United States Department of Agriculture

USDA

Economic Research Service

Outlook

GFA-21
July 2010

FOOD SECURITY ASSESSMENT, 2010-20

Indicators of food security improve in 2010 for many lower-income countries due in part to economic recovery.

United States Department of Agriculture

GFA-21

July 2010

Outlook

A Report from the Economic Research Service

www.ers.usda.gov

Food Security Assessment, 2010-20

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Abstract

Food security in 70 developing countries is estimated to have improved between 2009 and 2010, in part due to economic recovery in many of these countries. The number of food-insecure people in the developing countries analyzed by ERS researchers is estimated to decrease about 7.5 percent from 2009 to 882 million in 2010. The number of food-insecure people at the aggregate level will not improve much over the next decade, declining by only 1 percent. While there will be notable improvements in Asia and Latin America, the situation in Sub-Saharan Africa is projected to deteriorate after 2010. Food-insecure people are defined as those consuming less than the nutritional target of 2,100 calories per day per person.

Keywords: food security, prices, production, commercial imports, export earnings, capital inflows, remittances, foreign direct investment, food aid, Sub-Saharan Africa, North Africa, Asia, Latin America, the Caribbean, Commonwealth of Independent States

Preface

This report continues the series of food assessments begun in the late 1970s. *Global Food Assessments* were done from 1990 to 1992, hence the GFA series. In 1993, the title was changed to *Food Aid Needs Assessment* to more accurately reflect the contents of the report, which focuses on selected developing countries with past or continuing food deficits. In 1997, we widened our analysis beyond the assessment of aggregate food availability to include more aspects of food security. We therefore changed the title to *Food Security Assessment.*

Acknowledgments

Appreciation is extended to Molly Garber, Deputy Director for Outlook Communications, Market and Trade Economics Division, ERS; to Cheryl Christensen, Chief, Food Security and Development Branch, MTED, ERS; and to ERS colleagues Maurice Landes and Ron Trostle for valuable comments on the articles. We would also like to thank the reviewers for their comments, especially Carol Goodloe, USDA's Office of the Chief Economist; Sara Schwartz and George Douvelis, USDA's Foreign Agricultural Service; David Stallings, USDA's World Agricultural Outlook Board; and Keith Wiebe and David Dawe of the UN's Food and Agriculture Organization. Special thanks are extended to Dale Simms for editorial assistance, David Marquardt for map design, and Wynnice Pointer-Napper and Victor B. Phillips, Jr. for layout and cover design.

Cover photos: Woman farmer–Rwanda, United Nations Food Programme (WFP)/Ricardo Gangale; child eating hot porridge–Haiti, WFP/David Orr; school meals–Ghana, WFP; children receiving breakfast rations–Haiti, WFP/David Orr; mother feeding child–Niger, WFP/Marcus Prior.

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Summary

Indicators of food security point to improvement between 2009 and 2010 for the 70 countries covered in this report. The number of food-insecure people is estimated to decrease from about 953 million in 2009 to 882 million in 2010. Food-insecure people are defined as those consuming less than the nutritional target of 2,100 calories per day per person.

Any increase or decrease highlights the fact that consumption for large portions of the populations in lower income countries is clustered around the nutritional target. This implies that even a brief economic slowdown or food production shock can result in millions of additional people being subjected to food insecurity. Conversely, a slight improvement in economic conditions can propel people past the nutritional target.

What Is the Issue?

The 2010 results are based on the economic recovery assumptions by the International Monetary Fund (IMF), which is cautiously optimistic, but admits that there is a downside risk of an economic retreat. Among key factors influencing economic assumptions is the unknown issue of capital flows. According to the IMF, capital inflows will remain volatile because the current global economic rebound is mainly driven by major fiscal stimulus in support of credit markets, the impacts of which could be eroded before the end of 2010. In *Food Security Assessment, 2010-20,* ERS researchers estimate and project the number of food-insecure people regionally and in each of the 70 developing countries for 2010-2020.

What Did the Study Find?

Food security in 70 developing countries is estimated to have improved between 2009 and 2010, due in part to economic recovery in many of these countries. The number of food-insecure people in the developing countries analyzed by ERS researchers is estimated to decrease 7.5 percent from 2009 to 882 million in 2010. The number of food-insecure people at the aggregate level will not improve much over the next decade, declining by 1 percent from 2010 to 2020. While there will be notable improvements in Asia and Latin America, the situation in Sub-Saharan Africa (SSA) is projected to deteriorate after 2010.

Despite the unfavorable long-term projections, SSA's food security situation improved between 2009 and 2010 following stronger economic growth and a continuation of the recent upward trend in food production. The number of food-insecure people in the region is estimated at 390 million in 2010, a near 12-percent decline from 2009. The distribution gap—the amount of food needed to raise consumption in each income group to meet the nutritional target of 2,100 calories per person per day—also declined, albeit negligibly. Despite the improvement, nearly half of the region's population remains food-insecure. In addition, while accounting for only one-quarter of the population of the 70 countries included in this study, the region is estimated to account for 44 percent of the food-insecure people.

As the global economy slowly recovers from the worldwide recession, Asia will continue to make impressive gains in improving food security as the projected number of food-insecure people is projected to decline from 433 million in 2010 to 320 million in 2020. In absolute terms, the number of food insecure in Asia is large; however, in relative terms Asia is doing better than SSA. In 2010, Asia will account for nearly 64 percent of the population of the 70 developing countries included in this report, but will account for barely half of the estimated 882 million total food-insecure people.

By 2020, the number of food-insecure people in SSA is projected to exceed 500 million out of a total population of roughly 1 billion. In other words, without any significant increase in investment or change in historical trends of major indicators, more than half of the region's population will consume less than the nutritional target. The region's food security position will also deteriorate relative to the other regions included in this report. In 2020, the region will account for only 27 percent of the population of the 70 countries, but it will have about a 59-percent share of the total number of food-insecure people.

The long-term projections are made assuming continuation of current trends in several key factors affecting long-term food security—agricultural production, income, foreign exchange availability, and population growth. The question is how changes in these variables would affect the results. To do this, ERS developed two scenarios. The first scenario doubles capital inflows by 2020 to examine the impacts of improved food import capacity in all study countries. The food security baseline projections assume a constant capital inflow during the projection period.

The second scenario analyzes the effect of targeting the most vulnerable countries with the goal of improving their food production performance. The scenario stems from concerns raised in different forums among governments and donors that without significant improvements in production, vulnerability to shocks such as the global food price crisis of 2008 could continue. To examine the impact on food security of increased agricultural production in low-income countries, the second scenario couples the increase in capital flows from the first scenario with a 50-percent increase in projected grain yields in 2020. The countries selected for this scenario are the 37 in the SSA region and 4 in Central America and the Caribbean. (Guatemala, Honduras, Nicaragua, and Haiti were selected because they have the highest share of rural population relative to other countries in the region.)

In the first scenario, when capital inflows of the 70 countries are doubled in 2020, the number of food-insecure people is projected to decline 11 percent relative to the 2020 food security baseline projections. Scenario results indicate improvement in all regions. In Asia, the number of food-insecure people declines by 14 percent, in Latin America and Caribbean (LAC) by 31 percent, and in SSA by 8 percent. As expected, the regions that benefit under this scenario are those that are highly import-dependent (LAC) and those where external capital inflows (private and foreign assistance) are high relative to their export earnings (Asia).

The results under the second scenario show a significant improvement in food security in SSA. The number of food-insecure people falls by 67 percent (from 513 million in 2020 in the food security baseline to 168 million in this

scenario). In the selected LAC countries, the number of food-insecure people falls to less than 10 percent in all countries except for Haiti.

How Was the Study Conducted?

All historical and projected data are updated relative to the *Food Security Assessment, 2008-09* report. Food production estimates for 2009 are based on data from the United Nations' Food and Agriculture Organization (FAO) as of February 2010. Historical production data are from FAO and food aid data are from the World Food Programme (WFP). Financial and macroeconomic data are based on the latest World Bank data, as of February 2010. Projected macroeconomic variables either are based on ERS-calculated growth rates for the 1990s through the late 2000s or are IMF and World Bank projections. Projections of food availability include food aid, with the assumption that each country will receive the 2006-08 average level of food aid throughout the next decade.

Overview: Food Security Impact of Financial Recovery, 2010-20

Several indicators of food security—the number of food-insecure people, the food gap to meet the average nutritional requirement (nutritional gap), and the food gap associated with unequal purchasing power or food access (distribution gap)—all pointed to improvement between 2009 and 2010 for the 70 countries covered in this report (see box, "How Food Security Is Assessed: Methods and Definitions").[1] The distribution gap, which takes into account unequal purchasing power within countries, was estimated at about 24 million tons for 2010—down negligibly from 2009 (table 1). The number of food-insecure people is estimated to decrease 7.5 percent from 2009 to 882 million in 2010.[2] The difference in the estimated number of food-insecure people from 2009 to 2010 highlights the fact that large portions of the populations in lower income countries consume just barely more than the nutritional target. This implies that their food security is precarious: even a brief economic slowdown or food production shock can result in millions of additional people being subjected to food insecurity.

In This Report

Seventy developing countries are covered in this report. Projections of food availability include food aid, with the assumption that each country will

[1]The estimates of 2010 food security indicators are based on the food security baseline projections and constant stocks and food aid at the average 2006-08 level. Therefore, if countries decide to raise or lower stocks, or donors change the level of food aid commitments to countries in need, these estimates of gaps, as well as the number of food-insecure people, would change.

[2]A person is considered food insecure, or hungry, if average food availability or access to food falls below FAO-recommended average calorie intake levels of approximately 2,100 calories per day, depending on the region.

Table 1

Food availability and food gaps for 70 countries

Year	Grain production*	Root production *(grain equiv.)*	Commercial imports	Food aid receipts (*grain equivalent*)		Aggregate availability of all food
			1,000 tons			
2001	479,346	72,066	64,436	9,601		820,637
2002	462,621	74,578	75,694	8,284		835,356
2003	505,026	76,694	67,794	8,599		844,902
2004	502,468	82,010	68,494	6,654		853,178
2005	525,600	85,446	79,593	8,386		875,468
2006	541,270	88,909	88,145	6,698		899,241
2007	560,887	86,748	85,326	5,803		918,205
2008	579,900	93,159	99,805	5,992		951,523
2009(e)	576,980	92,957	91,256	6,174		
Projections				Food gap**		
				NG	DG	
2010	596,542	94,498	97,885	***11,553***	***24,230***	917,171
2015	654,076	102,531	108,466	***13,263***	***26,129***	1,000,552
2020	716,773	111,148	118,840	***14,832***	***28,151***	1,088,018

(e) estimate.

*Grain production includes rice expressed in milled rice equivalent.

**NG stands for nutritional gap and describes the amount of grain equivalent needed to support nutritional standards on a national average level. DG stands for distributional gap and describes that amount of grain equivalent needed to allow each income quintile to reach the nutritional requirement.

Sources: USDA, Economic Research Service, using data from FAOSTAT, UN Food and Agriculture Organization, and World Food Programme.

How Food Security Is Assessed: Methods and Definitions

The Food Security Assessment model used in this report is based on 2009 data (updated in February 2010), and therefore does not reflect any subsequent changes that may have transpired related to the food security of these countries. This annual update includes revision of all historical data, as sometimes new information leads to changes in historical data series. Updates can therefore change food-security estimates for past years. Food-security indicators for 2009 and 2010 are estimates; subsequent years are projections. Commodities covered in this report include grains, root crops, and "other," which represents the remainder of the diet. The 3 groups account for 100 percent of all calories consumed in the study countries and are expressed in grain equivalent. The conversion is based on calorie content. For example, grain has roughly 3.5 calories per gram and tubers have about 1 calorie per gram. One ton of tubers is, therefore, equivalent to 0.29 ton of grain (1 divided by 3.5), and 1 ton of vegetable oil (8 calories per gram) is equivalent to 2.29 tons of grain (8 divided by 3.5).

Food consumption and food access are projected in 70 lower income developing countries—37 in Sub-Saharan Africa, 4 in North Africa, 11 in Latin America and the Caribbean, 10 in Asia, and 8 in the Commonwealth of Independent States. (See appendix for a detailed description of the methodology and definitions of terms and appendix table 1 for a list of countries.) The 2009 estimates are based on FAO preliminary production assessments, and the longer term projections are based on 2006-08 production data and 2005-07 macro data. For commercial imports, the 2009 figure is based on projections, not actual data. The periods covered are 2009, 2010 (forecast), and 2020 (10-year projection). The model analyzes the gap between projected food availability (production plus commercial and food aid imports minus nonfood use) and two alternative consumption standards. The nutritional standard is the per capita nutritional requirements (NR) of roughly 2,100 calories per capita per day—depending on the region. The average ***nutrition gap*** is the gap between available food and food needed to support a per capita nutritional standard.

The estimated ***distribution gap*** measures the food needed to raise consumption in each income quintile to the nutritional requirement. In many countries, consumption in the lower income quintiles is significantly below the average (per capita) consumption for the country as a whole. In these countries, the distribution gap provides a measure of the intensity of hunger—the extent to which the food security of already hungry people deteriorates as a result of income or economic conditions. In some countries, average consumption of the poorest quintile (20 percent) of the population narrowly exceeds nutritional requirements. In such cases we include the lowest decile (10 percent) of the population in our estimation of food gaps. However, when our estimates show no distribution gap for the poorest 10 percent of the population, we consider the country food secure despite the fact that food insecurity may exist, but only for less than 10 percent of the population. Finally, based on the population share who consume below nutritional requirements and total population data, the projected number of people who cannot meet their nutritional requirements is calculated.

The common terms used in this report are:

- ***Domestic food supply*—**the sum of domestic production and commercial and food aid imports;
- ***Food availability*—**food supply minus nonfood use, such as feed and waste;
- ***Import dependency*—**the ratio of food imports to food supply;
- ***Food consumption*—**equal to food availability; and
- ***Food-insecure*—**occurs when per capita food consumption for a country or income quintile falls shorts of the nutritional requirement.

receive their 2006-08 average level of food aid throughout the next decade. All historical and projected data are updated relative to *Food Security Assessment, 2008-09.* Food production estimates for 2009 are based on data from the United Nations' Food and Agriculture Organization (FAO) as of February 2010. Historical production data are from FAO and food aid data are from the World Food Programme (WFP). Financial and macroeconomic data are based on World Bank data as of February 2010. Projected macroeconomic variables are either based on ERS-calculated growth rates for the 1990s through the mid-2000s or are IMF and World Bank projections. This report includes a special article, "Food Production Assessment in the Context

of Weather Variability," which details the importance of including measurements of weather variability in short-term agricultural production estimates to improve targeting of assistance.

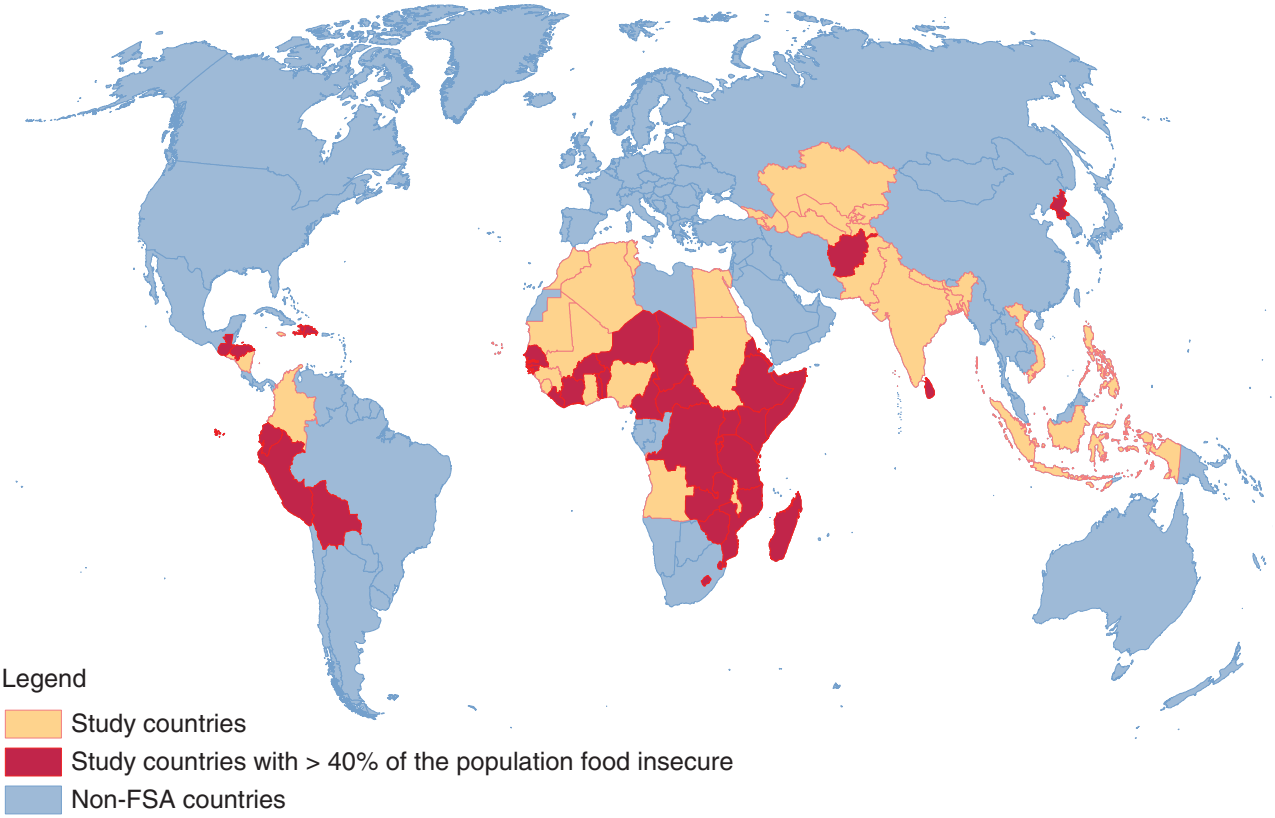
Food Security: Regional Perspective in 2010

The prevalence of food insecurity in countries covered by this report varies regionally (figs. 1 and 2). The number of food-insecure people in the Asian countries covered is estimated at 433 million, or 49 percent of the number of food-insecure people in the 70 countries in 2010 (table 2). Sub-Saharan Africa (SSA) is estimated to have 390 million food-insecure people, or 44 percent of the total. The Latin America and the Caribbean (LAC) region is home to an estimated 58 million food-insecure people, less than 7 percent of the total. The Commonwealth of Independent States (CIS) has only an estimated 2 million food-insecure people, down more than half from 2009. For North Africa (NA), even the poorest segment of the population (the lowest 10 percent in income) is estimated to have adequate food consumption, on average, with less than 10 percent of the population being food insecure. To put these estimates in perspective, in 2010 Asia accounted for 64 percent of the total population of the 70 countries, followed by SSA at 24 percent, LAC at 5 percent, NA at 5 percent, and CIS at roughly 2 percent (fig. 3).

Figure 1

In 37 (out of 70) developing countries, over 40% of the population is estimated to be food insecure

Lower income countries where 40% of the population is food insecure[1], 2010



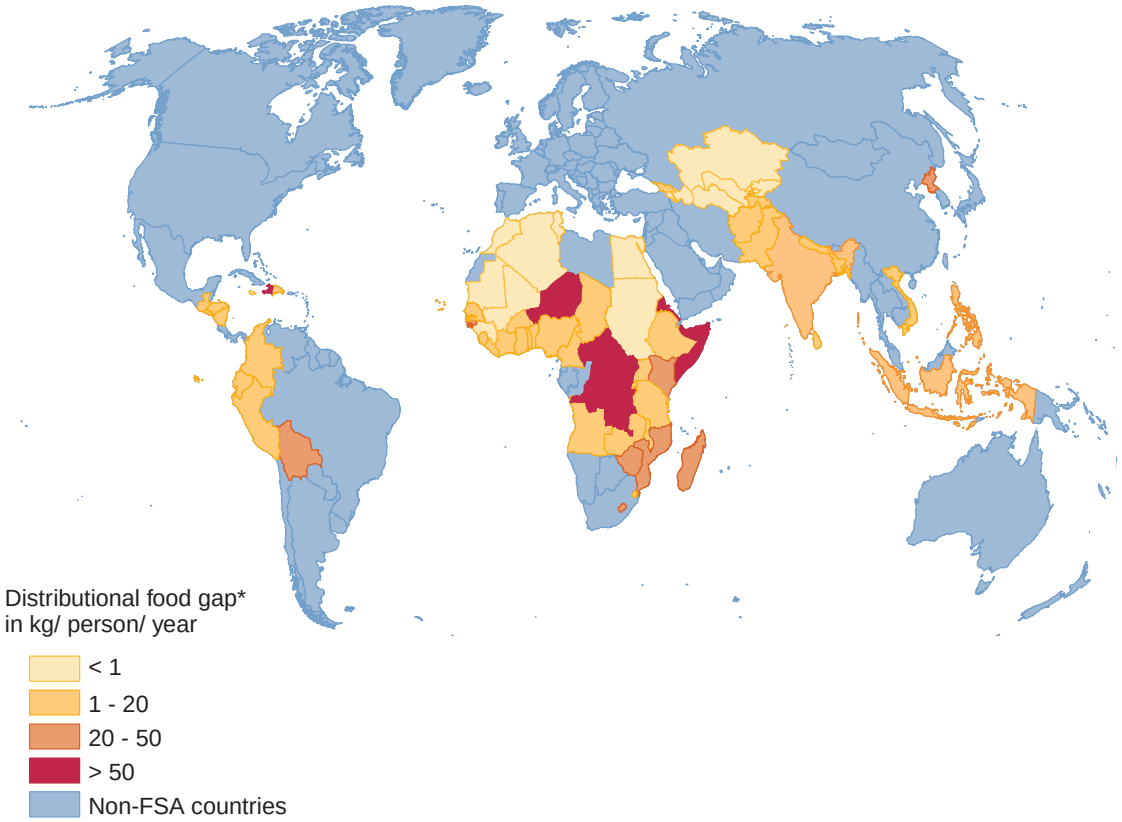
[1]Defined as consumption below the nutritional target of roughly 2100 calories per person per day.

Source: USDA, Economic Research Service.

Figure 2

Among the developing regions, the intensity of food insecurity is most severe in Sub-Saharan Africa

Intensity of food insecurity in 70 lower income countries, 2010



*Measures the food needed to raise consumption of each income group to the nutritional target of roughly 2100 calories per person per day.

Source: USDA, Economic Research Service.

Table 2

Estimates and projections of food-insecure people in 70 countries[1]

	Region					
	Total	Asia	LAC	NA	CIS	SSA
	Million					
2009 estimate	953	445	61	0	5	442
2010 projection	882	433	58	0	2	390
2020 projection						
Baseline	874	320	39	0	2	513
Scenario 1	777	275	27	0	2	473
Scenario 2	469	275	24	0	2	168

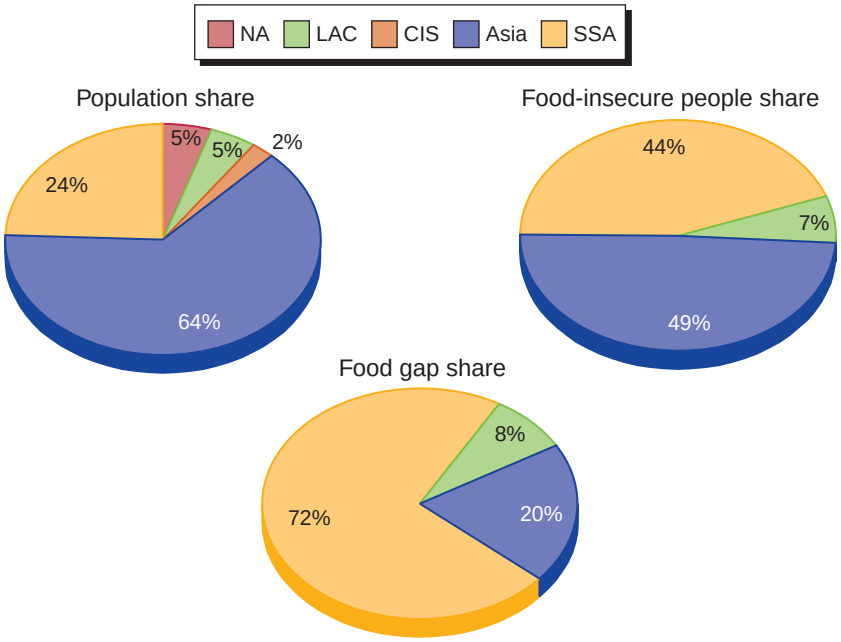
[1]When estimation shows that the lowest decile (10 percent) has adequate food, we consider the country food secure despite the fact that food insecurity may exist for up to 10 percent of population.

Source: USDA, Economic Research Service.

The results indicate that hunger is more intense in Sub-Saharan Africa than in other regions studied in this report. The region has by far the largest share of the food distribution gap, more than 70 percent of the total in 2010, or 17.5 million tons, compared to Asia at less than 5 million tons. This discrepancy in the food gap between the two regions is due to the fact that the gap

Figure 3

Total and food-insecure population share and food gap share by region, 2010



Source: USDSA, Economic Research Service and UN FAOSTAT.

between actual and target consumption of food, per person, is much larger in Sub-Saharan Africa than in Asia. LAC's share of the total distribution gap is 8 percent, or 2 million tons, which is consistent with its 7-percent share of food-insecure people.

Could the distribution gap be closed by boosting production or imports? The answer is yes, at the aggregate, national level. While the distribution gap for the 70 countries (24.2 million tons of food) is an estimated 24 percent of commercial grain imports in 2010, the gap is just 4 percent of grain production in the 70 countries. Therefore, if production were to rise 4 percent, the distribution gap could fall to zero. Again, this is at the aggregate level and the story shifts considerably country to country. For example, Ethiopia's food distribution gap is estimated at 1.5 million tons, or 10-12 percent of the country's estimated grain production in 2010. This is a large differential to close, particularly since the country imports very little commercially, relying largely on food aid imports. Conversely, India exports grain, and its estimated gap of 1.8 million tons could be negated by reducing those exports; the gap is less than one-third of its exports during 2006-08.

In general, those countries that are most vulnerable to food insecurity import less, and in most cases this is not by choice, but because of limited foreign exchange. Domestic production, on the other hand, contributes 60 to 95 percent of food consumption in many of these study countries. Growth in food production would not only boost food supplies, it would also increase farm incomes. Since most of the poor live in rural areas, a boost in agricultural income would reduce income inequality and enhance food security.

As is discussed in the box, "How Food Security Is Assessed," the estimations of the above indicators are based on several key assumptions, including the strength of economic and capital flow recovery, decline in food prices, and normal levels of domestic food production (i.e., no major droughts, floods, etc.). Any changes in these assumptions will alter the projection results.

Economic and capital flow recovery. An important assumption for 2010 is that economic growth in the study countries mirrors the global recovery, thus reducing the uncertainty of foreign capital inflow as is assumed in the *World Economic Outlook* (IMF, 2009). According to the IMF, this optimism is based, in part, on the fact that over the past decade many low-income countries have significantly improved their macroeconomic policies. This change has allowed them to make more effective use of increased financial resources, when available. The IMF, however, is cautiously optimistic and does not discount the risk of economic retreat. Key to economic recovery is the uncertain level of capital flows. According to the IMF, capital inflows will remain volatile because the current global economic rebound is mainly driven by the major fiscal stimulus of credit markets, and those impacts could be eroded before the end of 2010.

The impact of volatile capital inflows on these regions and countries varies depending upon their starting point prior to the economic crisis and how they have been affected by it. Asian countries had a moderate economic downturn in 2009, and recent indicators show a strong economic upturn. South Asian countries fared better than many countries during the crisis as their economies are driven more by domestic demand than by exports.

In Latin American and Caribbean countries (LAC), the pace of recovery varies significantly, largely because of differences in the composition and destination of exports, the degree of integration into the world economy, and policy responses to the crisis. The decline in export earnings in Colombia, Peru, Bolivia, and Ecuador in 2009 was significant, but the recent rebound in commodity prices points to improving economic outlooks for the countries. The economic recovery of the smaller countries in the region is predicated on export growth and the recovery of remittances that declined along with the U.S. economy.

Economies of the North African countries slowed significantly as a result of the global trade downturn and disruptions in global financial markets. However, growth is expected to accelerate as commodity prices rise with the global recovery. In these countries, the initial impact of the global recession was strong because their economies are highly integrated into global financial markets. The recent improvement in financial conditions and commodity prices will help these economies recover.

The economic downturn continues to weigh heavily on the economies of the lower-income CIS countries such as Armenia, Kyrgyzstan, and Tajikistan. This is due to their dependence on the Russian economy, which faced a severe recession in 2009. The impact was a sharp decline in remittances and demand for their exports. Energy exporters, with the exception of Kazakhstan, did not have the same experience as they are less dependent on Russia. In Kazakhstan, the economic shock stemmed from a sudden reversal of capital inflows in early 2008 caused by high oil prices. Overall, according

to the IMF, the path toward recovery will be difficult for most CIS economies, and the projection for the region is for modest growth of roughly 2 percent in 2010.

The outlook for Sub-Saharan Africa (SSA) is closely linked to the recovery of the global economy, particularly commodity markets. The prospects for capital inflows, remittances in particular, are also an important factor, but tighter global financial conditions are expected to have less of an impact than in other regions because of the SSA's lower level of dependency on private financing. A reduction in financial aid, however, will have serious implications, especially for the lowest-income countries where such aid is a large component of total foreign exchange earnings. According to a World Bank report, poverty in the region has increased significantly due to the decline in GDP, increases in unemployment, and the lack of adequate social safety nets (World Bank, *Poverty at a Glance*, Aug. 2009).

Many low-income countries have faced deteriorating terms of trade since 1980, meaning that their ability to purchase food imports from their export earnings has fallen. Their terms of trade (the relative prices of a country's exports to imports) declined from a peak of 189 (index of 2005=100) in 1991 to 129 in 2008. Food security of the countries with the highest trade deficits will remain vulnerable to uncertain credit flows. The 10 countries with the highest trade deficits relative to GDP are Mauritania (43 percent), Lesotho, Jamaica, Cape Verde, Eritrea, North Korea, Haiti, Afghanistan, Georgia, and Honduras (11 percent). For countries such as Eritrea, North Korea, Haiti, and Afghanistan that have political instabilities, any reduction in capital flows, particularly donor assistance, can have serious food security implications. Not all of the study countries have financial difficulties. Most mineral-exporting and oil-producing countries are in good financial positions. A good example is Angola, with the highest trade surplus at 36 percent of GDP in 2008.

Global and domestic food prices. Future price changes are another key factor that could alter food security estimates. According to the available projections, global prices for both food and raw material prices will decline in 2010 relative to 2009 (*World Global Commodity Markets: Review and Forecast, 2010*, World Bank; and USDA *Agricultural Projections to 2019*). The World Bank projects a 6-percent decline in the prices of these commodities, while USDA's baseline projections show even sharper price declines for grains, the staple foods of many low-income countries. Energy prices are projected to stabilize in 2010 because of the large inventory and low increase in demand. There is a high correlation between global energy and food prices (81 percent based on monthly prices; IMF data, 1992-2009) because energy prices affect production, processing, and (domestic and ocean) transportation costs.

At the country level, the projected decline in food prices for 2010 should be welcome news for the lower-income, food import-dependent countries in terms of relieving some pressure on their budgets. However, the rate of price transmission to consumers is expected to be limited because of poor market infrastructure and government intervention policies including trade restrictions or preferences, exchange rate policies, subsidies, and tax policies (Abbott, 2009). Imperfect price transmission means either lags in transmission or incomplete adjustment. In the study countries, the average grain price (corn, rice, and wheat) declined by 23 percent between 2008 and 2009,

but local retail prices declined less sharply than international prices (http://www.fao.org/giews/pricetool/). While grain prices at the regional level were lower in 2009 relative to 2008, the average rate of decline in all study regions was less than the 21-percent decline at the global level. The decline was the highest in Asian countries at 17 percent, followed by Latin America at 7 percent, and SSA at 4 percent. Food price data in most cases are for urban areas and/or capital cities, and may not reflect the market situation across the entire country, particularly in rural areas where much of the population resides. In low-income countries, food consumption of urban households has always been dependent on markets and how well they function. With lagging food production, many rural households are net buyers of food and face food insecurity when food prices increase (Simler, 2010).

Domestic food production shortfalls. Food production variability due to extreme weather can exacerbate food security vulnerability. In fact, domestic production shocks have stronger impacts on food security of poor countries than international economic shocks because the economies of these countries are far less integrated into the global financial market than those of higher income countries (*Global Economic Prospects 2010: Crisis, Finance, and Growth*, World Bank). Lower-income countries import less food because of a lack of adequate foreign exchange.

Since 1990, grain production shortfalls (when grain output falls below trend levels) in the 70 study countries in a given year were ranged from 5 percent in Egypt to 78 percent in Eritrea. The average annual production shortfall from trend between 1990 and 2008 was the highest in North Africa at 27 percent, followed by CIS at 19 percent, and SSA at 16 percent. The average shortfalls were lowest in LAC at 8 percent and Asia at 9 percent. In addition to the size of these shortfalls, another issue is their frequency. The probability of the occurrence of a production shortfall in a given year ranges from 44 percent in the Asian region to 58 percent in the LAC region. Countries with 1-year production shortfalls exceeding 50 percent below trend are North Korea in Asia; Algeria, Morocco, and Tunisia in North Africa; Georgia, Kazakhstan, and Turkmenistan in CIS; and Cape Verde, Eritrea, Lesotho, Liberia, Malawi, Mozambique, Sierra Leone, and Zimbabwe in SSA. The most serious case is when a country is hit by production shortfalls in 2 successive years, as happened to Zambia in 2001 and 2002 when the country was hit by drought.

Safety nets. A lack of safety net programs tends to amplify the impact of economic shocks by creating widespread anti-government sentiment (Arieff et al., 2009). This case has been demonstrated repeatedly in Sub-Saharan Africa, which has been devastated by years of political unrest. Therefore, in the absence of a major effort to buffer the impact of short-term production shocks, resources are used on a patchwork basis, leaving little available for investment in those areas that could stimulate long-term economic growth and food security.

Success stories do exist, however. Asian countries such as India and Bangladesh have invested in social protection and human development (such as India's National Rural Employment Guarantee Scheme) to ensure that shocks do not lead to permanent food insecurity. Such programs, however, are often countercyclical and too costly for governments burdened with low cash reserves and financial deficits (Alderman and Haque, 2005). In such

countries, donors and international financial institutions such as the IMF and World Bank have pledged to provide assistance to mitigate the impact of financial shocks and to help prevent the financial crisis from turning into a humanitarian crisis.

Food aid continues to be a major tool for the international community in reducing the impact of production shocks, but it falls short of meeting nutritional targets and eliminating food insecurity. The global quantity of food aid has fluctuated during the last two decades, and its share has declined relative to both total grain exports of food aid suppliers and total grain imports of low-income countries. Food aid, in grain equivalent, declined from an annual average of nearly 14 million tons in 1990-92 to 6.4 million tons in 2006-08. Sub-Saharan African countries have been by far the largest recipients of food aid, receiving nearly half of the volume since 2000. The allocations to individual countries, however, do not always correspond to estimated levels of need. For example, Cape Verde and Mauritania are among the top 5 recipients of food aid, on a per capita basis, despite the fact that less than 10 percent of their population is estimated to be vulnerable to food insecurity. These discrepancies are caused by the lack of information or systematic evaluation of the food situation of countries and/or absence of coordination among donors and recipients. Responses to crises such as political instability and financial difficulties are also reflected in food aid decisionmaking.

Outlook: Food Security in 2020

According to the ERS food security baseline projection, the number of food-insecure people at the aggregate level will decline by 1 percent by 2020. Notable improvements are projected in Asia and LAC, but our assumptions lead us to project deterioration in SSA food security. For the Asian countries studied, a 26-percent decline in the number of food-insecure people is projected. Among the LAC countries, an overall 33-percent decline is projected, with no change projected for the CIS countries. Only in Sub-Saharan Africa do our assumptions, including continuation of historical patterns of agricultural performance and productivity, lead to projections for a significant increase in the number of food-insecure people, up 32 percent or about 123 million (see table 2). One of the main food security pressures in the Sub-Saharan region is population growth of 2.4 percent per year, by far the highest growth of all the regions studied in this report. This rate of growth puts pressure on food supplies. While the region's production growth during 1980-2008 exceeded that in Asia and Latin America, its population growth, despite the AIDS epidemic, remains higher. Between 2010 and 2020, Sub-Saharan Africa must feed an additional 213 million people.

The distribution gap is projected to increase 16 percent during the next decade. SSA accounts for this entire increase, as the gap in both Asia and LAC declines significantly (table 3). The gap is estimated to be negligible in CIS and is projected to remain unchanged. No distribution gap is projected for North Africa.

Long-term projections of food security are made assuming continuation of current trends in several key factors—agricultural productivity, foreign exchange availability, and population growth. To determine how changes in these variables would affect the results, ERS developed two scenarios (see

box, “Scenarios Evaluate Likely Impact of Increased Capital Inflows and Technology Adoption”).

In the first scenario, when capital inflows of the 70 countries are doubled by 2020, the projected number of food-insecure people in 2020 declines 11 percent relative to the food security baseline projections (fig. 4). Improvement is projected in all regions. In Asia, the projected number of food-insecure people declines by 14 percent compared with the baseline, LAC numbers decline by 31 percent, and SSA numbers fall 8 percent. The regions that benefit under this scenario are those that are highly import-dependent (LAC) and those where external capital inflows (private and foreign assistance) are high relative to their export earnings (Asia). The distribution gap is estimated to decline by 22 percent under this scenario. The decline is sharpest in LAC, at more than 50 percent, followed by Asia at 33 percent, and SSA at 17 percent (table 3).

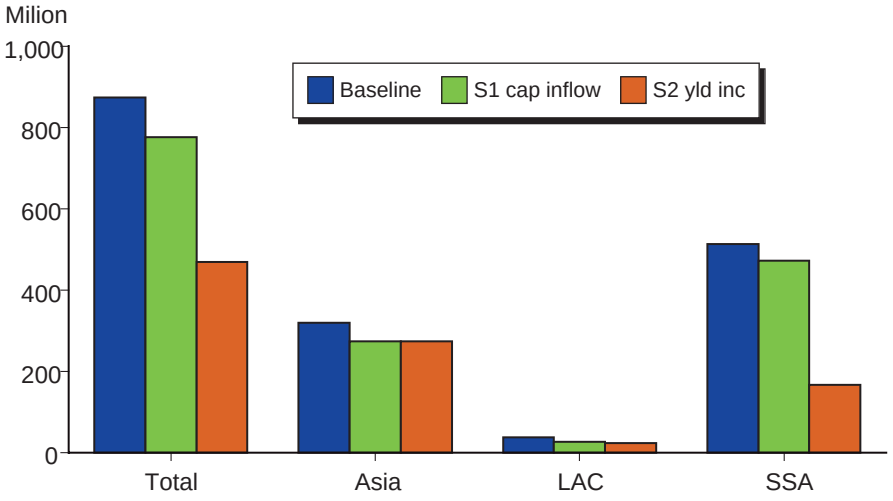
The second scenario shows a significant improvement in food security in SSA (see table 2). The number of food-insecure people is estimated to fall by 67 percent (from 513 million in the baseline to 168 million). The decline in the

Table 3
Estimates and projections of food distribution gaps in 70 countries

	Region					
	Total	Asia	LAC	NA	CIS	SSA
			Million tons			
2009 estimate	27.3	6.9	2.7	0	0.10	17.6
2010 projection	24.2	4.8	2.0	0	.02	17.5
2020 projection						
Baseline	28.2	3.2	1.6	0	.02	23.3
Scenario 1	22.2	2.2	0.7	0	.02	19.3
Scenario 2	12.0	2.2	0.6	0	.02	9.2

Source: USDA, Economic Research Service.

Figure 4
Number of food-insecure: Baseline versus scenarios



Source: USDA, Economic Research Service.

Scenarios Evaluate Likely Impact of Increased Capital Inflows and Technology Adoption

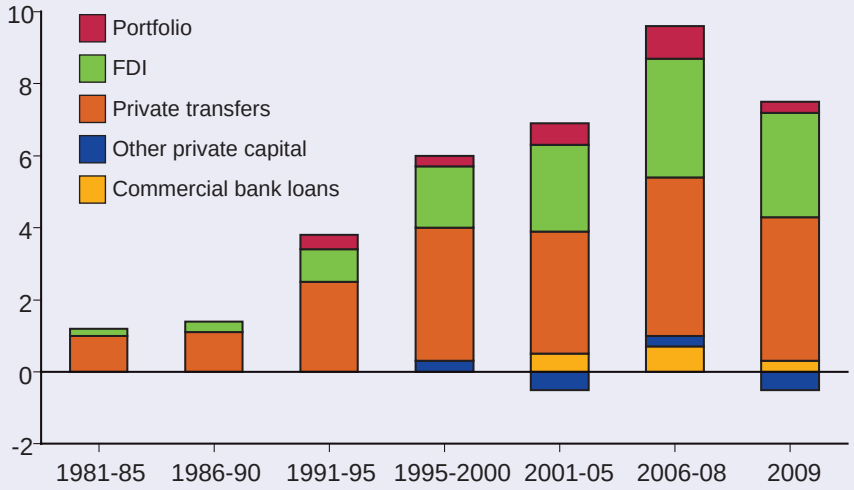
ERS developed two scenarios to evaluate the likely impact of a rebound in capital inflows and a technology-induced increase in food production on food security in lower income countries in 2020.

Scenario 1. Capital inflows to expand food import capacity of the 70 study countries are doubled in 2020. In this scenario, the secondary impacts of capital inflows on economic and trade growth are not taken into account. The literature is ambiguous on the impact of different types of capital flows on economic growth of low-income countries. In the baseline estimates, capital inflows are held constant annually through the projection period. A recent IMF study indicated that, prior to the financial crisis the inflow of capital to developing countries was increasing sharply (see figure below).

Scenario 2. A 50-percent increase in grain yields by 2020 is added to the assumptions in the first scenario in SSA and select LAC countries (Guatemala, Honduras, Nicaragua, and Haiti). All of these countries are characterized by inadequate food availability and access in the rural areas where a majority of the poor reside. The scenario reflects increased emphasis by governments and donors on significant improvements in agricultural productivity. The World Summit on Food Security in 2009 adopted a declaration to reverse the decline in domestic and international funding for agriculture. In 2009, at the L'Aquila Summit, donors committed $20 billion to support a renewed global effort to reduce poverty and improve food security. Historically, several lower income countries have achieved this level of improvement in yields in one decade, including India and Vietnam between the early 1980s and early 1990s, and Colombia and Ecuador between the early 1990s and early 2000s.

There was a sharp increase in capital inflows during 1980-2009 in low-income countries

Percent of GDP



Source: Dorsey et al., 2008.

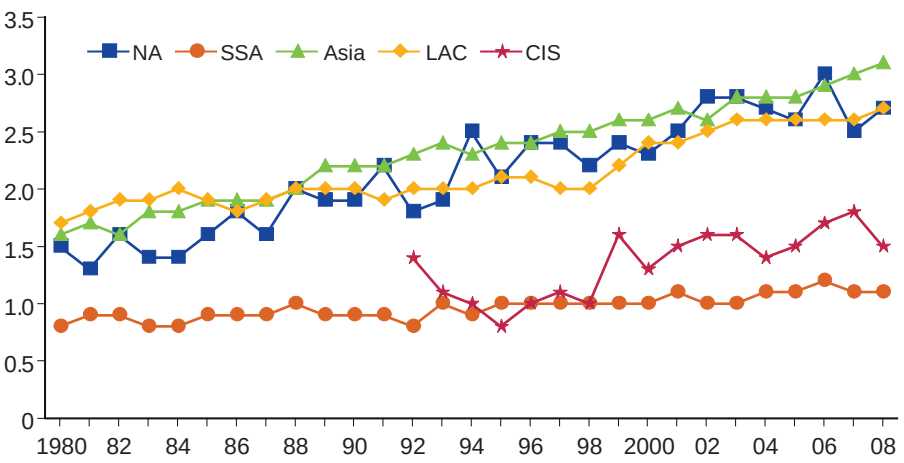
food gap is slightly smaller, about 61 percent, from more than 23 million tons to roughly 9 million tons (see table 3). The bulk of needs, however, remains concentrated in conflict-ravaged countries such as the Democratic Republic of Congo and Somalia. In the selected LAC countries, the number of food-insecure people under scenario 2 is projected to fall to less than 10 percent of the population in Guatemala, Honduras, and Nicaragua. In Haiti, the increased inflow of capital and the yield improvements are projected to result in a 12-percent increase in per capita consumption relative to the baseline levels. While this increase does not greatly affect the aggregate number of food-insecure people in our measure, those people consuming near the nutritional target prior to these improvements would now be consuming above that level. Therefore, at the disaggregated level, food insecurity in Haiti would likely fall to closer to 40 percent of the population as a result of the injection of investment and improvements in yields.

Raising food production is not an easy task, however. Population pressure has increased population density, limiting the long-term prospects for acreage expansion. Also, in most SSA countries, production expansion has been due to increases in planted area, which largely involved moving to low-yielding, marginal land. In countries such as Rwanda, Tanzania, Mozambique, and Niger, costs associated with depletion of soil nutrients were estimated to account for 12-25 percent of the agricultural share of GDP, and improving the quality of land under cultivation requires significant investment (Drechsel et al., 2001). In Sub-Saharan Africa, most of the productive land is already under cultivation, so the key to boosting production is to increase yields (Govereh et al., 1999). SSA grain yields have grown less than 1 percent per year since 1980, and in absolute terms are less than half of the average yields in the LAC and Asian countries included in this study (fig. 5). Limited resources and little use of new technology are the principal factors constraining yields in many SSA countries (National Research Council, 2008).

The question is how to increase yields. Finding the right mix of technologies is not easy, and the choice depends on the agro-physical and economic

Figure 5

Grain yields in Sub-Saharan Africa are less than half (37%) of Asia's average yield



Source: USDA, Economic Research Service based on FAOSTAT.

conditions of countries/regions. Currently governments, in collaboration with donors and international financial institutions, are examining agricultural technologies in low-income countries to identify models that work based on local needs and circumstances. The task is not easy. For example, in the case of small farmers in rainfed production environments, adopting new farm technology can be challenging because of weather-related yield risk, poor availability of inputs, and the price risk associated with marketing expanded output. To illustrate, consider the case of increased fertilizer use. In the Asian countries under study, average fertilizer use is 95 kg per hectare, compared with less than 10 kg in SSA countries. One reason for the low use in SSA is that fertilizer is costly and yield responses to fertilizer use are muted because of inadequate and variable water availability during the growing season.

Fertilizer is a key input in food production and global prices are closely linked to energy and crop prices. Fertilizers were subsidized in SSA during the 1980s, but with the exception of Malawi, subsidies were either reduced or eliminated after those countries adopted structural adjustment policies. Although fertilizer subsidies succeeded in helping to increase production in Malawi, they are costly and the production impacts are highly dependent on the levels of annual rainfall.

Irrigation can make the use of fertilizer and improved crop varieties profitable while increasing 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 Latin America, 13 percent of arable land is irrigated, and 38 percent is irrigated in Asia (FAO, FAOSTAT). The world average is 19 percent. There is potential for expanding irrigated area in Sub-Saharan Africa, but it is costly and requires investment (*World Development Report, 2008: Agriculture for Development*, World Bank). Other options include increased investments in drought-mitigating and water-harvesting techniques that could allow farmers to manage production risk more effectively.

Overall, promoting new technology needs to be location-specific, taking into account production variability and the associated risks of farmer investments. The literature indicates that some type of insurance program, along with access to credit, can play an important role in expediting the adoption of new technology (Foster and Rosenzweig, 2010). Another important finding is that the adoption behavior of farmers was consistent across crops, but that larger scale farmers have higher adoption rates than smaller farmers.

The challenge, therefore, is tailoring the technology package to small farmers. Smaller farmers can either increase production at a higher risk because it requires investment or continue to produce subsistence levels of food at low risk. Policymakers need to make technology attractive to small farmers if agricultural growth is to play a key role in reducing rural poverty. SSA countries are faced with growing food demand in rural areas where population growth is the highest. Small farmers could increase their incomes if they could supply to this market, but this is contingent on key inputs such as yield boosting technology, fertilizer, and credit. They also need risk management assistance and producer organizations to link them to the new markets.

Another neglected area related to food security is investment in rural market infrastructure, which would reduce transaction costs in rural areas. This is not a simple endeavor. In 2000, road density in Africa was about one-tenth of what it was in India at the start of the Green Revolution three decades ago (IFAD, 2005). According to the International Financial Corporation (World Bank Group), investment in infrastructure in SSA is about $10 billion per year, roughly half of what is needed to support sustained economic growth.

Food Security: Regional and Country Perspectives

Baseline food security is projected to either remain unchanged or improve over the next decade in all regions covered in this report except for Sub-Saharan Africa (SSA). However, the rates of change vary by country. The most significant improvement is expected in Asia, followed by Latin America and the Caribbean (LAC). Improvement in financial flows and investment in agricultural productivity in SSA can reduce the number of food-insecure and narrow the food distribution gap (associated with inadequate food access) by more than half under scenario 2 in 2020.

North Africa

Over the next decade, North Africa is projected to be the most food secure among all the developing regions included in this report (table 4). The food-insecure population in all countries studied (Algeria, Egypt, Morocco, and Tunisia) is expected to account for less than 10 percent of the total population. This result is not surprising, as North Africa has average per capita consumption levels exceeding 3,000 calories per day, much higher than in most developing countries and comparable to levels in developed countries. The high level of per capita food consumption in the region is due to high incomes and to government policies, primarily price subsidies that increase consumer purchasing power.

Income in the region remains highly skewed with the richest 20 percent of the population earning 44 percent of income and the poorest 20 percent accounting for less than 7 percent of income, on average. Households in the region typically spend nearly 40 percent of their income on food, with the poorest 20 percent most likely spending even a greater share on food. This places the lowest income quintile at significant risk of food insecurity if their purchasing power is eroded by high food prices or lower earnings. The government commitment in the region to subsidize food prices amid higher international prices helps stabilize consumption for low-income groups, but strains government budgets.

In the short run, food security prospects in North Africa remain positive. Food security in the region improved in 2009, reflecting good production and declining international grain prices. Algeria, Morocco, and Tunisia enjoyed record grain production in 2009, with grain production in Tunisia doubling its 2008 output. In Egypt, increased wheat production offset a decline in rice production. The regional increase in production reduced the need for imports to meet food needs in these countries. In addition, international grain prices fell 23 percent in 2009 from their 2008 levels, and are projected to fall further in 2010. The decline in international prices lessened the strain from government food subsidies and strengthened import capacity.

Despite the region's strong performance in 2009, future grain production remains unpredictable because of the region's dependence, with the exception of Egypt, on highly variable rainfall. The grain production shortfall—the percent by which grain production varies below the trend—averaged 37 percent in Algeria, 36 percent in Morocco, and nearly 33 percent in Tunisia

in shortfall years between 1980 and 2008. Aside from Eritrea, these are the highest shortfall variability values among the 70 developing countries included in this report. This erratic grain production heightens the need for imports as production shortfalls occur in the region about 50 to 60 percent of the time.

Trade is therefore very important to the North African region's food security. On average, imports have provided half of the region's grain supplies in the past and are expected to provide about 45 percent in 2010. Algeria and Tunisia are the most dependent on imports to meet food needs, importing an estimated 61 percent of their total grain supply in 2010, followed by Morocco at 46 percent of its grain supply. Even in Egypt, which has low production variability, imports are estimated to account for 36 percent of its food consumption in 2010.

In the long run, North Africa food imports will likely increase since the region's natural resources, such as arable land and water (even irrigated area for Egypt) are limited, meaning that future production increases will have to come primarily from increased input use and higher yields. While there is some potential for this, the dependence on rainfed production will limit potential yield increases.

North Africa's ability to finance its food imports depends on export earnings and capital inflows. Declines in these factors would likely have an impact on food security. It was thought at this time last year that the global recession and the decline in oil and phosphate prices would reduce the region's export earnings, thereby severely lessening its import capacity. The region, however, weathered the global downturn without a significant decline in export earnings. Egypt, Morocco and Tunisia all experienced slight increases in export earnings from 2008 to 2009. Algeria, the most dependent of the countries on oil to generate export earnings, was able to maintain its 2009 export earnings at its 2008 level. As a result, the NA region as a whole was able to maintain its commercial imports in 2009 slightly above 2008 levels.

Food security in the region is projected to worsen as per capita consumption declines an estimated 11 percent between 2010 and 2020. Commercial imports are not projected to expand sufficiently to compensate for inadequate growth in food production. Production of all crops in the region is projected to increase by 1.9 percent annually. However, commercial food imports for the region are expected to increase only 0.8 percent annually. Given that commercial imports are such an important component of food supplies, food availability is then projected to increase by 1.2 percent annually, versus the region's projected average population growth rate of 1.6 percent. Since a lack of arable land limits the prospects for significantly increasing domestic production, the ability of the region to finance food imports will determine whether they can meet their food needs. Despite this decline in per capita consumption, all income quintiles in these countries, on average, are still able to meet their nutritional requirements.

The slowing of consumption, however, means that the poorest segment of the population will face an increasing risk of food insecurity as the decade progresses. In Egypt, the poorest 10 percent of households are projected to barely meet their nutritional requirements on average by 2020. The poorest 20 percent

Table 4

Food availability and food gaps for North Africa

Year	Grain production	Root production *(grain equiv.)*	Commercial imports *(grains)*	Food aid receipts *(grain equivalent)*	Aggregate availability of all food
			1,000 tons		
2001	25,461	1,329	23,996	82	53,731
2002	25,944	1,483	27,456	72	54,374
2003	33,174	1,704	20,730	35	55,329
2004	33,495	1,885	19,855	58	55,802
2005	30,301	2,130	26,605	53	58,603
2006	35,146	1,946	23,239	56	56,577
2007	27,387	1,847	27,046	29	57,130
2008	30,523	2,165	32,702	38	66,046
2009(e)	39,283	2,232	26,169	41	63,906
Projections				Food gap*	
				NG DG	
2010	33,209	2,273	28,860	***0*** ***0***	61,501
2015	36,557	2,483	29,345	***0*** ***0***	62,725
2020	40,057	2,706	29,555	***0*** ***0***	62,965

*See table 1.

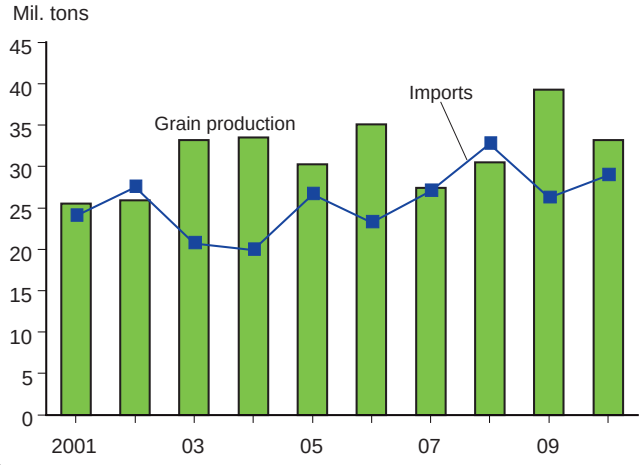
North Africa
(163 million people in 2010)

Frequent droughts affect North Africa's agricultural production, but food security is seldom endangered because of the region's ability to meet its food needs through imports.

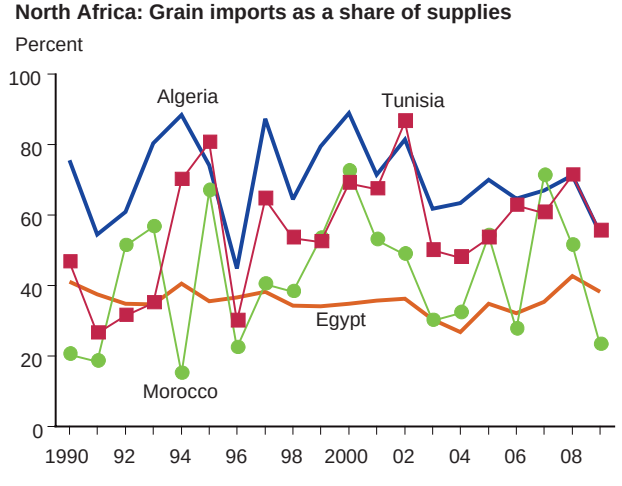
Food security prospects for the region are expected to remain positive. However, due to highly variable production and limited (land and water) resources, future domestic production increases will need to stem from higher productivity.

Production constraints mean further reliance on food imports, which in turn are dependent on the macroeconomic health of the domestic and global economies.

North Africa: Grain production and commercial imports



North Africa: Grain imports as a share of supplies



North Africa: Financial indicators, 2007

	Export earnings	Remittances*	Foreign direct investment	Sum
			Percent of GDP	
Algeria	47.8[1]	1.6	1.2	50.6
Egypt	34.0	5.9	8.9	48.8
Morocco	36.4	1.2	3.7	41.3
Tunisia	57.3	4.9	4.6	66.8

*Workers' remittances and compensation of employees, received.
[1]2005 data
Source: World Bank Indicators, 2009.

are projected to be consuming just 3 percent above the daily nutritional targets, on average. This means that by 2020, the poorest 20 percent of households in Egypt—or nearly 20 million people—may become food insecure if there is any significant reduction in Egypt's domestic production or import capacity.

Sub-Saharan Africa (SSA)

In the mid-2000s, Sub-Saharan Africa's real GDP growth was at historically high levels, increasing at more than 6 percent per year. In 2009, however, IMF estimates indicate growth slowed to about 1 percent, meaning that on a per capita basis, real incomes declined for the first time in a decade (IMF, 2009). Given that income levels in most of these countries were already among the lowest in the world, this is cause for concern. As expected, however, there is variation among countries in the region. Oil exporting countries such as Nigeria, Angola, Cameroon, and Chad have been the most adversely affected by the global economic slowdown.

In addition to slower economic growth, these countries were also faced with high inflation rates. Corn is the staple food in many eastern and southern African countries. The world price for corn increased from 2005 through 2008, and then declined a bit in 2009. In fact, the 2009 world price was very close to the 2007 price. In these countries, however, this was not the case. In Ethiopia, Malawi, Tanzania, and Uganda, for example, the 2009 corn price was more than twice as high as the 2007 price. In Kenya, Mozambique, and Rwanda, the prices were about 50-85 percent higher than 2 years earlier. Given that many of these countries have some of the lowest per capita incomes and calorie intake levels in the world, these high prices put additional pressure on people and hinder government efforts to achieve food security.

The IMF (Jan. 2010) projects that the region's real GDP will grow 4 percent in 2010. This growth is predicated on the continuation of factors that contributed to the region's earlier strong growth: improved governance, reduced macroeconomic imbalances, openness to trade, and support from abroad (investment, aid, export markets). Sub-Saharan Africa has increasingly diversified its export markets. In the early 2000s, the EU accounted for roughly 40 percent of Sub-Saharan Africa's exports. More recently, however, the region has significantly increased its exports to middle- and high-income countries outside the EU, as well as to China. In fact, China's share of the region's exports jumped from less than 5 percent in 2000-02 to more than 10 percent in 2007-09. This diversification helps stabilize export earnings if one of the trading partners suffers an economic downturn. Moreover, many of the countries to which the region has expanded trade have experienced higher economic growth than its traditional trading partners.

The region's food security improved from 2009 to 2010, following an improved economy and a continuation of the recent upward trend in food production (table 5). The number of food-insecure people in the region is estimated at 390 million in 2010, a near 11-percent decline from 2009. The distribution gap also declined, albeit negligibly. Despite the improvement, nearly half of the region's population remains food insecure. In addition, while accounting for only a quarter of the population of the 70 countries included in this study, the region is estimated to account for 44 percent of the food-insecure people. For 2010, the most vulnerable countries—those where

Table 5

Food availability and food gaps for Sub-Saharan Africa

Year	Grain production	Root production *(grain equiv.)*	Commercial imports *(grains)*	Food aid receipts *(grain equivalent)*	Aggregate availability of all food
			1,000 tons		
2001	74,333	46,631	13,084	3,722	159,029
2002	74,033	48,027	15,103	3,225	165,250
2003	81,436	49,331	14,428	5,422	171,170
2004	81,684	52,374	16,184	3,717	175,069
2005	90,525	54,266	18,129	4,872	182,606
2006	96,341	57,068	18,819	4,226	197,468
2007	92,954	54,287	17,281	3,340	193,908
2008	98,303	57,457	21,595	4,201	204,516
2009(e)	95,739	58,368	21,372	3,923	199,617
Projections				Food gap*	
				NG / DG	(w/o food aid)
2010	105,282	59,406	21,247	***10,237 / 17,477***	212,228
2013	119,052	64,843	24,457	***11,948 / 20,404***	237,872
2020	134,409	70,710	27,770	***13,530 / 23,324***	265,960

*See table 1.

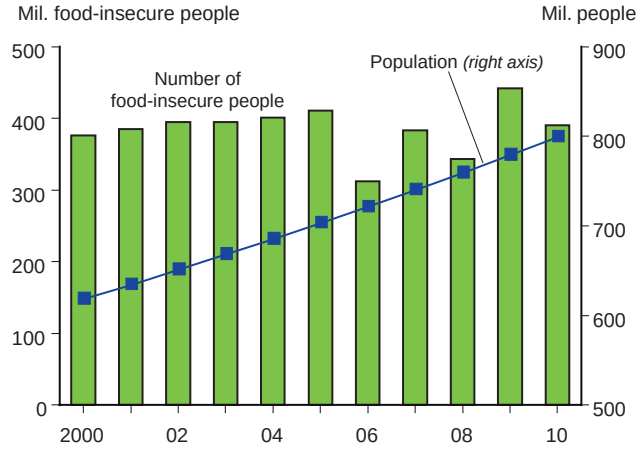
Sub-Saharan Africa (SSA)
(799 million people in 2010)

The region's food security situation improved from 2009 to 2010 as the number of food-insecure people decreased 11 percent to 390 million.

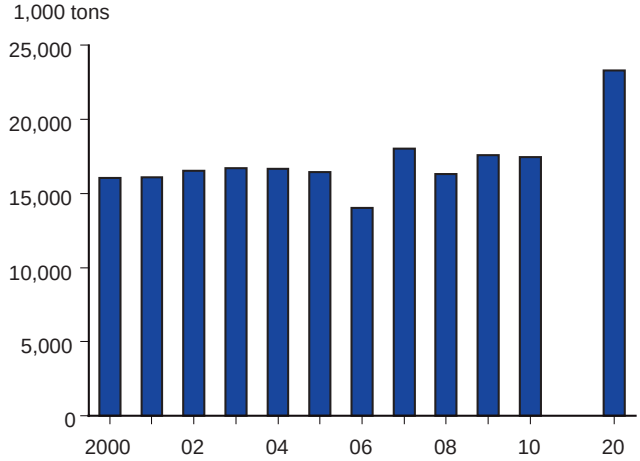
However, nearly half of the region's population remains food-insecure.

By 2020, the number of food-insecure people in the region is projected to exceed 500 million. The region's food security position will deteriorate relative to other regions included in this study.

SSA: Trend in number of food-insecure people vs. population



SSA: Distribution gaps



Sub-Saharan Africa: Financial indicators, 2007

	Export earnings	Remittances*	Foreign direct investment	Sum
			Percent of GDP	
Gambia, The	36.2	7.4	10.6	54.2
Kenya	25.3	5.9	2.7	33.9
Madagascar	29.7[1]	0.1	13.6	43.4
Nigeria	40.2	5.6	3.7	49.5
Uganda	21.4	3.8	4.1	29.3
Zambia	42.7	0.5	8.6	51.8

*Workers' remittances and compensation of employees, received.
[1]2006 data
Source: World Bank Indicators, 2009.

an estimated 80-100 percent of the population is food insecure—are clustered in central and eastern Africa. In many cases, these countries—such as the Democratic Republic of Congo, Eritrea, Kenya, and Somalia—have recently been in or are currently entrenched in some kind of civil strife.

By 2020, the number of food-insecure people in Sub-Saharan Africa is projected to exceed 500 million, out of a total population of roughly 1 billion. In other words, more than half of the region's population will consume less than the nutritional target. The region's food security position will also deteriorate relative to the other regions included in this report. In 2020, the region will account for only 27 percent of the population of the 70 countries, but it will have about 59 percent of the food-insecure people. The factors behind such a pessimistic projection include high population growth, slow food production growth—yields in particular—and inadequate foreign exchange earnings. In several countries, such as the Democratic Republic of Congo, Zimbabwe, and Somalia, an uncertain political outlook precludes any projection of economic recovery.

In addition to being the most food-insecure region of the world, Sub-Saharan Africa's agricultural sector is characterized by high variability in production. In a region with financial constraints to importing food, and where 80 percent of grain supplies are from domestic production, this variability can compromise food security at different points in time. On average, the region experiences a grain shortfall (when grain output falls below trend levels) every other year, with an average shortfall of 16 percent.

Safety Net Initiatives

Due to the severity and persistence of food insecurity throughout the region, some countries and international institutions have begun implementing safety net programs aimed at improving productivity and nutritional intake. For example, Ethiopia's Productive Safety Net Program began in 2005 and provides support more in the form of cash than food. This program reached more than 7 million people in 2006, focusing on rehabilitating infrastructure: terracing land, building roads, and creating irrigation schemes in food-insecure areas. More than half of the participants in the program claimed that as a result of the program, they were able to avoid selling assets in order to purchase food during shortages. Nearly 75 percent of the beneficiaries claimed to have consumed more or higher quality food. Many of the participants stated that they had better access to healthcare facilities and they had enrolled more of their children in school (Dominguez, 2010).

In response to high food and fuel prices, the World Bank established the Global Food Crisis Response Program in 2008, which helps protect the poor by ensuring access to food via cash transfer and school feeding programs. As part of this program, Burundi, the Central African Republic, Madagascar, and Sierra Leone received funding to continue or extend various school feeding programs. Liberia, Madagascar, Sierra Leone, and Guinea Bissau received funding for cash- or food-for-work programs.

In response to the higher food prices of 2006-08 and the global financial crisis, there has been an increased focus on food security for developing countries on the part of international institutions and donors. In July 2009,

at the G-8 Summit in Italy, participants pledged $20 billion over 3 years to reduce hunger and poverty by improving food security, nutrition, and sustainable agriculture. The World Bank's commitment to agriculture is highlighted in its Agricultural Action Plan, FY2010-2012. The Bank's support for agriculture and related sectors averaged roughly $4 billion per year over fiscal 2006-08. Funding under this new plan will increase significantly, with a projected range of $6.2 billion to $8.3 billion per year.

The African Union formed the Comprehensive Africa Agriculture Development Program in 2003 with a goal of eliminating hunger and reducing poverty. To achieve this goal, African governments have agreed to increase public investment in agriculture to a minimum of 10 percent of their national budgets and to achieve growth in agricultural productivity of 6 percent per year.

With this heightened level of interest in developing countries and their food security, we developed two scenarios to represent the potential implications of donor aid and the activities of international organizations. In the first scenario, we assumed a doubling of capital inflow by 2020. (In our baseline model, capital inflow is held constant.) Of the most food-insecure regions, the response to the injection of funds was the lowest in Sub-Saharan African countries; the number of food-insecure people fell an estimated 8 percent from the baseline (see table 2). This is likely because SSA food security is based largely on performance of the agricultural sector, as more than 80 percent of grain supplies come from domestic production. As a result, it is the second scenario that has a greater impact on this region. In this case, in addition to the increased capital inflows, crop yields are increased by 50 percent by 2020. Even under this optimistic scenario, SSA grain yields in 2020 are only about 70 percent of those projected for the Asian countries studied and 77 percent of those in Latin America under the baseline assumptions. Even so, this still has a tremendous impact on food security in the region—the projected number of food-insecure people declines nearly 70 percent relative to the base scenario. Overall, the assumed increases in capital inflows and crop yields are projected to reduce the share of the region's population that is food insecure to less than 20 percent.

The biggest challenge is how to expedite technology transfer in SSA. The region receives a large share of global aid, much of which is now targeted to the agricultural sector. Agriculture employs as much as 70 to 80 percent of the work force in many countries, but productivity remains low. Because of rapid population growth, Sub-Saharan Africa is becoming less land abundant, so production increases can no longer easily stem from area expansion. Therefore, improvements in productivity through adoption of new technology are critical for enhancing food security. The region has made some progress economically, but many countries remain highly dependent on food aid. SSA accounted for more than 70 percent of the food aid received by the 70 countries included in this study in 2008.

Asia

As the global economy slowly recovers from the worldwide recession, the Asian countries included in this study will continue to make impressive gains in food security as the projected number of food-insecure people is projected to decline from 433 million in 2010 to 320 million in 2020 (table 6). Even

at the height of the recession in 2008-09, when global real GDP contracted, economic growth in Asia slowed, but remained positive. Asia's encouraging macroeconomic performance and success in improving food availability, nonetheless, hide the region's food security problems. While Asia is not experiencing overall food shortages, many of the world's hungry can still be found here, since the region has some of the most densely populated and poorest countries in the world. Many people have not shared equally in the region's economic success. Income in South Asia, which averaged $885 per capita in 2007, remains one of the lowest among all developing regions.

In absolute terms, the number of food insecure in Asia is huge. However, in relative terms, Asia is doing better than Sub-Saharan Africa. While Asia accounts for over 63 percent of the population of the 70 developing countries included in this report, it accounts for barely half of the estimated 882 million total food-insecure people in 2010. Meanwhile, SSA accounts for only 24 percent of total population in the 70 countries but 44 percent of food-insecure people.

Asia's food security situation is projected to improve further as the decade progresses. Countries projected to experience a decline in the proportion of food-insecure people by 2020 include India, Indonesia, the Philippines, and Sri Lanka. Countries projected to show no change are Bangladesh, Nepal, Pakistan, and Vietnam. The region's food distribution gap is projected to decline by 32 percent from 2010 to 2020. Given our assumptions, Asia will account for 37 percent of the total number of food-insecure people in the 70 countries studied in 2020, compared to 49 percent in 2010.

Recent improvement in Asia's food security has been due to several factors, including a slowing of population growth, sustained growth in agricultural production, strong economic growth, and generally supportive agricultural and food policies in most of the countries in the region.

Over the last three decades, population growth has slowed considerably in the region. Population grew at 2.3 percent per year in the 1980s, but decelerated to 1.6 percent per year over 2000-09. It is projected to grow at about 1.3 percent per year over the next 10 years. India, growing at 1.2 percent per year in the next decade, is still projected to surpass China, growing at 0.55 percent, as the most populous country in the world by 2030. Despite the slowdown, population growth in this densely populated region will continue to put pressure on the region's agricultural resource base.

Grain production underpins Asian food security and is the dominant source of food supplies in the region. Domestic production accounted for more than 90 percent of available grain supply for the Asian countries studied in recent years. The region's projected grain production growth, at 1.9 percent per year, exceeds the projected population growth, so the region should be able to meet the grain needs of its growing population on an aggregate level.

Asia's historically strong growth in grain production stems primarily from increased yields. Since 1990, growth in grain yields has been strongest in Bangladesh, Indonesia, Pakistan, the Philippines, and Vietnam, increasing by over 2 percent per year. Increased irrigation has contributed to these yield

Table 6

Food availability and food gaps for Asia

Year	Grain production	Root production *(grain equiv.)*	Commercial imports *(grains)*	Food aid receipts *(grain equivalent)*	Aggregate availability of all food
			1,000 tons		
2001	339,973	19,189	13,697	4,209	546,673
2002	319,978	19,949	18,674	3,345	553,569
2003	347,585	20,293	17,991	2,379	555,263
2004	346,902	22,350	16,850	2,009	559,568
2005	361,704	23,536	17,205	2,492	571,792
2006	364,086	24,312	26,921	1,396	580,661
2007	390,449	24,615	19,812	1,752	594,800
2008	404,811	27,634	24,182	1,332	606,448
2009(e)	391,572	26,291	23,255	1,494	549,106
Projections				Food gap*	
				NG DG	
2010	408,033	26,672	25,313	***1,013*** ***4,754***	564,836
2015	445,709	28,649	28,880	***908*** ***3,945***	612,781
2020	486,654	30,743	32,368	***895*** ***3,221***	662,470

*See table 1.

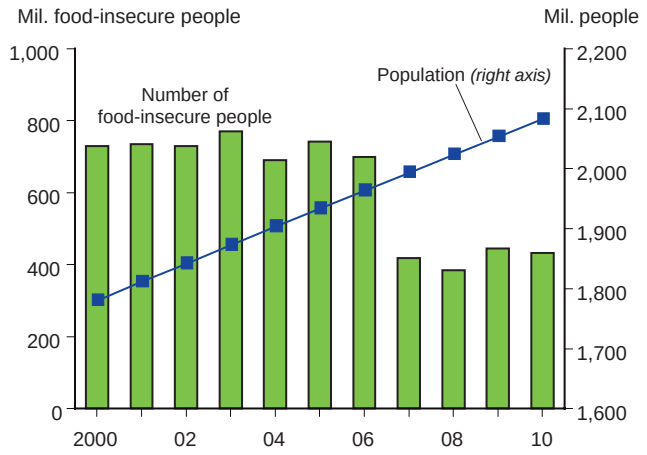
Asia (2.082 billion people in 2010)

Asia has made considerable progress in improving food security mainly because of sustained agricultural production growth, positive and relatively high economic growth rates, and slowing population growth. However, a large proportion of the world's hungry can still be found here, mainly due to skewed income distribution within countries.

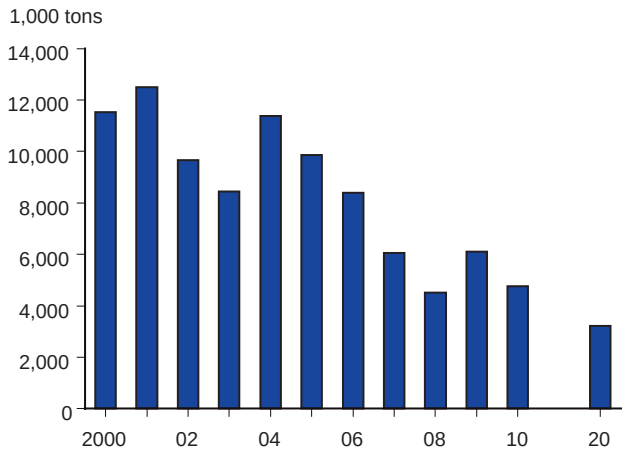
Afghanistan and North Korea are the region's most vulnerable countries with respect to food security.

Though food insecurity will remain, the absolute and relative number of food-insecure people in Asia is expected to decline over the next decade.

Asia: Trend in number of food-insecure people vs. population



Asia: Distribution gaps



Asia: Financial indicators, 2007

	Export earnings	Remittances*	Foreign direct investment	Sum
			Percent of GDP	
India	21.8	3.3	2.0	27.1
Indonesia	30.2	1.4	1.6	33.2
Pakistan	15.3	4.2	3.7	23.2
Philippines	41.2	11.3	2.0	54.5
Vietnam	79.5	8.0	9.8	97.3

*Workers' remittances and compensation of employees, received.
Source: World Bank Indicators, 2009.

increases, and enabled multiple cropping. However, grain yields in the region—except for Indonesia and Vietnam—still fall below the world average.

Also behind improved food security in Asia is the impressive economic growth of the region. Economic growth in the selected Asian countries, since 1990, has ranged from 3.8 to 8.5 percent per year. India, an emerging economy, leads the way with a GDP growth rate of 6 percent per year, even during the height of the economic crisis. Economic growth increases the demand for food, but when it is accompanied with sufficient export earnings and positive capital inflows, it permits financing of food imports when there are shortfalls in domestic production. Though the share of grain imports to grain supply for Asia is about 5 percent, the lowest among all the developing regions, it is an important coping strategy in response to production shortfalls.

Land area is one of the most limiting factors of production in Asia. Since 1990, area expansion has increased by less than 1 percent per year. As a result, the Asian countries will have to rely on yield increases and more intense cropping to increase or sustain output growth, and this may require sustained or accelerated investment in agricultural research and development.

Asia's vulnerability to production shortfalls is low. Variation in production below trend is low for most Asian countries due to the high proportion of irrigated area (30-85 percent of total cropland), which minimizes the risks of production deficits. A shortfall from the production trend occurs 30 to 50 percent of the time among the Asian countries studied. The average production shortfall is below 9 percent for most of the countries in the region. Afghanistan and North Korea were the most susceptible to a production shortfall, with average shortfalls of 21 percent and 26 percent from trend. Though average production shortfalls are relatively low, reductions in output can result in food shortages due to the vast size and density of the population in these Asian countries.

Declining international and domestic grain prices in 2009 helped improve food access for the poor. However, prices remain above pre-global food crisis (2007-08) levels. Food price stability has varied across countries and across commodities. In Bangladesh, prices of staple foods have been on the increase since December 2009. The domestic price of rice has been rising in Vietnam since October 2009. Since June 2009, prices of cereals, sugar, and pulses have been increasing in India (FAO/GIEWS, various years).

The impact of these price increases could be substantial for low-income households, and many countries have safety net programs aimed at mitigating the impacts of acute and chronic household food insecurity. For example, India distributes highly subsidized rice and wheat to below-poverty-line households, and it also has a program that guarantees 100 days of employment for rural workers. India continues to maintain and build up rice/wheat stocks for its distribution program, facilitated, in part, by bans on wheat and rice (except Basmati) exports implemented during the global food crisis and kept in place following India's 2009 drought. The country is continually reviewing its food security measures to better help those without adequate purchasing power.

The role of food aid has diminished over time in Asia, but it is still important during emergencies and transitional food shortages. North Korea and

Afghanistan are the region's most vulnerable countries, accounting for over 60 percent of total food aid in Asia. All 10 countries in Asia are projected to face distributional food gaps of different degrees, but North Korea and Afghanistan are the only two countries projected to have nutritional food gaps over the next decade.

North Korea's short- and long-term food security remains bleak as food shortages (nutritional and distributional) are projected each year over the next decade. In the past years, household food rations from the North Korea's Private Distribution System (PDS) have been unable to satisfy nutritional requirements of about 70 percent of its total population. The remaining 30 percent of North Korea's population are cooperative farmers and their families, who receive allocations from their low production output. Despite favorable weather in 2008 and 2009, North Korea exhibited below-average food production due to the long-term decline in soil fertility and persistent shortages of critical inputs, such as fuel and fertilizer. Beyond the agricultural sector, macroeconomic stagnation compounds food insecurity. As a result, North Korea is projected to be highly dependent on food aid and external assistance to mitigate chronic food problems.

Although Afghanistan experienced a bumper crop in 2009, doubling its grain harvest compared to the preceding drought years, the country will remain highly vulnerable. Food insecurity is expected to be a chronic problem in this country because of longstanding conflicts and political instability that disrupts economic activities, including farm investments and the supply of farm inputs needed to boost output and incomes. Inadequate purchasing power limits the ability of its population to obtain nutritionally adequate diets. There is limited financial capacity to invest in new infrastructures and to commercially import food during lean years. Compounding the situation, Afghanistan experiences frequent droughts that, on average, reduced grain production by more than 21 percent from trend levels between 1980 and 2008.

To evaluate the likely impact of a rebound in capital inflows as the global economy recovers and interest in developing countries heightens, scenario 1 doubles capital inflows by 2020, reducing the number of food-insecure people in Asia by 14 percent, or 45 million people, relative to the baseline (table 2). While this increase in capital inflow resulted in higher commercial imports and per capita consumption for most countries in the region, the impact on food security was greatest for Afghanistan, Bangladesh, and the Philippines. In Afghanistan and Bangladesh, the number of food-insecure people is projected to fall by half relative to the baseline scenario. In the Philippines, the share of food-insecure falls from 10-20 percent of the population to less than 10 percent.

In Asia, food insecurity will remain a problem, mainly because of income inequality within countries. Overall, the food security situation in the region is projected to improve over the next decade. In addition to having a large chronically food-insecure population, the Asian countries studied will continue to face transitory food insecurity problems associated with weather-related production shortfalls and fluctuations in commercial import capacity. The scale of Asia's population increases the enormity of the problem when such short-term food shortages occur.

Latin America and the Caribbean (LAC)

The LAC economies have become increasingly integrated into the global economy. The region's trade share of its total GDP increased from 30 percent in the early 1990s to 42 percent in the early 2000s to nearly 47 percent in recent years. As a result, the global financial crisis had an adverse impact on these countries as capital inflows turned negative, export earnings declined, remittances fell, and tourist revenue weakened.

Economic performance in Central America, which includes some of the poorer countries in this region, is closely tied to the economy of the United States. According to the IMF (Swiston, 2010), a 1-percent change in U.S. economic growth results in a 0.7- to 1-percent change in Central America's GDP. Central America's trade is closely tied to the United States due to geographical proximity as well as free and preferential trade agreements. On average, the United States is the destination for roughly 60 percent of the region's exports. And U.S. remittances grew from 3 percent of LAC's GDP in the 1990s to more than 8 percent in the 2000s. It is estimated that 80 percent of Central America's remittances come from the United States. For some countries, this dependency on remittances is even more significant. In El Salvador, for example, remittances averaged nearly 16 percent of GDP this decade; in Honduras, the share was about 13 percent. Therefore, recovery in the United States is crucial to growth and food security in this region.

Between 2008 and 2009, most of the 11 lower income countries studied in the Latin American and Caribbean region experienced negative or negligible real GDP growth. For 2010, the IMF estimates modest improvements from those rates. In Jamaica, real GDP growth is expected to continue to decline, albeit slightly. For the remaining countries, real growth is estimated to range from 0.5 percent in El Salvador to 5.8 percent in Peru. Economic growth is critical to a region that relies on imports for roughly 50 percent of its grain supplies.

The region's food security situation is estimated to improve between 2009 and 2010 (table 7). The number of food-insecure people is estimated to decline 5 percent while the distribution gap is projected to drop 26 percent from 2009 to 2010. However, roughly 37 percent of the region's population is estimated to remain food insecure in 2010. The region's distribution gap is estimated at nearly 2 million tons; this is more than 10 times the amount of food aid these countries have received annually in recent years.

Haiti is the region's most food-insecure country, followed by Bolivia and the Dominican Republic. For Haiti, 80 percent of the population is estimated to consume below the nutritional target in 2010, and this is before the impact of the January earthquake is taken into consideration. Despite improvements in the country's economic situation in recent years, Haiti remains the poorest country in the Western Hemisphere. Per capita income was roughly $700 in 2008. The country has a large trade deficit, as imports are generally three times larger than exports. In addition, the country is heavily dependent on aid, with official development assistance equal to roughly 10 percent of GDP.

Population growth in the region averaged 1.4 percent per year since 1990, about half that of Sub-Saharan Africa, reducing food demand pressure. Grain production has grown more than 2 percent per year since 1990, improving

Table 7

Food availability and food gaps for Latin America and the Caribbean

Year	Grain production	Root production *(grain equiv.)*	Commercial imports *(grains)*	Food aid receipts *(grain equivalent)*	Aggregate availability of all food
			1,000 tons		
2001	12,656	3,253	11,125	1,067	38,222
2002	13,315	3,355	11,680	1,127	39,653
2003	14,043	3,457	11,774	491	40,469
2004	13,841	3,395	12,055	568	40,432
2005	14,326	3,437	13,412	687	40,785
2006	14,410	3,587	14,832	671	42,049
2007	15,453	3,842	15,383	392	46,193
2008	15,726	3,688	14,932	362	47,457
2009(e)	15,612	3,822	14,603	485	44,001
Projections				Food gap*	
				NG / DG	
2010	15,984	3,870	16,051	***303*** / ***1,982***	46,318
2015	17,039	4,122	18,128	***406*** / ***1,766***	51,843
2020	18,209	4,388	20,121	***406*** / ***1,586***	57,931

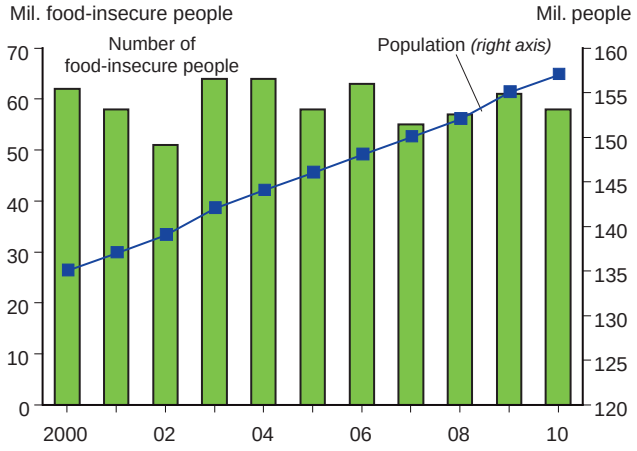
*See table 1.

Latin America and the Caribbean (LAC) (157 million people in 2010)

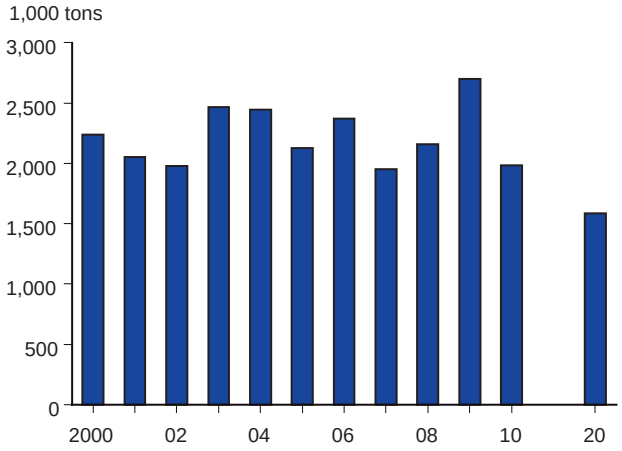
The region's food security situation is projected to improve over the next decade as per capita consumption increases and distribution gaps decline. Food production is expected to keep pace with population growth while imports, in most countries, will far exceed it.

Results indicate that the most food-insecure country in the region is Haiti, followed by Bolivia and the Dominican Republic.

LAC: Trend in number of food-insecure people vs. population



LAC: Distribution gaps



Latin America and the Caribbean: Financial indicators, 2007

	Export earnings	Remittances*	Foreign direct investment	Sum
			Percent of GDP	
Ecuador	35.0	6.8	0.4	42.2
Haiti	10.9	18.2	1.1	30.2
Honduras	51.9	21.5	6.7	80.1
Jamaica	37.7	16.4	6.6	60.7
Nicaragua	47.3	12.9	6.7	66.9
Peru	29.2	2.0	5.0	36.2

*Workers' remittances and compensation of employees, received.
Source: World Bank Indicators, 2009.

the outlook for food security. Per capita consumption is projected to rise 1 percent per year over the next decade. As a result, the distribution gap is projected to fall 20 percent by 2020, with the number of food-insecure people projected to fall by a third. With these improvements, about 22 percent of the region's population is projected to remain food insecure in 2020. In Jamaica, less than 10 percent of the population is projected to consume below the nutritional target. Colombia, El Salvador, and Peru are also projected to be more food secure than the region in general, with about 10 percent of the population projected to fall short of the nutritional target.

Peru is projected to improve more than any other country in the region over the next 10 years. The country's real GDP growth has been among the strongest in the region and, according to the IMF, growth is expected to near 6 percent in 2010. The country depends on gold, copper, and oil for most of its export earnings, and has benefited from the recent high prices of those commodities. The country's grain output, which accounts for about half of consumption, has outpaced population growth, and this is projected to continue through the next decade.

Capital inflows in general and remittances in particular are major sources of LAC import financing. Remittances to this region declined 11 percent in 2009. According to the IMF, the outlook for a rebound in capital inflows is positive. Doubling capital inflow by 2020 (scenario 1) benefits Latin America and the Caribbean more than other regions in this study, with the number of food-insecure people declining an estimated 31 percent in 2020 as compared with the base scenario (table 2). The greatest response to increased capital inflow is in Guatemala, although Nicaragua, Honduras, the Dominican Republic, El Salvador, and Haiti also see improvements in food security. Guatemala is highly import-dependent, so an increase in capital inflows raises commercial import capacity, thereby improving food security. In addition, per capita consumption in Guatemala, even for the lowest and second-lowest income quintiles, was not that far below the nutritional target in the base scenario. When imports were raised in scenario 1, consumption in these income groups increased enough to exceed the target.

With the new focus of donors and international organizations on agriculture in the most food-insecure countries, scenario 2 models the implications of adopting new agricultural technology. Grain yields in the LAC region averaged 2.4 tons per hectare in 2008. However, Guatemala, Haiti, Honduras, and Nicaragua have average yields far below the rest of the region. Yields in Haiti were 0.8 ton/ha while those in the other three countries were 1.6 tons/ha. As a result of this low productivity, these countries have increased food imports. On the low end is Nicaragua, which imports a third of its grain supplies. On the high end is Haiti, which imports 60 percent of its supplies. Relative to other LAC countries, the share of population in rural areas in these four countries is the highest (40 to 60 percent in 2006) and the share of agriculture in GDP is high (15 to 30 percent in 2006).

Scenario 2 (boosting grain yields by 50 percent) had the greatest impact on Nicaragua and the least impact on Haiti. In the case of Nicaragua, per capita consumption jumped 15 percent as a result of the boost in yields. Domestic production is a large share of Nicaragua's food consumption; therefore, projected production gains have a significant impact on reducing food gaps

and improving food security. In Haiti, however, per capita consumption rose only 5 percent in response to the yield increase. As a result, there was no impact on the number of food-insecure people in scenario 2. Haiti is one of the more import-dependent countries in the region, so an increase in production is not going to have as great an impact on food security as would a boost on the import side (like that in the first scenario).

The LAC's gains expected over the next decade are largely driven by projected increases in commercial imports. Food production is expected to keep pace with population growth whereas imports, in most countries, will far exceed it. Import growth is strongly linked to the performance of these countries' export sectors, which help finance the imports. The countries mainly export minerals and primary commodities, and they are sensitive to changes in global prices and demand.

Commonwealth of Independent States (CIS)

The countries of the Commonwealth of Independent States were severely affected by the global economic downturn. The IMF estimated that real economic growth for the region declined from 6.6 percent in 2008 to 1.5 percent in 2009. Performance among the countries varies widely, however. Four CIS countries are energy exporters: Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan. These countries actually benefited from the global economic downturn, with economic growth ranging from 4 to 8 percent, in real terms, in 2009. The same or stronger growth is estimated for 2010. The economies of the oil importers, on the other hand, did suffer. Armenia is highly integrated into world markets and therefore was the hardest hit. The IMF estimates that the country's real GDP fell more than 15 percent between 2008 and 2009. Georgia's economy contracted 4 percent. Recovery is expected for both countries in 2010, albeit at slow rates of 1 to 3 percent.

The CIS region is relatively food secure compared with many of the countries included in this report (table 8). In 2009 and 2010, only two countries in the region, Georgia and Tajikistan, experienced food insecurity for 10 percent or more of their population, but the situation improved in both countries as their economies showed some signs of recovery in 2010.

Over the next decade, per capita food consumption throughout the region is projected to rise in all countries in the region, except for Tajikistan. As a result, in 2020, an estimated 20 percent of Tajikistan's population will consume below the nutritional target. Tajikistan is the poorest country in this region with per capita GDP of $750 in 2008. In addition, Tajikistan's population growth rate is nearly 2 percent per year, while population in most other CIS countries is either growing more slowly or contracting.

Nearly half of Tajikistan's population works outside the country, mostly in Russia. The country's remittances grew 74 percent from 2003 through 2008, and equaled 47 percent of GDP in 2008. In addition to its dependence on the strength of the Russian economy, Tajikistan is also highly dependent on the cotton sector, which accounts for 20 percent of total export earnings. The sector, however, is characterized by debt and poor infrastructure.

Table 8

Food availability and food gaps for Commonwealth of Independent States

Year	Grain production	Root production *(grain equiv.)*	Commercial imports *(grains)*	Food aid receipts *(grain equivalent)*	Aggregate availability of all food
			1,000 tons		
2001	26,923	1,664	2,534	521	22,982
2002	29,351	1,764	2,780	516	22,511
2003	28,789	1,909	2,870	272	22,671
2004	26,546	2,006	3,551	301	22,307
2005	28,745	2,076	4,243	282	21,682
2006	31,288	1,995	4,333	348	22,487
2007	34,644	2,157	5,804	290	26,174
2008	30,536	2,214	6,395	58	27,055
2009(e)	34,774	2,245	5,856	232	33,130
Projections				Food gap*	
				NG / DG	
2010	34,035	2,276	6,415	***0*** / ***18***	32,288
2015	35,719	2,434	7,656	***0*** / ***14***	35,330
2020	37,445	2,602	9,026	***0*** / ***20***	38,692

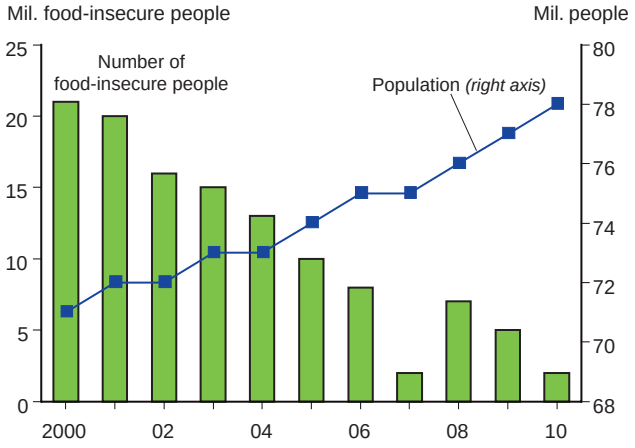
*See table 1.

Commonwealth of Independent States (CIS) (78 million people in 2010)

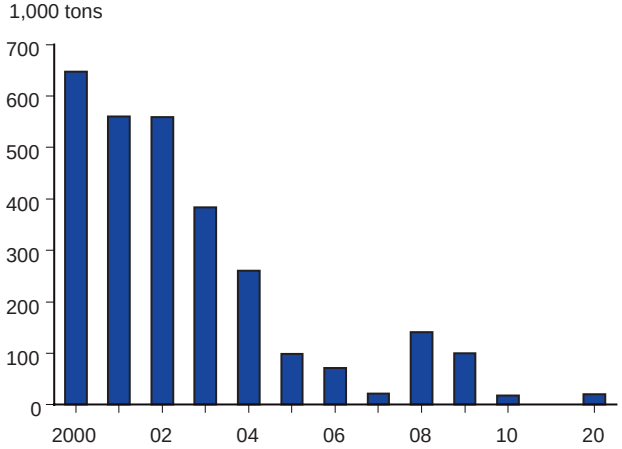
Countries in the CIS region are relatively food secure compared to the other countries included in this study. Only Georgia and Tajikistan experienced food insecurity in 10 percent or more of their population in 2010.

Over the next decade, the region's per capita consumption is projected to rise, with the exception of Tajikistan. As a result, an estimated 20 percent of Tajikistan's population will consume below the nutritional target in 2020.

CIS: Trend in number of food-insecure people vs. population



CIS: Distribution gaps



Commonwealth of Independent States: Financial indicators, 2007

	Export earnings	Remittances*	Foreign direct investment	Sum
			Percent of GDP	
Armenia	19.0	9.2	7.6	35.8
Georgia	31.3	6.8	17.0	55.1
Kazakhstan	49.5	0.2	9.7	59.4
Kyrgyz Republic	54.0	19.1	5.6	78.7
Tajikistan	45.9	45.4	9.7	101.0
Turkmenistan	72.2[1]	--	6.2	78.4

*Workers' remittances and compensation of employees, received.
[1]2006 data
-- = data unavailable or not applicable due to inconsistent data set.
Source: World Bank Indicators, 2009.

To reflect the current interest of international organizations and donors in developing countries, a doubling of capital inflow by 2020 (scenario 1) results in an increase in Tajikistan's per capita consumption of only 1.5 percent. As a result, the country's food security situation remains relatively unchanged, with 20 percent of the population continuing to consume below the nutritional target.

Conclusion

Food security in the 70 lower income countries studied is estimated to improve in 2010, responding to the global economic recovery. This improvement, however, could be undermined by uncertain capital inflows, commodity price trends, and domestic production shocks caused by adverse weather.

Alternative scenarios show the potential for significant improvement by 2020. The scenario in which capital flows to these countries are doubled finds that the resulting increase in commercial food import capacity reduces the number of food-insecure people by 97 million relative to the baseline estimates. The projected improvement is greater in Asia and LAC than in SSA. When yield increases (increasing grain yields by 50 percent in SSA and selected LAC countries) are added to the first scenario, the number of food-insecure people falls by almost half, from 874 million in the food security baseline estimates to 469 million in 2020.

The challenge of enhancing agricultural growth, particularly in Africa, is great. However, there is a consensus among governments and donors that agricultural development is essential to reducing food insecurity and poverty. Modern technology provides opportunities for production gains and official development assistance, and national governments are supportive of agricultural development. There are also ample lessons (some fully successful, some moderately successful) of earlier agricultural interventions and they could be used to tailor programs according to socioeconomic conditions of the lower income countries.

In 2009, the countries represented at the G8 Summit in L'Aquila agreed to reinforce their commitment to agricultural development in order to improve food security. This initiative not only includes additional resource commitments from donors, but it also attempts to coordinate their allocation of resources in order to maximize their effectiveness. Unlike the Green Revolution that significantly boosted production in Asia, this new initiative will have a broader focus, including providing good governance, empowering women, increasing funding for research and development, and developing seed varieties that are unique to target locations and climates. There is also strong support for regional integration on trade and information sharing to reduce the impacts of domestic production shocks.

The promises of the new initiative are welcome news, but success requires a long term commitment and carefully designed strategy at the country level. Given the high levels of poverty and low levels of savings, these 70 developing countries have little resources to deal with economic shocks. In addition to agricultural development, improvement in economywide productive capacities and diversification of economic activities need to be part of the strategy to strengthen the economic resilience of the countries.

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Special Article

Food Production Assessment in the Context of Weather Variability

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Introduction

Agriculture is a weather-driven enterprise and, for this reason, is subject to natural variability and risk, which can have a substantial impact on food security. The Food and Agricultural Organization of the United Nations (FAO) estimates that at least 50 percent of global variability in agricultural production is due to weather (Gommes, 1999). As the frequency and magnitude of climatic shocks are expected to increase because of climate change (IPCC, 2001), there is increased concern for food security, especially in areas already prone to droughts.

In lower-income countries, domestic agricultural production is critical to food security because it often makes up the largest portion of consumption. However, the agricultural systems of lower-income countries are primarily rainfed and therefore are subject to weather variability. For those countries already facing sluggish or declining production trends, any shortfalls can have serious food security implications. These production declines are also exacerbated by financial constraints that limit imports in many countries and by inadequate domestic safety net programs, forcing many areas to rely upon food aid that is often not sufficient or timely. Understanding the production effects that may result from increased rainfall variability can contribute to more timely responses and better coping mechanisms in these vulnerable areas.

This article reviews and discusses the importance of including measurements of weather variability in estimates of annual agricultural production in order to reduce the number of food emergencies and improve targeting of assistance and support for mitigation measures. We focus on six countries (Burkina Faso, Chad, Gambia, Mali, Niger, and Senegal) in the Sahel region of Sub-Saharan Africa that are vulnerable to drought in order to show the potential role of weather or satellite data in short-term projections of agricultural production in semi-arid areas. To do this, we estimate the impact of weather on production using precipitation data as well as the Normalized Difference Vegetation Index (NDVI). The results clearly support the inclusion of a weather variable in production projections and call for more disaggregated agricultural production data.

Variability of Agricultural Water and Food Security

Climate change will arguably not only have long-term effects on agricultural production through increased temperatures, but also may lead to increased rainfall variability and more extreme weather events (IPCC, 2001). Availability and variability of agricultural water is one of the biggest food security concerns regarding the effects of changing climatic patterns.

The uncertainty of water supply is especially troublesome for grain production, which constitutes the largest share of the diet in the developing world. Agricultural water is already subject to demands from a variety of other uses, such growing urban, industry, and population needs. This demand has long-term effects. For example, in developing countries, groundwater is often used to mitigate the effects of rainfall fluctuations, and this has led to groundwater levels that are falling by 1 to 3 meters per year (FAO, 2003).

Sufficient water is essential not only for the biophysical needs of crops, but also because of its effects on the productivity of other inputs. One way to increase food production in Sub-Saharan Africa is to increase use of improved seed and fertilizer (Rosen and Caswell, 2006). However, their impacts on productivity can be seriously undermined by variability in precipitation, as can efforts to increase production in these areas through regional expansion (via increased intensity, scale, and yields).

In Sub-Saharan Africa, food is produced mainly by small-scale farmers with limited economic resources to recover from weather shocks. In addition, the impacts of precipitation variability also have larger economic effects because of the importance of agricultural activity to the economy as a whole. In many poor countries, agriculture is responsible for more than 40 percent of the GDP and at least 80 percent of employment (World Bank, 2008). Not only do droughts increase risk to producers, but they also create disincentives for future investment (Grey and Sadoff, 2006). A single drought in Ethiopia can raise poverty rates by 12 to 14 percent, and unmitigated hydrological variability can reduce the economy's growth potential by 40 percent over 10 years (World Bank, 2006). The vicious circle of food insecurity is well known: it reduces productivity, which further increases poverty; poverty limits the ability to respond to risk and deepens vulnerability to food insecurity. In a volatile economic environment, breaking this circle is difficult, but better information about vulnerabilities and risk can help inform decisions that could alleviate some of these effects.

Satellite Imaging and Production Variability

Precipitation and temperature are good indicators of environmental conditions and therefore are traditionally the main focus for measurement of weather. However, these measurements often cannot be obtained in a timely fashion, especially in developing countries. In addition, they can be prone to measurement error from averaging between collection points and from dissimilar collection methods (Hoogenboom, 2000).

Collection of rainfall data is very difficult; the best rainfall data require up to six different types of observations at different resolutions, and rely upon ground observations for calibration. Therefore, these data are vulnerable to changes in the density and reliability of meteorological stations through time and tend to be updated annually. As such, they cannot be used for short-term analyses, such as early warning systems or agricultural forecasts.

As an alternative or supplement to rainfall data, a vegetation index has been recognized as an indicator of crop yields over large areas (Tucker et al., 1980; Bartholome, 1988). A vegetation index from satellite data can provide information that is not subject to the same constraints as surface-collected data.

In particular, regional and local research has explored the relevance of the Normalized Difference Vegetation Index (NDVI) when predicting primary productivity (Fang et al., 2001). NDVI is produced daily and provides information about the consequences of weather variability by directly measuring the photosynthetic activity of plants.[1] Measurements of NDVI have been accepted for use in food security analysis because of their timeliness and extent of coverage (Ross et al., 2009). This measure can also provide comprehensive information on growing conditions as it accounts for runoff and soil moisture through its measurement of vegetative growth.

Unlike measurements of precipitation, NDVI measures the health of the vegetation directly and does not require any calibration through ground observations, which is important in vulnerable areas as they may stop providing these measurements amid a food security crisis. For example, a combination of high-resolution maps of agricultural areas and daily NDVI data via satellite have been used to produce very accurate assessments of crop production in Zimbabwe, a country with a rapidly changing agricultural system (Funk and Budde, 2009).

However, while NDVI has much to offer in terms of estimating production, it does have a few disadvantages that are more pronounced in certain regions. For example, NDVI data more accurately estimate herbaceous biomass than woody biomass, and this must be considered when looking at global measurements (UNEP, 2000). While precipitation and temperature data would be an asset in estimating production, in areas without reliable or timely access to these data, NDVI may be a good substitute, especially in areas without much woody biomass.

Impact of Weather Variability on Predicting Production Changes

To better understand short-term resource variability and its effects on agricultural output, we analyzed the value of integrating measures of precipitation variability or remotely sensed satellite observations of vegetation production variability into a model of agricultural production variability for Africa. Due to its biophysical and economic characteristics, Africa is particularly vulnerable to climate change. An estimated 65 percent of the increase in hunger from the effects of climate changes will be in Africa (Parry et al., 2009). Since NDVI is an apt barometer of food production in semi-arid regions with low tree cover, we first apply this model in a semi-arid area: specifically Burkina Faso, Chad, Gambia, Mali, Niger, and Senegal. These Sahelian countries are a representative mix of arid regions, with similar weather patterns across the agricultural production areas, and they are relatively well-integrated economically and politically.

Traditionally, estimates of agricultural production assume that the effects of crop water are endogenously captured in the observed results for production or yield. This assumption is made because it is difficult to get accurate and timely measurements of water fluctuations and/or other weather events. Modeling production variability as a result of resource variability has also been limited. For example, in Switzerland, grain yield variability increased from 1961 to 2006, possibly due to droughts, extreme heat, or heavy rainfall, though the cause was not formally tested (Finger, 2007). However, recent

[1]NDVI (in a range from 0 to 1.0) measures the difference in the red-light region of the electromagnetic spectrum (where chlorophyll causes absorption of incoming sunlight) and the near infrared region of the spectrum (where plants reflect light to prevent damage to chlorophyll) (Asrar et al., 1984). Therefore, healthy vegetation will have low red-light reflectance but high near-infrared reflectance, leading to high NDVI values (Tucker, 1979).

work by NASA has successfully estimated the impact of historical rainfall variability on food security (Funk and Brown, 2009).

Building upon previous work and data collected by Fuglie (2009, from FAOSTAT and other sources), we specify a Cobb-Douglas agricultural production function to evaluate the importance of weather variability in production variability. The estimated production function includes growing-season measures of annual NDVI and annual measures of precipitation on agricultural land.[2] The model is estimated from 1982 to 2006 for a panel consisting of the previously noted Sahelian countries. To evaluate variability in this region (a region with large seasonal variation of rainfall), we estimated annual growing-season measures of NDVI from monthly measurements.[3]

To measure the impact of weather variability on production variability, we use the normalized mean difference of NDVI or precipitation and regress this difference on the normalized mean difference of production. Taking the differences from the means allows us to measure the variation of each variable at time (t) from its long-term mean (which in our case is the mean of the preceding 24 years). Therefore, when we refer to variability, we refer to the variability of production and weather at time (t) relative to its long-term average. In addition to NDVI and precipitation, we also include as regressors the normalized mean differences of the production inputs of livestock use, labor, fertilizer use, tractor use, and land. The econometric specification and the calculation method of the normalized mean differences are discussed in the box, "Econometric Specification".

Including weather through measurements of NDVI or precipitation increases the explanatory power of long-term production variations in the production function. Even though precipitation has a higher elasticity in this case, it seems that NDVI and precipitation are good substitutes. Figure 1 shows the relationship between the normalized mean difference of growing season NDVI and the normalized mean difference of annual precipitation. This strong relationship points to the possibility of using NDVI as a substitute for precipitation when ground-based weather data are not available.

The model was estimated with precipitation variability, with NDVI variability, and without these two variables, to compare the results of the model-derived estimates with the observed measurements of long-term production variability. The predictive power of the model increases by an average of 10 percent when a weather variable is included, and both precipitation variability and NDVI variability are significantly (and positively) associated with production variability (table A-1).

This relationship holds whether cereal yields, total production, or the productivity index is used as the dependent variable, and the results do not change significantly despite multiple specifications of the model. The results regarding the explanatory power of weather variability are significant in both specifications. A 1-percent change in the variability of NDVI can explain 0.24 percent of the variability of production, and a 1-percent change in the variability of precipitation can explain over 0.35 percent of the production variability (table A-1). Variability in fertilizer, cattle, and labor use are all significantly (and positively) associated with production variability as well

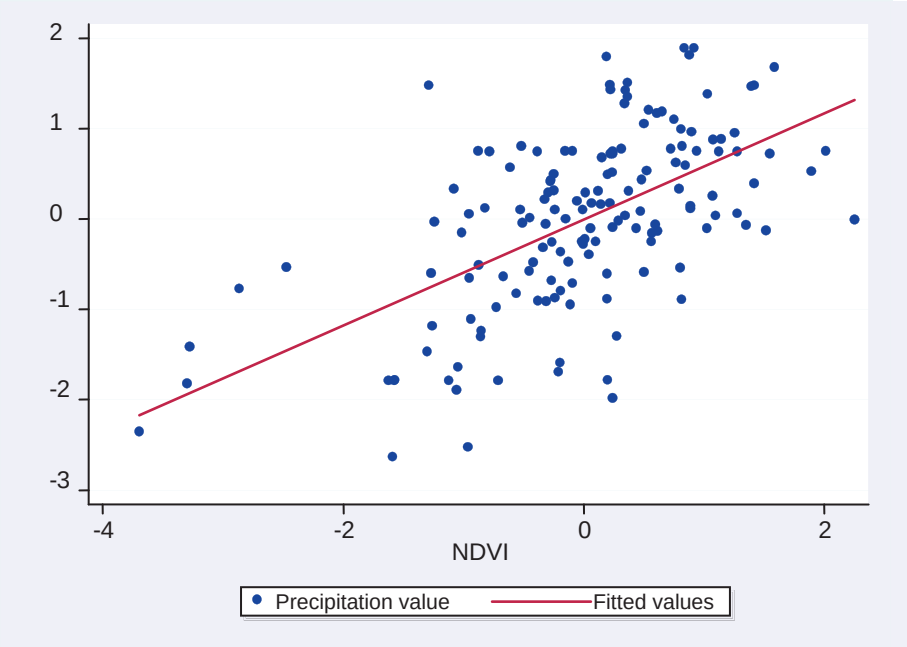
[2]The precipitation data used here are coarse resolution information averaged from daily observations at meteorological stations (New and Hulme 1997). Annual precipitation averages from 1981 to 2006 (using monthly East Anglia CRU climatic data at half-degree resolution grid) were used. To specify the amount of precipitation over agricultural land, an agricultural grid was generated using data from IFPRI's Harvest Choice project (You, Guo, Koo, Ojo, Sebastian, Tenorio, Wood, Wood-Sichra 2009) and this was overlaid with the precipitation data. NDVI composite measurements were taken from the NASA Global Inventory Monitoring and Modeling Systems (GIMMS) group at NASA's Biospheric Sciences Branch from July 1981 to December 2008 (Tucker et al. 2005). Details of the data and their calibration can be found in previous studies (Tucker et al., 2005).

[3]The growing season used was based on the growing season for the top one or two crops in each country, in terms of production amounts. This "growing season" NDVI was then adjusted to account for agricultural land (as defined by harvested pixels in Harvest Choice) (You, Guo, Koo, Ojo, Sebastian, Tenorio, Wood, Wood-Sichra 2009).

(table A-1). However, variability in land or machinery use is not significant. This could be due to the fact that these factors do not change significantly from year to year (additional land is often not acquired and machinery use is minimal in the six countries studied).

Figure A-1

NDVI and annual precipitation show a close relationship



Source: USDA, Economic Research Service.

Table A-1

Sensitivity of production variation to weather changes

Variables	No weather variable	NDVI	Precipitation
NDVI		0.242***	
		(3.76)	
Precipitation			0.356***
			(5.54)
Fertilizer	0.361**	0.331**	0.253*
	(2.12)	(2.06)	(1.68)
Livestock	0.340**	0.320**	0.293**
	(2.41)	(2.42)	(2.41)
Land	-0.0340	-0.0246	-0.0540
	(-0.47)	(-0.36)	(-0.86)
Machinery	0.0171	-0.0137	-0.0348
	(0.20)	(-0.17)	(-0.46)
Labor	0.276**	0.198*	0.236**
	(2.39)	(1.80)	(2.37)
Constant	0.011	0.011	-0.004
	(0.18)	(0.19)	(-0.08)
R^2	0.524	0.581	0.643
N	138	138	138

Note: t-statistics in parentheses. p-values: *** p<0.01, ** p<0.05, * p<0.1

Econometric Specification

To estimate our model, we use data that has been compiled from FAOSTAT by Fuglie (2009) for Burkina Faso, Chad, Gambia, Mali, Niger, and Senegal. The agricultural input data include labor (calculated as the number of economically active males and females employed in agriculture) and capital use (calculated as number of tractors used and value equivalents for livestock). Fertilizer consumption is a measure of the annual fertilizer use from both the International Fertilizer Association and FAOSTAT (Fuglie, 2009). However, many of these variables could be endogenously determined. As an example, we analyze the use of fertilizer.

Fertilizer usage in Africa, and in particular in the Sahelian countries of West Africa, is very low relative to other developing countries and the world. The effect of fertilizer is directly dependent on the rate of use. However, in Africa, the rate of fertilizer use has been linked to issues pertaining to accessibility, availability, and farmers' risk aversion (Sanders et al., 1996; Crawford et al., 2005). Accessibility is a matter of having the capital to purchase the input as well as fertilizer price; availability refers to the physical availability of fertilizer; and risk aversion is usually due to a lack of familiarity with the product and knowledge about its use, which can be compounded by weather fluctuations as well as accessibility and availability. Therefore, the rate of usage (which would affect yields) is endogenously determined by these three factors, noting the need for instrumental variables in the model.

We tested and found significant endogeneity for fertilizer use. Therefore, we instrument the variability of fertilizer use on its lagged value for the previous 2 years. The variation in the rate of fertilizer use in previous years captures changes in accessibility, availability and farmers risk aversion toward using fertilizer, which affects fertilizer use in the current year.

To measure variability, we calculated the fluctuations from the mean of each country's production index, NDVI, precipitation, and other regressors in the model at time (t) from their long-term average. This difference was then normalized by the standard deviation for the whole period. All variables in the model are in natural logs. As an example, the normalized mean difference for production is calculated as $\tilde{y}_{it} = (y_{it} - \overline{y}_i) / \sigma_i$, where y_{it} is the production index for country i at time t; $\overline{y}_{it}$ is the mean for the production index for country i over the 24-year period of estimation; σ_i is its standard deviation in country i over the same period; and $\tilde{y}_{it}$ is the normalized mean difference of the production index in country i at time t. Once these calculations have been made for all variables, the model is specified as follows:

$$\tilde{x}_{it} = \tilde{x}'_{it}\beta_{it} + (\alpha_i + \varepsilon_{it}) \quad (1)$$

In this equation, $\tilde{y}_{it}$ is the normalized mean difference of production at time t for country i from its long term mean, as explained above, and $\tilde{x}'_{it}$ is the matrix of the normalized mean differences of the individual regressors. β_{it} is the matrix of the corresponding constant elasticities for each regressor. The error term (α_i+ε_{it}) in equation 1 allows for a limited form of endogeneity as $\tilde{x}'_{it}$ regressors are assumed to be correlated with the time- invariant component of the error α_i, while assuming no correlation between $\tilde{x}'_{it}$ and the idiosyncratic error ε_{it} (Cameron and Trivedi, 2009). Therefore, our estimation approach assumes fixed effects and the model is estimated using robust standard errors.

Conclusions and Recommendations

Our approach allows us to quantify the effects of water variability over a 24-year period at a national level for six Sahelian countries. The results show a significant impact of agricultural water variability on production variability. Interestingly, production variability is better explained through the highly significant weather variables, such as precipitation and NDVI, than through many other factors that are commonly considered when estimating production, such as labor.

In addition, when the production function, as specified here, is estimated without precipitation and NDVI, predictions of production variability are less accurate. The ability to include timely measures of NDVI for production estimates could allay food insecurity concerns in areas such as the Sahel without timely precipitation statistics or ground-based monitoring programs to collect such data. An analytical approach, such as the one described above, would help developing countries deal with both seasonal shocks and long-term changes in climate.

While the modeling, as shown above, can be done for homogeneous areas, estimations could be made for more heterogeneous areas if disaggregated data were available. Aggregation of all data on agricultural inputs, precipitation, and NDVI over an entire country masks any variability and spatially distinct properties, factors which would likely lead to much more robust results. To maximize use of a model such as this to forecast future production levels given observed weather events, more regionally disaggregated data are needed. Such data do not exist for many Sub-Saharan African countries (You, Wood, and Wood-Sichra, 2009). The results found for the Sahel regarding agricultural production variability may be applicable to other areas with more humid environments if more disaggregated data were available that allowed either crop-specific disaggregation of the production function or disaggregation into ecological zones.

Access to disaggregated data is crucial because variability in rainfall is region-specific. Given poor infrastructure and functioning of markets in most cases, there is a strong need for targeted action. This will be increasingly important if climate change increases precipitation variability. Government agencies and the international community concur that there is a great need to foresee food production shocks and to improve both internal and external response to these shocks. Proposals to mitigate such shocks include supporting food stocks, diversification of production, and crop insurance. Implementing any of these proposals requires site-specific information on weather variability and corresponding short-term production. Unfortunately, in developing countries, meteorological stations are often not established, so precipitation data is often nonexistent (Demeke and Zeller, 2009). Methods using satellite data, such as the one described here, could provide timely information on possible production shortfalls and areas in need of assistance.

Of course, the use of these models for decisions regarding food security policies is not straightforward given the multi-sectoral nature of this research. To take advantage of climate data in agricultural projections, increased collaboration will be needed, especially between meteorological and agricultural support institutions given their different mandates and expertise (Hansen,

2002). To be useful, weather data must be provided at the appropriate scale, to the right groups, and with enough lead time to inform decisions regarding responses (Hansen, 2002). As has been shown here, satellite data could offer some assistance in filling this gap.

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Appendix—Food Security Model: Definition and Methodology

The Food Security Assessment model used in this report was developed by USDA's Economic Research Service for use in projecting food consumption and access and food gaps (previously called food needs) in low-income countries through 2020. Food is divided into three groups: grains, root crops, and a category called "other," which includes all other commodities consumed, thus covering 100 percent of food consumption. All of these commodities are expressed in grain equivalent.

Food security of a country is evaluated based on the gap between projected domestic food consumption (produced domestically plus imported minus nonfood use) and a consumption requirement. Like last year, we use total food aid data (cereal and non-cereal food commodities) provided by the World Food Program (WFP). All food aid commodities were converted into grain equivalent based on calorie content to allow aggregation. For example: grain has roughly 3.5 calories per gram and tubers have about 1 calorie per gram. One ton of tubers is therefore equivalent to 0.29 ton of grain (1 divided by 3.5), 1 ton of vegetable oil (8 calories per gram) is equivalent to 2.29 tons of grain (8 divided by 3.5).

While projection results will provide a baseline for the food security situation of the countries, results 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.

Two kinds of food gaps are estimated and projected:

1) The national average *nutrition gap*, where the objective is to maintain the minimum daily caloric intake standards of about 2,100 calories per capita per day—depending on the region--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.

2) The *distribution gap*, where the objective is to let each income group reach the minimum caloric standard. Based on a methodology explained below, food availability by income group is calculated. If food availability in a given income group is lower than minimum requirements, that difference is part of the distribution gap for this country.

This nutrition-based target assists in comparisons of relative well-being. Large nutrition-based needs mean additional food must be provided if improved nutrition levels are the main objective. The national average nutritional gap approach, however, fails to address inequalities of food distribution within a country. Those are addressed by the distribution gap.

Structural framework for estimating and projecting food consumption in the aggregate and by income group

Projection of food availability. The simulation framework used for projecting aggregate food availability is based on partial equilibrium recursive models of 70 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 grain and root crops are 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. Commercial imports are assumed to be a function of domestic price, world commodity price, and foreign exchange availability. Food aid received by countries is assumed constant at the base level during the projection period. 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. The projection 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 by commodities such as meat and dairy products to the diet was overlooked. The plan is to enhance this aspect of the model in the future.

For the commodity group grains and root crops (*c*), food consumption (*FC*) is defined as domestic supply (*DS*) minus nonfood use (*NF*). *n* is a country index and *t* is a 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*), changes in stocks (*CSTK*), and food aid (*FA*).

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

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

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

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

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

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

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

where *AR* is area, *YL* is yield, *LB* is rural labor, *FR* is fertilizer use, *K* is an 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:

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

where *WPR* is real world food price, *NWPR* is real world substitute price, *FEX* is real foreign exchange availability, 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.

Estimations/projections of food consumption by income group. Inadequate access to food is the most important cause of chronic food insecurity among developing countries and is related to income level. 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 study 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.[1] It should be noted that this approach ignores the consumption substitution of different food groups by income class. 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 (income distributions are assumed constant during the projection period).

[1]The method is similar to that used by Shlomo Reutlinger and Marcelo Selowsky in "Malnutrition and Poverty," World Bank, 1978.

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

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

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

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

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

$$i = 1 \text{ to } 5$$

where *C* and *Y* are known average per capita food consumption (all commodities in grain equivalent) and per capita income (all quintiles), C_o is total food consumption, *P* is the total population, *i* is income quintile, *a* is the intercept, *b* is the consumption income propensity. A consumption-income elasticity, *b/C*, is calculated for individual countries. To estimate per capita consumption by income group, the parameter *b* was estimated based on cross-country (70 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.

Data

Historical supply and use data for 1990-2008 are from FAOSTAT as of March 2010. Food aid data are from the UN's World Food Program (WFP) for 1988-2007, and financial data are from the International Monetary Fund and World Bank. The base year data used for projections are the average for 2006-08, except export earnings, which are 2005-07.

Endogenous projection variables:

Production, area, yield, commercial imports, domestic producer prices, and food consumption.

Exogenous projection variables:

Population—data are medium United Nations population projections as of 2008.

World price—data are USDA/baseline projections.

Stocks—USDA data; assumed constant during the projection period.

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

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

Inputs—fertilizer and capital projections are, in general, extrapolations of historical growth data from FAO.

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

Net 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.

(Shahla Shapouri)

Appendix table 1a

List of countries and their food gaps in 2010

	2010 food gaps			2010 food gaps	
	Nutrition[1]	Distribution[2]		Nutrition	Distribution
			1,000 tons		
Angola	0	73	Algeria	0	0
Benin	0	102	Egypt	0	0
Burkina Faso	0	130	Morocco	0	0
Burundi	468	568	Tunisia	0	0
Cameroon	0	189	**North Africa**	**0**	**0**
Cape Verde	0	1			
Central African Republic	113	264	Afghanistan	0	492
Chad	0	203	Bangladesh	0	421
Congo, Dem. Rep.	6,868	7,304	India	0	1,777
Côte d'Ivoire	0	223	Indonesia	0	506
Eritrea	346	386	Korea, Dem. Rep.	1,013	1,164
Ethiopia	792	1,540	Nepal	0	72
Gambia	0	18	Pakistan	0	25
Ghana	0	41	Philippines	0	102
Guinea	0	0	Sri Lanka	0	85
Guinea-Bissau	0	33	Vietnam	0	110
Kenya	301	1,160	**Asia**	**1,013**	**4,754**
Lesotho	0	66			
Liberia	0	58	Bolivia	0	284
Madagascar	71	506	Colombia	0	230
Malawi	0	15	Dominican Republic	0	171
Mali	0	0	Ecuador	0	133
Mauritania	0	0	El Salvador	0	31
Mozambique	443	878	Guatemala	0	160
Niger	277	839	Haiti	303	559
Nigeria	0	457	Honduras	0	98
Rwanda	125	204	Jamaica	0	0
Senegal	1	228	Nicaragua	0	25
Sierra Leone	0	6	Peru	0	291
Somalia	433	522	**Latin America and the Caribbean**	**303**	**1,982**
Sudan	0	0			
Swaziland	0	23			
Tanzania	0	437	Armenia	0	0
Togo	0	78	Azerbaijan	0	0
Uganda	0	344	Georgia	0	8
Zambia	0	251	Kazakhstan	0	0
Zimbabwe	0	327	Kyrgyzstan	0	0
Sub-Saharan Africa	**10,237**	**17,477**	Tajikistan	0	10
			Turkmenistan	0	0
			Uzbekistan	0	0
			Commonwealth of Independent States	**0**	**18**
			Total	**11,553**	**24,230**

[1]Nutrition gap: gap between available food and food needed to support a per capita nutritional standard.

[2]Distribution gap: amount of food needed to raise consumption in each income quintile to the nutritional standard.

Source: USDA, Economic Research Service.

Appendix table 1b

List of countries and their food gaps in 2020

	2020 food gaps			2020 food gaps	
	Nutrition[1]	Distribution[2]		Nutrition	Distribution
			1,000 tons		
Angola	0	163	Algeria	0	0
Benin	79	251	Egypt	0	0
Burkina Faso	0	319	Morocco	0	0
Burundi	438	566	Tunisia	0	0
Cameroon	0	187	**North Africa**	**0**	**0**
Cape Verde	0	1			
Central African Republic	198	353	Afghanistan	85	1,020
Chad	0	209	Bangladesh	0	163
Congo, Dem. Rep.	8,515	9,096	India	0	363
Côte d'Ivoire	0	122	Indonesia	0	135
Eritrea	536	583	Korea, Dem. Rep.	810	973
Ethiopia	0	1,191	Nepal	0	43
Gambia	0	19	Pakistan	0	117
Ghana	0	44	Philippines	0	38
Guinea	0	0	Sri Lanka	0	59
Guinea-Bissau	0	31	Vietnam	0	310
Kenya	463	1,533	**Asia**	**895**	**3,221**
Lesotho	0	62			
Liberia	0	24	Bolivia	0	266
Madagascar	225	739	Colombia	0	178
Malawi	0	82	Dominican Rep.	0	54
Mali	0	17	Ecuador	0	83
Mauritania	0	0	El Salvador	0	21
Mozambique	217	844	Guatemala	0	191
Niger	1,379	1,957	Haiti	406	681
Nigeria	0	567	Honduras	0	36
Rwanda	210	300	Jamaica	0	0
Senegal	309	509	Nicaragua	0	13
Sierra Leone	0	7	Peru	0	62
Somalia	932	1,032	**Latin America and the Caribbean**	**406**	**1,586**
Sudan	0	0			
Swaziland	29	49			
Tanzania	0	862	Armenia	0	0
Togo	0	111	Azerbaijan	0	0
Uganda	0	963	Georgia	0	0
Zambia	0	245	Kazakhstan	0	0
Zimbabwe	0	288	Kyrgyzstan	0	0
Sub-Saharan Africa	**13,530**	**23,324**	Tajikistan	0	20
			Turkmenistan	0	0
			Uzbekistan	0	0
			Commonwealth of Independent States	**0**	**20**
			Total	**14,832**	**28,151**

[1]Nutrition gap: gap between available food and food needed to support a per capita nutritional standard.

[2]Distribution gap: amount of food needed to raise consumption in each income quintile to the nutritional standard.

Source: USDA, Economic Research Service.

Appendix table 2

Number of food-insecure people, 2010 and 2020

	2010	2020		2010	2020
			Million people		
Asia	433	320	**SSA**	390	513
Afghanistan	17	32	Cameroon	8	10
Bangladesh	33	37	CAR	4	4
India	243	137	Zaire	68	88
Indonesia	47	25	Burundi	9	10
Korea	24	25	Eritrea	5	7
Nepal	6	7	Ethiopia	68	65
Pakistan	18	23	Kenya	33	42
Philippines	19	11	Rwanda	8	11
Sri Lanka	8	4	Somalia	9	12
Viet Nam	18	20	Sudan	0	0
			Tanzania	18	36
LAC	58	39	Uganda	14	28
Bolivia	6	5	Angola	4	10
Colombia	9	5	Lesotho	1	1
Dominican R.	6	2	Madagascar	16	21
El Salvador	1	1	Malawi	2	4
Guatemala	6	7	Mozambique	19	23
Haiti	8	9	Swaziland	1	1
Honduras	3	2	Zambia	5	7
Jamaica	0	0	Zimbabwe	8	9
Nicaragua	1	1	Benin*	6	10
Ecuador	6	3	Burkina Faso	7	13
Peru	12	3	Cape Verde	0	0
			Chad	7	9
North Africa	0	0	Cote d'Ivoire	9	5
Algeria	0	0	Gambia	1	1
Egypt	0	0	Ghana	5	3
Morocco	0	0	Guinea	0	0
Tunisia	0	0	Guinea-Bissau	1	1
			Liberia	2	1
CIS	**2**	**2**	Mali	0	2
Armenia	0	0	Mauritania	0	0
Azerbaijan	0	0	Niger	13	23
Georgia	0	0	Nigeria	32	39
Kazakhstan	0	0	Senegal	8	13
Kyrgyzstan	0	0	Sierra Leone	1	1
Tajikistan	1	2	Togo	3	5
Turkmenistan	0	0			
Uzbekistan	0	0			
			Total	**882**	**874**

Source: USDA, Economic Research Service.

Appendix table 3

Country indicators

Region and country	Population, 2010	Population annual growth rate	Grain production: Annual growth rate, 1990-2009	Grain production: Coefficient of variation, 1990-2009	Root production annual growth rate, 1990-2008	Projected annual growth in supply, 2009-19
	1,000	*Percent*				
North Africa:						
Algeria	35,423	1.5	3.8	48.4	4.6	0.9
Egypt	84,474	1.8	3.0	16.9	3.4	1.3
Morocco	32,381	1.2	0.3	49.2	3.1	-0.2
Tunisia	10,374	1.0	0.0	38.6	3.5	0.9
Central Africa:						
Cameroon	19,958	2.2	3.4	19.4	3.0	2.5
Central African Rep.	4,506	1.9	6.4	32.6	1.2	1.7
Congo, Dem. Rep.	67,827	2.7	0.1	3.3	-1.7	2.9
West Africa:						
Benin	9,212	3.1	4.4	31.6	5.5	1.7
Burkina Faso	16,287	3.4	3.7	24.7	2.6	2.6
Cape Verde	513	1.4	-2.8	74.4	0.5	1.8
Chad	11,506	2.7	6.0	35.6	1.3	5.0
Côte d'Ivoire	21,571	2.4	0.8	6.7	3.6	3.0
Gambia	1,751	2.7	5.8	38.8	1.9	2.4
Ghana	24,333	2.1	2.5	19.6	4.8	1.8
Guinea	10,324	2.5	6.2	36.2	3.0	1.5
Guinea-Bissau	1,647	2.2	1.1	15.7	3.5	3.3
Liberia	4,102	3.7	4.6	44.9	4.7	4.3
Mali	13,323	2.8	3.7	25.9	14.2	1.8
Mauritania	3,366	2.3	0.6	29.2	1.7	3.1
Niger	15,891	3.9	4.3	29.6	1.4	3.2
Nigeria	158,259	2.3	2.3	14.8	4.4	2.4
Senegal	12,861	2.6	1.3	29.4	14.3	0.8
Sierra Leone	5,836	2.5	3.6	52.5	5.8	2.2
Togo	6,780	2.4	3.6	21.7	2.7	1.9
East Africa:						
Burundi	8,519	2.6	-0.3	7.5	1.3	2.8
Eritrea[1]	5,224	3.0	2.2	60.1	-1.6	1.5
Ethiopia[1]	84,976	2.6	5.8	28.7	4.0	2.9
Kenya	40,863	2.7	1.1	13.4	2.1	2.9
Rwanda	10,277	2.8	3.6	39.1	5.8	2.1
Somalia	9,359	2.5	-0.4	33.6	5.0	1.1
Sudan	43,192	2.2	3.1	29.5	3.4	2.9
Tanzania	45,040	3.0	3.1	23.7	-0.1	2.8
Uganda	33,796	3.3	2.9	17.9	4.1	2.6

See footnotes at end of table.

Continued——

Appendix table 3

Country indicators—Continued

Region and country	Macroeconomic indicators					
	Per capita GNI, 2008	Per capita GDP annual growth, 2008	GDP annual growth, 2008	Export earnings annual growth, 2008	Official development assistance as a share of GNI, 2007	External debt present value as a share of GNI, 2007
	U.S. dollars	*Percent*				
North Africa:						
Algeria	4,260	1.5	3.0	5.0	0.3	4.1
Egypt	1,800	5.1	7.1	27.8	0.8	23.2
Morocco	2,580	4.6	5.8	5.1	1.5	27.3
Tunisia	3,290	4.1	5.1	8.0	0.9	60.8
Central Africa:						
Cameroon	1,150	1.9	3.9	24.6	9.4	15.3
Central African Rep.	410	0.9	2.8	6.9	10.4	57.2
Congo, Dem. Rep.	150	3.2	6.2	5.7	13.1	142.9
West Africa:						
Benin	690	1.8	5.1	--	8.7	15.8
Burkina Faso	480	1.5	4.5	--	13.8	21.7
Cape Verde	3,130	4.5	6.0	13.0	11.5	43.2
Chad	530	-3.1	-0.4	-11.7	6.1	29.2
Côte d'Ivoire	980	-0.1	2.2	7.4	0.9	73.6
Gambia	390	3.0	5.9	8.8	12.1	122.9
Ghana	670	4.0	6.2	4.7	7.7	29.9
Guinea	390 ('07)	6.0	8.4	7.7	5.0	72.7
Guinea-Bissau	250	0.5	2.7	5.1 ('07)	32.9	213.6
Liberia	170	2.4	7.1	--	124.3	442.1
Mali	580	1.9	5.0	3.4 ('07)	13.7	30.6
Mauritania	840 ('07)	-0.6 ('07)	1.9 ('07)	4.9 ('07)	13.2	62.0
Niger	330	6.0	9.5	--	12.8	23.0
Nigeria	1,160	3.0	5.3	--	1.3	6.0
Senegal	970	-0.2	2.5	6.2	7.5	23.4
Sierra Leone	320	2.4	5.1	--	32.9	21.4
Togo	400	-1.4	1.1	--	4.9	80.1
East Africa:						
Burundi	140	1.4	4.5	--	47.9	154.6
Eritrea[1]	300	-1.2	2.0	-2.3 ('07)	11.3	64.1
Ethiopia[1]	280	8.5	11.3	3.1	12.5	12.6
Kenya	770	0.9	3.6	-4.2	4.7	30.3
Rwanda	410	8.2	11.2	--	21.0	14.9
Somalia	--	--	--	--	--	--
Sudan	1,130	5.9	8.3	23.0	5.0	45.9
Tanzania	440	4.4	7.5	--	17.4	31.4
Uganda	420	6.0	9.5	7.3	14.8	14.0

See footnotes at end of table.

Continued——

Appendix table 3

Country indicators

Region and country	Population, 2010	Population annual growth rate	Grain production: Annual growth rate, 1990-2009	Grain production: Coefficient of variation, 1990-2009	Root production annual growth rate, 1990-2008	Projected annual growth in supply, 2009-19
	1,000	*Percent*				
Southern Africa:						
Angola	18,993	2.7	6.2	42.7	12.1	1.8
Lesotho	2,084	0.8	-1.2	40.3	3.8	1.4
Madagascar	20,146	2.7	2.3	19.8	0.9	1.8
Malawi	15,692	2.8	4.0	38.2	17.7	1.2
Mozambique	23,406	2.2	7.6	40.2	3.1	1.7
Swaziland	1,202	1.4	-5.0	37.8	1.2	0.5
Zambia	13,257	2.5	1.5	30.9	3.0	2.1
Zimbabwe[3]	12,644	1.0	-2.5	41.6	3.2	2.6
Asia:						
Afghanistan	29,117	3.4	3.1	33.2	1.9	1.8
Bangladesh	164,425	1.4	3.3	20.1	8.6	1.7
India	1,214,464	1.4	1.5	9.2	3.6	1.9
Indonesia	232,517	1.1	2.7	13.3	1.3	1.7
Korea, Dem. Rep.	23,991	0.4	-3.2	40.5	7.7	0.0
Nepal	29,853	1.8	2.5	14.2	6.1	2.2
Pakistan	184,753	2.2	2.9	17.7	5.6	1.8
Philippines	93,617	1.8	2.8	19.4	-0.4	2.7
Sri Lanka	20,410	0.8	2.1	17.2	-2.2	0.9
Vietnam	89,029	1.1	4.6	24.7	4.9	2.2
Latin America and the Caribbean:						
Bolivia	10,031	1.7	4.2	25.7	0.7	2.4
Colombia	46,300	1.4	0.9	13.8	-0.4	1.6
Dominican Republic	10,225	1.3	1.8	15.8	0.6	1.8
Ecuador	13,775	1.1	2.6	18.3	-1.7	2.0
El Salvador	6,194	0.5	1.2	16.7	-1.3	1.2
Guatemala	14,377	2.5	-0.5	11.3	6.2	2.3
Haiti	10,188	1.5	0.3	9.9	0.9	1.8
Honduras	7,616	2.0	-0.9	11.9	3.8	2.7
Jamaica	2,730	0.4	-4.6	35.7	-3.3	0.7
Nicaragua	5,822	1.4	4.2	25.3	5.1	1.1
Peru	29,496	1.1	5.9	31.7	5.5	2.3
Commonwealth of Independent States:[2]						
Armenia	3,090	0.2	2.3	24.0	3.2	1.7
Azerbaijan	8,934	1.2	4.5	32.8	16.3	3.2
Georgia	4,219	-1.0	-0.7	28.1	-0.9	1.5
Kazakhstan	15,753	0.7	-0.9	33.9	1.6	0.3
Kyrgyzstan	5,550	1.2	1.0	14.7	10.5	0.9
Tajikistan	7,075	1.8	9.0	46.2	13.2	1.4
Turkmenistan	5,177	1.3	11.9	49.6	18.1	3.8
Uzbekistan	27,794	1.1	8.6	37.3	7.0	1.6

See footnotes at end of table.

Continued——

Appendix table 3

Country indicators—Continued

Region and country	Macroeconomic indicators					
	Per capita GNI, 2008	Per capita GDP annual growth, 2008	GDP annual growth, 2008	Export earnings annual growth, 2008	Official development assistance as a share of GNI, 2007	External debt present value as a share of GNI, 2007
	U.S. dollars	*Percent*				
Southern Africa:						
Angola	3,450	11.8	14.8	..	0.5	26.2
Lesotho	1,080	3.4	3.9	-22.0	6.2	33.7
Madagascar	410	4.0	6.9	2.9	12.2	22.7
Malawi	290	6.9	9.7	-5.4	20.6	24.6
Mozambique	370	4.5	6.5	6.8	24.4	44.0
Swaziland	2,520	1.1	2.5	6.4	2.1	13.3
Zambia	950	2.4	6.0	20.7	10.4	27.9
Zimbabwe[3]	360	-5.2	-5.3	-3.4	11.6	132.1
Asia:						
Afghanistan	..	..	16.2 ('07)	..	38.8	19.7 ('06)
Bangladesh	520	4.7	6.2	8.7	2.0	30.0
India	1,070	5.7	7.1	0.0	0.1	18.9
Indonesia	2,010	4.8	6.1	9.5	0.2	33.9
Korea, Dem. Rep.	--	--	--	--	--	--
Nepal	400	3.6	5.3	--	5.8	35.0
Pakistan	980	3.7	6.0	-8.9	1.5	28.0
Philippines	1,890	2.0	3.8	-1.9	0.4	41.9
Sri Lanka	1,780	5.2	6.0	--	1.8	43.8
Vietnam	890	4.8	6.1	21.0 ('07)	3.7	36.3
Latin America and the Caribbean:						
Bolivia	1,460	4.3	6.1	15.6	3.7	38.2
Colombia	4,660	1.3	2.5	7.9	0.4	22.5
Dominican Republic	4,390	4.1	5.3	2.7	0.3	29.8
Ecuador	3,640	5.4	6.5	1.5	0.5	41.3
El Salvador	3,480	2.1	2.5	6.9	0.4	44.5
Guatemala	2,680	1.5	4.0	8.1	1.3	18.7
Haiti	660	-0.5	1.3	--	11.4	26.1
Honduras	1,800	2.2	4.2	3.5	4.0	28.0
Jamaica	4,870	-1.8	-1.3	--	0.2	101.2
Nicaragua	1,080	2.2	3.5	3.9	14.9	60.6
Peru	3,990	8.6	9.8	10.1	0.3	32.6
Commonwealth of Independent States:[2]						
Armenia	3,350	6.6	6.8	-14.0	3.7	30.5
Azerbaijan	3,830	9.6	10.8	14.9	0.8	11.5
Georgia	2,470	2.8	2.0	4.8	3.7	22.0
Kazakhstan	6,140	1.9	3.2	1.0	0.2	103.7
Kyrgyzstan	740	6.8	7.7	25.3 ('07)	7.4	65.0
Tajikistan	600	6.2	7.9	1.8	6.1	34.0
Turkmenistan	2,840	8.4	9.8	--	0.2	5.9
Uzbekistan	910	7.2	9.0	15.8	0.7	17.3

[1] = data start in 1993.
[2] = data start in 1992.
[3] = data is from 2005 for macroeconomic indicators.
-- = data unavailable or not applicable due to inconsistent data set.

Source: Population = FAOSTAT, UN 2008 revision (medium variant), Macroeconomic indicators = World Development Indicators, 2009, World Development Report 2008, World Bank.