in Asia are projected to follow the recent trend (since the

Figure 5  
**Projected growth in food production, 1998-2008**  
*Production growth needed to close the nutrition gap in Sub-Saharan Africa far exceeds projected rates.*



mid-1990's), which is slower than the growth of the last two decades. In LAC and Sub-Saharan Africa, while yield growth is projected to at least match that of 1980-97, it falls short of the growth required to significantly improve food security. Sub-Saharan Africa's annual yield growth would need to accelerate to 2.2 percent from projected rates of 1.4 percent to eliminate the nutrition food gap by 2008. In LAC, yield growth would need to increase 1.5 percent per year, or three times the historical rate (table 4).

Average regional grain yields are the highest in North Africa, followed by Asia, the NIS, LAC, and Sub-Saharan Africa (fig. 6). The quality of resources and use of new technology are the reasons behind this ranking. During 1980-97, yields declined in the NIS countries and increased only marginally in LAC. In Sub-Saharan Africa, yields grew 1.4 percent per year. Distorted policies, limited resources, low input use, and little use of new technology are the principal factors constraining yields in many countries in these regions. Despite constraints, Asia and North Africa experienced relatively strong yield growth of 2.6 and 3.5 percent per year during 1980-97. In Egypt, the combination of fertile land and the adoption of high-yielding crop varieties boosted the country's yields significantly in the early 1990's, thereby raising the average regional yields. During the 1970's, most of Asia's production gains stemmed from the use of "Green

Revolution" technology and crop varieties, expansion in the land base through irrigation, as well as improved cultivation practices. Use of improved inputs also contributed to yield growth. Farmers who adopt improved crop varieties must use more fertilizer and timely water application and drainage to achieve yield potential. In Asia, many governments made a package of

**Table 4—Grain yield growth by region**

*Yield growth must accelerate to eliminate the nutrition gap in most regions.\**

Regions	1980-97	1998-2008	Growth to fill gap
<i>Percent per year</i>			
North Africa	3.5	1.5	0.8
Sub-Saharan Africa	1.4	1.4	2.2
Asia	2.6	1.3	1.4
LAC	0.5	0.9	1.5
NIS	NA	1.0	1.7

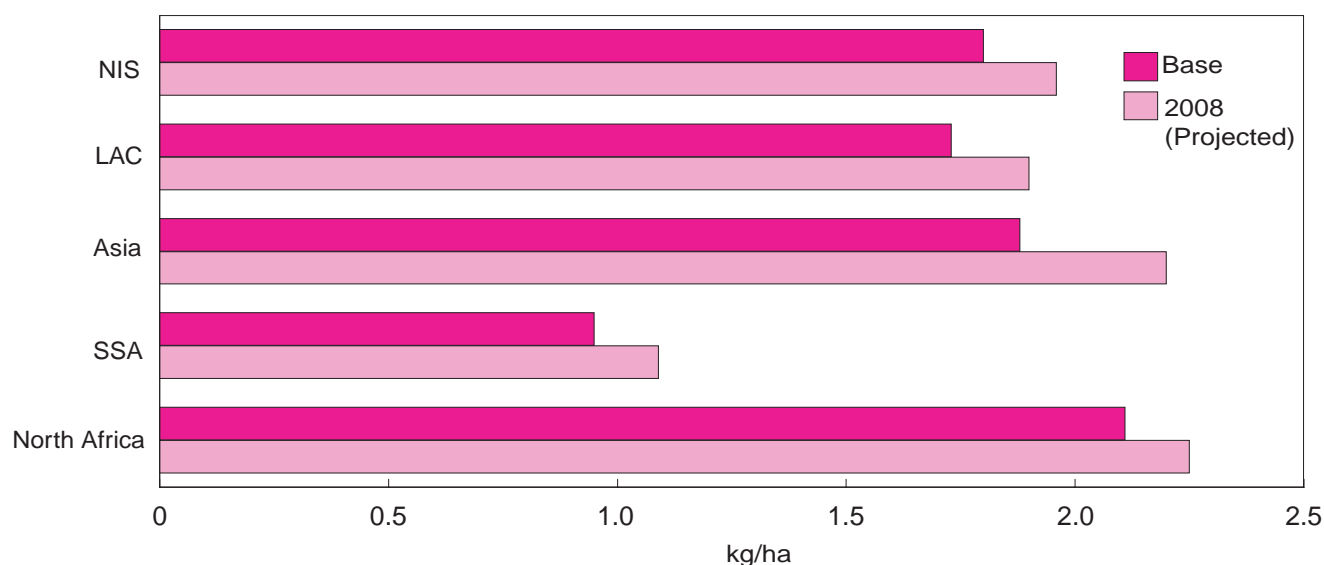
NA = not available.

\* Given projected import growth.

Figure 6

### Grain yields by region

*Average grain yields are influenced by quality of resources and use of technology.*





technologies (high-yielding varieties, adequate fertilizer, and chemicals) available to farmers. In countries with limited support for inputs, the adoption rate was very slow. The pace of yield growth, however, has slowed during the last decade and the current slower trend is expected to continue.

Yield projections are based on the use of improved inputs, particularly fertilizer use. The Asian countries use the most fertilizer, 95 kg per hectare, followed by LAC at 76 kg, North Africa at 74 kg, and Sub-Saharan Africa at a very low level of 7 kg. Sub-Saharan Africa accounts for only 1 percent of the world's fertilizer use. This study assumes higher fertilizer applications for yield projections in all regions. But yield does not increase proportionally to increases in fertilizer use. In this study, a 1-percent increase in fertilizer use is projected to result in a 0.1–0.3 percent increase in yield (estimates based on cross country data of the 66 countries) (2,6). Because of such low responsiveness, growth rates of fertilizer use are projected to be low—in the range of 1 to 4 percent annually. In Sub-Saharan Africa, growth is projected to be positive, reversing the trend during 1980-97. Despite this assumption of growth, fertilizer use per hectare will remain low by world standards, rising to only 9 kg by 2008. Because of Sub-Saharan Africa's low response of yields to fertilizer use, this increase will translate into only a small gain in yields—6 percent in 10 years.

The principal factor limiting yield response to fertilizer use is the inadequate supply of water during the growing season. Although water availability varies considerably across the regions, it has become a serious problem in many countries. According to the World Bank study "Resources and Global Food Prospects," depletion and degradation of water resources are major problems facing many low-income countries (4,5). Within 10 years, if population grows at projected rates, per capita water availability will decrease by an average of 20 percent in developing countries and 34 percent in African countries. The agricultural sector consumes over half the annual freshwater withdrawals in most of the countries and could face greater competing demands from household and industrial uses in the future.

The sparse rainfall that characterizes much of Sub-Saharan Africa affects fertilizer response and demand (5,9). Farmers are very reluctant to risk fertilizer use until rain falls, since without adequate moisture to dissolve nutrients in fertilizer (especially nitrogen), crops

can "burn." Irrigation can make the use of fertilizer profitable and increase agricultural output. However, in Sub-Saharan Africa, only 4.3 percent of arable land is irrigated. This is low, even when compared with other developing regions. In LAC, 13 percent of arable land is irrigated, and 38 percent is irrigated in Asia (13). The world average is 19 percent. There is potential for expanding irrigated area in Sub-Saharan Africa, but it is costly and requires investment. Increasing the use of fertilizer raises production costs. In many low-income countries, particularly those in Sub-Saharan Africa and LAC, almost all fertilizer is imported, and the lack of adequate foreign exchange constrains availability.

The effects of technical change, improvements in infrastructure, and research on yield growth are difficult to quantify. A paper by USDA economists summarizing earlier studies on agricultural productivity in Sub-Saharan Africa indicates that policy reform, improvement in infrastructure, and research expenditures encourage adoption of yield-increasing technologies (16). In recent years, however, public spending on these activities has declined in most countries. This trend could have detrimental implications for increasing food production.

## Increasing Imports

The performance of domestic production would be less critical to food security if countries could import their required foods. Financial constraints are important factors limiting the role of imports in many countries. In some regions, the size of the food gaps are quite small relative to commercial imports, meaning that if imports grew at a slightly higher rate than projected, the gaps could close. This is the case in North Africa and LAC. In Asia, the ratio of the nutrition gap to commercial imports is projected to be more imposing, however, at 20 percent in 2008. In Sub-Saharan Africa, the ratio of the average nutrition gap to commercial imports is projected at 229 percent. Given the region's prospects for slow import growth, it is highly unlikely that the gap will be filled by expanding imports. To close nutrition gaps, food imports must grow nearly 13 percent per year in Sub-Saharan Africa, 5.6 percent in the NIS, 4.7 percent in Asia, and just under 4 percent in LAC (table 5). The North African countries do not have any nutrition gaps, but to maintain their consumption, food imports need to grow nearly 3 percent per year. Given the import patterns of

the regions during 1980-97, the most difficult challenge is the significant import growth required in Sub-Saharan Africa.

The outlook for the financial conditions of most of the study countries permits only slow growth in food imports. During 1980-97, food imports expanded in all regions. Asian imports increased at the fastest rate, nearly 8 percent per year (13). Sub-Saharan Africa's imports grew at the slowest rate, 1.9 percent. The positive import growth was a response to a combination of factors: declining world food prices, slow domestic production growth (particularly in Sub-Saharan Africa and LAC), improvements in financial conditions (in North Africa and Asia), and the relaxation of import restriction policies in many countries.

Food imports are supported by foreign exchange availability. Foreign exchange availability, in this study, is defined as the sum of real export earnings and real net external financial flows. The response of food imports to foreign exchange availability is not one-to-one in this study (inelastic response in the range of 0.6 to 0.8, depending on the country—estimates based on cross country data). This means that, everything being equal, to achieve a 1-percent growth in food imports, foreign exchange availability must grow by 1.3 to 1.7 percent. Export earnings growth is projected to be

**Table 5—Food import growth**

*Food import growth must accelerate to close nutrition gaps.\**

Regions	1980-97	1998-2008	Growth to fill gap
<i>Percent per year</i>			
North Africa	3.7	2.6	2.6
Sub-Saharan Africa	1.9	1.9	12.7
Asia	7.7	3.1	4.7
LAC	5.9	3.4	3.8
NIS	NA	3.2	5.6

NA = not available.

\* Given projected production growth.

positive in all regions, while the real net external financial flow (credit and external assistance) is assumed to remain constant at 1995-97 levels. This projection assumes that performance of exports will be the key determinant of food imports. For example, to achieve the target import growth, Sub-Saharan Africa's export earnings must increase by 13 to 17 percent annually.

While Sub-Saharan Africa's projected growth rate for exports is almost double the growth experienced during 1980-97, it falls well short of the growth required to fill the food gaps. Continued political instability in Liberia, the Congo, Central African Republic, Sudan, Somalia, Rwanda, Burundi, and Angola dampens the region's prospects for export growth. In addition, Sub-Saharan Africa continues to depend on the exports of a few primary commodities—such as coffee, tea, sugar, and tobacco—for most of its export earnings. Prices for these commodities are projected to decline in the long term. According to the World Bank, in real terms, non-energy and agricultural commodity prices are projected to decline on average by nearly 2 percent per year in 1997-2006, metals by 1.8 percent, and beverages by 3.5 percent (19). Internal market conditions (demand, supply) of Sub-Saharan countries generally have no significant influence on world market prices. Therefore, their export earnings are influenced by world commodity prices and shifts in foreign demand. Consequently, lower commodity prices will limit export earnings, and thereby limit imports, which will ultimately increase the region's vulnerability with respect to food security.

Any significant increase in the net external financial flows to these countries is unlikely. Average net flows of money to the regions of North Africa, Sub-Saharan Africa, and LAC declined during the last decade, while the flow to the Asian countries in this study grew less than 1 percent per year (19). External credit and assistance has contributed roughly 10 to 15 percent of the total annual value of imports of the countries during the last decade, although there is a wide variation among countries. For countries such as Mozambique, as much as 75 percent of imports were supported by external assistance in the last 5 years, while countries with political problems, such as Algeria, are faced with a net loss due to capital flight. For a number of countries, the debt burden continues to dampen growth prospects and the risks of setbacks are considerable;

therefore, financial conditions remain difficult. According to the World Bank, the ratio of debt to exports exceeded 200 percent in the low- and middle-income countries of Sub-Saharan Africa, LAC, and South Asia in 1995 (19).

To deal with the financial squeeze, many countries have responded by taking economic or political steps to help provide a more financially stable future. These programs emphasize currency devaluation, privatization, and reduction in market distortions. They are also expected to promote export performance, but it is not clear how much these policies will influence the amount of foreign capital these countries receive. The annual growth of earnings from exports (which is deflated by 2.5 percent, the World Bank's projected inflation rate in the countries designated by the Organization of Economic Cooperation and Development) is projected to be highest in the Asian countries, at 6 percent, and the lowest in Sub-Saharan Africa, at 1.5 percent (19).

### Reducing Population Growth

High population growth rates are the principal factors stimulating food demand. The United Nations projects a declining trend in population growth, but at varied rates across regions. The highest rate of decline is projected for North Africa, where during 1980-97, popula-

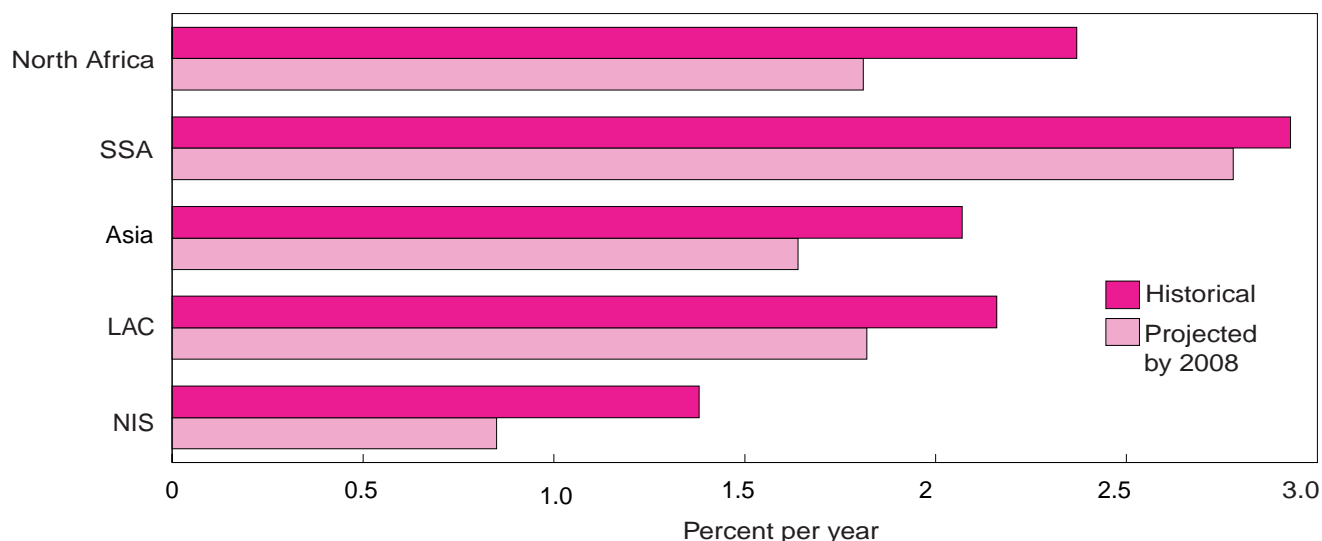
tion growth was 2.4 percent and is projected to slow to 1.7 percent by 2008 (fig. 7). The smallest decline is expected in Sub-Saharan Africa where the growth of 3 percent per year during 1980-97 is projected to decline to 2.7 percent during 1998-2008. If population growth in this region were to decline to 2.3 percent, the projected growth in domestic food production would be adequate to eliminate the nutrition gap.

Sub-Saharan Africa's population more than doubled to an estimated 527 million between 1960 and 1990, and by the year 2008 it will approach 800 million. There is little doubt that prolonged rapid population growth, in the absence of subsequent increases in agricultural investment and sustainable cultivation methods, causes bleak prospects for most countries in Sub-Saharan Africa. The decision to reduce family size, however, will not happen automatically. A large number of factors such as agrarian structure, stagnant rural incomes, and religious and cultural beliefs are believed to be important determinants of a family's demand for children in the region (8,10). With the exception of successful family planning initiatives in Botswana, Kenya, and Zimbabwe, there is no indication of a sustained decline in Sub-Saharan Africa's population growth rate. The present age composition will also lead to continued high population growth. Between 35 and 50 percent of the region's population is 15 years old or younger. With such a large percentage of the region's

Figure 7

### Population growth rates

*Population growth rates are projected to slow.*



inhabitants about to enter their reproductive years, population growth likely will remain high even if average fertility rates decline.

The extensive food production systems common in Sub-Saharan countries create a strong incentive for large families, because the ability to increase cultivated area increases with family size. Family size is even more important because most of the food-production work is done by women and children. Until the time that an additional child becomes more expensive than the income and labor that the child contributes, households will have few incentives to restrict family size. Therefore, to reduce population growth, governments need to curb incentives for large families by promoting technology as a means of raising agricultural productivity. This would be achieved through investments in

market infrastructure as well as research and extension. If new agricultural technologies are not adopted, labor will remain the principal input in production, and large families will be the norm. Such a scenario would continue the trend of little or no growth in per capita food supplies, stagnant or deteriorating caloric intake, and declining nutritional status (2).

In many parts of Sub-Saharan Africa, population pressure has forced people in traditional agriculture to work harder without being able to maintain their incomes or their standard of living—measured in terms of food consumption and production. Ill health caused by malnutrition, unexpected illness, disease, and accidents hinders a country's development potential and traps it in a cycle of rapid population growth, falling per capita food production, and insufficient health care.

## Conclusion

Uneven distribution of the world's resources means that the poor, low-resource countries are vulnerable to food insecurity. Per capita food consumption is projected to decline in 47 of the 66 study countries in the next decade, and 39 countries are projected to be unable to meet their minimum nutritional requirements. Sub-Saharan Africa is identified as the most food-insecure region, and the situation is projected to deteriorate further during the next decade. The region's per capita consumption is projected to decline 0.5 percent per year through the next decade. The NIS region is projected to achieve the largest gains in per capita consumption—roughly 1 percent per year. The regional overview, however, masks the food problems faced by individual countries. For example, countries such as Afghanistan in Asia, Haiti in LAC, and Tajikistan in the NIS region are also considered vulnerable to food insecurity, despite their regions' more positive outlook, because their food consumption through 2008 is projected to be less than 80 percent of their nutritional requirement.

The main factors influencing the food security position of the countries are domestic food production, foreign exchange availability, population growth, and distribution of income. Among these factors, domestic food production is the most crucial. Domestic production contributes to more than 90 percent of consumption in the most food-insecure countries. In North Africa, LAC, and the NIS, domestic production contributed 50-60 percent of consumption. Domestic production, in addition to its direct impact on consumption, has a strong link to population growth. Improvements in technology reduce the traditional reliance on human labor and therefore the desirability of large families.

Sub-Saharan Africa, the most food-insecure region, is caught in a web of interlocking problems. Finding solutions amid continuing crises is the challenge facing policymakers. Based on the current trend, agricultural growth lags behind population growth, thereby widening food gaps and putting pressure on purchasing power. Commercial food imports, used to fill food gaps, divert limited foreign exchange availability from domestic investment. The countries remain unsuccessful in adopting new technologies to raise food crop yields and increase productivity, leaving people reliant on large families as the principal input in production. This will lead to little or no growth in per capita food

supplies, stagnant or deteriorating caloric intake, and declining nutritional status. In addition, African countries face unfavorable terms of trade because of declining prices for their exports, and civil strife and political instability have continued even into the post-cold war period.

During 1980-97, Sub-Saharan Africa's imports were supported by external assistance—food aid provided additional support to reduce the financial burden of food imports. With the decline in external assistance, a larger share of foreign exchange availability must be allocated to food imports. Any increase in spending on food imports, however, will crowd out spending on essential raw materials and spare parts, raising concern over the region's long-term economic health. Most countries depend on imports of energy and capital to complement domestic production. In the long run, import capacity of the countries will depend mainly on the performance of their export sectors. Annual growth in Sub-Saharan Africa's export earnings was less than 1 percent during 1980-95, and agricultural exports accounted for 20 to 40 percent of the region's total export earnings. Although prices for these commodities are projected to decline in the next decade, an increase in the volume of exports can have a positive effect on the trend.

To improve food security, it is essential to promote policies that accelerate agricultural growth, particularly in Sub-Saharan Africa. Foreign exchange availability is limited, which limits imports. Increases in production would translate into a gradual increase in food supplies, a decline in population growth, and an increase in export earnings to support food imports. A significant improvement in agricultural performance, however, requires innovative technologies to increase productivity of both land and labor. Reports indicate that such technologies are available throughout the region, but only experimentally and on a small scale (2). Kenya and Zimbabwe adopted high-yielding corn varieties and significantly increased yields in the region during the last two decades. Improved production practices such as mixed cropping, which is currently used extensively, can be used to further increase yields. Therefore, to close food gaps, regions must disseminate these technologies to prevent further food insecurity and perhaps stimulate domestic production.

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## Appendix 1

### Structural Framework for Projecting Food Consumption in the Aggregate and by Income Group

**Projections of Food Availability**— The simulation framework used for projecting aggregate food availability is based on partial equilibrium recursive models of 66 lower income countries. The country models are synthetic, meaning that the parameters that are used are either cross country estimates or are estimated by other studies. Each country model includes three commodity groups, grains, root crops, and “other.” The production side of the model is divided into yield and area response. Crop area is a function of 1-year lag return (real price times yield), while yield responds to input use. The projections of consumption for the “other” commodities is simply based on a trend that follows the projected growth in supply of the food crops (grains plus root crops). Although this is a very simplistic approach, it represents an improvement from the previous assessments where the contribution to the diet of commodities such as meat and dairy products was overlooked. The plan is to enhance this aspect of the model in the future.

Commercial imports are assumed to be a function of domestic price, world commodity price, and foreign exchange availability. Foreign exchange availability is a key determinant of commercial food imports and is the sum of the value of export earnings and net flow of credit. Foreign exchange availability is assumed to be equal to foreign exchange use, meaning that foreign exchange reserve is assumed constant during the projection period. Countries are assumed to be price takers in the international market, meaning that world prices are exogenous in the model. However, producer prices are linked to the international market.

For each commodity group (c), food consumption (FC) is defined as domestic supply (DS) minus nonfood use (NF).  $n$  is country index and  $t$  is time index.

$$FC_{cnt} = DS_{cnt} - NF_{cnt} \quad (1)$$

Nonfood use is the sum of seed use (SD), feed use (FD), exports (EX), and other uses (OU).

$$NF_{cnt} = SD_{cnt} + FD_{cnt} + EX_{cnt} + OU_{cnt} \quad (2)$$

Domestic supply of a commodity group is the sum of domestic production (PR) plus commercial imports (CI), food aid (FA), and changes in stocks (CSTK).

$$DS_{cnt} = PR_{cnt} + CI_{cnt} + FA_{cnt} + CSTK_{cnt} \quad (3)$$

Production is generally determined by the area and yield response functions:

$$PR_{cnt} = AR_{cnt} * YL_{cnt} \quad (4)$$

$$YL_{cnt} = f(LB_{cnt}, FR_{cnt}, K_{cnt}, T_{cnt}) \quad (5)$$

$$RPY_{cnt} = YL_{cnt} * DP_{cnt} \quad (6)$$

$$RNPY_{cnt} = NYL_{cnt} * NDP_{cnt} \quad (7)$$

$$AR_{cnt} = f(AR_{cnt-1}, RPY_{cnt-1}, RNPY_{cnt-1}, Z_{cnt}) \quad (8)$$

where AR is area, YL is yield, LB is rural labor, FR is fertilizer use, K is indicator of capital use, T is the indicator of technology change, DP is real domestic price, RPY is yield times real price, NDP is real domestic substitute price, NYL is yield of substitute commodity, RNPY is yield of substitute commodity times substitute price, and Z is exogenous policies.

The commercial import demand function is defined as:

$$CI_{cnt} = f(WPR_{ct}, NWPR_{ct}, FEX_{nt}, DR_{cnt}, M_{nt}) \quad (9)$$

where WPR is real world food price, NWPR is real world price of nonfood items, FEX is real foreign exchange availability, DR is real domestic price, and M is import restriction policies.

The real domestic price is defined as:

$$DP_{cnt} = f(DP_{cnt-1}, DS_{cnt}, NDS_{cnt}, GD_{nt}, EXR_{nt}) \quad (10)$$

where NDS is supply of substitute commodity, GD is real income, and EXR is real exchange rate.

### **Projections of Food Consumption by**

**Income Group-** Inadequate economic access is the most important cause of chronic undernutrition among developing countries and is related to the level of income. Estimates of food gaps at the aggregate or national level fail to take into account the distribution of food consumption among different income groups. Lack of consumption distribution data for the countries is the key factor preventing estimation of food consumption by income group. An attempt was made to fill this information gap by using an indirect method of projecting calorie consumption by different income groups based on income distribution data.<sup>1</sup> The procedure uses the concept of the income/consumption relationship and allocates the total projected amount of available food among different income groups in each country.

Assuming a declining consumption and income relationship (semi-log functional form):

$$C = a + b \ln Y \quad (11)$$

$$C = C_0/P \quad (12)$$

$$P = P_1 + \dots + P_i \quad (13)$$

$$Y = Y_0/P \quad (14)$$

$$I = 1 \text{ to } 5 \quad (15)$$

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<sup>1</sup> The method is similar to the method used by Shlomo Reutlinger and Marcelo Selowsky in "Malnutrition and Poverty," World Bank, 1978.

where C and Y are known average per capita food consumption (calorie consumption) and per capita income (all quintiles),  $C_0$  is total food consumption, P is the total population, I is income quintile, a is the intercept, b is the consumption income propensity, and  $b/C$  is consumption income elasticity (point estimate elasticity is calculated for individual country). To estimate per capita consumption by income group, the parameter of b is estimated based on cross country (66 low-income countries) data for per capita calorie consumption and income. The parameter a is estimated for each country based on the known data for average per capita calorie consumption and per capita income. In the next step, point consumption/income elasticities are estimated for each country using base level country income and consumption data. These elasticities are then used to estimate calorie consumption by different income groups in each country. The estimated distribution gap measures the food needed to bring food consumption of each income group up to the nutritional requirements. To estimate the number of people vulnerable to food insecurity, the portion of population that consumes less than the requirement is multiplied by the total population to estimate the number of people who have inadequate access to food. Country income distribution is assumed constant during the projection period. For countries where income distribution data are not available (mainly in Sub-Saharan Africa), average sub-regional income distribution data are used.



## Appendix II

### Data Sources and Assumptions

#### Historical Data

Historical supply and use data for 1980-97 for most variables are from a USDA database. Data for grain production in 1997 for most countries are based on a USDA database as of October 1997. Food aid data are from the UN's Food and Agriculture Organization (FAO), and financial data are from the International Monetary Fund and World Bank. Historical nonfood-use data, including seed, waste, processing use, and other use, are estimated from the FAO Food Balance series. The base year data used for projections are the average for 1995-97, except export earnings, which are 1994-96.

#### Model Assumptions

**Endogenous variables:** Production, area, yield, commercial import, and domestic producer price.

**Exogenous variables:**

Population—data are UN population projections.

World prices—data are USDA/baseline projections.

Stocks—assumed constant during the projection period.

Seed use—projections are based on area projections using constant base seed/area ratio.

Industrial use—projections are based on extrapolation of historical trends.

Food exports—projections are either based on the population growth rate or extrapolation of historical trends.

Inputs—Fertilizer and capital projections are, in general, an extrapolation of historical growth.

Agricultural labor—projections are based on UN population projections, accounting for urbanization growth.

Food aid—assumed no food aid during the projection period (food aid is included only in the base year).

Net foreign credit—net real flow of foreign credit is assumed constant during the projection period.

Value of exports—projections are based on World Bank (Global Economic Prospects and the Developing Countries, various issues), IMF (World Economic Outlook, various issues), or an extrapolation of historical growth.

Export deflator or terms of trade—World Bank (Commodity Markets—Projection of Inflation Indices for Developed Countries).

Income—projected based on World Bank report (Global Economic Prospects and the Developing Countries, various issues) or extrapolation of historical growth.

Income distribution—World Bank data. Income distributions are assumed constant during the projection period.

#### Model Coefficients and Assumptions

Technical coefficients used in the model are either estimated, using cross country data, or synthesized from other sources. With the exception of countries with political problems, the model was validated using the historical data (1980-96). Growth in crop area and yield per hectare are functions of crop prices, fertilizer use, labor, and technological progress. Area response to price changes is small, in the range of 0.1 to 0.3. Similarly, yield response to fertilizer use is 0.1 to 0.2 and the labor/land ratio (as an indicator of intensification) is in the range of 0.2 to 0.3. The main determinant of commercial import growth is the availability of foreign exchange which is defined as the sum of exports and net flow of capital. World food prices, non-food prices, and expected domestic production (indicator of government import policy) also influence food imports. The food import response to foreign exchange availability is in the range of 0.6 to 0.8 and the response to food prices is in the range of 0.3 to 0.5. The response to non-food price changes is in the range of 0.1 to 0.2.





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The cover photograph of a field of millet in Niger was taken by P. Cenini of the UN Food and Agriculture Organization.