United States Department of Agriculture

Economic Research Service

Outlook

GFA 29

June 2018

International Food Security Assessment, 2018-2028

Food security projected to improve through 2028 as incomes rise.

United States Department of Agriculture

Economic Research Service
www.ers.usda.gov

Recommended citation format for this publication:

Thome, Karen, Birgit Meade, Kamron Daugherty, and Cheryl Christensen. *International Food Security Assessment, 2018-2028*, GFA-29, U.S. Department of Agriculture, Economic Research Service, June 2018.

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International Food Security Assessment, 2018-2028

Karen Thome, Birgit Meade, Kamron Daugherty, and Cheryl Christensen

Abstract

The International Food Security Assessment (IFSA) from USDA's Economic Research Service projects three food security indicators: the number of food-insecure people, the share of the population that is food insecure, and the food gap—a measure of the depth of food insecurity. Projections are made for the current year and 10 years out using a demand-oriented model, which includes information on domestic prices and consumer responsiveness to changes in prices and incomes. Given expected lower food prices and rising incomes for many of the 76 low- and middle-income countries included in the IFSA, food security is projected to improve. Projections for the next decade (2018-28) suggest that the share of the population that is food insecure will fall from 21.1 percent in 2018 to 10.4 percent, the number of food-insecure people will fall from 782 million to 446 million, and the intensity of food insecurity will decline by 34 percent.

Keywords: Food security, food prices, income, food demand, trade, production, commercial imports, export earnings, food aid, calories, caloric target, Sub-Saharan Africa, North Africa, Asia, Latin America and the Caribbean

Acknowledgments

Thanks to Mark Jekanowski, Deputy Director for Outlook, Market and Trade Economics Division (MTED), Economic Research Service (ERS) and Steven Zahniser, ERS/MTED for their comments. We also thank the following external reviewers for their feedback, David Stallings, USDA's World Agricultural Outlook Board; Sharon Sydow, Office of the Chief Economist; Joyce Friendenberg, Candice Bruce, J. Bret Tate and Dan Archibald of USDA's Foreign Agricultural Service; and Lorenzo Bellu, Cindy Holleman, and Aikaterini Kavallari of the UN's Food and Agriculture Organization. Special thanks to Dale Simms for editorial assistance, David Marquardt for map design, and Cynthia A. Ray for layout and cover design.

Preface

This report continues the series of food assessments in developing countries begun in the late 1970s by USDA's Economic Research Service. From 1990 to 1992, these reports were entitled *Global Food Assessments*, hence the GFA series that identifies all international food assessments conducted since 1990, including this one. 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 recent or ongoing 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*. Starting with the report published in July 2011, we changed the name to *International Food Security Assessment* to clarify that this is not an assessment of U.S. food security.

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A report summary from the Economic Research Service June 2018

International Food Security Assessment, 2018-2028

Karen Thome, Birgit Meade, Kamron Daugherty, and Cheryl Christensen

What Is the Issue?

International food price spikes over the past decade impacted of price shocks on the food security of vulnerable populations. Low food prices and rising incomes can improve a country's food security situation because people can more readily afford and access food. The speed of improvement in food security is also affected by inequality in income and consumption, as well as agricultural production and market conditions. Understanding how these factors combine provides a measure of progress in food security and its drivers.

What Did the Study Find?

Given projections for lower food prices and rising incomes for most countries in this report, food security is expected to improve between 2018 and 2028: the share of the food-insecure population is expected to fall from 21.1 percent to 10.4 percent; the number of food-insecure people is projected to fall from 782 million to 446 million; the food gap—the amount of food required to allow all food-insecure people to reach the caloric target of 2,100 calories per person per day—is projected to decline from 36 million tons to 24 million.

Gains in food security vary across regions. In ***Asia***, where income growth is strong, the share of the food-insecure population is projected to decline from 16.6 percent in 2018 to 4.7 percent in 2028. The challenge is greater in ***Sub-Saharan Africa*** (SSA) where population growth is higher and income growth lower. In 2018, SSA is projected to have 35.3 percent of its population food insecure; despite improvements, 24 percent are still food insecure in 2028. In ***Latin America and the Caribbean*** (LAC), the share of the population that is food insecure is projected to drop from 19.5 percent in 2018 to 9.5 percent in 2028. Food security is also projected to improve for ***North Africa***, s the most food-secure region in the study. There, the share of the population that is food insecure falls from 4.9 percent in 2018 to 2.3 percent in 2028.

How Was the Study Conducted?

The ERS demand-oriented International Food Security Assessment (IFSA) model projects food consumption (food demand) and food gaps in 76 low- and middle-income countries through 2028. Food security is evaluated for each country by estimating the share of the population unable to reach a caloric target of 2,100 calories per person per day. The intensity of food insecurity is measured by determining the gap between projected food consumption (food demand) for those falling below the threshold and the caloric target. Food demand is expressed in grain equivalent based on caloric content to allow aggregation across four separate food groups: the major grain consumed in the country, other grains, roots and tubers, and all other food.

Average per capita food consumption data are from the United Nations' Food and Agriculture Organization (FAO) Food Balance Sheets and FAO's cereal balances. Observed domestic prices are from FAO's Global Information Early Warning System (GIEWS) database. Tariff data are from the World Bank World Integrated Trade Solution (WITS). Incomes, exchange rates, and Consumer Price Indexes (CPI) are from the ERS International Macroeconomic Dataset. World prices are from USDA's *Agricultural Projections to 2027.*

Overview

The ERS International Food Security Assessment (IFSA) model projects per capita food demand and evaluates that against a caloric target of roughly 2,100 calories per person per day to determine whether populations in 76 low- and middle-income countries (historic food aid recipients) should be considered food secure. Demand projections are based on prices and incomes, using a demand-oriented framework that also captures the relationship between the unequal distribution of income and consumption within each country (see box, "How Food Security Is Assessed" and Appendix for more detail). Given projections for lower food prices and rising incomes over the next 10 years, food security is expected to improve through 2028.

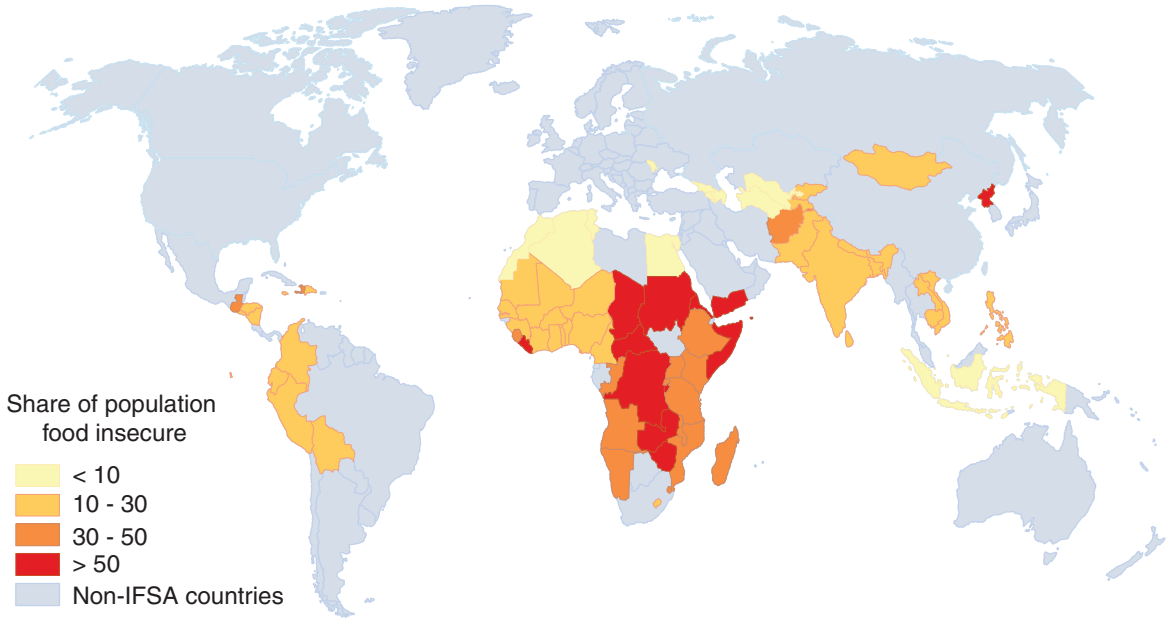
For the 76 countries covered by this report, 21 percent of the population was estimated to be food insecure in 2018. Thus, about 782 million people out of 3.7 billion total do not have access to the daily caloric target of 2,100 calories.

Projected income growth remains positive, and international price projections for major grains continue to show slight declines or steady levels. However, local prices are often unaffected by global trends and instead respond to local shortages or other local factors. This year, several countries in Sub-Saharan Africa with weak currencies or disruptions along the food supply chain suffered food price hikes, which resulted in more food insecurity. Despite some setbacks, the total share of food-insecure people is projected to drop to 10 percent for the 76 countries studied by 2028, with the total number of food-insecure people dropping by 43 percent to about 446 million.

The food gap—the amount of food needed to allow all food-insecure people to reach the caloric target—is an indicator of the intensity of food insecurity. It is expressed in calories per capita per day (per capita food gap) or in grain-equivalent quantities, as a national annual shortfall (total food gap). The total food gap is projected to decline in all regions and in most countries, from a total of 36 million tons in 2018 to 24 million tons in 2028, which is further demonstration of improving food security around the world.

While trends in food security are improving over time, food security indicators differ greatly by region: Sub-Saharan Africa (SSA) has the highest share of food-insecure people with 35.3 percent. Food insecurity is estimated to affect 19.5 percent in Latin America and the Caribbean (LAC) and 16.6 percent in Asia. The North Africa region has the lowest level of food insecurity, at an estimated 4.9 percent in 2018. All regions are projected to see noticeable improvements over the coming decade, with the biggest improvement projected for Asia, where the share of the population that is food insecure is projected to fall more than 70 percent to 4.7 percent by 2028. Food insecurity in SSA improves by 32 percent, with a projected share of 24 percent in 2028. LAC is projected to improve to 9.5 percent food insecure, a drop of more than 50 percent. North Africa is on track to see a further decline in its food-insecure share, to 2.5 percent by 2028.

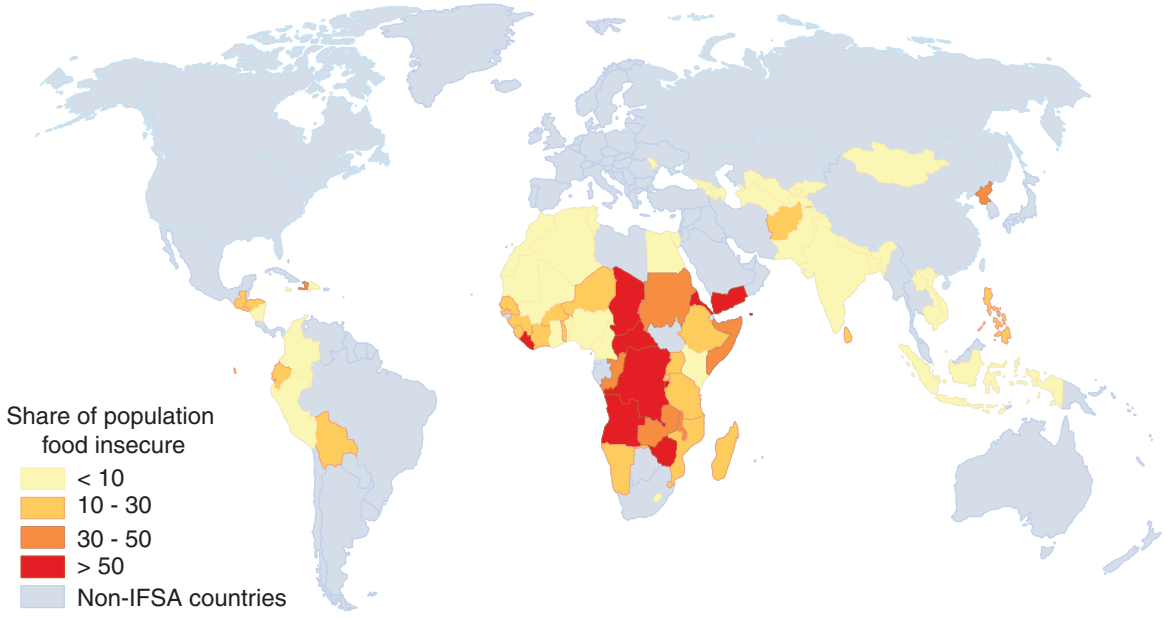
Figure 1
Share of population that is food insecure, 2018



IFSA = International Food Security Assessment.

Source: USDA, Economic Research Service.

Figure 2
Share of population that is food insecure, 2028

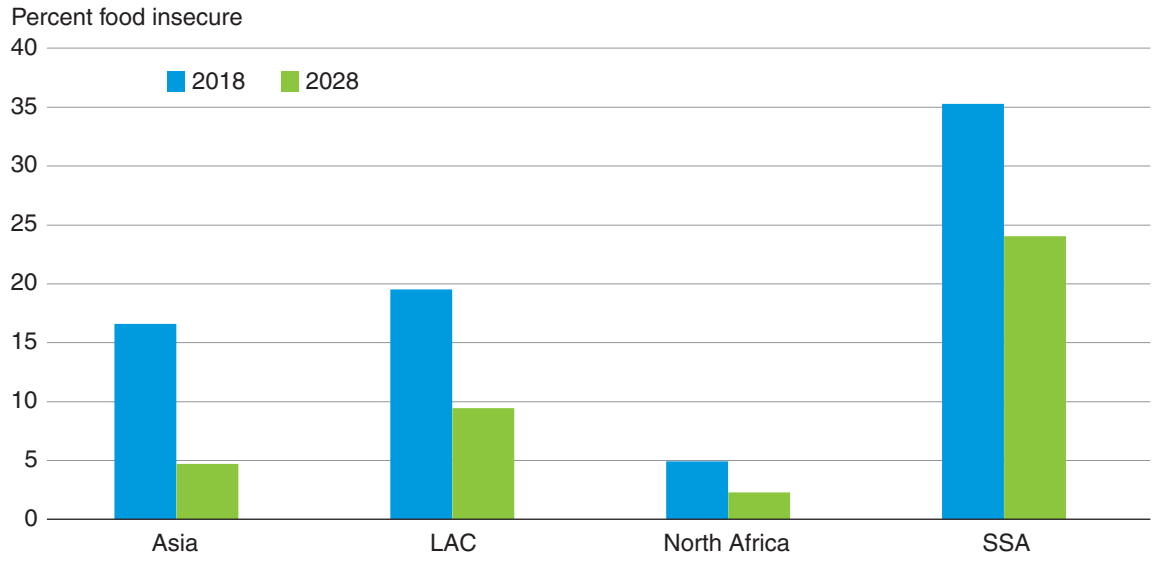


IFSA = International Food Security Assessment.

Source: USDA, Economic Research Service.

Figure 3a

The share of the population that is food insecure is projected to fall by 2028

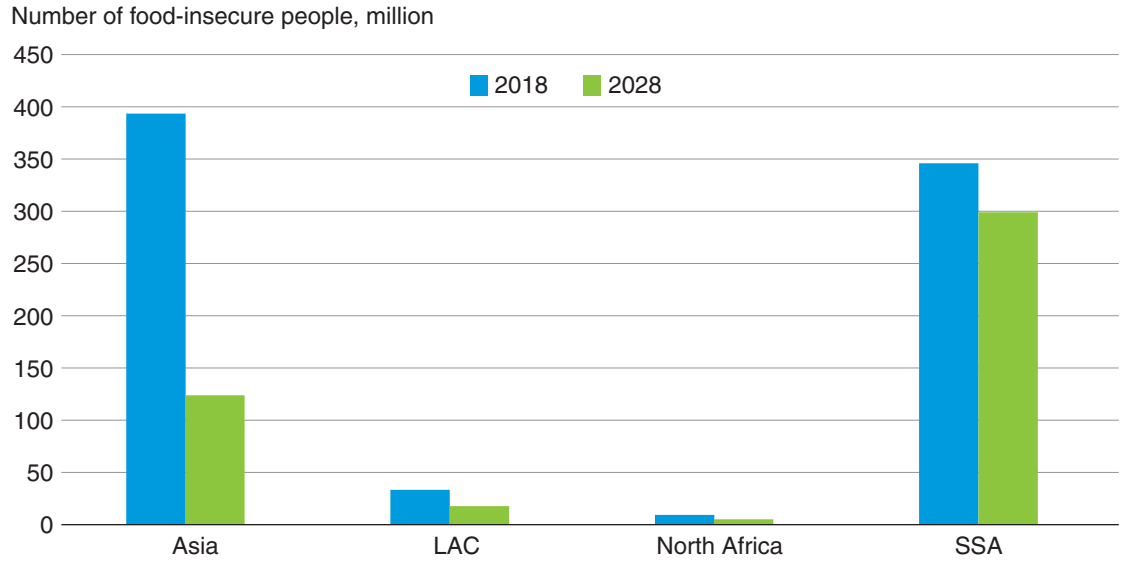


LAC = Latin America and the Caribbean, SSA = Sub-Saharan Africa.

Source: USDA, Economic Research Service.

Figure 3b

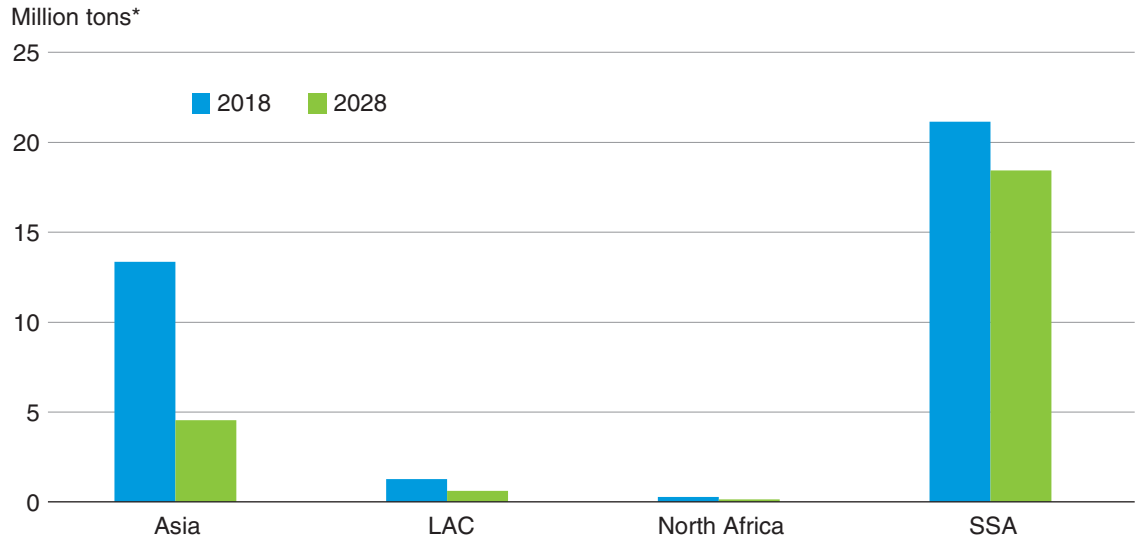
The number of food-insecure people is projected to decline



LAC = Latin America and the Caribbean, SSA = Sub-Saharan Africa.

Source: USDA, Economic Research Service.

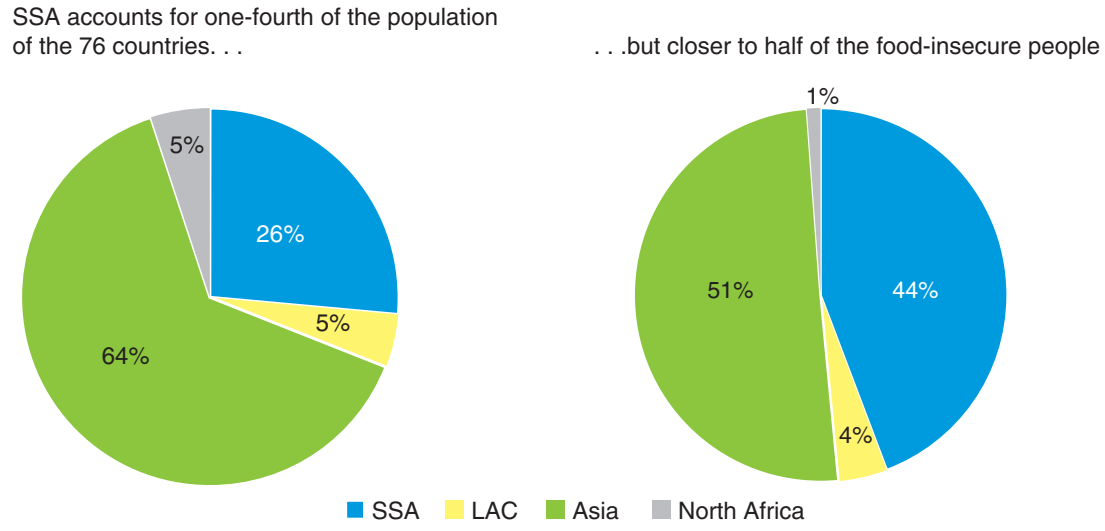
Figure 3c
The total food gap is projected to decline by 2028



*Measured in grain equivalent.
LAC = Latin America and the Caribbean, SSA = Sub-Saharan Africa.

Source: USDA, Economic Research Service.

Figure 4
While SSA's share of food-insecure people is more than double the share in Asia, the number of affected people is almost the same in 2018



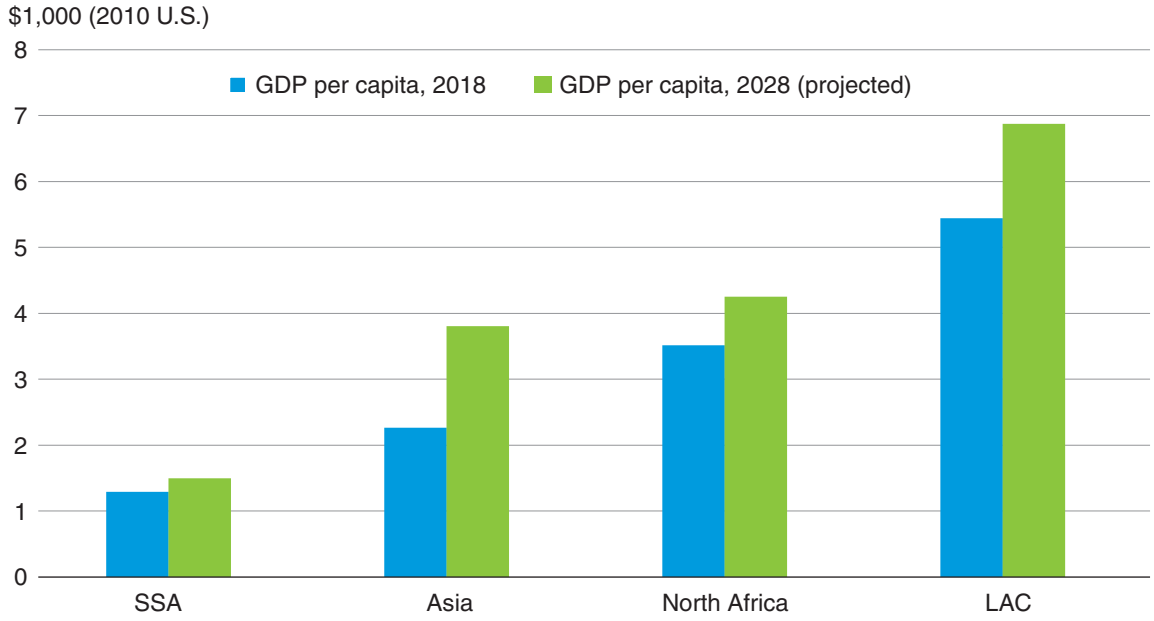
SSA = Sub-Saharan Africa, LAC = Latin America and the Caribbean.
Source: USDA, Economic Research Service.

Per capita income is projected to increase in almost all countries from 2018 to 2028 (figure 5). Economic growth is initially slower than in the early 2000s, but then rises as economies affected by low oil and mineral prices begin to grow again and Asian GDP continues to expand. In Asia, strong GDP growth—particularly in India and Southeast Asia—combined with lower population growth has led to sustained improvements in per capita incomes. Despite improving GDP growth projections, rapid population growth in Sub-Saharan Africa means that its per capita income growth is the slowest of all regions.

International food prices are expected to remain low in real terms over the projection period (figure 6). Oil prices are projected to rise near the end of the projection period, however, and grain production is projected to increase due to increased global demand (USDA, *Agricultural Projections to 2027*). In some markets, world and domestic food prices are integrated through trade. In other cases, significant barriers to trade can cause domestic food prices to move independently of world prices; some agricultural commodities are rarely traded (e.g., cassava).

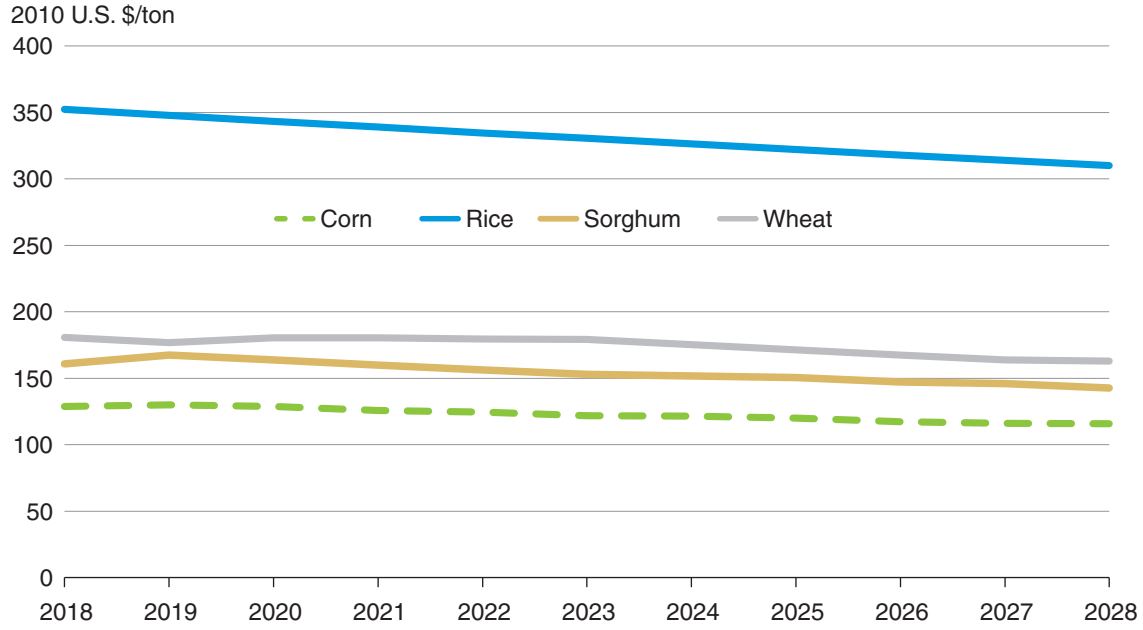
Exchange rate fluctuations and inflation can also cause domestic prices to rise even if world prices are falling. Prices of internationally traded commodities can differ across countries because they are converted into local currency and therefore depend on the real exchange rate. The U.S. dollar is projected to weaken over the next decade, and many currencies in this study begin to appreciate vis-à-vis the U.S. dollar. This reverses the previous trend where a stronger dollar partially offset potential gains from falling food prices. As countries' currencies strengthen, they can better afford imported food (and other goods).

Figure 5
Real incomes per capita by region, 2018 and 2028



SSA = Sub-Saharan Africa, LAC = Latin America/Caribbean. Note: Value in 2010 U.S. dollars to adjust for inflation.
Source: USDA, Economic Research Service calculations using ERS Macroeconomic Data Set.

Figure 6
Real prices of major grains, 2018-2028



Note: Prices in 2010 U.S. dollars to adjust for inflation.

Source: USDA Agricultural Projections to 2027, Long-term Projections report OCE-2018-1.

Increases in food grain demand, as well as grain demand for feed and other uses, will be met by domestic production and imports (table 1). Feed grain demand is projected to grow faster than food grain demand. As incomes increase, diets become more diverse as people consume more meat, dairy, and produce; feed grain demand increases as well. As diets diversify, people obtain a smaller share of their caloric intake from cereal, and grain demand per capita stabilizes. This trend is most noticeable in South and Southeast Asia. Because grains are staple foods for the poorest consumers, the overall grain food demand increases 2.4 percent per year through 2028 as population grows and levels of caloric consumption improve in most countries.

Grain production for the 76 countries is projected to increase 1.9 percent per year from 2018 to 2028. In most regions, production gains are expected to come from improved yields, since there is little additional area to bring into production and low world prices discourage expansion. In Sub-Saharan Africa, grain production is expected to rise faster than the 76-country average. Input use and yields there are very low to start with, leaving room for improvement, and area expansion is expected to contribute to increased production as well.

The gap between grain production and demand grows over the projection period for the 76 countries. Historically, commercial import growth has outpaced production (Tandon et al., 2017). Latin America/Caribbean and North Africa depend on imports for over half of their grain supplies, and in Sub-Saharan Africa demand for wheat and rice is beginning to grow, outpacing local supplies.

Table 1
Food security indicators for total of 76 low- and middle-income countries, 2018 and 2028

Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	Million tons			
2018	581	239	618	202
2028	742	342	746	338

*Other grain demand includes seed, feed, waste, and processing.
**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

How Food Security Is Assessed: Method and Definitions

Food consumption and food access are projected for 76 low- and middle-income countries—39 in Sub-Saharan Africa, 4 in North Africa, 11 in Latin America/Caribbean, and 22 in Asia. Food is divided into four groups covering all of food consumption: the major grain consumed in the country, other grains, root crops, and all other food. The IFSA model's projections of food demand are expressed in grain equivalent based on their caloric content to allow aggregation across food groups; this grain equivalent is easily expressed in kilograms or calories. For example, grains have 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 (see Appendix—Food Security Model: Definition and Methodology for a detailed description of methodology and terms and see appendix table 1 for a list of countries.)

The IFSA model analyzes the gap between projected food demand and a caloric target of 2,100 calories per capita per day. In many countries, per capita consumption at the lower income levels is significantly less than per capita consumption for the country as a whole. IConsumption is assessed across the entire income distribution, where the poorest consume less than the national average. Our first food security indicator is the ***share of the population that is food insecure*** (figure 1).

Our second food security indicator is the ***number of food insecure people*** (fig. 3b)—those who cannot meet the caloric target. This indicator is based on total population and the population share that consumes below the caloric target.

Our third indicator of food insecurity is the ***food gap*** (fig. 3c). This is an indicator of the intensity of food insecurity and measures the amount of food needed to raise consumption of food insecure people at every income level to the caloric target. This measure can be expressed on a per capita basis (as calories per day - the per capita food gap), or as an aggregate annual measure of the total tons of food needed to fill the gap for each country (the total food gap).

Terms commonly used in this report include:

- **Food consumption**—equal to food availability or food demand.
- **Food access**—depends on a consumer's purchasing power. Food consumption is estimated based on income level within each country, modeled on an income-consumption relationship.
- **Food-insecurity**—occurs when estimated per capita food consumption for a consumer at a certain income level falls short of the caloric target of 2,100 calories per person per day.

Conflict and Food Security Emergencies

Conflict has contributed to more serious food security problems in several countries covered in the IFSA. Conflict affects food security in many ways, including weakening the ability of local farmers to produce; disrupting transportation, marketing, and supply chains; and creating displaced populations within conflict countries, as well as refugee flows from conflict countries to neighboring states.

Yemen is currently facing the most severe food insecurity situation in the world. ERS's analysis shows that about 88 percent of the Yemeni population is food insecure. The World Food Program (WFP) reports that 60 percent of the country's population needs food assistance. The ongoing conflict has made meeting these needs difficult. In November 2017, a coalition of countries blockaded all of Yemen's ports, cutting off imports. While the ports have since been reopened for humanitarian assistance and commercial imports, imports have not returned to pre-blockade levels.

Sudan has experienced multiple years of conflict and insecurity in Darfur and in the South Kordofan and Blue Nile states, resulting in nearly 2 million internally displaced persons (IDPs) across the country. Malnutrition remains prevalent and some 5.5 million people require humanitarian assistance. Hunger and instability in neighboring *South Sudan* have caused a major influx of South Sudanese *refugees* sheltering in Sudan, with nearly 420,000 arriving since December 2013.

More than 4 years of conflict have made **South Sudan**—a relatively new country that gained its independence from Sudan in 2011 and is not currently covered by the IFSA—one of the most food-insecure countries in the world. The WFP (2018b) estimates that in February 2018, 6.3 million people in South Sudan—almost half the population—face acute food insecurity. This is a 40-percent increase compared to January 2017. The 2017 harvest was 14 percent below the average for the previous 5 years, due to fall armyworm infestations and disruptions to seasonal planting as farmers fled ongoing conflict, the UN's Food and Agriculture Organization (FAO) reports. Decreased crop production, insecurity restricting market access, and extreme economic instability have contributed to high food prices in South Sudan, making it harder for households in areas where markets are still functioning to purchase enough to eat. The conflict has also displaced an estimated 1.9 million people and created 2.4 million refugees who have fled to neighboring countries, especially Uganda.

In **Somalia,** violence and recurrent droughts and floods have contributed to widespread food insecurity. Conflict—primarily related to al-Shabaab attacks, resultant military operations, and intercommunal violence—continues to restrict trade and market activities while contributing to population displacement and food insecurity. Four consecutive poor rainy seasons have led to severe drought in some areas and, consequently, large-scale livestock losses and poor production. Attacks against civilians and aid workers also disrupt livelihoods and hinder humanitarian response activities, particularly in areas that lack established local authorities or where al-Shabaab is present. Since late 2016, prolonged drought conditions have amplified the negative impacts of Somalia's complex emergency, exacerbating food insecurity and acute malnutrition levels, particularly for IDPs and other vulnerable populations.

Continued—

Conflict and Food Security Emergencies—continued

Nigeria is also affected by conflict. Although the country as a whole is more food secure than many countries in SSA, ERS estimates that about 10 percent of the population is food insecure in 2018. However, prolonged conflict with Boko Haram in northeast Nigeria has displaced many people and undermined food security. As of February 2018, the conflict had displaced more than 1.6 million people and created 214,000 refugees, going mainly to Cameroon, Chad, and Niger.

Conflict in the **Democratic Republic of the Congo** (DRC) contributes to the country's high prevalence of food insecurity (25 percent in 2018). In 2016, the longrunning crisis in the east spilled over to previously stable regions, some 1.7 million people fled their homes last year, bringing the number of internally displaced persons (IDPs) to 4.5 million. The DRC hosts more IDPs than any other African country. Severe food insecurity afflicts 7.7 million people, an increase of 30 percent from 2017. Fighting and violence cause displacement and loss of agricultural livelihoods. Poor transport infrastructure and price volatility further exacerbate the situation. More than 600,000 Congolese nationals are refugees in neighboring countries, and DRC hosts more than half a million refugees from Rwanda, Central African Republic, and South Sudan.

Conflict continues to threaten food security in **Afghanistan**, where more than three decades of war, sustained flows of returnees, civil unrest, insurgent activity, and recurring natural disasters have contributed to chronic humanitarian need. As of March 2018, conflict in Afghanistan had internally displaced over 42,200 people, and 147,500 undocumented Afghans have returned from Iran and Pakistan, according to the UN. Widespread conflict, poor rainfed staple production, and limited employment opportunities are the main drivers of acute food insecurity in Afghanistan, the Famine Early Warning Systems Network (FEWS NET) reports. Afghanistan is experiencing below-average rainfall during the October 2017–May 2018 wet season, threatening the agricultural output of farmers and pastoralists in areas where March and April rainfall is critical to harvest outcomes and rangeland conditions.

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Regional Overview

The food security indicators and model projections presented here for 2018 and 2028 are based on historic data and projections from the ERS macroeconomic database. Production data are as of December 2017, so events since that time such as drought and flooding are not reflected in historical food production data even though they may have caused crop failures and damage in selected countries.

Gains in food security vary across regions. In Asia, where income growth is strong, the share of people food insecure is projected to decline fastest. The challenge is greater in Sub-Saharan Africa (SSA) where population growth is higher and income growth slower. SSA food security is projected to improve, but more slowly. In Latin American and the Caribbean, the share of the population that is food insecure is projected to drop by more than half by 2028. Food security improvement is also projected for North Africa, which is the most food-secure region in the study.

Sub-Saharan Africa

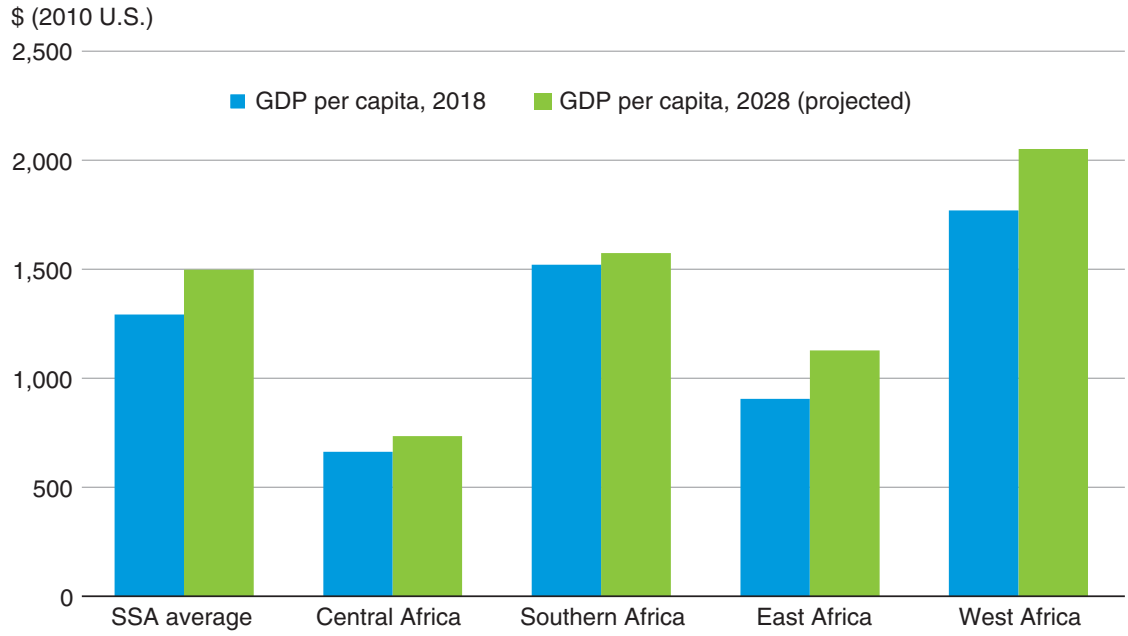
The Sub-Saharan Africa (SSA) region has a population of almost 1 billion people and has the highest share of its population estimated as food insecure in this assessment (35 percent, or 346 million people). Food insecurity is projected to decrease by all measures, but by 2028 SSA will still have the largest number of food-insecure people (299 million, or 24 percent of the population). The 39 SSA countries have diverse climatic, social, and economic conditions that affect their food security situations today and projections for the future. In this year's assessment, we provide subregional overviews for East, West, Southern, and Central Africa. The countries comprising a subregion often face similar food-security trajectories, and this special focus on SSA allows more detailed analysis of some of the most food-insecure regions.

Growth in per capita income drives improvements in food security. SSA has the fastest population growth of any region, at 2.4 percent per year, meaning that the 3.9-percent annual increase in GDP translates to only 1.5 percent growth in per capita terms, behind the fast growing Asian economies. In SSA, per capita GDP growth is fastest in East and West Africa, the two regions that also see the largest improvements in food security over the projection period. Economic growth and progress in food security is slowest in Southern and Central Africa.

East and West Africa make similar progress in food security over the 10-year projection period, reducing the share of food insecure people by 44 and 45 percent respectively, and the number of food-insecure people by 29 and 30 percent. Within Sub-Saharan Africa, West Africa has the largest population and GDP, and the highest per capita income (figure 7). Improvements in food security lead to less than 10 percent of the population being food insecure in 2028. While incomes are lower in East Africa, sustained growth projections lead the share of food-insecure people to fall from 43 percent in 2018 to 24 percent in 2028.

Southern Africa and East Africa begin with similar shares of population food insecure, but Southern Africa makes much slower progress in reducing this share and is left with more people food insecure in 10 years than it has today. Both regions have faced adverse weather conditions and pest challenges in recent years, but East Africa has sustained diversified economic growth and has some of the fastest growing economies in the region. Southern Africa, on the other hand, is more dependent on extractive industries, which along with the fastest population growth in SSA, makes it difficult to sustain progress in food security.

Figure 7
Real incomes per capita by SSA subregion, 2018 and 2028



SSA = Sub-Saharan Africa. Note: Value in 2010 U.S. dollars to adjust for inflation.

Source: USDA, Economic Research Service calculations using ERS Macroeconomic Data Set.

Central Africa is the poorest subregion in SSA and likely to remain so. Due to forecast slow economic growth and macroeconomic instability, the overall number of food-insecure people is projected to increase by 11 percent, to 89 million, though there are improvements in other measures such as the intensity of food insecurity. Central Africa has also faced conflict and civil unrest, leading to a number of IDPs and disrupting livelihoods and agricultural production, compromising the food security for millions of people.

While parts of East and West Africa have also faced crises with refugees and political conflict, higher incomes and more stability have made them more resilient, and intraregional trade has filled some of the food needs resulting from weather challenges or disrupted markets.

SSA's agricultural production is projected to grow over 2 percent per year, as input use increases and area expands. While the total food gap for the region declines over 2018-28, cereal demand for both food and feed grows with higher incomes. Demand will be greater than supplies and the implied additional supply required (IASR) of grain—for example, through imports that allow countries to meet this demand—is expected to grow over the next decade (table 2).

Table 2
Food security indicators for Sub-Saharan Africa, 2018 and 2028

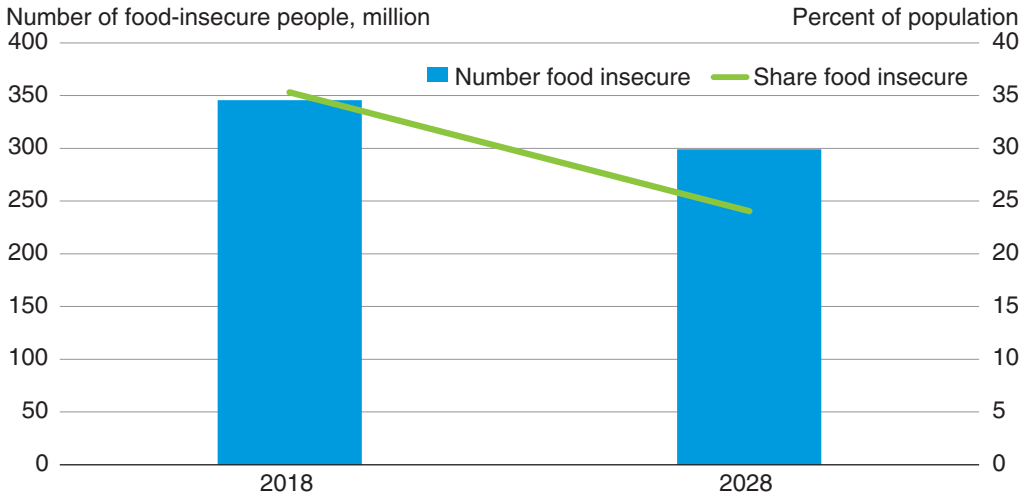
Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	122,747	32,220	122,405	32,562
2028	172,102	44,425	152,850	63,677

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

Sub-Saharan Africa indicators of food insecurity



Source: USDA, Economic Research Service.

Sub-Saharan Africa
(980 million people in 2018)

Sub-Saharan Africa (SSA) has the highest share of food-insecure people, with 35.3 percent of the population in 2018, or 346 million. We project a 13.5-percent decrease in the number of food-insecure people in SSA over the next decade and a 32-percent reduction in the share of people food insecure.

Thanks to strong income growth, several countries are projected to make great strides toward improving their food security in the next decade.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
Sub-Saharan Africa	**980**	**1,244**	**345.8**	**299.1**	**35.3**	**24.0**	**528**	**532**	**21,147**	**18,437**
Central Africa	121.7	151.2	81.3	89.9	66.8	59.4	874	784	8,342	8,278
East Africa	344.6	435.9	148.9	105.6	43.2	24.2	430	425	7,528	5,276
Southern Africa	139.6	182.4	61.1	65.6	43.8	35.9	456	461	3,258	3,540
West Africa	373.8	474.3	54.5	38.1	14.6	8.0	325	310	2,019	1,343

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

Fall Armyworm

Fall Armyworm (FAW), a New World native, was first detected in Central and West Africa in January 2016. As of February 2018, it had been detected in all of contiguous Sub-Saharan Africa (SSA) except Lesotho, Mauritania, Eritrea, and Djibouti; FAW has also spread to Madagascar. FAW has no natural enemies, consumes more than 80 species of plants (though it is most damaging to corn), and flies over 500 miles to lay eggs, meaning that the pest can spread rapidly across borders. FAW is expected to become endemic in SSA; there is no frost to kill it off, and many parts of the region provide an ideal habitat for FAW with warm temperatures and bimodal rainy seasons.

Control of FAW in the Americas is achieved with pesticides applied by commercial farmers. Genetically modified (GMO) corn is also largely resistant to FAW. This management approach is difficult to apply to smallholder corn production in SSA. Pesticides and GMO seed are costly and not affordable for many subsistence producers, and many SSA countries ban GMOs altogether. In addition, smallholders, who produce 80 percent of the food in SSA, do not regularly use pesticides (FAO, 2017). Incorrect pesticide use can be ineffective (for instance, the timing of treatment matters) and dangerous (lack of personal protection, contamination, etc.).

In the absence of control, a 2017 Centre for Agriculture and Bioscience International (Day et al.) report estimated that FAW could cause losses of 21-53 percent of the corn crop over 3 years in the first 12 countries affected. This represents up to 13.5 million tons of corn, or 20 percent of SSA corn production. In the 39 SSA countries in our analysis, 15 percent of calories are obtained from corn, and this share approaches 50 percent in parts of Southern Africa (Malawi, Zambia, and Lesotho). Because of the potential for widespread losses, national governments and international organizations launched a coordinated continentwide response, including technical assistance, communication, and capacity building. Nongovernmental and aid organizations have produced technical guides, but the response also includes coordination at the local levels.

The technical guidance on managing FAW focuses on making management affordable and accessible for smallholders, who could be left behind due to the cost and expertise needed to properly apply pesticide. In addition, nonchemical management strategies exist. In general, a healthy crop resists better than a stressed crop because the FAW eats leaves, and too much defoliation will results in yield losses. The lack of rain in recent seasons could exacerbate the FAW problem; this is the condition faced by corn growers in Southern Africa and parts of East Africa this year.

Losses due to FAW at the national level have not been catastrophic, as was feared, though there are areas with significant localized damage. Over the past year, FAW has damaged corn crops in Southern Africa particularly in Zimbabwe, Zambia, Malawi, and Namibia. This damage is compounded by the ongoing drought and has led to the re-imposition of an export ban in Malawi. East Africa's agricultural production is recovering from drought, and rain has helped mitigate FAW damages there. All of East Africa has reported infestations, but in Uganda and Tanzania infestations are expected to affect corn production substantially; other crops have not been damaged. Governments have moved to contain and stop the damage. For example, Malawi provided pesticides and training and Kenya and Ethiopia both provided coordinated responses.

SSA: Subregional Analysis

Central Africa

The Central African region has the highest share of food-insecure people in 2018, with 67 percent of the population (81 million people) estimated to be food insecure. Due to widespread conflict and displacement, Central African countries are forecast to improve food security slowly, with a projected 11-percent decrease in the share of population food insecure, to 59 percent, by 2028.

Food insecurity in the Central African region's four countries differs greatly. Food insecurity in Cameroon and Congo is moderate, with 16 percent of the total population of 31 million people food insecure. In contrast, food security is more acute in the Central African Republic (CAR) and the Democratic Republic of Congo (DRC), where 84 percent of the total population of 91 million people are food insecure. Conflicts in both countries complicate their populations' ability to access food, resulting in high food insecurity estimates and projections from 2018 to 2028. Conflicts in Central Africa and neighboring subregions cause millions of internally displaced people and refugee flows to bordering countries (see box, "Conflict and Food Security Emergencies," pp. 8-9) .

DRC has the most food-insecure people in Sub-Saharan Africa, at 72 million, almost double the 39 million food insecure in Ethiopia. DRC's intensity of food insecurity, measured as the per capita food gap and fueled by political instability and widespread displacement, is the highest among all countries at 941 calories per capita per day. All Central African countries are projected to see slight decreases in the share of their population food insecure over the next 10 years, with a 7-percent decrease forecast for the region in total. The number of people insecure, however, is projected to increase in all countries, reflecting rapid population growth. Central Africa's population is projected to grow by 24 percent from 122 million in 2018 to 151 million in 2028. Most of the increase is in the DRC, which is projected to add 8 million food-insecure people by 2028. Modest growth in per capita gross domestic product (11 percent) also prevents faster improvement in Central African food security.

A relatively uniform increase in grain production is projected throughout Central Africa. From 2018 to 2028, a 24-percent increase in grain produced (from 5.2 to 6.4 million metric tons) suggests developing diversification in Central African economies. Still, with a projected 24-percent increase in Central Africa's population and a 33-percent increase in food grain demand during 2018-28, gains in grain production are likely to be outpaced by growing domestic demand.

The intensity of food insecurity is projected to decrease in all of the Central African countries. The largest improvement is found in DRC, where the per capita food gap is projected to close from 941 calories to 840 calories per day in 2028. Little change is projected for Cameroon. The region's declining food gap corresponds with a 14-percent increase in per capita GDP by 2028.

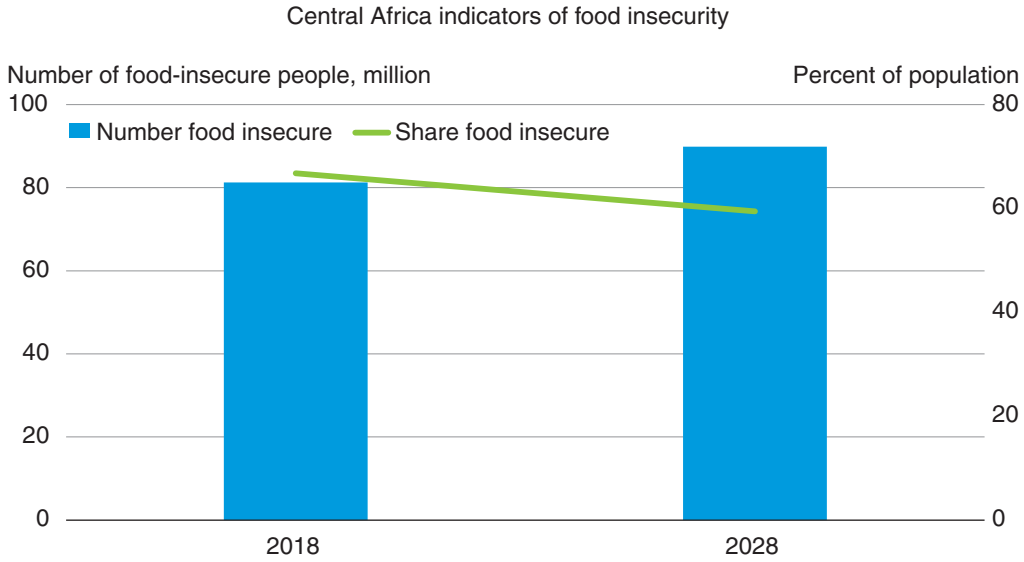
Table 3
Food security indicators for Central (SSA) Africa, 2018 and 2028

Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	6,403	997	5,169	2,231
2028	8,539	1,196	6,409	3,327

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.



Source: USDA, Economic Research Service.

Central Africa
(122 million people in 2018)

Central Africa is the poorest performer in SSA. Due to forecast slow economic growth and macroeconomic instability, the overall number of food-insecure people is projected to increase by 11 percent over the next 10 years, even though intensity of food insecurity will ease.

Central Africa suffers frequent conflict, civil unrest, and internally displaced persons (IDPs), disrupting livelihoods and agricultural production, and hindering improvements in food security over the medium term.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
Central Africa	**122**	**151**	**81.3**	**89.9**	**66.8**	**59.4**	**874**	**784**	**8,342**	**8,278**
Cameroon	25.6	32.8	3.0	3.0	11.7	9.3	230	220	82	80
Central African Republic	5.7	7.0	4.8	5.7	84.1	80.7	643	609	355	397
Congo	5.1	6.4	1.9	2.2	37.5	33.9	329	317	75	82
Congo, DR	85.3	105.0	71.5	79.0	83.9	75.2	941	840	7,830	7,719

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

Southern Africa

Food security in Southern Africa is slightly higher than the SSA average with 44 percent of the subregion's population of 140 million food insecure. Despite difficulties in rebounding from recent droughts and a poor harvest in 2017, the share of food insecurity is projected to decrease in the majority of Southern Africa's countries by 2028.

The Southern Africa region consists of nine countries—Angola, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Swaziland, Zambia, and Zimbabwe. Zimbabwe has the highest proportion of its population food insecure, at 63 percent. Many Southern African countries have had difficulty fulfilling demand for food with domestic grain production because of adverse weather and pests. Regional grain production is an estimated 13 million metric tons in 2018, while demand is 17 million tons.

In both Zambia and Zimbabwe, 63 percent of the population is estimated to be food insecure. Among the countries of Southern Africa, the intensity of food insecurity is most severe in Zambia and Zimbabwe at 623 calories and 518 calories, respectively, below the daily caloric target of 2,100 calories.

With a population of just 2 million people, Lesotho has Southern Africa's lowest share of food-insecure people (19 percent) and the least intense food insecurity (a f per capita food gap of 286 calories per capita per day). These relatively low food insecurity numbers come despite erratic weather hampering agricultural output in Lesotho.

Food insecurity is projected to decrease in Southern Africa from 44 to 36 percent food insecure by 2028. However, the per capita food gap will increase slightly due to a 7-percent increase in annual food demand. Despite overall improvements in food security in the region, the population shares that are food insecure in Angola and Zimbabwe are projected to increase by 19 percent (to 43 percent food insecure) and by 22 percent (to 78 percent food insecure), respectively. The intensity of food insecurity is also projected to increase in both countries over the next decade, by 10 percent in Angola and 19 percent in Zimbabwe. Given the likelihood of economic, weather, and political shocks, per capita incomes (in local currency) in Angola and Zimbabwe are forecast to decrease by 12 and 20 percent, respectively, by 2028.

Lesotho and Mozambique are projected to have among the largest improvements in food security in SSA, with the food-insecure share of the population falling over the next decade by 86 percent (to 4 percent) in Lesotho and by 69 percent (to 10 percent) in Mozambique. These improvements correspond with high projected growth in per capita incomes—38-percent growth in Lesotho and 47 percent in Mozambique by 2028.

Southern Africa overall is projected to have rapidly growing food demand. A 28-percent increase in grain production for the region (to 16 million tons) will be more than offset by a 39-percent increase in grain demand (to 24 million tons) by 2028, driven by strong population growth and a 6-percent annual increase in per capita grain demand. Still, improvements in food security are projected for the region as a whole even with Southern Africa's rapidly growing population and food demand.

Table 4

Food security indicators for Southern (SSA) Africa, 2018 and 2028

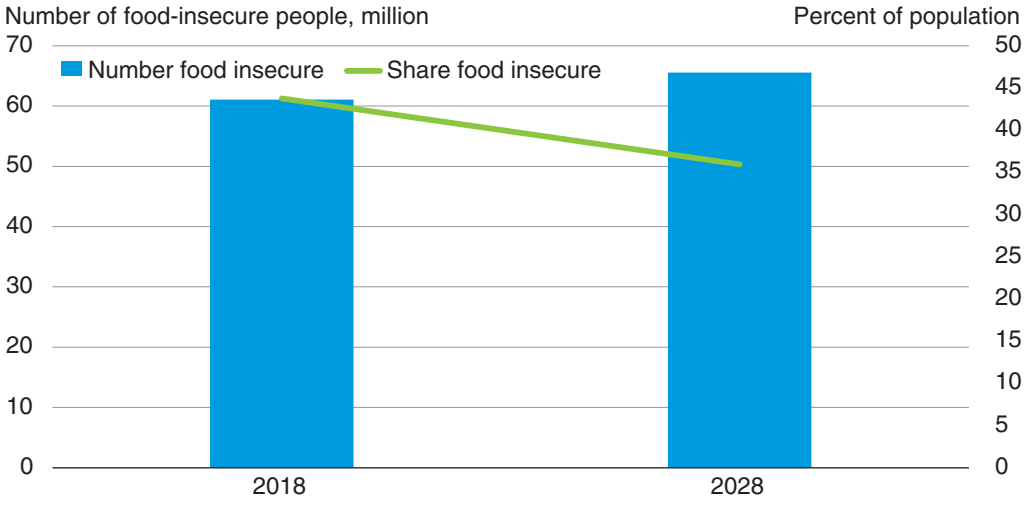
Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	17,078	3,726	12,818	7,987
2028	23,732	5,436	16,376	12,792

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

Southern Africa indicators of food insecurity



Source: USDA, Economic Research Service.

Southern Africa
(140 million people in 2018)

Southern Africa has made relatively slow progress in reducing the share of food insecure and is projected to have more people food insecure in 10 years than it does today. The region has faced adverse weather conditions and pests in recent years.

Southern Africa is overly dependent on extractive industries, which along with the fastest population growth in SSA, make it difficult to sustain progress in food security measures.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
Southern Africa	**140**	**182**	**61.1**	**65.6**	**43.8**	**35.9**	**456**	**461**	**3,258**	**3,540**
Angola	30.4	42.5	11.0	18.4	36.4	43.2	382	409	524	933
Lesotho	2.0	2.0	0.4	0.1	19.1	4.3	286	216	13	2
Madagascar	25.7	32.1	11.7	7.8	45.5	24.3	395	315	477	253
Malawi	19.8	27.5	8.1	11.2	41.0	40.7	412	411	388	531
Mozambique	27.2	34.8	8.9	3.5	32.6	10.1	419	313	448	132
Namibia	2.5	3.0	1.1	0.9	43.4	29.7	338	292	45	32
Swaziland	1.5	1.6	0.5	0.4	36.5	24.6	326	286	19	13
Zambia	16.4	21.9	10.4	10.2	63.3	46.5	623	526	772	638
Zimbabwe	14.0	17.0	8.9	13.2	63.4	77.5	518	614	573	1,005

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

East Africa

The share of the population that is food insecure in East Africa—Burundi, Chad, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, and Uganda—is projected to decrease by almost half, from 43 percent in 2018 to 24 percent in 2028. This corresponds to a 30-percent decrease in the total population food insecure, from 149 million to just over 105 million in 2028. Per capita income growth in East Africa – projected to be the fastest among SSA subregions—drives a reduction in food insecurity at the subregional level, with the larger countries improving the most over the 10-year horizon.

These aggregate improvements in food security mask considerable variation across the region. Several countries are projected to have large reductions in both the number and share of the population food insecure. The share of the population that is food insecure in Ethiopia, Kenya, Rwanda, Tanzania, and Uganda are all projected to decline by over 50 percent over the next 10 years, resulting in less than 20 percent of their populations food insecure (and less than 10 percent in Kenya) in 2028. These countries all experience strong income growth over the projection period (per capita GDP grows at least 4.5 percent per year). In early 2018, Ethiopia surpassed Ghana as the fastest growing SSA economy. Despite these strong gains, there will be approximately 50 million food-insecure people in these 5 countries in 2028.

The East African countries with higher shares of population food insecure in 2018 are expected to make the slowest improvements through 2028. Eritrea and Burundi both have extremely high measures of food insecurity, and are projected to regress or make little improvement over the next 10 years. In 2028, about 90 percent of each country's population is projected to be food insecure: together, the two countries' combined number of food-insecure people is projected to surpass 20 million. In Burundi, population grows faster than 3 percent per year, well above the regional average, and per capita incomes are the lowest in the region. Both countries have few resources on which to base broad economic progress.

Sudan and Somalia are projected to make small, but consistent, improvements in all food security measures over the next 10 years. Both the number of people food insecure and share of population food insecure, as well as the depth of food insecurity, are projected to improve. However, Sudan and Somalia will still have almost 50 percent of their populations food insecure in 2028. Chad is also projected to reduce the share of population food insecure from 57 percent in 2018 to 53 percent in 2028, but the number of food-insecure people is projected to increase by over half a million as population grows, leading to a larger total food gap as well.

Conflict, drought, and policy challenges have hindered economic growth and food access in much of East Africa. Last year, agricultural production recovered in Chad and Sudan, and economic sanctions on Sudan were lifted, a change that could improve economic prospects and food security in the country. In Somalia, pastoral regions have been devastated by prolonged drought that killed livestock and destroyed livelihoods, contributing to the great number of IDPs and the level of food insecurity in the country.

Much of the rest of East Africa is recovering from drought. Rains have improved and there was a controlled response to fall armyworm, which has had just a minor impact on maize production in Kenya, Uganda, and Ethiopia. Pastoral regions of eastern Kenya and southeastern Ethiopia still face significant weather challenges, however, with the loss of livelihoods leading to displacement and greater food insecurity. Kenya and Ethiopia have been better positioned to deal with the weather-related challenges than Somalia because of their broader economic bases.

The total food gap for the region (7.5 million tons in 2018) falls 30 percent over the projection period, and is slightly less than 10 percent of the total grain food demand by 2028. While the subregion's grain production is expected to grow 1.5 percent per year over the next 10 years, the implied additional supply required grows significantly as both food and feed grain demand rise. Trade within the subregion, especially of corn, is important for food security and is expected to increase in 2018. Tanzania and Uganda are the traditional corn exporters and Ethiopia is expected to increase exports; export bans may affect grain availability in the rest of the subregion.

The drought created a number of IDPs in pastoral areas, but conflict and political unrest have also been large contributors to the number of refugees and IDPs in East Africa, including those from DRC and South Sudan. Kenya, Uganda, Rwanda, and Tanzania all host refugees, and Burundi is both a host and a source of refugees in the region.

Table 5

Food security indicators for East (SSA) Africa, 2018 and 2028

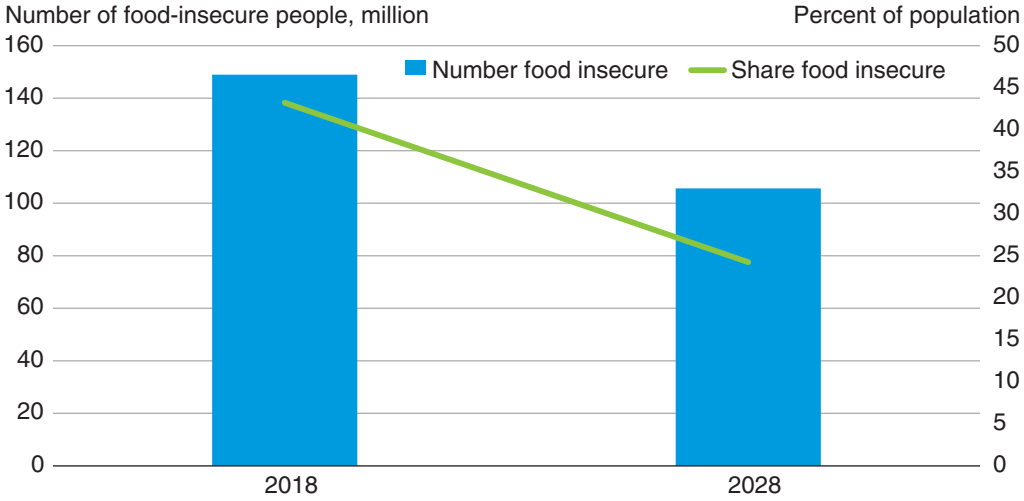
Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	37,220	12,569	51,796	-2,008
2028	53,283	17,169	59,925	10,527

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

East Africa indicators of food insecurity



Source: USDA, Economic Research Service.

East Africa
(345 million people in 2018)

East Africa is projected to reduce the share of food-insecure people by 44 percent and the number of food-insecure people by 29 percent over the next 10 years.

East Africa has sustained diversified economic growth and contains some of the fastest growing economies in Sub-Saharan Africa, despite setbacks in recent years caused by adverse weather and pests.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
East Africa	**345**	**436**	**148.9**	**105.6**	**43.2**	**24.2**	**430**	**425**	**7,528**	**5,276**
Burundi	11.8	16.2	10.3	14.6	87.2	90.0	661	700	795	1,190
Chad	12.3	14.6	7.1	7.8	57.4	53.2	550	527	481	508
Eritrea	6.0	6.7	5.4	5.9	90.4	89.0	667	647	448	476
Ethiopia	108.4	141.8	38.8	19.6	35.8	13.8	346	265	1,483	573
Kenya	48.4	55.2	16.6	4.8	34.4	8.7	296	209	585	120
Rwanda	12.2	14.5	4.7	2.7	38.4	18.6	423	339	230	107
Somalia	11.3	14.3	6.9	6.7	61.5	46.8	494	424	392	326
Sudan	38.0	44.9	21.7	21.2	57.2	47.2	472	426	1,239	1,095
Tanzania	55.5	72.3	22.1	13.9	39.8	19.3	462	368	1,147	578
Uganda	40.9	55.3	15.4	8.3	37.6	15.1	398	305	729	303

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

West Africa

West Africa has the largest population and total GDP of the SSA subregions in this report. We cover 16 countries in West Africa: Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. West Africa is the most food secure of the SSA subregions, in terms of population share that is food insecure. In 2018, this indicator is 15 percent (corresponding to 55 million people), and it is projected to fall to 8 percent (38 million people) by 2028. Improvements in West Africa's food security are founded on high per capita income growth, which averages above 1.2 percent per year during the projection period when measured in local currency.

Nigeria is West Africa's largest country, with 70 percent of the subregion's GDP and 50 percent of its population. It is also the subregion's most food-secure country, according to our indicators. Nigeria's per capita income is higher than the subregional average, and it has one of the lowest shares of food-insecure people within the subregion (just over 10 percent).

Nigeria is emerging from a recession (2014-16) as both oil prices and production increase and the Nigerian currency strengthens. Economic growth is expected to pick up through 2028, driven by non-oil sectors like agriculture, but is still projected to lag growth in much of the subregion. The share of the Nigerian population that is food insecure is projected to fall to just over 4 percent by 2028. Due to the size of the country, this still leaves 10 million people food insecure, which is one-fourth of the West Africa total in 2028. While much of Nigeria has benefitted from recent macroeconomic improvements, civil unrest in the northeast has disrupted agricultural production and livelihoods, displaced families, and led to pockets of food insecurity.

Economic growth is strong for much of the rest of West Africa, and six additional countries (Benin, Cabo Verde, Gambia, Ghana, Mali, and Mauritania) are projected to have less than 10 percent of their populations food insecure by 2028. In addition, Senegal, Togo, and Côte d'Ivoire are projected to near the 10-percent threshold in 2028. Diversified exports and economies and less dependence on petroleum leads to sustained growth, higher incomes, and improved access to food in these countries by 2028.

Burkina Faso, Guinea, Guinea-Bissau, and Niger enter 2018 with moderate levels of food insecurity, with the shares of their populations that are food insecure above 20 percent. The food security situation in all four countries is projected to improve through 2028, with the share of the population food insecure falling by between 28 percent (Burkina Faso) and 37 percent (Guinea-Bissau) from 2018 measures. The reduction in *number* of food-insecure people is smaller in percentage terms because population grows quickly (2.9 percent per year in Burkina Faso and 3.1 percent per year in Niger) while the number of food-insecure people in these 4 countries falls by 9 percent to 11.6 million people in 2028.

Neighbors Sierra Leone and Liberia are the poorest countries in West Africa and have the highest prevalence of food insecurity, at 40 and 71 percent in 2018, respectively. Both countries were affected by the Ebola outbreak, but their economies have begun to recover. The number of people in Sierra Leone who are food insecure is projected to decrease by 20 percent by 2028, and the share of population that is food insecure will drop from 40 to 25 percent. Liberia's economic recovery from the Ebola crisis has been slower than its neighbors'. Relatively slow GDP growth plus fast population growth lead the number of food-insecure people to increase from 3.4 million in 2018 to 3.5 million

in 2028; the share of food-insecure people falls from 70 to 55 percent over the projection period, and the total food gap falls as well, indicating an improvement in the depth of need.

The total food gap, or food required for all food-insecure people to meet the caloric target, is small in aggregate; it is less than 2 percent of West Africa's total grain demand. Intraregional agricultural trade is important for regional food security and follows distinct routes. Grains flow up from the coastal areas to the Sahel, and livestock and cash commodities move from the Sahel down toward richer coastal population centers (e.g., Accra, Ghana; Abidjan, Côte d'Ivoire, and cities in Nigeria).

Eight countries (Benin, Burkina Faso, Guinea-Bissau, Côte d'Ivoire, Mali, Niger, Senegal, and Togo) are members of the West African Economic and Monetary Union and use a common currency, the CFA franc, which is pegged to the euro. This common currency has kept inflation lower in the monetary union than in many other SSA countries, but depreciation of the naira (Nigeria) and to a lesser extent of the cedi (Ghana) has lowered livestock demand in these countries in recent years, affecting pastoralists in the Sahel. Incidents of violence have also affected trade flows in Mali, Niger, and Nigeria.

Cereal production in West Africa is projected to grow almost 3 percent per year. In the past year, the region has avoided widespread drought or disease. Pockets of low water availability exist in parts of the Sahel and some FAW damage occurred in Burkina and Ghana. Rice is the preferred cereal in most of West Africa, and demand is growing. Regional and national self-sufficiency policies focus on investments in productivity and new land for rice. The implied additional supply required is expected to grow over the next 10 years, as growth in production lags the increase in demand resulting from income and population growth.

Table 6

Food security indicators for West (SSA) Africa, 2018 and 2028

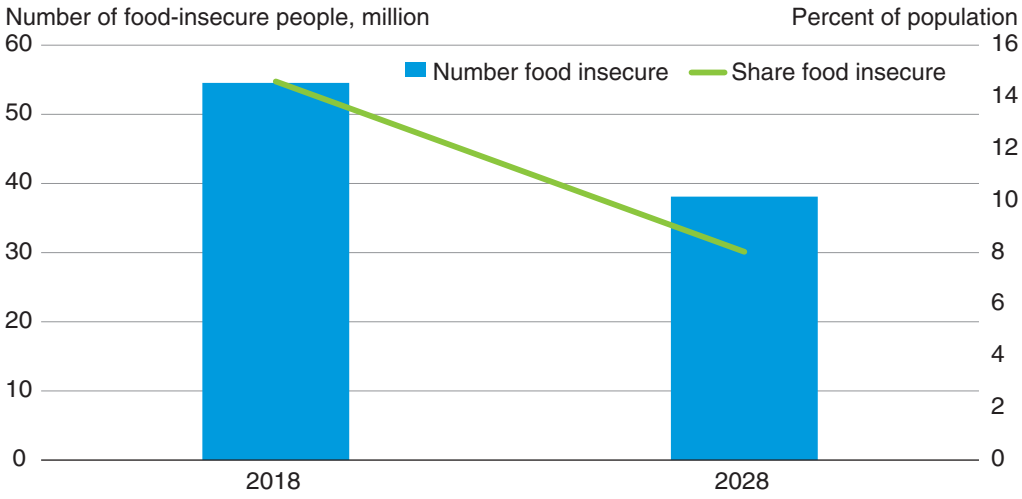
Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	62,046	14,928	52,622	24,352
2028	86,548	20,623	70,140	37,030

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

West Africa indicators of food insecurity



Source: USDA, Economic Research Service.

West Africa
(374 million people in 2018)

West Africa is projected to match East Africa in reducing the share of food-insecure people by 45 percent and the number of food-insecure people by 30 percent over the next 10 years.

Parts of West Africa have faced crises with refugees and conflict, but greater stability and higher incomes have insulated the populations some. Intraregional trade was used to fill some of the food needs that arose due to weather-induced shortfalls.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
West Africa	**374**	**474**	**54.5**	**38.1**	**14.6**	**8.0**	**325**	**310**	**2,019**	**1,343**
Benin	11.3	14.6	1.8	1.1	16.1	7.3	283	242	57	28
Burkina Faso	20.7	27.6	5.1	4.8	24.4	17.5	428	393	271	237
Cabo Verde	0.6	0.6	0.1	0.1	22.1	9.1	287	235	4	2
Côte d'Ivoire	24.6	28.9	4.1	3.3	16.7	11.4	373	344	175	129
Gambia	2.1	2.5	0.4	0.1	19.6	5.5	288	223	13	3
Ghana	28.1	34.7	2.9	1.5	10.2	4.3	257	222	85	38
Guinea	12.7	16.4	2.8	2.4	21.7	14.8	334	304	97	78
Guinea-Bissau	1.8	2.2	0.6	0.5	34.9	22.0	354	306	24	15
Liberia	4.8	6.3	3.4	3.5	70.7	55.0	714	606	244	211
Mali	18.4	24.6	1.9	1.5	10.0	6.0	273	249	58	42
Mauritania	3.8	4.7	0.4	0.2	11.6	4.5	264	224	14	5
Niger	19.9	26.8	4.3	3.9	21.9	14.5	306	277	180	146
Nigeria	195.3	247.1	19.9	10.1	10.2	4.1	232	199	541	236
Senegal	15.0	18.7	2.7	2.0	17.9	10.4	253	224	80	52
Sierra Leone	6.3	8.1	2.5	2.0	39.3	24.5	427	364	116	79
Togo	8.2	10.5	1.6	1.2	19.8	11.9	307	273	59	40

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

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Asia

In 2018, the Asia region had the most food-insecure people—394 million—of any of the regions in the IFSA, but the second lowest share of population food insecure at 16.6 percent. Food insecurity is projected to improve in all countries in the region due to strong income growth and low or declining food prices in most countries. The share of Asia's population that is food insecure is projected to decline to 4.7 percent by 2028.

Some countries have much larger shares of their population food insecure in 2018, including Afghanistan (45 percent), North Korea (54.1 percent), and Yemen (86 percent).

The intensity of food insecurity (measured by the number of calories per capita per day required to bring consumption to a 2,100-calorie target) is low for the region—287, compared with the global average of 396. The gap is significantly higher in Yemen (646 calories), North Korea (404), and Afghanistan (330).

The Asia region has the second largest total food gap in 2018—13.4 million tons of grain—accounting for about 37 percent of the total gap of 36.2 million tons. This gap measures the amount of food necessary to allow all income groups to reach the caloric target. Three countries account for two-thirds of the Asia gap—India (5.1 million tons), Pakistan (1.9 million tons), and Yemen (1.9 million tons). India and Pakistan are large countries with relatively small per capita food gaps, while Yemen is a small country with a very deep per capita gap.

In general, Asian grain production benefited from favorable weather and good yields in 2017. India, which accounts for almost half of the regional grain production, had significant production increases for both wheat and rice. Favorable weather conditions also supported strong grain production in Cambodia, Indonesia, Pakistan, and the Philippines. Bangladesh, on the other hand, was affected by flooding and Sri Lanka and North Korea suffered drought. Asian grain production is projected to continue growing over the next decade, rising by almost 20 percent to 538 million tons by 2028, driven primarily by higher yields.

ERS projections indicate a substantial reduction in food insecurity in Asia over the next decade. The primary driver of improved food security is robust per capita GDP growth for most of the region. Asia contains some of the most rapidly growing economies in the world. Strong growth, coupled with projected low food prices, supports improved food security.

The number of food-insecure people in Asia is projected to decline from 393.5 million in 2018 to 123.8 million in 2028, with the share of the population that is food insecure dropping from 16.6 percent to 4.7 percent. Asia, with a projected population of 2.6 billion people in 2028, would thus have far fewer food-insecure people than SSA, even though the latter is projected to have less than half as many people (1.2 billion) by 2028.

Most of the projected improvement in Asia's food security occurs in South and Southeast Asia (SSEA). This region has countries with high real GDP growth rates. Eight countrie—Bangladesh, Cambodia, India, Indonesia, Laos, Pakistan, Philippines, and Vietnam—have projected annual real GDP growth rates of 5 percent or more. Together they account for 90 percent of the Asian population (2018) covered in this report. India, with a GDP growth rate of 7.5 percent, is projected to see the number of food-insecure people decline faster than Asia as a whole. India's food-insecure population

of 186.2 million in 2018 is projected to decline to 19.1 million in 2028. In 2018, India accounted for almost half of the food-insecure population in Asia. By 2028, it would be less than 15 percent.

Other South/Southeast Asian countries are also projected to have substantial gains in food security. Indonesia, Laos, and Vietnam are projected to have less than 3 percent of their population food insecure in 2028. Pakistan and the Philippines are projected to have higher shares of their population food insecure in 2028—7.7 percent and 10.3 percent, respectively—but substantial declines from the 2018 rates of 22.2 percent and 20 percent, respectively.

The Commonwealth of Independent States (CIS- Armenia, Azerbaijan, Georgia, Kyrgyzstan, Moldova, Tajikistan, and Uzbekistan) in Central Asia already has relatively high levels of per capita income, with moderate growth likely over the next decade. Collectively, CIS countries have an estimated 4.4 million food-insecure people in 2018. This number is projected to decline to 1.7 million by 2028. All the CIS countries except Tajikistan are projected to have 2 percent or less of their population food insecure by 2028.

The most food-insecure countries in the Asia region are Afghanistan, North Korea, and Yemen. Afghanistan faces major challenges, including continuing conflict, deteriorating security, and increased flows of refugees from Pakistan, Iran, and other countries. Normal weather may stimulate agricultural production after 3 years of contraction. Yemen continues to experience conflict and internal population displacement. These three countries are projected to continue to have high levels of food insecurity over the next decade. The food-insecure populations in Afghanistan and North Korea are projected to decline by 5 million and 2 million respectively, but 24.5 percent of Afghanistan's population and 43.7 percent of North Korea's population would remain food insecure in 2028 even with this improvement. The number of food-insecure people in Yemen is projected to increase, leaving 77 percent of the population food insecure in 2028. As a result, the food-insecure population in IFSA's Asia region is increasingly concentrated in Yemen and North Korea, leading to an increased intensity of food security in the region.

Table 7

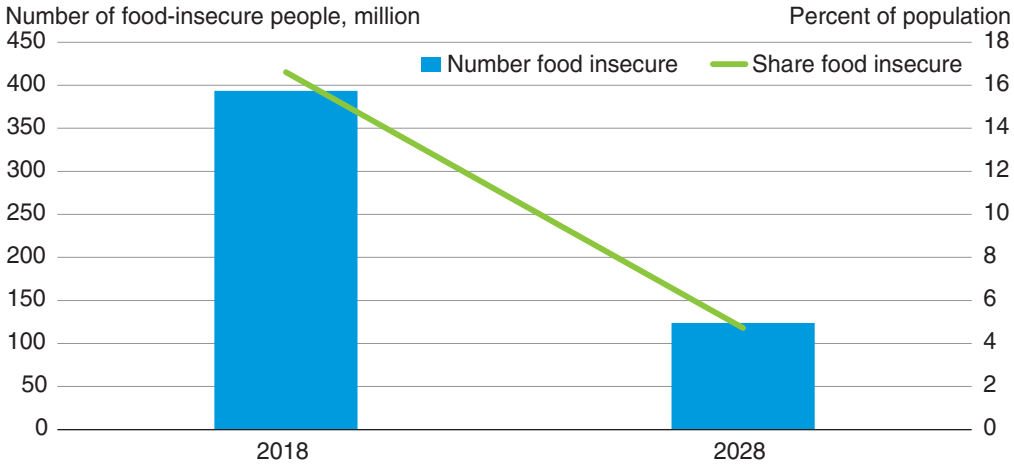
Food security indicators for Asia, 2018 and 2028

Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	392,757	155,445	448,766	99,436
2028	488,686	224,879	537,551	176,014

*Other grain demand includes seed, feed, waste, and processing. **The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

Asia indicators of food insecurity



Source: USDA, Economic Research Service.

Asia
(2,369 million people in 2018)

Food insecurity is projected to improve in all countries studied here except Yemen.

Given above-average per capita income growth projected for the region, many countries can improve food security sharply by 2028, with less than 5 percent projected food insecure for the average of the 22 countries. Ongoing conflict in Yemen dims hopes for food security improvements there.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
Asia Total	**2,369**	**2,623**	**393.5**	**123.8**	**16.6**	**4.7**	**287**	**311**	**13,352**	**4,552**
Afghanistan	34.9	43.8	15.7	10.7	45.0	24.5	330	264	599	327
Armenia	3.0	2.9	0.1	0.0	4.4	0.9	179	147	3	0
Azerbaijan	10.0	10.7	0.2	0.1	2.1	0.9	155	141	4	2
Bangladesh	159.5	174.5	35.1	8.3	22.0	4.8	287	211	1,023	179
Cambodia	16.4	18.6	3.8	1.1	23.0	5.8	310	233	124	26
Georgia	4.9	4.9	0.4	0.1	7.6	2.4	220	185	11	3
India	1,296.8	1435.5	186.2	19.1	14.4	1.3	249	173	5,057	361
Indonesia	262.8	282.0	17.6	6.4	6.7	2.3	223	191	438	137
Kyrgyzstan	5.8	6.3	0.7	0.2	11.7	3.5	238	195	21	6
Laos	7.2	8.3	1.3	0.2	17.4	2.5	251	180	36	4
Moldova	3.4	3.1	0.3	0.0	7.7	1.2	179	139	6	1
Mongolia	3.1	3.4	0.5	0.1	15.5	2.9	253	190	16	2
Nepal	29.7	32.1	4.4	1.6	14.6	5.0	259	213	131	40
North Korea	25.4	26.5	13.7	11.6	54.1	43.7	404	364	632	480
Pakistan	207.9	237.1	46.2	18.3	22.2	7.7	336	268	1,883	594
Philippines	105.9	122.4	21.2	12.6	20.0	10.3	317	274	746	383
Sri Lanka	22.6	23.9	6.1	3.0	26.9	12.4	394	325	266	107
Tajikistan	8.6	9.9	2.0	1.0	23.7	10.0	303	248	76	30
Turkmenistan	5.4	5.9	0.3	0.1	6.4	1.0	205	162	9	1
Uzbekistan	30.0	32.5	0.6	0.1	1.9	0.4	167	142	12	2
Vietnam	97.0	104.4	12.6	2.2	13.0	2.1	270	203	360	48
Yemen	28.7	34.5	24.6	26.8	86.0	77.7	646	567	1,899	1,817

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

Latin America and the Caribbean

Food insecurity for the 11 Latin American and Caribbean (LAC) countries included in this report is estimated to affect 19.5 percent of the LAC population, or 33 million people, in 2018 and is projected to decline to 9.5 percent, or 18 million people, by 2028. The 11 countries have a population of just under 170 million in 2018, which is projected to rise to 187 million over the next 10 years. Population growth averages 1 percent, much lower than just 10 years ago, and leads to stronger per capita income gains.

Food security and food access is improved by income growth and declining prices for major grains and roots/tubers. Per capita income growth has been positive in most developing countries over the last decade, helping to improve food security as food prices have normalized after peaking in 2007/08 and 2011. Economic growth in the LAC region is currently solid, with positive growth in all countries except Ecuador, where per capita income growth is expected to decline by 0.4 percent over the next decade. In the remaining countries, per capita income growth averages 3.5 percent, ranging from 1.3 percent in Bolivia to 6.2 percent in Peru.

Regional averages mask individual country differences. **Haiti** remains the LAC country with the highest share of food insecure population, at just under 50 percent in 2018. In recent years, the country has suffered devastating natural disasters such as earthquakes and hurricanes, in addition to political instability. Deforestation has resulted in extensive soil erosion, which in turn exacerbates more frequent droughts. Agriculture remains an essential sector to the economy despite its vulnerability to natural disasters. If economic growth prospects remain positive through 2028 as assumed in this analysis, food insecurity may be reduced by 25 percent, cutting the number of food insecure in Haiti from 5.4 million to 3.7 million. Measured in calories, Haiti's per capita food gap is by far the largest in the region at 649 calories per capita; this gap is projected to decline to 537 calories by 2028.

Guatemala is the largest economy in Central America and has one of the most unequal income distributions in the Western Hemisphere, with the richest 20 percent of the population owning about 51 percent of the country's wealth. About one-third of the population of 16 million people live in and around the capital. Of those living in rural areas, 40 percent are of indigenous origin, and this population is, on average, poorer and more likely to be food insecure. An estimated 35 percent of Guatemalans are food insecure in 2018. Annual GDP growth is projected between 3 and 4 percent over the next 10 years, but Guatemala has the fastest population growth in the LAC, averaging 1.6 percent per year, resulting in the slowest per capita income growth in the region. Agriculture remains one of the country's most important sectors, contributing about 13.5 percent of GDP and accounting for more than 40 percent of total exports. Remittances and tourism continue to be important sources of foreign exchange and income. By 2028, food insecurity is projected to decline to 24 percent, or 4.4 million people. Guatemala's per capita food gap, at 377 calories, is the second highest among LAC countries after Haiti's, and it is projected to decline by less than 12 percent in the coming decade.

Bolivia, Ecuador, El Salvador, Honduras and Nicaragua have food insecurity shares estimated at between 20 and 30 percent in 2018, with a low in Nicaragua of just under 20 percent and a high in Bolivia at just under 30 percent. **Bolivia**, a landlocked South American country with a population of 11 million, suffered an historic drought in 2016. Crop losses were exacerbated by a locust attack that destroyed 1,500 hectares (or 1 percent of total planted area) of corn, sorghum, and other crops. Crop conditions were more favorable in 2017/18, with wheat production recovering but still below

Bolivia's 5-year average. Per capita incomes are projected to grow at about 2 percent per year over the coming decade, strong enough to help reduce food insecurity by 60 percent to 11.4 percent, or 1.5 million people, by 2028.

Ecuador is the only country covered in this region that derives a significant share of its income from crude petroleum exports. A sustained period of declining and relatively low oil prices through the end of 2017 translated into tight fiscal budgets and declining or slow economic growth. Ecuador, one of the region's upper-middle-income countries, has suffered economic decline and a slow recovery in recent years and those problems are projected to linger into the near future. Food security is projected to improve, but slowly, with the share food insecure decreasing from 21.2 percent in 2018 to 11.2 percent by 2028.

Projections of food insecurity in **Honduras** are almost the same as those for Ecuador, with 22 percent estimated to be food insecure in 2018, and a projected improvement over the coming decade to 11 percent by 2028. Honduras is a lower-middle-income country, and remittances accounting for 18 percent of GDP are even more important than the agriculture sector, which contributes 14 percent. However, agriculture employs a larger share of workers, at 28 percent, than any other sector. Despite economic and agricultural diversification, many Hondurans depend on subsistence farming, with little access to additional income sources. Food insecurity among the rural population continues to be a problem. Honduras' food gap in 2018 is estimated at 334 calories per capita, or about 16 percent of requirements, and is projected to decline to 284 calories by 2028.

El Salvador is the smallest country in Central America and the country with the highest population density, with a population of about 6.4 million. Food insecurity in 2018 was estimated at 22 percent, a result of sluggish economic growth unlike several of its regional neighbors. Tourism has become a key sector and is contributing to improved economic prospects. Food insecurity is projected to decline to 12.5 percent by 2028.

Food insecurity in **Nicaragua**, the poorest of the Central American countries included in this report, is lower than in several of its neighbors, estimated at just under 20 percent in 2018 and projected to decline to 5.4 percent by 2028. Nicaragua has the most equal income distribution in the region, distributing lower incomes more evenly across all income groups. The positive food security outlook is largely based on Nicaragua's stable economy and low inflation. As in the other Central American countries, agriculture is still an important sector, accounting for 15 percent of GDP and almost 75 percent of the country's exports. Subsistence farming in rural areas is prevalent in Nicaragua, while the urban population depends on food imports.

In the remaining four LAC countries covered by IFSA—Colombia, the Dominican Republic, Jamaica, and Peru, all upper-middle income countries—food insecurity is estimated between 10 and 13 percent in 2018. With strong income growth forecast, those shares are projected to drop below 5 percent in all four countries by 2028.

Table 8

Food security indicators for Latin America and the Caribbean, 2018 and 2028

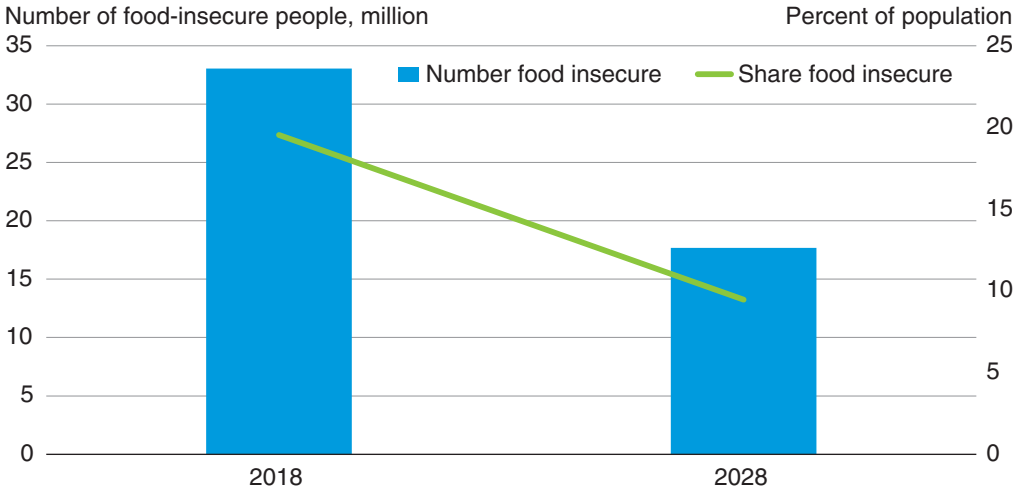
Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	19,064	16,559	17,146	18,476
2028	22,951	21,768	21,130	23,588

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

Latin America and the Caribbean indicators of food insecurity



Source: USDA, Economic Research Service.

Latin America and the Caribbean
(169 million people in 2018)

Per capita incomes in the LAC region are the highest, on average, among IFSA countries and regions. Despite setbacks due to adverse weather or natural disasters such as hurricanes, economic growth prospects are positive.

The region has greatly improved food security and is expected to remain on this path through 2028, with food insecurity declining by more than half in the 11 LAC countries. Haiti remains the most food-insecure country in the region.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
LAC Total	**169**	**187**	**33.0**	**17.7**	**19.5**	**9.5**	**342**	**309**	**1,280**	**619**
Bolivia	11.3	12.9	3.3	1.5	29.1	11.4	279	220	111	40
Colombia	48.2	52.3	4.9	2.2	10.2	4.2	249	215	142	55
Dominican Republic	10.9	12.0	1.4	0.3	12.7	2.6	234	181	37	7
Ecuador	16.5	18.4	3.5	2.1	21.2	11.2	244	210	100	51
El Salvador	6.2	6.3	1.4	0.8	22.2	12.5	287	250	43	21
Guatemala	15.7	18.3	5.5	4.4	35.1	23.8	377	333	234	163
Haiti	10.8	12.1	5.4	3.7	49.9	30.2	649	537	366	207
Honduras	9.2	10.5	2.0	1.1	21.8	10.6	334	284	75	36
Jamaica	3.0	3.2	0.3	0.1	10.3	3.5	224	188	8	2
Nicaragua	6.1	6.7	1.2	0.4	19.9	5.4	335	260	45	10
Peru	31.3	34.0	4.1	1.2	13.2	3.6	245	196	119	28

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

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North Africa

Our analysis includes four countries from the North Africa region-- Algeria, Egypt, Morocco, and Tunisia--all of which are among the most food-secure countries covered in this report. Food insecurity is estimated at just under 5 percent on average in 2018, and further improvements are projected by 2028 when the food-insecure share in the region is projected to drop to 2.4 percent. People in these four countries have been consuming at a caloric level comparable to many high-income countries, thanks in part to consumption support policies that become increasingly difficult to finance in the future.

Algeria is the only oil exporter among the four countries covered in this region. Falling and low oil prices put a strain on Algeria's fiscal situation through the end of 2017. This is one reason its Government has been pursuing policies—like the extension of irrigated agricultural land, and the exploitation of fallow land—to ensure the continued development and modernization of the agricultural sector as an alternative to the energy sector. Grain production in Algeria continues to be highly variable due to frequent and severe droughts and insufficient irrigation. Hot and dry weather resulted in 2017 grain production levels 17 percent below average, as well as delayed winter plantings at the end of the year. Food insecurity was estimated at 6.6 percent in 2018, higher than the region's average. Per capita incomes are forecast to grow sufficiently fast to reduce food insecurity to 3.2 percent by 2028.

Egypt is the largest country in this region, with a population of 100 million people, as well as the country with by far the fastest annual population growth rate, 2.1 percent, more than 3 times the rate of Tunisia. Crops are grown almost entirely with irrigation. Average food consumption, as measured by average daily calorie intake, has been high relative to income levels thanks to support policies such as a bread subsidy that entitles every beneficiary to 5 loaves of bread per day. In recent years, the subsidy program shifted to a SMART card system that allows conversion of bread rations to any of 44 other authorized food items to encourage diversified diets. The program covers about 80 million beneficiaries and is now fully automated. Inflation, improving from a peak of 33 percent in 2017 to under 20 percent in early 2018, had led some consumers to shift from higher priced rice to pasta. Consumers also have increased their consumption of frozen vegetables and chicken. Egypt has lower average per capita income than its neighbors, but GDP is forecast to grow at more than 4 percent per year over the coming decade. Inflation, however, makes real per capita incomes harder to predict. This analysis's projections indicate that food insecurity will decline from 4.2 percent in 2018 to 2.1 percent in 2028; these projections are based on the assumption of sustained real per capita income growth in Egypt.

Tunisia is the most food-secure country in IFSA's North Africa region. The share of the population that is food insecure is projected to decline from 3.5 percent in 2018 to 1.1 percent by 2028. Incomes have been growing slowly, and structural reforms undertaken by the Tunisian Government are expected to progress slowly. Agriculture makes up 10.4 percent of GDP and the tourism industry, which suffered greatly after the 2011 Jasmine Revolution, raised its share back to 8 percent in 2016. Tunisia has a nonconvertible currency and is highly dependent on trade, with the highest trade-to-GDP ratio in North Africa, ranging from 90 to 110 percent, which means that the annual value of imports and exports taken together is about the same as the country's entire gross domestic product. The purchasing power of future per capita incomes will depend on moderate inflation, which is forecast to remain around 4 percent per year over the next decade.

Morocco benefits from economic and political stability. Its openness to trade and investment and its strategic location have attracted significant investment and helped to develop Morocco's agriculture and value-added sectors over the past decade. Food insecurity affects an estimated 5.5 percent of the Moroccan population of 35 million, whose income is distributed more unequally than Algeria's or Egypt's. Projected steady income growth in the absence of high inflation results in a marked decline in food insecurity to 1.9 percent by 2028.

Table 9

Food security indicators for North Africa, 2018 and 2028

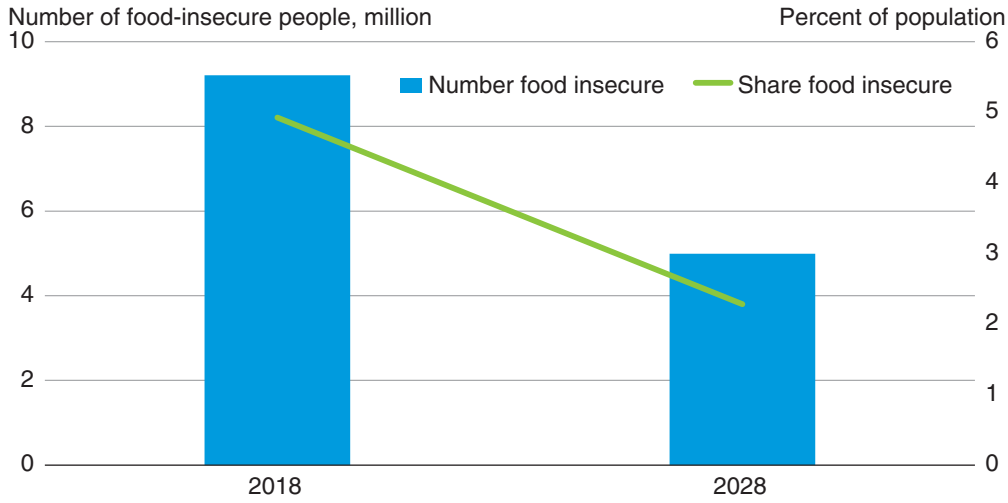
Year	Food grain demand	Other grain demand*	Grain production	Implied additional supply required**
	1,000 tons			
2018	46,526	35,089	30,135	51,480
2028	58,460	50,730	34,637	74,554

*Other grain demand includes seed, feed, waste, and processing.

**The gap between grain demand and domestic grain production.

Source: USDA, Economic Research Service.

North Africa indicators of food insecurity



Source: USDA, Economic Research Service.

North Africa
(187 million people in 2018)

Per capita incomes in the four North African countries are among the highest, and food insecurity, already at low levels in 2018, is projected to drop by more than half, assuming continued income growth, steady food prices, and absence of conflict-related crises.

Investment in technology to make food consumption less vulnerable to weather-induced losses will contribute to future improvements in food security.

	Population		Population food insecure		Population share food insecure		Food gap (per capita)		Food gap (total)*	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
North Africa Total	**187**	**219**	**9.2**	**5.0**	**4.9**	**2.3**	**247**	**221**	**283**	**137**
Algeria	41.7	47.3	2.8	1.5	6.6	3.2	253	227	91	44
Egypt	99.4	122.0	4.2	2.6	4.2	2.1	250	229	118	68
Morocco	34.3	37.3	1.9	0.7	5.5	1.9	253	220	63	21
Tunisia	11.5	12.3	0.4	0.1	3.5	1.1	224	195	11	3

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

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Appendix –Food Security Assessment Model: Definitions and Methodology

The International Food Security Assessment (IFSA) model used in this report projects food consumption (food demand), food access, and food gaps in 76 low- and middle-income countries through 2028. Food is divided into four groups covering 100 percent of food consumption: major grain (determined by calorie share), other grains, root crops, and all other food.

The food security of a country is evaluated based on the gap between projected domestic food consumption (food demand) and a caloric target, which we set at 2,100 calories per capita per day—a calorie level necessary to sustain life at a moderate level of activity. The model projections of food demand are expressed in grain equivalent based on each food group's caloric content to allow aggregation across food groups; this grain equivalent is easily expressed in either kilograms or calories.[1]

Three food security indicators are provided: (1) the share of food insecure, which is the share of the total population unable to reach the caloric target; (2) the number of food insecure people; and (3) the food gap, which is the amount of food needed to allow each individual consuming below the threshold level to reach the caloric target. This caloric target indicates relative well-being and helps quantify unequal food access within a country.

Projection results provide a baseline for the food security situation in each country, and the results depend on the specification of the model and the underlying assumptions. The simulation framework used to project food demand is based on partial-equilibrium models for each country in the assessment. Beghin et al. (2015a) introduce the methodology and demand, and Beghin et al. (2017) provide more detail on price transmission and food security projections.

Each country model comprises a price-independent generalized log-linear (PIGLOG) demand system for each of the four food groups (Muellbauer, 1975). The demand system is calibrated on a 3-year average of prices and incomes (2015-17), on observed consumption levels, on a measure of inequality, and on income and price elasticities. Demand projections are based on projected prices and incomes; the model implicitly assumes the preferences represented by the demand system—as well as the income distribution embedded in the calibration and projection—are constant over time.

The distribution of consumption used to calculate food security measures is described by a constant coefficient of variation, which implies an increasing standard deviation of consumption as consumption rises over the projection period but does not account for potential structural changes in an economy. The implied price and income elasticities evolve over the projection period as prices and incomes change; generally, food groups become more income-inelastic because incomes rise.

[1]For example, grains have roughly 3.5 calories per gram, and tubers have roughly 1 calorie per gram. One ton of tubers is therefore equivalent to 0.29 ton of grain.

Structural Framework for Estimating and Projecting Food Demand in the Aggregate

Demand system definition and calibration

We specify demand q_i^h for a given food group i for income-decile h as:

$$q_i^h = \left(x_i^h / p_i\right)\left(A_i(p_i) + B_i(p_i)\ln\left(x^h\right)\right) \quad (1)$$

where p_i is the price (expressed in real local currency), and x^h is the decile-level income. We further specify $A_i(p_i) = a_{i0} + a_{i1}p_i$, and $B_i(p_i) = b_{i0} + b_{i1}p_i$.

The PIGLOG demand formulation allows for aggregation of income decile-level demands in (1) into average per capita market demand for each food group i (2).

$$\bar{q}_i = \left(\frac{x_i}{p_i}\right)\left((a_{i0} + a_{i1}p_i) + (b_{i0} + b_{i1}p_i)(\ln\left(\bar{x}\right) + \ln(\frac{10}{z})\right) \quad (2)$$

The latter is a function of average per capita income and Theil's entropy measure of income inequality z.

We also define average expenditure share for food category i as:

$$\bar{w}_i = (a_{i0} + a_{i1}p_i) + (b_{i0} + b_{i1}p_i)(\ln\left(\bar{x}\right) + \ln(\frac{10}{z})) \quad (3)$$

The elasticity of average demand for good i with respect to average income (or total expenditure) is:

$$\varepsilon_{\bar{q}_i\bar{x}} = 1 + (b_{i0} + b_{i1}) / \bar{w}_i \quad (4)$$

The own-price elasticity of the average demand is

$$\varepsilon_{\bar{q}_i p_i} = -1 + \left(\frac{p_i}{\bar{w}_i}\right)\left(a_{i1} + b_{i1}(\ln\left(\bar{x}\right) + \ln(\frac{10}{z})\right)) \quad (5)$$

In each country, consumers at different income levels have similar underlying preferences over food i as embodied in parameters a_{i0}, a_{i1}, b_{i0}, b_{i1}, but their respective consumptions vary because their respective incomes vary.

With a system of three linear equations (equations 3, 4, and 5) with four unknown variables, one parameter remains free. The free parameter (chosen to be b_{i0}) is used to ensure that decile demands behave consistently with stylized facts of food security as follows: price sensitivity and income responsiveness decline with income levels; own-price elasticities must be negative; and food expenditure shares tend to fall with increasing income. A range of values of the free parameters allows ensuring these stylized facts are satisfied by the calibrated demand system. Here we pin down b_{i0} such that the ratio of price elasticities for the bottom and top deciles is equal to the ratio of the natural logarithm of their national income shares.

For any given free parameter value, the system of equations is solved for parameters b_{i1}, a_{i1}, and a_{i0} as a function of the free parameter. Once these three parameters are recovered, parameters $\tilde{a}_{i0}, \tilde{a}_{i1}, \tilde{b}_{i0}, \text{and } \tilde{b}_{i1}$, along with income x^h and price p_i are used to generate the consumption level of good *i* for each decile specified in equation (1). In this initial calibration, the quality of any good *i* is assumed constant across the income distribution.

For each country, we calibrate a demand system for each of the four food groups based on income, consumption levels, and prices from the 3 years preceding the projection period (2015-17). Prices and incomes are expresesed in real local currency. We determine the major grain (which varies across countries) based on caloric share in the diet. The other grains food group contains all other grains; the prices for this food group are weighted by its components' caloric shares. At the calibration stage, we either observe domestic food prices (including the components of a price index for other grains that is weighted by caloric share) or create synthetic prices.

For the food prices that we do not observe in the calibration stage, we create a synthetic domestic price, p_i^{ds}, that is linked to the world price, p_i^w, and expressed in real local currency[2]. The parameter θ is the price transmission slope, which we assume is 0.7. The parameter trc^{int} represents international transportation and market costs (e.g., cost, insurance and freight (CIF) and free on board (FOB)), which we assume are 10 percent, and trc^{dom} represents domestic trade costs, which we assume are 20 USD per ton in real terms.

$$p_i^{ds} = \theta^* p_i^w * \left(1 + trc^{int} trc_{int} / \theta\right) * \left(1 + tariff / \theta\right) + trc^{dom} \tag{6}$$

At this stage, we also calibrate a price transmission equation that links the domestic price (either observed or synthetic) to the world price. The generic price transmission equation is:

$$p_i^{dom} = \theta^* p_i^w + \hat{I} \tag{7}$$

During the calibration stage, we solve for the intercept, *I*, in real terms, and hold it constant during the projection period.

Projection of food demand calculation and food security indicators

The IFSA food security indicators (share of food insecure population, the number of food insecure people, and the food gap) are derived from the levels of food demand projected using the calibrated demand system.

For each country, we use the demand parameters and projected income, x_t, and prices, p_{it}, to project food demand, q_{it}, for each of the four food groups *i* in each year *t* so that $q_{it} = \widehat{A_i}\left(x_t / p_{it}\right)\left((p_{it}\right) + \widehat{B_i}(p_{it}) \ln\left(x_t\right)$. We aggregate demand for the four food groups into total food demand expressed in calories, so that $\sum q_{it} = Q_t$, which we also refer to as food or calorie consumption. We use this measure of total demand to calculate food security indicators.

[2] We observe at least one grain price for 67 of the 76 countries and more than one for 49 of these countries. We observe root prices for 29 countries and oil prices (other food) for 5 countries. The rest of the domestic prices are synthetic.

We follow FAO (2015) to estimate the distribution of calorie consumption beginning with a coefficient of variation (CV) of food availability, which characterizes consumption distributed with a mean *m* and variance *v*, so that $CV = \left(\sqrt{v}/m\right)$.[3] Given the CV and the projected mean caloric consumption (Q_t), we can recover the variance, *v*, of the empirical distribution for a given year *t*.

Assuming food consumption *Qt* is distributed lognormal, then *ln(Qt)* is distributed *N(μ,σ2)* with $\mu = \ln\left(\frac{m^2}{\sqrt{v+m^2}}\right)$ and $\sigma^2 = \ln\left(1+v/m^2\right)$. Once μ and σ^2 are computed, we recover the proportion of the population that falls below the calorie target (2,100 calories per capita per day) using the standard normal CDF, Φ: $\Phi^{insecure} = \Phi\left(\frac{\ln(2100-\mu)}{\sigma}\right)$. Here, $\Phi^{insecure}$ indicates t**he share of the population that is food insecure**. Using this share and total population in the respective country, we obtain the total **number of food insecure people** in this country.

Next, the expected average food intake of food insecure people, $q_{cal\ average}^{food\ insecure}$, can be recovered using the partial mean of the calorie availability below the target (2,100), which we calculate as

$q_{cal}^{food} = e^{\mu-\sigma/\Phi\text{^}2100\left[\phi((\ln(2100)-\mu)/\sigma\right]}$, where ϕ is the standard normal density function.

The **food gap** is the difference between the caloric target of 2,100 and the average calorie availability for food insecure people. This provides a measure of the food gap in calories per day per food-insecure person (per capita food gap). The latter multiplied by the number of food insecure people and converted into grain equivalent per year yields a food gap measure based on annual grain volume (total food gap).

Data

The model is calibrated for each of the four food groups based on average prices and income from 2015-17. Prices are expressed in real local currency units. Quantities are expressed in grain-equivalent units.

Calibrated parameters and variables:

Demand Parameters ($\tilde{a}_{i0}, \tilde{a}_{i1}, \tilde{b}_{i0}, \text{and } \tilde{b}_{i1}$), Price Intercepts, Domestic Prices (Synthetic)

Projections are based on data from the ERS International Macroeconomic data set and the USDA Agricultural Projections to 2027, and utilize the calibrated demand parameters and price transmission between world and domestic prices.

Endogenous projection variables:

Food Demand, Domestic Prices

Exogenous variables used in calibration and projection:

[3]See the appendix of Beghin et al. (2015b) for more detail.

Average Consumption Per Capita – FAO Food Balance Sheet (most recent available)[4]

Grain Shares – FAO Food Balance Sheet[5]

Elasticities of Price and Income – unpublished calculations by Jim Seale using 2011 International Comparison Program (ICP) data, following the methodology in Muhammad et al., 2011[6]

Domestic Prices (Observed) – FAO Global Information and Early Warning System (GIEWS, annual average; market depends on reporting)

Tariffs – World Bank's World Integrated Trade Solution (WITS)[7]

Exchange Rates and Consumer Price Indices (CPIs) – ERS International Macroeconomic Data Set [8]

Population – U.S. Census Bureau

World Prices – USDA Agricultural Projections to 2027[9]

Per Capita Income – generated using GDP and population from ERS International Macroeconomic Data Set [10]

Income Distribution – World Bank Data Bank.[11] Assumed constant during the projection period

Coefficient of Variation (CV) of Food Consumption – FAO State of Food Insecurity (SOFI, 2017). Assumed constant during the projection period.

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[4]Food Balance Sheets (FBS) are for 2013. There are no current FBS for Somalia, Eritrea, Burundi, DR Congo. We use grain consumption levels and share of grains in total calories as reported in the FAO-GIEWS *Cereal Supply and Demand Balance for Sub-Saharan African Countries: situation as of November 2016* report to generate per capita consumption for each food group. We bring forward the reported consumption of all food groups using information from FAO's grain supply data and changes in caloric intake.

[5]There are no FBS for Burundi, DR Congo, Eritrea, or Somalia. For Somalia, we use an FBS from the original FAOSTAT, which is no longer maintained. We use FBS of neighboring countries (Burundi-Rwanda; DR Congo-Congo; Eritrea-Ethiopia) to approximate the shares of grains and roots and tubers in total calories for the other countries.

[6]Elasticities are not available for all countries. We use estimates from neighboring countries (Somalia-Ethiopia; Eritrea-Ethiopia; Algeria-avg. Tunisia and Morocco; Afghanistan-avg. Tajikistan and Pakistan; Turkmenistan-avg. Tajikistan, Kyrgyzstan, Kazakhstan; Uzbekistan-avg. Tajikistan, Kyrgyzstan, Kazakhstan). We use less elastic values for major grain in Vietnam, Philippines, Indonesia, India, Pakistan, and Bangladesh, and for other grain in India.

[7]Tariffs are available through 2016. Somalia and North Korea do not report to WTO. Somalia tariffs are the means observed for Sub-Saharan African IFSA countries, and North Korea tariffs are the maximum observed tariffs for IFSA countries.

[8]We modeled Ecuador and El Salvador in USD instead of local currency as in the ERS International Macroeconomic data set, based on data from the International Monetary Fund (IMF) and Oxford Economics. We constructed projections for Somalia, North Korea, and Zimbabwe using data from IMF and Oxford Economics.

[9]The world price series are: maize (US gulf #2 yellow); rice (Thai, B, fob Bangkok); sorghum (US Gulf, #2 yellow); wheat (gulf, #2 HRW); barley (EC, French, Rouen); Oats (US Farm); roots and tubers (cassava; tapioca, hard pellets, Rotterdam, fob); other food (represented by soybean oil, Dutch fob, ex-mill). World price projections are not available for all cereals represented in the FAO Food Balance Sheets and the FAO GIEWS price database. We use the world price of wheat to represent rye; and sorghum to represent all other cereals (e.g., millet, teff, fonio).

[10]Projections were constructed using information from IMF, Oxford Economics and IHS Markit for Zimbabwe, Somalia, North Korea, Ecuador, El Salvador, Yemen, DR Congo, Malawi, and Haiti.

[11]Income distributions are not available for all countries. We use: (Eritrea- Ethiopia; Somalia-Ethiopia; Zimbabwe-Zambia; North Korea-Mongolia; Afghanistan-avg. Uzbekistan, Pakistan, Tajikistan).

Modeling Staple Cereal Production

Agricultural production is decomposed into yield (production per hectare) and area for grains. Production (*PR*) for a given country *c* in year *t* is obtained by multiplying projected yield (*YL*) and area (*AR*).

$$PR_{ct} = AR_{ct} * YL_{ct}$$

The projections cover the period 2016-28. They are based on producer price projections in local currency units and world price projections from the USDA Agricultural Projections.

Yield

Yield projections are based on parameters estimated econometrically using panel data, and are calibrated to observed yields for 2014-16. Yields respond to expected relative return ratios per hectare (*RR*), autonomous technical change over time (*T*), and include a country specific effect.

$$YL_{ct} = f(RR_{ct}, T_{t)}$$

The return ratios are the ratio of the return per hectare (price, *p*, times yield) divided by the price of fertilizer, $RR_{ct} = p_{ct} Y_{ct} / p_t^{fert}$. The expected return ratios include a contemporaneous and a long-term expectation component and are expressed in real local currency (rlcu). We use USDA Agricultural Projections (to 2025) prices for superphosphate and the major grain by production volume (for grain). We express the international price in rlcu, and then use the transmission equation $p^{domestic} = 0.7p^{world} + 0.3I$ to model the domestic price. The intercept, *I*, is the mean of the price over the regression time period (1985-2016). The production data is from FAO.

Modeling area

Following the typical older Nerlovian specification, we specify area as a function of lagged area and of expected relative prices (output price and fertilizer price).

$$AR_{ct} = f(p_{ct}, p_{ct}^{fert}, A_{ct-1}, T)$$

The expectation takes the average of contemporaneous and lagged relative prices. We also include a time trend in area to capture non-price shifters in area decisions, and a country fixed effect. We numerically calibrate the area equation to the base-year average of 2014-16 using consensus estimates for price and lagged acreage responses.

Modeling IASR

The Implied Additional Supply Required (IASR) quantifies the total grain demand in each country that is not projected to be met through domestic production. Total grain demand (TD) is comprised of food demand (FD), generated by our demand-driven model, and nonfood use (NFD), which is comprised of seed, feed, processing, and other uses. The IASR for grains thus can be expressed as: IASR=TD-PR.

We assume that demand for grain for processing, seed, and other uses grows at the same rate as production. The demand for grain feed grows at the average rate observed from 2006 to 2016.

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Appendix: Food Security Measure for IFSA Countries, 2018 and 2028

Appendix table 1

2018 IFSA model results

	Population		Population food insecure		Share of population food insecure		Food gap (per capita)		Food gap* (total)	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
GRAND TOTAL	3,705	4,273	782	446	21.1	10.4	396	457	36,063	23,745
Asia Total	2,369	2,623	394	124	16.6	4.7	287	311	13,352	4,552
Afghanistan	34.9	43.8	15.7	10.7	45.0	24.5	330	264	599	327
Armenia	3.0	2.9	0.1	0.0	4.4	0.9	179	147	3	0
Azerbaijan	10.0	10.7	0.2	0.1	2.1	0.9	155	141	4	2
Bangladesh	159.5	174.5	35.1	8.3	22.0	4.8	287	211	1,023	179
Cambodia	16.4	18.6	3.8	1.1	23.0	5.8	310	233	124	26
Georgia	4.9	4.9	0.4	0.1	7.6	2.4	220	185	11	3
India	1,296.8	1,435.5	186.2	19.1	14.4	1.3	249	173	5,057	361
Indonesia	262.8	282.0	17.6	6.4	6.7	2.3	223	191	438	137
Kyrgyzstan	5.8	6.3	0.7	0.2	11.7	3.5	238	195	21	6
Laos	7.2	8.3	1.3	0.2	17.4	2.5	251	180	36	4
Moldova	3.4	3.1	0.3	0.0	7.7	1.2	179	139	6	1
Mongolia	3.1	3.4	0.5	0.1	15.5	2.9	253	190	16	2
Nepal	29.7	32.1	4.4	1.6	14.6	5.0	259	213	131	40
North Korea	25.4	26.5	13.7	11.6	54.1	43.7	404	364	632	480
Pakistan	207.9	237.1	46.2	18.3	22.2	7.7	336	268	1,883	594
Philippines	105.9	122.4	21.2	12.6	20.0	10.3	317	274	746	383
Sri Lanka	22.6	23.9	6.1	3.0	26.9	12.4	394	325	266	107
Tajikistan	8.6	9.9	2.0	1.0	23.7	10.0	303	248	76	30
Turkmenistan	5.4	5.9	0.3	0.1	6.4	1.0	205	162	9	1
Uzbekistan	30.0	32.5	0.6	0.1	1.9	0.4	167	142	12	2
Vietnam	97.0	104.4	12.6	2.2	13.0	2.1	270	203	360	48
Yemen	28.7	34.5	24.6	26.8	86.0	77.7	646	567	1,899	1,817
LAC Total	169	187	33	18	19.5	9.5	342	309	1,280	619
Bolivia	11.3	12.9	3.3	1.5	29.1	11.4	279	220	111	40
Colombia	48.2	52.3	4.9	2.2	10.2	4.2	249	215	142	55
Dominican Republic	10.9	12.0	1.4	0.3	12.7	2.6	234	181	37	7
Ecuador	16.5	18.4	3.5	2.1	21.2	11.2	244	210	100	51
El Salvador	6.2	6.3	1.4	0.8	22.2	12.5	287	250	43	21
Guatemala	15.7	18.3	5.5	4.4	35.1	23.8	377	333	234	163
Haiti	10.8	12.1	5.4	3.7	49.9	30.2	649	537	366	207
Honduras	9.2	10.5	2.0	1.1	21.8	10.6	334	284	75	36
Jamaica	3.0	3.2	0.3	0.1	10.3	3.5	224	188	8	2
Nicaragua	6.1	6.7	1.2	0.4	19.9	5.4	335	260	45	10
Peru	31.3	34.0	4.1	1.2	13.2	3.6	245	196	119	28
North Africa Total	187	219	9	5	4.9	2.3	247	221	283	137
Algeria	41.7	47.3	2.8	1.5	6.6	3.2	253	227	91	44
Egypt	99.4	122.0	4.2	2.6	4.2	2.1	250	229	118	68
Morocco	34.3	37.3	1.9	0.7	5.5	1.9	253	220	63	21
Tunisia	11.5	12.3	0.4	0.1	3.5	1.1	224	195	11	3

Continued—

Appendix table 1

2018 IFSA model results—continued

	Population		Population food insecure		Share of population food insecure		Food gap (per capita)		Food gap* (total)	
	2018	2028	2018	2028	2018	2028	2018	2028	2018	2028
	Million		*Million*		*Percent*		*Kcal/day*		*1,000 MT*	
Sub-Saharan Africa Total	980	1,244	345.8	299.1	35.3	24.0	528	532	21,147	18,437
Central Africa	**121.7**	**151.2**	**81.3**	**89.9**	**66.8**	**59.4**	**874**	**784**	**8,342**	**8,278**
Cameroon	25.6	32.8	3.0	3.0	11.7	9.3	230	220	82	80
Central African Republic	5.7	7.0	4.8	5.7	84.1	80.7	643	609	355	397
Congo	5.1	6.4	1.9	2.2	37.5	33.9	329	317	75	82
Congo, DR	85.3	105.0	71.5	79.0	83.9	75.2	941	840	7,830	7,719
East Africa	**344.6**	**435.9**	**148.9**	**105.6**	**43.2**	**24.2**	**430**	**425**	**7,528**	**5,276**
Burundi	11.8	16.2	10.3	14.6	87.2	90.0	661	700	795	1,190
Chad	12.3	14.6	7.1	7.8	57.4	53.2	550	527	481	508
Eritrea	6.0	6.7	5.4	5.9	90.4	89.0	667	647	448	476
Ethiopia	108.4	141.8	38.8	19.6	35.8	13.8	346	265	1,483	573
Kenya	48.4	55.2	16.6	4.8	34.4	8.7	296	209	585	120
Rwanda	12.2	14.5	4.7	2.7	38.4	18.6	423	339	230	107
Somalia	11.3	14.3	6.9	6.7	61.5	46.8	494	424	392	326
Sudan	38.0	44.9	21.7	21.2	57.2	47.2	472	426	1,239	1,095
Tanzania	55.5	72.3	22.1	13.9	39.8	19.3	462	368	1,147	578
Uganda	40.9	55.3	15.4	8.3	37.6	15.1	398	305	729	303
Southern Africa	**139.6**	**182.4**	**61.1**	**65.6**	**43.8**	**35.9**	**456**	**461**	**3,258**	**3,540**
Angola	30.4	42.5	11.0	18.4	36.4	43.2	382	409	524	933
Lesotho	2.0	2.0	0.4	0.1	19.1	4.3	286	216	13	2
Madagascar	25.7	32.1	11.7	7.8	45.5	24.3	395	315	477	253
Malawi	19.8	27.5	8.1	11.2	41.0	40.7	412	411	388	531
Mozambique	27.2	34.8	8.9	3.5	32.6	10.1	419	313	448	132
Namibia	2.5	3.0	1.1	0.9	43.4	29.7	338	292	45	32
Swaziland	1.5	1.6	0.5	0.4	36.5	24.6	326	286	19	13
Zambia	16.4	21.9	10.4	10.2	63.3	46.5	623	526	772	638
Zimbabwe	14.0	17.0	8.9	13.2	63.4	77.5	518	614	573	1,005
West Africa	**373.8**	**474.3**	**54.5**	**38.1**	**14.6**	**8.0**	**325**	**310**	**2,019**	**1,343**
Benin	11.3	14.6	1.8	1.1	16.1	7.3	283	242	57	28
Burkina Faso	20.7	27.6	5.1	4.8	24.4	17.5	428	393	271	237
Cabo Verde	0.6	0.6	0.1	0.1	22.1	9.1	287	235	4	2
Côte d'Ivoire	24.6	28.9	4.1	3.3	16.7	11.4	373	344	175	129
Gambia	2.1	2.5	0.4	0.1	19.6	5.5	288	223	13	3
Ghana	28.1	34.7	2.9	1.5	10.2	4.3	257	222	85	38
Guinea	12.7	16.4	2.8	2.4	21.7	14.8	334	304	97	78
Guinea-Bissau	1.8	2.2	0.6	0.5	34.9	22.0	354	306	24	15
Liberia	4.8	6.3	3.4	3.5	70.7	55.0	714	606	244	211
Mali	18.4	24.6	1.9	1.5	10.0	6.0	273	249	58	42
Mauritania	3.8	4.7	0.4	0.2	11.6	4.5	264	224	14	5
Niger	19.9	26.8	4.3	3.9	21.9	14.5	306	277	180	146
Nigeria	195.3	247.1	19.9	10.1	10.2	4.1	232	199	541	236
Senegal	15.0	18.7	2.7	2.0	17.9	10.4	253	224	80	52
Sierra Leone	6.3	8.1	2.5	2.0	39.3	24.5	427	364	116	79
Togo	8.2	10.5	1.6	1.2	19.8	11.9	307	273	59	40

*Measured in grain equivalent.

Source: USDA, Economic Research Service.

Appendix table 2

Food availability for all 76 IFSA countries, 2009-17

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	572,621	109,260	95,276
2010	598,784	120,907	104,300
2011	616,333	124,887	109,333
2012	636,549	114,045	111,417
2013	650,625	140,006	114,973
2014	663,682	148,659	120,457
2015	643,967	156,538	121,357
2016	662,388	168,360	121,086
2017	683,501	167,171	na
		Percent	
Average annual growth	2.24	5.46	3.48

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 3

Food availability for SubSaharan Africa, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	95,924	27,746	62,096
2010	112,135	27,112	69,164
2011	104,775	30,932	70,838
2012	112,622	30,022	72,377
2013	109,921	34,528	74,519
2014	123,797	33,218	79,411
2015	115,366	34,497	80,164
2016	122,312	37,536	80,460
2017	126,309	36,196	na
		Percent	
Average annual growth	3.50	3.38	3.77

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 4

Food availability for Central Africa, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	4,569	1,895	7,901
2010	4,719	1,951	8,092
2011	4,684	1,777	8,272
2012	4,641	1,952	8,339
2013	4,705	2,053	8,405
2014	4,647	2,171	8,612
2015	4,452	2,154	8,819
2016	4,065	2,338	8,980
2017	4,143	2,379	na
		Percent	
Average annual growth	-1.22	2.88	1.85

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 5

Food availability for Southern Africa, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	14,880	3,247	10,721
2010	16,165	3,201	12,619
2011	16,971	3,492	13,118
2012	14,098	3,859	11,352
2013	14,174	4,703	12,246
2014	16,694	4,000	9,735
2015	14,192	4,836	9,604
2016	13,259	5,741	10,897
2017	17,283	4,141	na
		Percent	
Average annual growth	1.89	3.09	0.23

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 6

Food availability for East Africa, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	33,310	9,671	9,270
2010	43,303	7,581	9,620
2011	39,298	8,927	10,112
2012	45,144	8,028	11,651
2013	44,574	9,896	12,134
2014	53,222	10,427	12,341
2015	47,269	10,896	12,582
2016	50,974	11,224	11,615
2017	50,639	11,154	na
		Percent	
Average annual growth	5.38	1.80	3.27

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 7

Food availability for West Africa, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	43,165	12,933	34,204
2010	47,948	14,379	38,833
2011	43,822	16,736	39,337
2012	48,739	16,183	41,035
2013	46,468	17,876	41,734
2014	49,234	16,620	48,722
2015	49,453	16,611	49,159
2016	54,014	18,233	48,968
2017	54,244	18,522	na
		Percent	
Average annual growth	2.90	4.59	5.26

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 8

Food availability for Asia, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	422,196	35,387	26,920
2010	441,032	41,793	28,574
2011	462,006	39,097	31,682
2012	473,567	35,182	31,742
2013	486,314	45,479	32,713
2014	489,631	52,263	33,282
2015	474,344	54,833	33,262
2016	495,158	64,887	32,853
2017	504,110	62,838	na
		Percent	
Average annual growth	2.24	7.44	2.89

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 9

Food availability for Latin America and the Caribbean, 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	15,263	15,739	4,208
2010	14,684	17,329	4,235
2011	14,663	17,245	4,176
2012	15,820	16,547	4,474
2013	15,797	19,378	4,775
2014	15,020	20,470	4,772
2015	16,200	21,699	4,882
2016	15,605	21,451	4,690
2017	16,552	21,526	na
		Percent	
Average annual growth	1.02	3.99	1.56

*Grain production includes rice expressed in milled-rice equivalent.

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

Appendix table 10

Food availability for North Africa 2009-2017

Year	Grain production	Grain imports	Root and tuber production
		1,000 tons	
2009	39,238	30,388	2,052
2010	30,933	34,673	2,326
2011	34,889	37,613	2,636
2012	34,540	32,294	2,825
2013	38,593	40,621	2,966
2014	35,234	42,708	2,991
2015	38,057	45,509	3,049
2016	29,313	44,486	3,082
2017	36,530	46,611	na
		Percent	
Average annual growth	-0.89	5.49	5.98

*Grain production includes rice expressed in milled-rice equivalent.

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