USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

Economic Research Service

Outlook

GFA-34

August 2023

International Food Security Assessment, 2023–2033

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Yacob Abrehe Zereyesus, Lila Cardell, Kayode Ajewole, Jarrad Farris, Michael Johnson, Jennifer Kee, Constanza Valdes, and Wendy Zeng

Abstract

Millions of people around the world are food insecure and do not have access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life. Using the demand-driven International Food Security Assessment (IFSA) model, this report helps the U.S. Department of Agriculture (USDA) and its stakeholders estimate food security trends in 83 low- and middle-income countries. Compared with 2022, food security in the countries covered in the IFSA report is estimated to improve in 2023, with 228.9 million fewer people facing food insecurity relative to 2022. This reduction is due to an average of 3.7 percent growth in per capita income and the easing of international and domestic food commodity prices. However, estimated food insecurity remains elevated due to the lingering effects of the Coronavirus (COVID-19) pandemic, high food commodity prices, and risks associated with the ongoing Russian military invasion of Ukraine. The number of food insecure people in 2023 is estimated at 1.14 billion in the 83 low- and middle-income countries covered by this assessment, 16.8 percent lower than 2022 estimates. Overall, 26.6 percent of the IFSA population may be unable to consume 2,100 kilocalories a day, an average caloric level necessary to sustain a healthy and active lifestyle. Despite challenges in the near-term outlook, food security is projected to improve in the next 10 years in all countries included in this assessment due to projected gains in per capita income and lower food commodity prices that will make food accessible. By 2033, the number of food insecure people in the 83 IFSA countries is projected to be 385.9 million (7.9 percent of the population), which is 66.1 percent less than the number of people estimated to be food insecure in 2023. The results presented in this report are based on the macroeconomic assumptions completed as of August 2022.

Keywords: Calories, Coronavirus, COVID-19, pandemic, food demand, food insecurity, food prices, income, inflation, caloric threshold, Ukraine, Sub-Saharan Africa, Middle East and North Africa, Former Soviet Union, Asia, Latin America and the Caribbean, U.S. Department of Agriculture, USDA, Economic Research Service, ERS

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Preface

This report continues the series of Global Food Assessments (GFA) in low- and middle-income countries that began in the late 1970s by the U.S. Department of Agriculture, Economic Research Service (ERS). In 1993, the title of the series was changed to Food Aid Needs Assessment (FANA) to reflect the report's contents more accurately, which assessed select low- and middle-income countries with recent or ongoing food deficits. However, not all countries experiencing significant food deficits are included in the assessment due to a lack of data on key metrics, such as average caloric consumption, prices, or macroeconomic figures. In 1997, USDA, ERS widened the analysis beyond the assessment of aggregate food availability to include more dimensions of food security and the title was revised to Food Security Assessment (FSA). Starting in July 2011, USDA, ERS changed the report's name to International Food Security Assessment (IFSA) to clarify the geographic scope of the analysis.

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International Food Security Assessment, 2023–2033

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What Is the Issue?

Millions of people around the world lack access to sufficient, safe, and nutritious food. Several factors affect the prevalence of food security including food availability (agricultural production and market conditions), access to food (economic and physical), stability (price and income shocks), and utilization (food safety and nutritional knowledge). Among the major factors affecting the ability of people to access food are personal income, food prices, and economic inequality. Food security can be worsened by declining income levels, high food prices, and/or food supply shocks. This report focuses on the availability and access dimensions of food security. Using a demand-driven model that integrates income, food prices, and food supply, the International Food Security Assessment (IFSA) analysis helps the U.S. Department of Agriculture (USDA) and its stakeholders assess food security for 83 countries in 5 regions: Sub-Saharan Africa, the Middle East and North Africa, the Former Soviet Union, Asia, and Latin America and the Caribbean. The 2023 report is based on observed country-level domestic commodity prices up to December 2022 and macroeconomic and international agricultural commodity price projections completed as of August 2022, to estimate and project the potential impact on present and future food insecurity levels.

What Did the Study Find?

The 2023 food insecurity estimates reflect the global and country-level macroeconomic conditions and price observations at the time of estimation. The macroeconomic and international agricultural commodity prices for the 2023–2033 period are based on per capita Gross Domestic Product (GDP) and international price projections completed in August 2022. These factors account for the lingering effects of the Coronavirus (COVID-19) pandemic, higher inflation amidst Russia's invasion of Ukraine, and tighter global monetary policies that continue to dampen global economic output and affect agricultural commodity prices (USDA, 2023).

The main findings for the 83 countries covered by this report are:

- Food security is estimated to improve in 2023 relative to 2022, due to an average of 3.7 percent growth in per capita GDP and relative easing of international and domestic food commodity price levels. In particular, the decline in the international price of vegetable oils in 2023 is estimated to decrease the real price of other foods (one of the four food groups in the IFSA model) in 98.0 percent of the IFSA countries.
- Despite improvements, food insecurity in 2023 remains elevated, with the prevalence of food insecurity estimated at 26.6 percent for the 83 countries included in IFSA. This number corresponds to 1.14 billion people potentially unable to consume 2,100[1] kilocalories (kcal) per day, or the average caloric threshold deemed necessary to sustain a healthy and active lifestyle. This number is 228.9 million fewer food insecure people in 2023 than estimated in 2022 (a 16.8-percent reduction from the 2022 estimate).
- Food insecurity is projected to significantly decline by 2033 in IFSA countries, with 385.9 million people projected to be food insecure (a 66.1-percent reduction from its 2023 estimate). The share of the population unable to consume 2,100 kcal per day is projected to fall to 7.9 percent by 2033 (a 70.3-percent reduction from its 2023 estimate). This share is driven by projected improvements in per capita GDP, particularly in the South Asia and South East Asia subregions that include India, Pakistan, and Indonesia.
- The food gap—defined as the amount of food needed for all food insecure people to reach the caloric threshold of 2,100 kcal per day—indicates the intensity of food insecurity. For the 83 countries examined, the average daily caloric food gap is projected to decline over the next 10 years by 7.8 percent, from 387 kcal in 2023 to 357 kcal in 2033.

How Was the Study Conducted?

The USDA, Economic Research Service (ERS) demand-driven IFSA model (described in appendix A) projects food demand and food gaps in 83 low- and middle-income countries through 2033. Food security is evaluated for each country by estimating the share of the population unable to reach a caloric threshold of 2,100 kilocalories per person per day. The intensity of food insecurity for those falling below the minimum caloric target is measured by the gap between projected food demand and this caloric threshold. Food demand is expressed in grain equivalents and is based on caloric content to allow aggregation across four separate food groups: the primary 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 Global Information Early Warning System's (GIEWS), Country Cereal Balance Sheet, February 2023 dataset. Observed domestic prices are from the FAO-GIEWS Food Price Monitoring and Analysis Tool. Tariff data are from the World Bank's World Integrated Trade Solution. Incomes, exchange rates, and Consumer Price Indexes are from the USDA, ERS International Macroeconomic Data Set (USDA, 2022). World prices are from the *USDA Agricultural Projections to 2032* report (USDA, 2023).

[1] The caloric threshold considered in the assessment is an average across sex, age, region, and activity level.

International Food Security Assessment, 2023–2033

Introduction

The U.S. Department of Agriculture, Economic Research Service (ERS) International Food Security Assessment (IFSA)[2] estimates per capita food demand and compares the estimations against a global caloric threshold of 2,100 kilocalories[3] (kcal) per person per day. The caloric threshold set by the United Nations[4] is an average calorie level necessary to sustain a healthy and active lifestyle. The aim of IFSA is to anticipate food security trends for the current year and 10 years out in 83 low- and middle-income countries for USDA and its stakeholders.

The current report incorporates assumptions for key macroeconomic variables (e.g., income growth, inflation, and exchange rates) and populations, as reflected in USDA, ERS's International Macroeconomic Data Set, and international and domestic food price trends in the short and medium term.[5] Nearly all economies included in the assessment sharply contracted in 2020 due to the Coronavirus (COVID-19) pandemic. This contraction resulted in lockdowns and other control measures impacting business activity,[6] employment, and incomes. The total population in the 83 countries included in the IFSA report is estimated to be 4.3 billion in 2023. In 2023, the average per capita Gross Domestic Product (GDP) level for the IFSA countries (2,415 U.S. dollars in 2015 prices) exceeded the average for the 2020–22 period (2,253 U.S. dollars in 2015 prices). This change indicates a sign of recovery from multiple shocks that affected the global economy including the COVID-19 pandemic, high food and input price inflation, and the ongoing Russian military invasion of Ukraine. As a result of the growth in per capita GDP and relative easing of inflation for the majority of the 83 countries in the assessment, the level of food insecurity (in the IFSA countries) in 2023 is estimated to decrease from 2022. Over the next decade, food security is projected to improve for most countries covered by the assessment. Key findings for IFSA countries include:

[2] The results from the IFSA model are not directly comparable with other analyses, such as the United Nations' Food and Agriculture Organization's (FAO) modeling work for its report on the State of Food Insecurity (SOFI), which has a broader country coverage and different methodology. Because IFSA also uses aggregate data, IFSA cannot be directly compared with evaluations using household-level surveys. It is also difficult to extrapolate results to the Food Security Information Network's (FSIN) report on global crises, which uses the five-phase food insecurity measure, which is a consensus approach across international organizations and development practitioners directly responding to major crises. For a more in-depth discussion and comparison of USDA's IFSA model with other modeling approaches, see Tandon et al. (2017).

[3] A kilocalorie is the same as 1 Calorie. A kilocalorie is the amount of heat required to raise the temperature of 1 kilogram of water 1 degree Celsius.

[4] The 2,100-kilocalorie per capita per day threshold was an internationally agreed upon level set by the United Nations as the recommended level of dietary energy intake for a healthy, well-nourished individual and is an average across sex, age, region, and activity level (FAO, 2004).

[5] Long-term price projections are taken from the *USDA Agricultural Projections to 2032* report (OCE-2023-1). These projections are used to project medium-term domestic price trends using data from the Global Information and Early Warning System (GIEWS) country cereal balance sheet dataset of the United Nations Food and Agriculture Organization.

[6] Some of the control measures that impacted business included (but were not limited to) curfews, closures of large venues, restrictions on operations of hotels and restaurants, and closures of borders.

- Food security is estimated to improve in 2023 relative to 2022, due to an average of 3.7 percent growth in per capita GDP and easing of international and domestic food commodity price levels. In particular, the decline in the international price of vegetable oils in 2023 is estimated to decrease the real price for other foods (one of the four food groups in the model) in 98.0 percent of the IFSA countries.

- Despite improvements, food insecurity in 2023 remains elevated, with the prevalence of food insecurity estimated at 26.6 percent for the 83 countries included in IFSA, corresponding to 1.14 billion people potentially unable to consume 2,100[7] kilocalories (kcal) per day, an average caloric threshold deemed necessary to sustain a healthy and active lifestyle. This number represents 228.9 million fewer food insecure people in 2023 than estimated in 2022, a 16.8-percent reduction from the 2022 estimate.

- Food insecurity is projected to significantly decline by 2033 in IFSA countries, with 385.9 million people projected to be food insecure (a 66.1-percent reduction from its 2023 estimate). The share of the population unable to consume 2,100 kcal a day is projected to fall to 7.9 percent by 2033 (a 70.3-percent reduction from its 2023 estimate). This decline is driven by projected improvements in per capita GDP, particularly in the South Asia and South East Asia subregions that include India, Pakistan, and Indonesia.

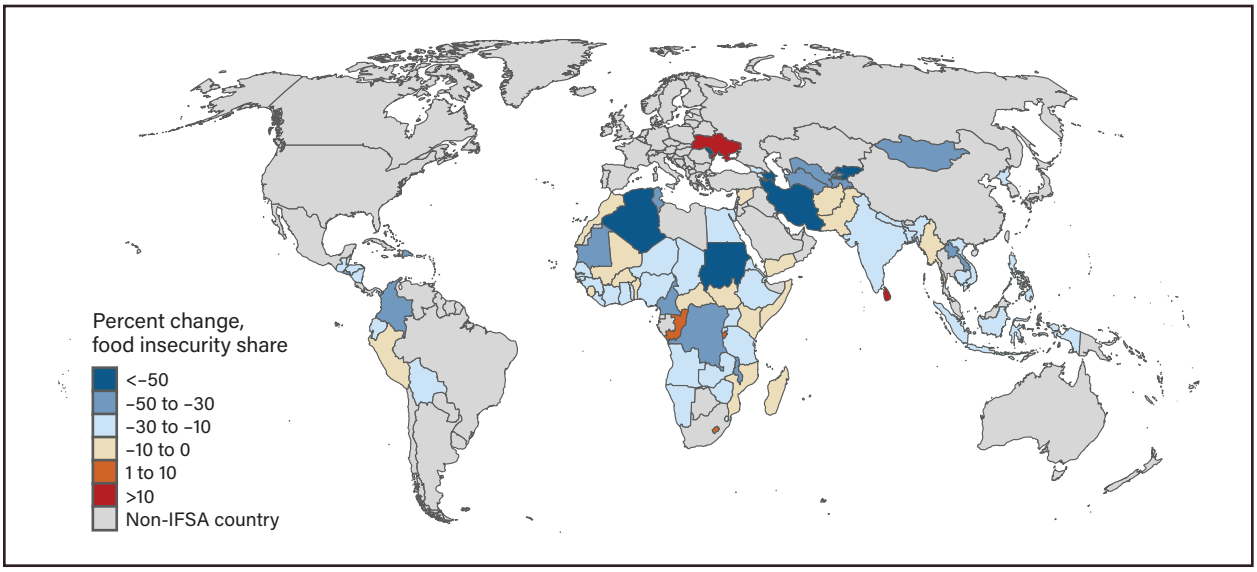
- The food gap—defined as the amount of food needed for all food insecure people to reach the caloric threshold of 2,100 kcal per day—indicates the intensity of food insecurity. For the 83 countries examined, the daily caloric food gap is projected to decline over the next 10 years by 7.8 percent, on average, from 387 kcal in 2023 to 357 kcal in 2033.

- Per capita income and population growth are projected to lead to 34.6 percent higher food demand in IFSA countries in the next 10 years. Population growth is responsible for 41.4 percent of this growth, and per capita consumption (demand) is responsible for 51.3 percent of the growth. The remaining 7.3 percent is due to the interaction between population and per capita consumption.

[7] The caloric threshold considered in the assessment is an average across sex, age, region, and activity level.

Figure 1

Improved food security rates in most IFSA countries in 2023 (relative to 2022) are associated with higher per capita GDP and easing of commodity prices

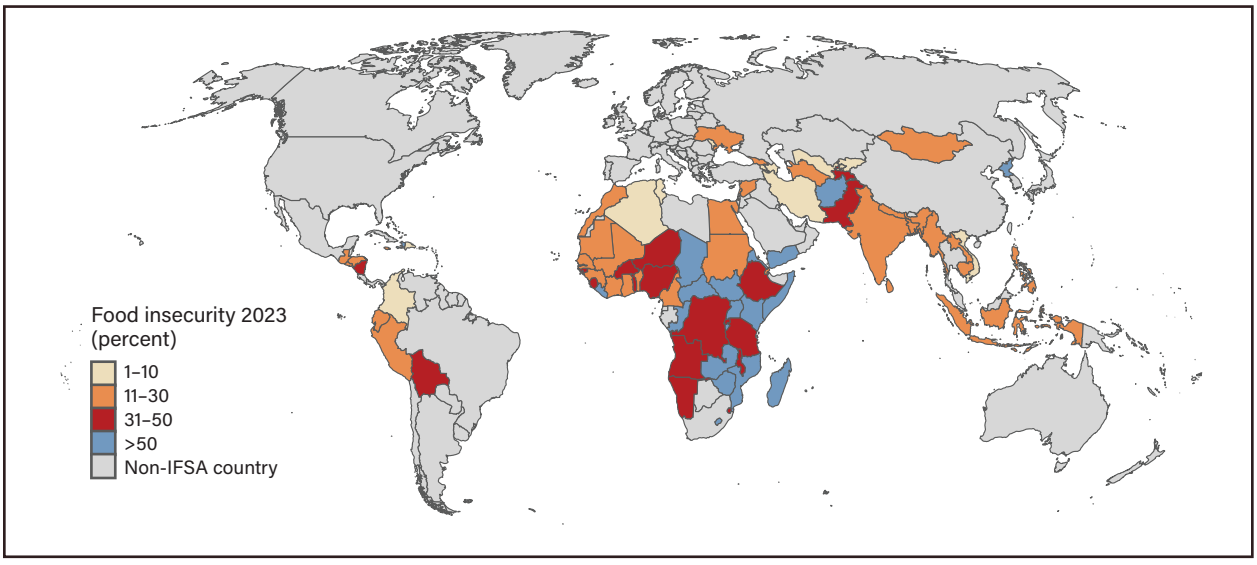


IFSA = International Food Security Assessment. GDP = Gross Domestic Product.

Source: USDA, Economic Research Service based on results from the International Food Security Assessment model.

Figure 2

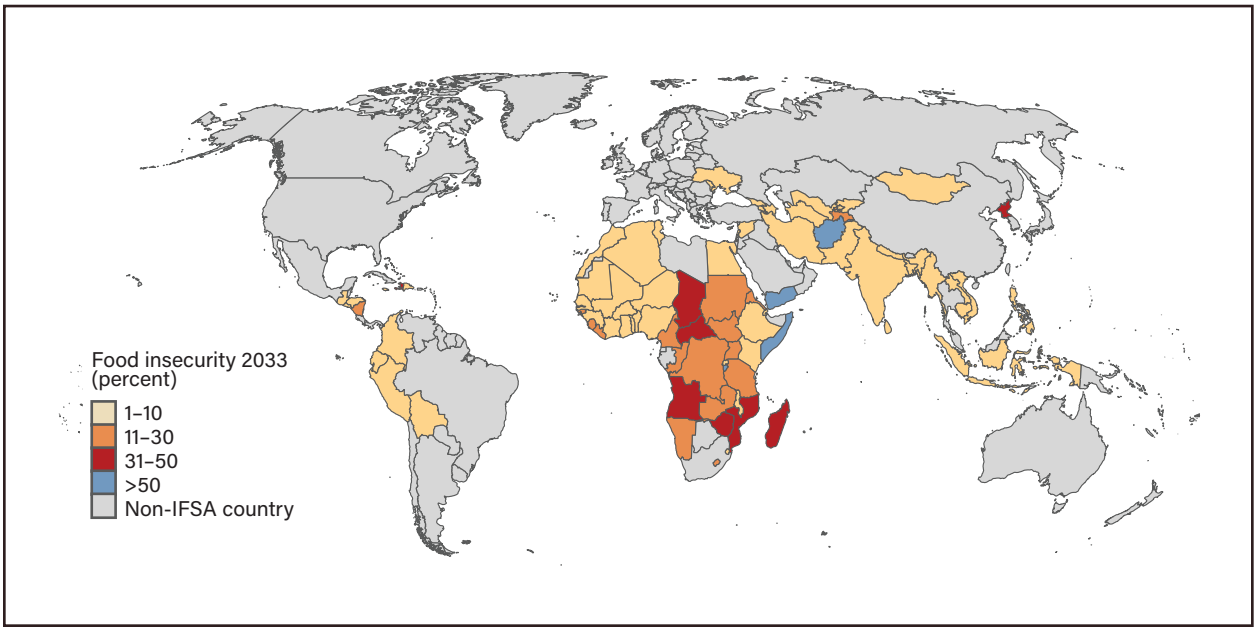
Share of IFSA population estimated to be food insecure, 2023



IFSA = International Food Security Assessment.

Source: USDA, Economic Research Service based on results from the International Food Security Assessment model.

Figure 3
Share of IFSA population estimated to be food insecure, 2033



IFSA = International Food Security Assessment.

Source: USDA, Economic Research Service based on results from the International Food Security Assessment model.

Adding Six Low and Lower Middle-Income Countries to the IFSA

The 2023 IFSA Report includes six additional low- and lower middle-income countries, and a reorganization of the regional and sub-regional designations. A review of the World Bank designation for economies for 2023 identified six countries classified as low-income and lower middle-income that had sufficient data for inclusion in the IFSA model. For 2023, the World Bank classified economies using 2021 Gross National Income (GNI) per capita, which was calculated using the World Bank Atlas Method (Fantom & Serajuddin, 2016). The six additional countries are Djibouti, South Sudan, Syria, Iran, Lebanon, and Burma.

Additionally, the regional and sub-regional classifications were reviewed to align with the USDA Agricultural Baseline designations (Hjort, et. al., 2018). The Latin America and Caribbean (LAC) region now has three sub-regions: Caribbean, Central America, and South America. The North Africa region has been expanded to the Middle East and North Africa (MENA), with two sub-regions: Middle East and North Africa. A new region is added, the Former Soviet Union, in line with the USDA classification. The Asia region now has three sub-regions: South Asia, East Asia, and South East Asia. The USDA does not distinguish sub-regions within Sub-Saharan Africa (SSA), therefore the Africa Union designations for regions of member states in SSA were applied as sub-regions (Africa Union Resolution, 1976).

To provide comparative regional and sub-regional estimates for the prior year based on the new set of countries, regions, and sub-regions—some of the 2022 estimates (including region, sub-regions, and the world totals) were recalculated using the new aggregations.

Gross Domestic Product (GDP) Expectations in the International Food Security Assessment (IFSA) Countries

The macroeconomic projections for the countries covered by the IFSA report, last completed by USDA, ERS in August 2022, provide the long-term data for the food demand and supply projections reported in IFSA. Shipping bottlenecks, which previously contributed to higher commodity prices, have largely diminished over the last year. However other factors have affected growth prospects around the world, in IFSA regions and nearby countries that may result in negative spillover effects. High inflation (especially for food during quarters 2 and 3 of 2022), the war in Ukraine, ongoing conflicts in many IFSA countries, and tighter monetary policy around the world continue to restrain global economic output and affect agricultural commodity prices in the IFSA analysis (USDA, 2023).

GDP[8] for the countries covered by the IFSA report[9] is estimated to be $10.3 trillion in 2023, with a growth rate of 5.2 percent relative to 2022 (appendix C). In the long run, GDP is projected to grow at an average annual rate of 4.8 percent for the next 10 years and reach $16.6 trillion by 2033 (appendix C). This number is lower than during the 2020–22 period, when the annual GDP growth rate was an average of 5.1 percent, despite the stresses of the COVID-19 pandemic. Although the overall growth rate for 2023–2033 is projected to be lower compared with 2020–22, most countries are expected to report positive GDP growth in 2023, which is an improvement over the expectations from the 2022 IFSA report, in which multiple countries were expected to report a decline in GDP growth that year (Zereyesus et al., 2022). In 2023, only one country covered by the IFSA report, Afghanistan, is estimated to show a 1.3-percent decline in the GDP growth rate, although this is still an improvement over its 16.1-percent average annual decline from 2020–22 (appendix C).

Environmental disasters, catastrophic flooding, and other major disasters have also damaged economic growth prospects around the world, particularly in countries covered by the IFSA report, such as Pakistan, the Philippines, Nigeria, and Sri Lanka. During the summer and fall 2022, a record number of countries experienced issues with hydroelectric generation due to droughts across several continents, which significantly impacted trade and consumer prices (Arita et al., 2022; Wallis, 2022). Drought is also directly affecting the economic prospects of Africa's Great Lakes region and Horn of Africa countries with Kenya, Somalia, and Ethiopia bearing the brunt of the impact (International Federation of Red Cross and Red Crescent Societies (IFRC), 2022; Famine Early Warning Systems Network (FEWS NET), 2023).

The total population in the countries included in the IFSA report is estimated to be 4.3 billion in 2023. The population is projected to grow at a slightly slower annual rate of 1.4 percent per year over the next 10 years compared with the previous years' estimates and reach 4.9 billion people by 2033 (appendix C). On average across the IFSA countries, per capita GDP is estimated to be higher in 2023 relative to 2022, with an average per capita GDP growth of 3.7 percent across all IFSA countries (table 1). This progress continues an increasing trend that was noted in the 2022 IFSA report (Zereyesus et al., 2022). At the country level, per capita GDP is estimated to grow in 2023 in almost 90 percent of the countries covered by the IFSA report with the most notable exceptions being Afghanistan and Syria (table 1, appendix C).

On average across the IFSA countries, per capita GDP is projected to grow at an annual rate of 3.4 percent over the next 10 years (table 1). Between 2023 and 2033, per capita GDP in the Latin America and the Caribbean (LAC) region is projected to grow 2.7 percent per year. The LAC region suffered a steep decline in

[8] Gross Domestic Product (GDP) and per capita GDP are both expressed in 2015 real price terms throughout the IFSA report.

[9] A full list of the IFSA countries (with corresponding details on the major macroeconomic variables) is provided in appendix C.

per capita GDP due to the COVID-19 pandemic but rebounded in 2021 and continues to grow. Countries such as Peru, the Dominican Republic, El Salvador, Guatemala, and Colombia achieved record growth rates in recent years, contributing to the LAC region's 6.0-percent annual growth rate during the 2020–22 period (appendix C). In the Asia region, per capita GDP is projected to grow at an annual rate of 4.6 percent between 2023 and 2033. Much of the anticipated income increases in Asia reflect robust per capita GDP growth in the South and the South East Asia sub-regions. In the Middle East and North Africa region, per capita GDP growth expectations continue to be more modest, averaging 2.4 percent per year between 2023 and 2033. In Sub-Saharan Africa (SSA), per capita GDP is projected to grow at 1.6 percent per year over the next 10 years (table 1). The estimated per capita GDP growth for the SSA region lags behind the other four regions, which mainly reflects the high population in SSA with 2.6 percent annual average population growth over the next 10 years (appendix C). In the Former Soviet Union region, per capita GDP growth is expected to average around 4.7 percent annually in the 2023–2033 period, a marked improvement over the growth rate of –2.8 percent annually in the 2020–22 period (table 1). This change is primarily driven by a current assessment of the situation in Ukraine and the expected recovery from the devastation of the war on the Ukrainian economy (USDA, Office of the Chief Economist (OCE), 2023). The U.S. dollar continues to be strong relative to other currencies and is projected to continue the trend over the next 10 years. This trend is likely to continue to push domestic prices (including food prices) higher for IFSA countries in their local currency units, as imports remain relatively expensive.

The macroeconomic projections for GDP, inflation, and exchange rates are developed using several forecasting services, including publicly available projections from the World Bank's World Development Indicators and the International Monetary Fund's (IMF) World Economic Outlook. Additional sources of data included the subscription services of IHS Global Insight, Oxford Economics Forecasting, and U.S. Government projections. Estimated and projected values are developed by USDA, ERS's regional and country experts. The projections assume no policy changes nor additional shocks (e.g., political crises, conflicts, disease outbreaks, or weather events). These macroeconomic projections were completed in August 2022 and are based on expectations at that time.[10]

Table 1
Inflation-adjusted per capita Gross Domestic Product (GDP) in IFSA regions, 2023 and 2033

Region	2020–22 (average)	2023	2033	Annual growth rate	
				(2022–2023)	(2023–2033)
	U.S. dollars, 2015			Percent	
IFSA Total	**2,253**	**2,415**	**3,388**	**3.7**	**3.4**
Former Soviet Union	3,037	3,095	4,885	7.9	4.7
Asia	2,225	2,440	3,821	4.7	4.6
Latin America and the Caribbean	5,266	5,636	7,364	2.0	2.7
Middle East and North Africa	3,595	3,834	4,843	4.0	2.4
Sub-Saharan Africa	1,345	1,375	1,607	1.2	1.6

IFSA = International Food Security Assessment.

Note: Regions include only countries that are covered by the International Food Security Assessment.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

[10] Since the macroeconomic projections were completed in August 2022, there have been events that have the potential to depress economic growth in IFSA countries—including the Sudan conflict, escalated fighting in Ukraine, and continued global tightening of interest rates by central banks to further fight inflation. However, stronger demand and spending in large economies have boosted the overall global economy, leading to expectations for overall growth in IFSA countries to be similar or slightly higher than the official projections made in August 2022.

International Food Price Projections and Trends

USDA's international agricultural commodity price projections have followed an upward trend since 2021, supported by rising global demand for feed and food grains and tighter global supplies (USDA, OCE, 2022). High commodity prices persisted through 2022 due to rising international energy and fertilizer prices and Russia's military invasion of Ukraine. Although fertilizer prices subsided towards the second half of 2022, the risks associated with the conflict in Ukraine remain. Poor weather conditions in several key grain producing countries and low stock-to-use ratios for some commodities are expected to exert upward pressure on international commodity prices (Agricultural Market Information System (AMIS), 2022; USDA, Foreign Agricultural Service (FAS), 2022). Higher projected international wheat prices are partly related to persistent dryness in the United States, worsening drought conditions in Argentina, and slow winter wheat planting progress in the Russian Federation (AMIS, 2022; USDA, FAS, 2022). Based on the baseline projections, the prices for corn, rice, sorghum, and wheat are estimated to remain higher in 2023 relative to 2022 (figure 4). International rice prices are estimated to remain higher in 2023 in response to policy decisions in some countries (e.g., a 20-percent export duty and a ban on 100 percent of broken rice from India) and expected production shortfalls (e.g., heavy floods in 2022 caused significant damage to 2022/23 production in Pakistan). Beginning in 2024, international agricultural commodity prices are projected to trend downward and remain relatively stable for the majority of the next 10 years[11] (figure 4) due to a projected food supply that will outweigh global demand (USDA, OCE, 2023).

International commodity prices are transmitted to domestic markets through trade.[12] Access to food by vulnerable households is constrained when food commodity prices are high. High food price inflation, in turn, negatively affects food security, particularly in lower income households that spend a relatively higher proportion of their budget on food (World Food Programme (WFP) & Food and Agriculture Organization of the United Nations (FAO), 2021). Although farmers might benefit from higher commodity prices, many vulnerable smallholder farmers are net food buyers (i.e., purchase more food than they sell) and, therefore, are constrained by higher food prices. In IFSA countries, world and domestic food prices are integrated through trade, although the degree of market integration may vary from one country to another. With most countries experiencing food price increases of 10–30 percent in 2023 over 2022, domestic food price inflation is particularly worrisome (AMIS, October 2022). Many IFSA countries experienced high domestic commodity and food price inflation in 2022 due to high energy and fertilizer prices, supply chain disruptions associated with the COVID-19 pandemic, and complications due to Russia's invasion of Ukraine (Zereyesus et al., 2022). The combined impacts of supply-side factors (such as input and fertilizer prices, weather and climate changes, and uncertainties with agricultural production) are expected to further drive commodity prices in the IFSA countries. Despite some signs of easing, high domestic food price inflation continues to affect these countries. Eighty-two percent of the 83 countries[13] covered by the IFSA report are projected to have rising real domestic prices of their major grains in 2023 (appendix D). Thirteen percent of the 83 IFSA countries are estimated to have more than a 10-percent increase in real domestic price of their major grains in 2023, relative to 2022. Prices of various food categories (measured in grain equivalent prices) are also estimated to follow similar trends. Prices of other grains, roots, and tubers (measured in grain equivalent prices) are estimated to remain elevated in 2023. However, due to the decline in the relative price of vegetable oils, the real price of other

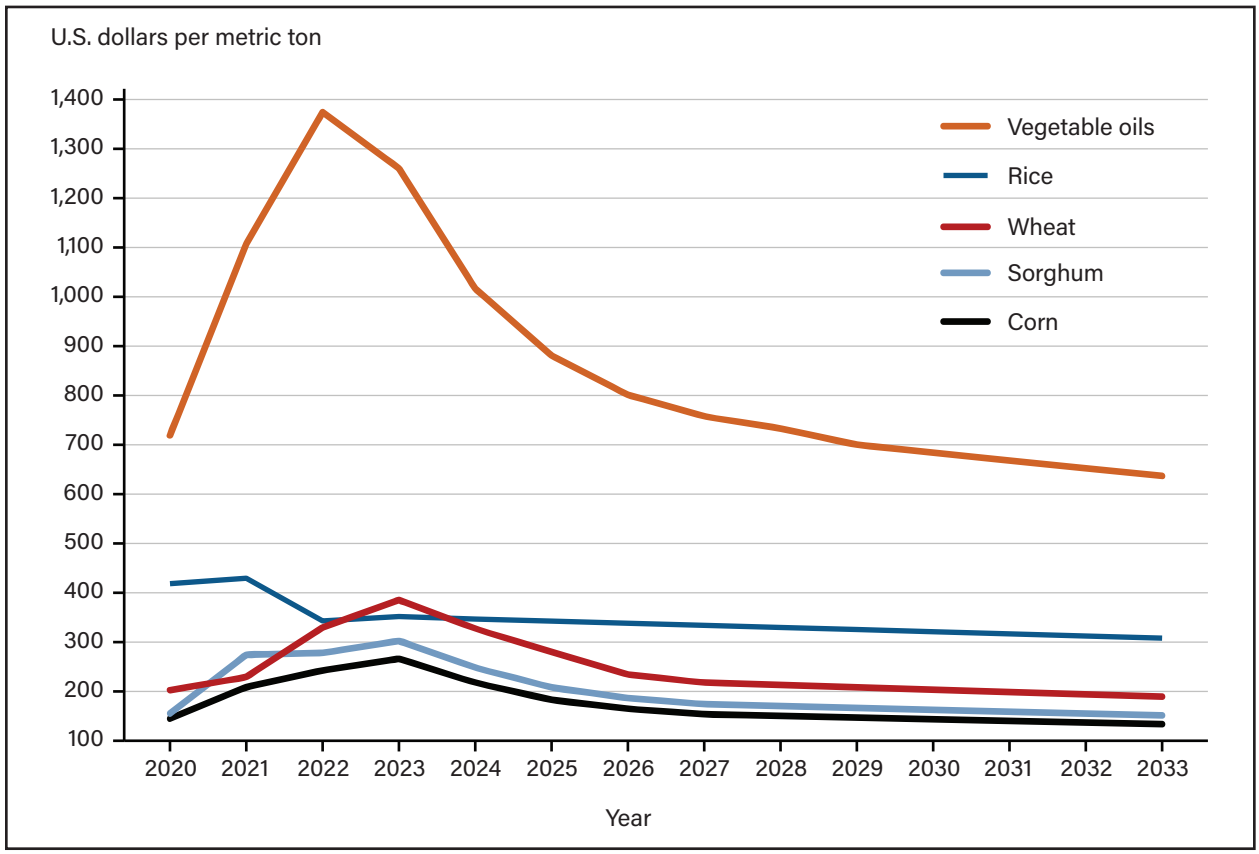
[11] Price projections come from the *USDA Agricultural Projections to 2032* long-term projections report (USDA, OCE, 2023) and are expressed in 2015 prices, adjusted for inflation.

[12] See appendix A for details about the international price transmission equations used for the IFSA countries in the IFSA demand modeling.

[13] The full set of food projections at the country, sub-regional, and regional levels of anticipated price changes of their major grains are included in appendix D.

food groups (expressed in grain equivalent prices) is estimated to be lower in 2023 in 98.0 percent of IFSA countries (appendix D).[14]

Figure 4
Food price increases are estimated to ease in 2023, with declining vegetable oils prices



Note: Value in 2015 U.S. dollars.

Source: USDA, Economic Research Service using data from *USDA Agricultural Projections to 2032* long-term projections report (OCE-2023-1).

Grain Demand, Production Trends, and the Implied Additional Supply Required

The difference between grain demand and domestic food production in IFSA countries provides an estimate of the shortfall/surplus in food availability, which is referred to as the Implied Additional Supply Required (IASR). The grain demand has two components: food and other demand. The total grain demand for IFSA countries is estimated to be nearly 1.8 billion metric tons in 2023. In the next 10 years, total grain demand is projected to increase by 2.4 percent per year across all 83 countries to reach 2.3 billion metric tons by 2033 (table 2). Food demand, which forms the largest share of total grain demand in the IFSA countries, is projected to grow at 3.0 percent per year.

[14] See the box "How Food Security is Assessed: Method and Definitions" for more on the four food group categories and grain equivalent conversions and prices.

Despite the robust growth in grain production in IFSA countries, growth is not projected to keep pace with demand. From 2023 to 2033, grain production is projected to grow by 1.9 percent per year (table 2), which is below the growth rate for total grain demand and the demand for food grains for the IFSA countries. Over the next 10 years, the Former Soviet Union (FSU) region is projected to see the highest annual growth rate of grain production among IFSA regions, growing at an annual rate of 3.4 percent. The annual grain production growth rate in the FSU region is projected to be more than growth in total grain demand, resulting in excess food availability in the region. In contrast, projected annual grain-production growth in all other regions will fall below the growth of demand for grains for food and other uses (table 2). Globally, demand for grain for other uses (such as for animal feed) is projected to outpace the demand for food. SSA's projected rate of growth in grain production (1.6 percent a year) is the lowest of any region. Grain production in the Middle East and North Africa (MENA) and LAC regions is projected to grow 2.5 and 2.1 percent per year from 2023 to 2033, respectively.

The gap between domestic grain production and demand for grain is projected to widen for all regions in the assessment during the next 10 years, except the FSU (table 2). The IASR as a whole—which provides an estimate of the gap between demand and supply for grains—is projected to increase by 2.7 percent per year between 2023 and 2033.

Table 2
Demand for grains is projected to outpace grain production over the 2023–2033 period, driven mainly by demand from the Asia and Sub-Saharan Africa regions

Region	Food demand		Other demand		Grain production		Implied additional supply required[1]	
	2023	2033	2023	2033	2023	2033	2023	2033
	Million tons							
IFSA Total	**773.6**	**1,041.4**	**1,015.8**	**1,219.2**	**747.3**	**905.2**	**1,042.2**	**1,355.3**
Former Soviet Union	18.9	25.5	48.2	61.0	73.3	102.5	–6.3	–16.0
Asia	501.7	647.8	563.6	674.2	480.5	569.5	584.8	752.5
Latin America and the Caribbean	24.4	29.7	64.7	76.4	17.9	22.0	71.2	84.1
Middle East and North Africa	76.0	100.8	71.6	75.1	51.7	65.9	95.9	110.0
Sub-Saharan Africa	152.7	237.6	275.7	326.5	123.9	145.3	304.5	418.8

IFSA = International Food Security Assessment.

[1] The implied additional supply required is the gap between total grain demand (food demand plus other demand) and domestic grain production.

Note: Other grain demand includes seed, feed, waste, and processing.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model.

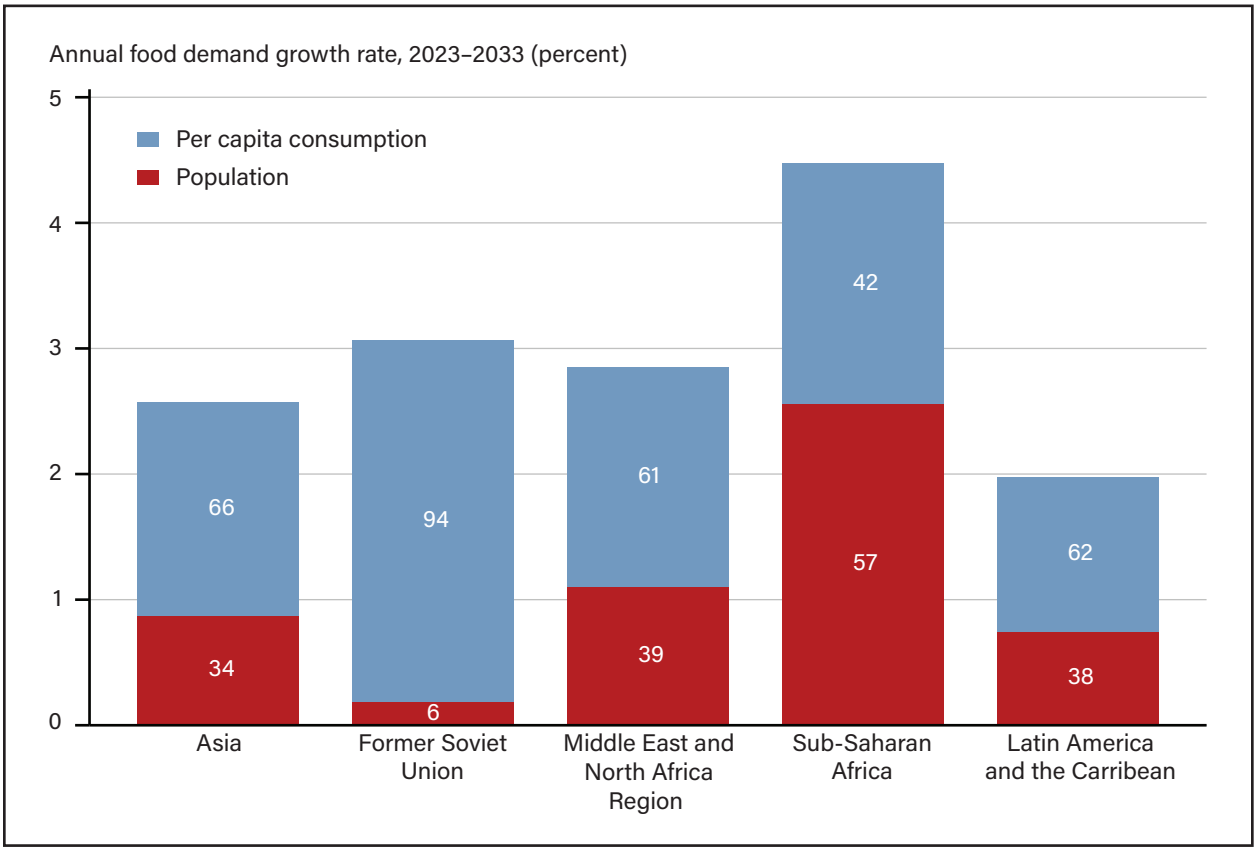
Decomposition of Regional Food Demand Growth

Results in figure 5 show the overall annual growth rate of food demand for the countries included in IFSA by region. The average annual food demand across the IFSA population is projected to grow during the next decade at an annual rate of 3.0 percent, from 773.6 million metric tons in 2023 to 1,041.4 million metric tons in 2033 (table 2). The SSA region is projected to have the highest growth rate of annual food demand, with 4.5 percent per year for the next 10 years, which projects demand growth from 152.7 million metric

tons in 2023 to 237.6 million metric tons in 2033. The MENA and FSU regions are projected to have an annual growth rate of 2.9 percent and 3.0 percent, respectively. In absolute terms, the Asia region is projected to grow the most by 145.9 million metric tons from 501.0 million metric tons to 646.9 million metric tons in 2033. However, this growth would correspond to an annual growth rate of 2.6 percent during the next 10 years. Meanwhile, the LAC region (with a 2.0 percent annual growth rate) is projected to have the lowest food demand growth across all regions (figure 5).

The total food demand growth rate can be decomposed into per capita food consumption and population growth rates. The average annual per capita food consumption for the IFSA countries is projected to grow 1.7 percent per year from 180.6 kilograms in 2023 to 212.6 kilograms in 2033, making up 56.7 percent of the 3.0 percent total annual IFSA food demand growth rate. Although regional population growth rates vary significantly, the total IFSA population is projected to grow by an average of 1.4 percent per year for the next 10 years (appendix C). The regional growth rate in total food demand is driven mainly by per capita food consumption rather than population growth rate in all regions except for the SSA region. For the FSU region, 94 percent of the overall food demand growth in the next 10 years is driven by growth in per capita food consumption because of the significant growth in per capita income, which is higher than the average population growth rate of the region. While the SSA region has the highest annual food demand consumption growth rate, 57 percent of the growth rate in total food demand in SSA is due to population growth rate (figure 5).

Figure 5
Sub-Saharan Africa has the highest total annual food demand growth rate between 2023 and 2033, mainly driven by higher population growth rate



Note: Percentages may not add up to 100 due to rounding.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model.

How Food Security Is Assessed: Method and Definitions

The International Food Security Assessment (IFSA) projects food demand for 83 low- and middle-income countries—41 in Sub-Saharan Africa, 8 in the Middle East and North Africa, 11 in Latin America and the Caribbean, 14 in Asia, and 9 in the Former Soviet Union. Food is divided into four groups: (1) the major grain consumed in the country; (2) other grains; (3) root crops; and (4) all other food. The IFSA model's projections of food demand are expressed in grain equivalents, based on the caloric content of food items to allow for aggregation across food groups. A grain equivalent may be expressed in either kilograms or kilocalories. For example, grains have roughly 3.5 kilocalories per gram, and tubers have about 1 calorie per gram. One ton of tubers is therefore equivalent to 0.29 tons of grain.

The real domestic price in a grain equivalent (expressed per kilocalories) is used to generate price indices for the four food groups: price for the major grain is the same as its own price, whereas the prices of 'other grains', and 'roots and tubers' are the weighted average prices expressed in grain equivalents of each of the food items consumed in the food groups. Prices for 'all other foods' (in grain equivalents) are obtained by using vegetable oil prices as a proxy for the food group.

The IFSA model analyzes the gap between projected food demand, which is a function of per capita income and food prices, and a caloric threshold of 2,100 kilocalories per capita per day. This report uses three indicators of food insecurity.

1. The **food gap** measures the food needed to raise consumption at every income level to the caloric threshold. In many countries, per capita consumption in the lower income deciles is significantly less than the per capita consumption for the country. In these countries, the distribution gap provides a measure of the intensity of hunger—the extent to which the food security of already hungry people deteriorates because of income declines or other negative economic conditions. This measure can be expressed on a per capita basis (in kilocalories per day) or as an aggregate measure (the total tons of food needed to fill the gap in each country).

2. The **share of the population that is food insecure**. Food demand is assumed to be met and equal to consumption. Consumption is not assessed by income decile but instead in a continuous manner across all income levels.

3. The **number of food insecure people**—those who cannot meet the caloric threshold—is based on the total population and the population share that consumes less than the caloric threshold.

Terms commonly used in this report include:

Food consumption—equal to food demand if we assume demand is met.

Food access—depends on a consumer's purchasing power. Food access is estimated based on income level and food prices within each country, according to 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 threshold of 2,100 kilocalories per person per day.

For more detailed information on the model, see appendix A.

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Regional Coverage and Estimated Food Security Trends

The 83 countries[15] covered by this International Food Security Assessment (IFSA) report are sub-divided across 5 regions: 41 countries and 4 sub-regions in Sub-Saharan Africa (SSA), 14 countries and 3 sub-regions in Asia, 11 countries and 3 sub-regions in Latin America and the Caribbean (LAC), 8 countries and 2 sub-regions in the Middle East and North Africa (MENA), and 9 countries in the Former Soviet Union (FSU). Estimated levels of food insecurity for 2023 vary greatly across these regions. Asia (537.3 million people) and SSA (481.2 million people) account for 89 percent of the total number of food insecure people in 2023 (figure 6). LAC (40.3 million people), MENA (60.9 million people), and the FSU (17.8 million people) account for the remaining 11 percent of food insecure people in the 2023 assessment. The SSA region has the highest estimated share of the population that is food insecure at 41.2 percent. By contrast, 21.8 percent of the population in Asia and 22.6 percent of the population in the LAC region are estimated to be food insecure in 2023. The prevalence of food insecurity in 2023 in the MENA region stands at 17.4 percent. The FSU region (15.2 percent), which is comprised primarily of middle-income countries, has the lowest prevalence of food insecurity (table 3).

Despite significant improvements in food security metrics across the 5 regions, by 2033 SSA is projected to have the highest number of food insecure people across IFSA regions, with 239.5 million people (or 62.1 percent of the food insecure people in IFSA) potentially unable to consume 2,100 calories per day. By contrast, Asia is projected to have 102.4 million food insecure people (or 26.5 percent of the food insecure people in IFSA) by 2033 (table 3). The daily caloric food gap measures the intensity of food insecurity; however, the regional averages do not capture the full distribution of country level food gaps. While the median food gap is projected to decline in all regions between 2023 and 2033, certain countries (such as Haiti, Yemen, and many countries in the SSA region) are projected to maintain caloric deficits above 400 calories per capita per day (figure 7).

Table 3
Food Security results in IFSA countries, 2023 and 2033

Region	Population		Population food insecure		Share of population food insecure	
	2023	2033	2023	2033	2023	2033
	Million		Million		Percent	
IFSA Total	**4,279.8**	**4,895.6**	**1,137.6**	**385.9**	**26.6**	**7.9**
Asia	2,466.8	2,690.6	537.3	102.4	21.8	3.8
Former Soviet Union	117.3	119.5	17.8	1.4	15.2	1.2
Middle East and North Africa	350.1	390.8	60.9	29.2	17.4	7.5
Sub-Saharan Africa	1,167.4	1,502.8	481.2	239.5	41.2	15.9
Latin America and the Caribbean	178.1	191.9	40.3	13.3	22.6	6.9

IFSA = International Food Security Assessment.

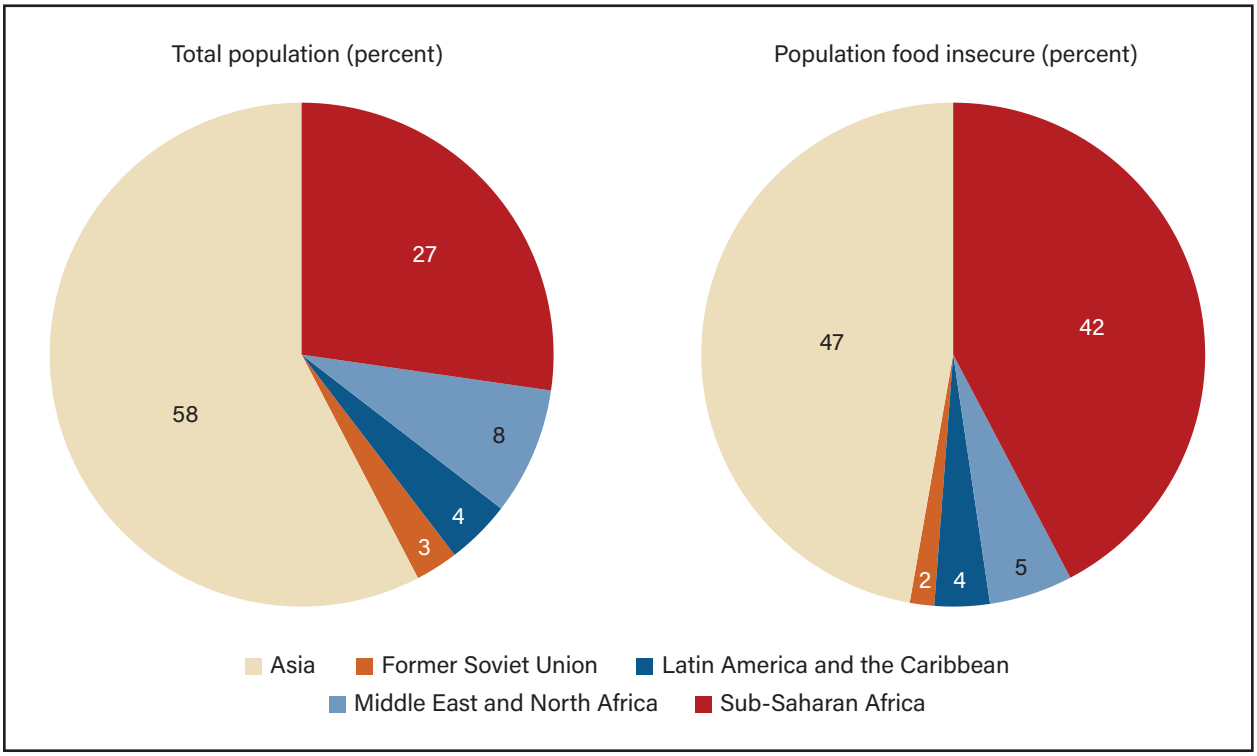
Note: Regions only include countries that are in the International Food Security Assessment.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model.

[15] The IFSA report covers major drivers of food security at a global, regional, sub-regional, or country level. Country-level discussions are included to highlight the importance of specific countries in food security trends, e.g., India, which comprises 31.6 percent of the IFSA population, significantly shapes food security projections across the IFSA countries. Additional data on income, prices, and food security trends for each of the 83 countries is provided in the appendix.

Figure 6

Asia is estimated to have the highest number of food insecure people in 2023

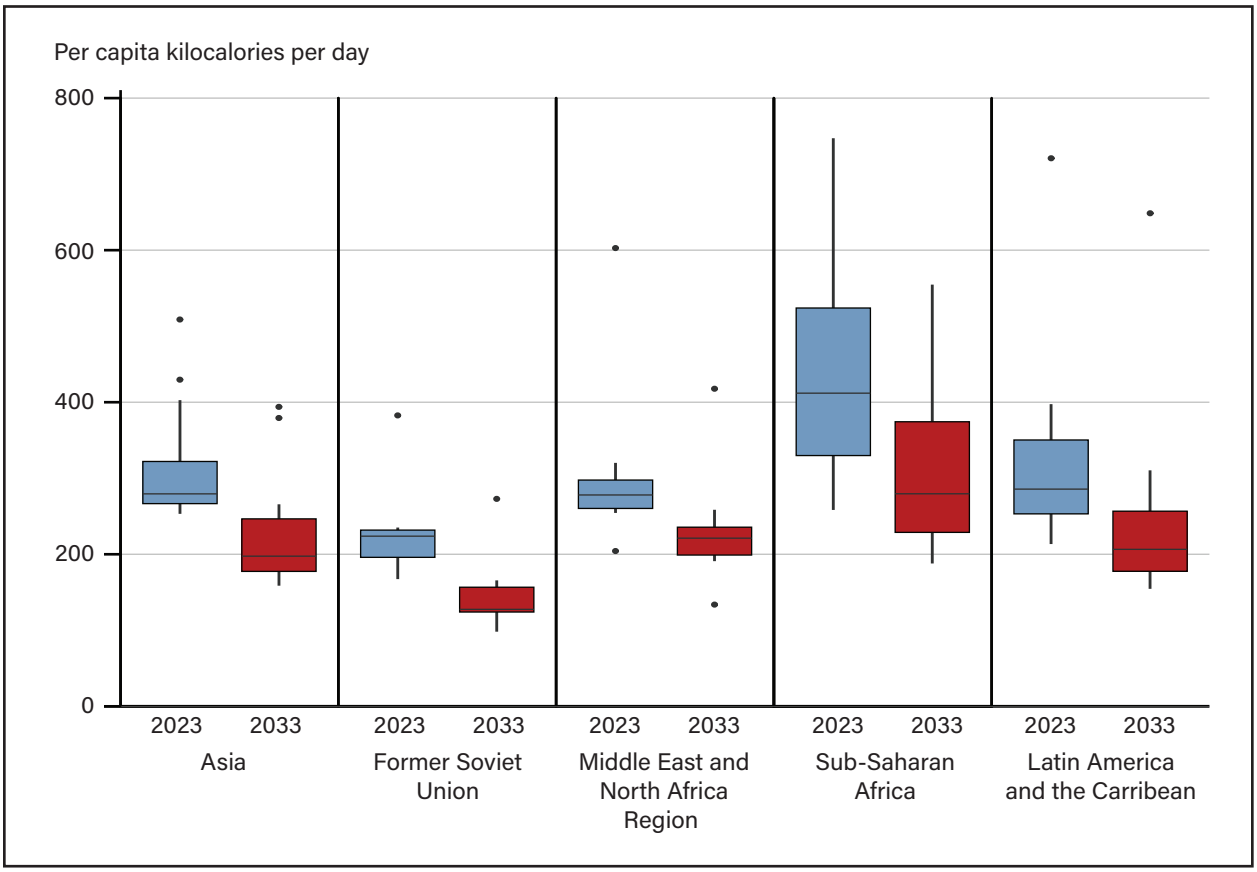


Note: Regions only include countries that are in the International Food Security Assessment.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model.

Figure 7

For both 2023 and 2033, the largest food gap is estimated in Sub-Saharan Africa, although there is significant variability within each region



IFSA = International Food Security Assessment.

Note: Regions only include countries that are in the International Food Security Assessment. The boxplot shows the distribution of the food gap in each region, where the black line represents the median food gap, and the points show countries in the region above the interquartile range (25–75 percent of the distribution). A kilocalorie is the same as 1 Calorie. A kilocalorie is the amount of heat required to raise the temperature of 1 kilogram of water 1 degree Celsius.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model.

Sub-Saharan Africa

The prevalence of food insecurity in Sub-Saharan Africa (SSA) is expected to decline from 50.9 percent in 2022 to 41.2 percent in 2023. Over the coming decade, food insecurity in the region is projected to continue to fall to 15.9 percent in 2033, a reduction of 61.0 percent from 2023. This projection implies that the number of food insecure people in the region would decline from an estimated 481.2 million in 2023 to 239.5 million in 2033, halving the number of people affected by food insecurity (table 4). Despite these improvements in food security measures, SSA is expected to represent an increasingly larger share of the world's total food insecure population by 2033, rising from 42.3 percent in 2023 to 62.1 percent by 2033 (table 3).

SSA is projected to have the fastest population growth rate of the five IFSA regions over the next decade, growing by 2.6 percent per year on average. By 2033, the population of SSA is projected to be more than 1.5 billion, an increase of 335.4 million from the 2023 estimate (table 4). Due in part to the region's high population growth, per capita GDP in SSA is projected to grow at the slowest rate of all the IFSA regions

over the 2023–2033 period, at 1.6 percent per year on average. As a result, the inflation-adjusted per capita GDP in the SSA region (which is estimated to be $1,375 in 2023) is projected to have only moderate gains over the coming decade (table 5). However, economic growth will vary by country, with least developed economies likely growing faster due to their lower base levels (Organisation for Economic Cooperation and Development (OECD) & the Food and Agriculture Organization of the United Nations (FAO), 2022).[16] Key drivers affecting these trends in SSA include the recent spikes in global prices, weather-related shocks, and armed conflicts.

The recent spikes in global commodity prices for energy and food products, especially during the second half of 2021 and throughout 2022, have affected food security in all areas of SSA. Russia's military invasion of Ukraine disrupted global food supplies of major agricultural commodities, such as wheat and corn, as well as reduced the availability of some fertilizers, raising global prices (World Food Programme of the United Nations (WFP) & Food and Agriculture Organization of the United Nations (FAO), 2022; Sowell et al., 2023; Zereyesus et al., 2022). As a result, the food import bill for SSA was projected to have reached a record high in 2022 of $4.8 billion (FAO, 2022). High fertilizer prices were also projected to double the global import bill for fertilizers from levels reported in 2020 (FAO, 2022). The stabilization of global commodity prices will continue to be an important factor for improving food security outcomes in SSA. Despite lingering effects from the COVID-19 pandemic and Russia's military invasion of Ukraine, there are signs of modest improvements in 2023. The commodity price outlook is expected to improve over the next 10 years as the inflation-adjusted domestic prices of major grains in most countries in the SSA region are projected to decline between 2023 and 2033 (appendix D). The projected reduction in food prices will in turn help reduce the prevalence of food insecurity in the SSA region, as more consumers are able to access and purchase adequate quantities of food.

In addition to food price inflation, food insecure people in SSA are increasingly facing abnormal occurrences of natural disasters and changing weather patterns related to climate change, such as droughts, floods, and heat waves. For example, the Horn of Africa ended 2022 with its longest drought on record (Famine Early Warning Systems Network (FEWS NET), 2023a). In general, SSA is considered the most vulnerable among the world's major regions to threats of food insecurity from climate and weather-related shocks. The bulk of food production in the region relies on rain-fed agriculture. The SSA region has continued to experience changing seasonal rainfall patterns and increased occurrences of flooding and prolonged droughts. The region experiences one-third of global droughts (International Monetary Fund (IMF), 2022) and is projected to be the hardest hit by climate change, impacting the region's heavily the agricultural productivity of crops and livestock systems (Challinor et al., 2014; Trisos et al., 2022).

Conflict risks also remain a source of acute food insecurity in SSA, with much of the affected population residing in countries facing increased frequencies of organized violence and armed conflict. Unlike weather-induced price variability, which tends to dissipate within a few months, violence-induced food price effects often extend over several years (Okou et al., 2022). The combined impacts of higher fertilizer prices, uncertain rainfall patterns, and natural disasters from climate change are likely to reduce agricultural productivity and output in the region. This productivity reduction will likely increase the already high food import dependency among many SSA countries.

The prevalence of food insecurity in SSA varies widely across countries and sub-regions, depending on the presence of these and other drivers and their frequency of occurrence. Most countries in the Central Africa (CAF) sub-region experience some of the highest food insecurity prevalence rates in SSA, ranging from 47.6 percent in the Democratic Republic of the Congo (DRC) to 85.2 percent in Burundi. Cameroon, with a

[16] Examples include the Democratic Republic of the Congo, Niger, and Togo (appendix C).

relatively low projected food insecurity prevalence of 21.5 percent in 2023, remains the sole exception (table 4). Many countries in the CAF sub-region are heavily reliant on food imports and earn much of their export revenue and foreign exchange from natural resource exports. The terms of trade among affected countries typically favor food imports during times of global price booms in their main export commodity and this food import dependency results in domestic food prices being highly sensitive to global price changes (Okou et al., 2022). A 2022 USDA, ERS research report showed that the dependence on oil export revenue and the drop in global oil prices in March and April 2020 may have led to a decline in the consumption and imports of rice, wheat, and poultry in SSA during the COVID-19 pandemic. Such a decline in consumption and imports is—in part—due to depreciating exchange rates resulting from the over reliance on single commodity exports for foreign exchange (Gerval & Hansen, 2022). Current global commodity price trends will likely continue to be important for food security in the CAF sub-region.

Aside from food import dependency, long, drawn-out internal conflicts also drive food insecurity rates higher in the CAF sub-region. In particular, the armed conflict in the DRC continues to affect the food insecurity status of millions of people in the region (WFP & FAO, 2022). In 2023, 53.2 million people in the DRC are estimated to be food insecure. Although this number is an improvement over the estimated 86.3 million food insecure people in 2022, the country continues to face persistent food insecurity challenges. The CAF sub-region has the highest daily per capita food gap in SSA (580 kcal per capita per day), with the intensity of food insecurity the greatest in Burundi (638 kcal per capita per day) and the DRC (615 kcal per capita per day). Furthermore, DRC is projected to account for more than half of the food insecure population in CAF in 2033 (table 4).

In the East Africa (EAF) sub-region, South Sudan and Somalia have the highest rates of food insecurity, with expected 2023 food insecurity shares of 81.1 percent and 85.7 percent, respectively (table 4). This number is due in part to protracted internal conflicts in these countries (WFP & FAO, 2022). The prolonged drought in the Horn of Africa (Ethiopia, Kenya, and Somalia), the fifth consecutive season of drought, has also further exacerbated food insecurity in EAF (FEWS NET, 2023). Somalia is particularly vulnerable given the dual presence of an armed conflict and an already-high food insecurity prevalence rate of 88.5 percent in 2022 and a food gap nearing 700 kcal per capita per day on average between 2020 and 2022, the highest of all IFSA countries (appendix B). In 2023, the food gap is estimated to rise even further to 747 kcal per capita per day (table 4) and the country faces a high risk of famine during the year (FEWS NET, 2022; World Bank, 2022). However, despite the drought, both Ethiopia and Kenya are projected to maintain steady growth rates in per capita GDP to 2033, growing at about 3.2 and 3.0 percent per year (close to the 3.2 and 3.4 percent average growth rates reported between 2020 and 2022), respectively (appendix C). Sudan's projected food insecurity improvements in 2023 (relative to 2022) are largely due to falling domestic food prices, following a period of rapid food price inflation (appendix D). However, Sudan's food insecurity needs have since increased in the near term due to an emerging conflict which began in April 2023, after IFSA estimations were completed (FEWS NET, 2023b).

Although the EAF sub-region has the second lowest average per capita GDP among SSA's sub-regions, average inflation-adjusted per capita GDP in EAF is projected to increase from $1,096 in 2023 to $1,419 in 2033 (table 5). This nearly 30-percent projected increase in average per capita GDP is expected to lead to substantial improvements in food security over the next decade. For example, Rwanda's per capita GDP is projected to grow by 5.8 percent per year, on average, over the next 10 years, which is projected to result in a large decline in the prevalence of food insecurity in the country from 41.0 percent in 2023 to 3.6 percent in 2033 (table 4, appendix C). Similarly, the per capita food gap is projected to be almost halved over the same period, from 412 to 238 kcal per day. Overall, per capita incomes in EAF are projected to grow faster, on average, relative to other sub-regions in SSA. This projected growth is partially due to the performance of larger domestic economies that have an active trading environment in the sub-region (such as Ethiopia,

Kenya, and Tanzania), which are all projected to maintain average annual per capita GDP growth rates above 3.0 percent (appendix C). These three countries accounted for 60.7 percent of the total GDP among all IFSA countries in the EAF sub-region (averaged between 2020 and 2022) and are projected to increase their share to 64.9 percent in 2033. These countries also represent more than half of the total number of estimated food insecure people in the EAF sub-region in 2023 (table 4). Therefore, the expected growth among these three larger economies is a major contributor to a projected decline in the prevalence of food insecurity in EAF, from 47.3 percent in 2023 to 15.2 percent in 2033 (table 4).

The Southern Africa (SAF) sub-region of SSA has the highest food insecurity prevalence of SSA's major sub-regions, with 51.8 percent of its regional population estimated to be food insecure in 2023 (table 4). Mozambique leads the SAF sub-region in terms of the estimated number of food insecure people, with 20.1 million in 2023, followed by Angola (15.9 million), Zimbabwe (11.2 million), and Zambia (10.8 million) (table 4). Countries in the SAF sub-region also have some of the highest food gaps in SSA with an average food gap in 2023 of 503 kcal per capita per day, behind only the CAF sub-region (table 4). The sub-region has been facing an increasing frequency of natural disasters from cyclones and flooding, especially in Mozambique and Malawi (as in Madagascar in the EAF region) (WFP & FAO, 2022). The northern areas of Mozambique have also seen an increase in organized violence by extremist groups, which is partially contributing to the country's higher estimated food insecurity prevalence of 62.0 percent in 2023 and a food gap of 537 kcal per capita per day (WFP & FAO, 2022). The highest prevalence of food insecurity in the sub-region is in Zimbabwe, with an estimated 72.8 percent of the population being food insecure in 2023 (table 4). Macroeconomic instability in Zimbabwe has been a key driver of rising food insecurity by fueling some of the highest rates of food price inflation in the world. For example, the food component of the Consumer Price Index (CPI) in Zimbabwe rose by more than 300 percent in 2022 (World Bank, 2022). Zimbabwe is projected to experience a 41.8 percent annual growth rate in its CPI in 2023 relative to 2022 and is projected to see little progress in reducing its prevalence of food insecurity over the next 10 years. Both Zimbabwe and Zambia are estimated to have a daily per capita food gap of nearly 600 calories per day in 2023 (table 4).

Among all the sub-regions in SSA, the West Africa (WAF) sub-region is the most food secure. An estimated 29.1 percent of the population is estimated to remain food insecure in 2023 (table 3), with 59.2 percent (75.5 million people) of the food insecure population of WAF residing in Nigeria, the most populous country in the sub-region (table 4). Armed conflict by extremist groups in the Sahel region of WAF continues to displace people and threaten economic livelihoods in areas most affected by the violence. For example, in northern Nigeria, the Boko Haram insurgency continues to disrupt local economic livelihoods and increase the number of food insecure people in the region (FEWS NET, 2022). The conflict, which began more than a decade ago, has also since spilled over into neighboring areas of southern Niger and northern Cameroon. A similar rise of violence and armed conflicts by extremist groups in parts of Burkina Faso and Mali has also been occurring, which has resulted in a growing prevalence of acute food insecurity among affected communities.

Table 4

Food security results in the Sub-Saharan Africa region, 2023 and 2033

Region/sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
Sub-Saharan Africa	**Region total**	**1,167.4**	**1,502.8**	**481.2**	**239.5**	**41.2**	**15.9**	**468**	**380**
Central Africa	**Sub-region total**	**185.5**	**247.8**	**90.5**	**63.1**	**48.8**	**25.5**	**580**	**451**
	Burundi	13.2	17.4	11.2	11.2	85.2	64.4	638	482
	Cameroon	30.1	39.2	6.5	4.0	21.5	10.2	304	257
	Central African Republic	6.2	7.3	4.7	2.3	76.2	31.0	572	350
	Chad	18.5	24.8	10.9	8.9	59.1	35.7	559	443
	Congo	5.7	7.1	4.0	1.9	69.7	27.3	465	295
	Democratic Republic of the Congo	111.9	152.0	53.2	34.8	47.6	22.9	615	480
East Africa	**Sub-region total**	**413.5**	**523.8**	**195.5**	**79.8**	**47.3**	**15.2**	**470**	**365**
	Djibouti	1.0	1.2	0.2	0.0	20.2	3.0	318	225
	Eritrea	6.3	7.1	4.3	1.4	68.4	19.4	473	277
	Ethiopia	116.5	145.8	42.1	7.0	36.2	4.8	348	219
	Kenya	57.1	69.4	31.2	6.4	54.8	9.2	407	236
	Madagascar	28.9	35.3	20.4	14.5	70.8	41.0	519	377
	Rwanda	13.4	15.7	5.5	0.6	41.0	3.6	412	238
	Somalia	18.1	24.3	15.5	15.2	85.7	62.7	747	555
	South Sudan	11.1	13.3	9.0	3.1	81.1	23.6	630	332
	Sudan	49.2	63.6	11.4	6.5	23.1	10.2	330	274
	Tanzania	64.3	83.6	27.4	10.4	42.6	12.5	496	350
	Uganda	47.7	64.7	28.4	14.6	59.6	22.6	524	356
Southern Africa	**Sub-region total**	**131.1**	**169.6**	**67.9**	**50.8**	**51.8**	**29.9**	**503**	**410**
	Angola	36.0	50.0	15.9	17.2	44.2	34.5	414	374
	Eswatini	1.1	1.2	0.4	0.1	31.0	9.5	307	229
	Lesotho	2.1	2.2	1.2	0.3	56.2	12.4	427	259
	Malawi	22.1	27.2	7.2	0.6	32.6	2.1	378	222
	Mozambique	32.5	42.0	20.1	15.8	62.0	37.7	537	420
	Namibia	2.8	3.3	1.1	0.4	38.3	10.6	308	217
	Zambia	19.1	25.1	10.8	7.4	56.6	29.6	593	453
	Zimbabwe	15.4	18.6	11.2	9.0	72.8	48.1	593	454

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Region/sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
West Africa	**Sub-region total**	**437.3**	**561.5**	**127.4**	**45.9**	**29.1**	**8.2**	**367**	**277**
	Benin	14.2	19.6	3.2	0.8	22.2	4.0	326	235
	Burkina Faso	22.5	28.0	8.0	2.7	35.8	9.6	483	347
	Cabo Verde	0.6	0.7	0.1	0.0	19.4	2.4	277	192
	Cote d'Ivoire	29.4	36.0	6.4	2.2	21.9	6.2	407	316
	Gambia	2.3	2.9	0.5	0.1	19.9	2.7	289	202
	Ghana	31.7	38.8	3.3	0.4	10.5	1.1	258	188
	Guinea	13.6	17.8	2.7	1.4	20.0	7.7	345	283
	Guinea-Bissau	2.1	2.7	1.0	0.7	48.7	26.9	408	325
	Liberia	5.5	7.2	2.9	1.4	51.8	19.5	577	412
	Mali	21.4	28.3	5.2	1.7	24.4	6.0	345	257
	Mauritania	4.3	5.1	0.7	0.1	16.2	2.6	302	221
	Niger	25.4	36.4	8.1	1.6	31.8	4.4	425	280
	Nigeria	230.9	296.2	75.5	29.6	32.7	10.0	346	256
	Senegal	17.1	21.4	3.5	0.6	20.5	2.6	271	188
	Sierra Leone	7.2	8.8	3.4	2.3	48.0	26.0	512	409
	Togo	9.3	11.7	2.9	0.4	31.6	3.2	342	214

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

Table 5

Inflation-adjusted per capita Gross Domestic Product (GDP) in the Sub-Saharan Africa region, 2023 and 2033

Region/sub-region	2020–2022 (average)	2023	2033	Annual growth rate	
				(2022–2023)	(2023–2033)
	U.S. dollars, 2015			Percent	
Sub-Saharan Africa	**1,345**	**1,375**	**1,607**	**1.2**	**1.6**
Central Africa	621	639	767	1.8	1.8
Eastern Africa	1,053	1,096	1,419	2.3	2.6
Southern Africa	1,560	1,569	1,721	0.7	0.9
Western Africa	1,862	1,894	2,118	0.8	1.1

Note: Values are expressed in 2015 U.S. dollars. Regions include only countries that are covered by the International Food Security Assessment. For full country statistics, see appendix C.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

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Middle East and North Africa

The Middle East and North Africa (MENA) region is one of the most food secure of the five International Food Security Assessment (IFSA) regions, with an estimated food insecurity prevalence of 17.4 percent in 2023. The region is estimated to have an inflation-adjusted per capita GDP of $3,834 in 2023, with an annual average per capita GDP growth rate of 2.4 percent over the next 10 years. Population growth over the same period is expected to be low at a 1.1 percent annual growth rate, resulting in higher per capita incomes of $4,843 in 2033 (table 7). The income improvements and a slower population growth rate are anticipated to lead to further improvements in MENA's food security. By 2033, 7.5 percent of the region's population is projected to be food insecure (table 6).

A key challenge for ensuring food security in the MENA region is the region's high reliance on food imports, and—therefore—a high exposure to global price shocks, such as the recent spike in global food and fertilizer prices. While most IFSA countries in the North Africa (NAF) sub-region have largely remained food secure during the crisis (such as Algeria, Morocco, and Tunisia) Egypt has faced more persistent challenges in reducing its higher rates of food insecurity. Egypt has an estimated food insecurity prevalence of 16.4 percent and an estimated food insecure population of 18 million in 2023 (table 6). This number is partially due to the country's heavy reliance on wheat imports, which is driven by the combined effects of high bread consumption, limited domestic wheat production, and domestic consumption support policies that subsidize the cost of bread (Zereyesus et al., 2022). Egypt is the world's largest wheat importer and the majority of Egyptian imports are supplied from Ukraine and Russia. The spike in international wheat prices and the disruption of Ukrainian wheat shipments to Egypt (following Russia's military invasion of Ukraine in February 2022) increased food insecurity in Egypt. This disruption has since been eased following the Black Sea Grain Initiative in July 2022, which facilitated safe passage of grain exports from Ukraine (Sowell et al., 2023)—in addition to Egypt's own immediate response of releasing its grain reserves, maintaining its consumer subsidy, and depreciating its currency—to limit the transmission of global prices in domestic markets and preserve foreign exchange reserves (Abay et al., 2022; FAO, 2022). These policies have contributed to Egypt's first expected decline in food insecurity prevalence following 2 consecutive years of food insecurity increases (Baquedano et al., 2021; Zereyesus et al., 2022) but comes at a great cost to the country's fiscal outlays.

In the Middle East sub-region, the food security outlook remains more mixed, in part, due to protracted armed conflicts in Syria and Yemen. Both countries are estimated to have the highest prevalence of food insecurity in the MENA region in 2023: 81.8 percent in Yemen and 20.0 percent in Syria. Both countries also make up almost half of the total estimated food insecure population across all IFSA countries in the MENA region (table 6). Syria's food security remains impacted by its continued internal conflict, which began in 2011 and has displaced more than 12 million people, both within and outside the country (World Food Programme of the United Nations (WFP), 2021). Inflation also continues to be a driver of food insecurity in Syria, with a CPI annual growth rate of 132.1 percent over the 2020–22 period (appendix D). In northern and western Syria, acute food assistance needs have more recently been further exacerbated by magnitude 7.8 and 7.5 earthquakes that struck in February 2023, although these events happened after IFSA estimations were completed (Gunasekera et al., 2023). Yemen faces an even more severe food insecurity situation. With 81.8 percent of its 31.6 million people estimated to be food insecure in 2023, Yemen is the most food insecure of the 8 countries included in IFSA's MENA region and one of the most food insecure in the total sample of IFSA countries. Yemen also has some of the lowest per capita income levels and highest food gaps with its estimated per capita income at an inflation-adjusted $512 and its estimated food gap is at more than 600 kcal per capita per day in 2023 (table 6). The elevated food insecurity situation in Yemen continues to be driven by its prolonged internal conflict, which has disrupted livelihoods and deteriorated an already weak economy (Famine Early Warning Systems Network (FEWS NET), 2022). According to the Food and Agriculture Organization of the United Nations (FAO), acute levels of food insecurity and malnutrition have

continued to increase, with an estimated 19 million people in need of emergency food assistance in 2022 (FAO, 2022).

Price inflation has also been a key factor driving the food insecurity situation in some countries in the MENA region. Lebanon has been experiencing substantial inflation, with an overall CPI annual growth rate of 176.5 percent over the 2020–22 period (appendix D). At the same time, the rapidly declining purchasing power of the Lebanese pound is making imports of food products more costly as the real exchange rate of the Lebanese pound relative to the U.S. dollar is expected to decline by more than 30 percent in 2023 relative to 2022 (appendix D). Lebanon also has one of the highest per capita refugee populations in the world, mostly due to the ongoing conflict in Syria, which has increased its food assistance needs (WFP, 2017).

Table 6
Food Security results in the Middle East and North Africa region, 2023 and 2033

Region/sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
Middle East and North Africa	**Region total**	**350.1**	**390.8**	**60.9**	**29.2**	**17.4**	**7.5**	**425**	**357**
Middle East	**Sub-region total**	**147.5**	**164.8**	**34.0**	**21.3**	**23.1**	**12.9**	**520**	**397**
	Iran	87.6	94.4	2.5	0.0	2.9	0.0	204	134
	Lebanon	5.3	5.6	1.0	0.4	19.3	7.6	277	228
	Syria	22.9	27.4	4.6	1.8	20.0	6.7	279	223
	Yemen	31.6	37.3	25.9	19.0	81.8	51.0	603	418
North Africa	**Sub-region total**	**202.6**	**226.0**	**26.9**	**7.9**	**13.3**	**3.5**	**305**	**250**
	Algeria	44.8	49.6	3.6	0.6	8.1	1.1	262	202
	Egypt	109.3	124.5	18.0	6.5	16.4	5.2	320	259
	Morocco	36.6	39.4	4.3	0.7	11.9	1.9	290	220
	Tunisia	12.0	12.5	1.0	0.1	8.1	0.9	254	191

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

Table 7
Inflation-adjusted per capita Gross Domestic Product (GDP) in the Middle East and North Africa region, 2023 and 2033

Region/sub-region	2020–2022 (average)	2023	2033	Annual growth rate	
				(2022–2023)	(2023–2033)
	U.S. dollars, 2015			Percent	
Middle East and North Africa	**3,595**	**3,834**	**4,843**	**4.0**	**2.4**
Middle East	3,224	3,506	4,260	6.1	2.0
North Africa	3,862	4,074	5,268	2.8	2.6

Note: Values are expressed in 2015 U.S. dollars. Regions include only countries that covered by the International Food Security Assessment. For full country statistics, see appendix C.
Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

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Former Soviet Union

The Former Soviet Union (FSU) region is one of the most important regions for global food supply. The ongoing Russian military invasion of Ukraine threatens the supply of major food commodities from the Black Sea region. In 2023, food supply from Ukraine is expected to be below the average level in recent years due to reduced planting area and uncertainty in the exportability of grains from storage in Ukraine (Agricultural Market Information System (AMIS), 2023; USDA, Office of the Chief Economist (OCE), 2023). In 2023, the estimated prevalence of food insecurity in the FSU region is 15.2 percent (17.8 million people), ranging from 3.7 percent in Azerbaijan to 39.4 percent in Tajikistan. Among the FSU countries covered in the IFSA report, Armenia, Azerbaijan, Kyrgyzstan, Moldova, and Uzbekistan are estimated to have under 10.0 percent of their populations considered food insecure in 2023 (table 8).

The population in the FSU region is projected to grow at annual rate of 0.2 percent, from 117.3 million in 2023 to 119.5 million by 2033, the lowest regional growth in the IFSA assessment (table 8). The per capita FSU Gross Domestic Product (GDP) is projected to grow at annual rate of 4.7 percent from $3,095 in 2023 to $4,885 by 2033 (table 9). Higher incomes, declining populations, and stable food commodity prices are expected to lead to significant improvements in food security in the region. By 2033, the FSU region is projected to have the lowest food insecurity rate among the five IFSA regions, with 1.2 percent of the population in the region unable to consume the 2,100 kcal per day and an average food gap of 256 kcal per capita per day (table 8).

Ukraine is estimated to have the highest number of food insecure people in the region in 2023, due to disruptions in agricultural production and reduced economic activity associated with the ongoing conflict. More than 9.4 million people (21.7 percent of the population) in Ukraine are estimated to be food insecure in 2023 (table 8). Between 2020 and 2022, the per capita GDP of Ukraine contracted by nearly 25.0 percent as it was heavily affected by the Russian military invasion of the country in February 2022. The invasion led to population displacement, including farmers being unable to access their farming fields or market their crops and livestock products (Food and Agriculture Organization of the United Nations (FAO), 2022). The 2023 wheat production is expected to be lower than the 2022 level by 18.6 percent, and Ukraine's supply of grain to the global market is also forecasted to remain below the pre-war levels (USDA, 2023). Access to farms is important for food security because agriculture is the primary income source for around 13 million Ukrainians (FAO, 2022).

Despite the geopolitical challenges that Ukraine is currently facing, its economic prospects in the long run seem relatively better. Ukrainian per capita GDP is projected to grow by an average annual growth rate of 9.6 percent in the next 10 years, the highest growth rate among the countries included in the assessment (appendix C). As a major food supplier in the region, growth in food supply from Ukraine is projected to have a positive spillover effect in the food security prospects of the countries in the FSU region.

Tajikistan is estimated to have the highest share of its population considered food insecure among the FSU countries. In 2023, 39.4 percent of the population in Tajikistan (3.7 million people) are estimated to be food insecure (table 8). Despite the progress achieved in the country over the last decade, the food insecurity rate in Tajikistan remains among the highest in the FSU region (WFP, 2023). With only 7 percent of the country's land arable for cultivation, extreme weather events and damage to the environment regularly destroy crops, land, and the general livelihood of the Tajikistan population (WFP, 2023). Because the country is heavily dependent on imports to cover food needs, disruptions to agricultural markets and global price surges have a negative impact on the country, in addition to the impact of the war in Ukraine (World Bank, 2022). Tajikistan is also dependent on foreign aid, loans, and remittances from migrant workers with the

latter accounting for about 30 percent of rural households' income (United States Agency for International Development (USAID), 2023).

Table 8
Food Security results in the Former Soviet Union region, 2023 and 2033

Region/sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
Former Soviet Union	**Region total**	**117.3**	**119.5**	**17.8**	**1.4**	**15.2**	**1.2**	**258**	**256**
Former Soviet Union	Armenia	3.0	2.8	0.2	0.0	6.1	0.1	196	124
	Azerbaijan	10.4	11.0	0.4	0.0	3.7	0.3	167	128
	Georgia	4.9	4.9	0.5	0.0	10.2	0.4	232	155
	Kyrgyzstan	6.1	6.6	0.6	0.1	9.7	0.9	230	166
	Moldova	3.3	2.9	0.3	0.0	8.1	0.0	189	107
	Tajikistan	9.3	10.5	3.7	1.2	39.4	11.8	383	273
	Turkmenistan	5.7	6.2	0.6	0.0	10.3	0.7	224	157
	Ukraine	43.3	41.2	9.4	0.0	21.7	0.0	235	98
	Uzbekistan	31.4	33.5	2.3	0.0	7.2	0.1	202	127

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

Table 9
Inflation-adjusted per capita Gross Domestic Product (GDP) in the Former Soviet Union region, 2023 and 2033

Region/sub-region	2020–2022 (average)	2023	2033	Annual growth rate	
				(2022–2023)	(2023–2033)
	U.S. dollars, 2015			Percent	
Former Soviet Union	**3,037**	**3,095**	**4,885**	**7.9**	**4.7**

Note: Values are expressed in 2015 U.S. dollars. Regions include only countries that covered by the International Food Security Assessment. For full country statistics, see appendix C.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

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Asia

A solid harvest season in India, recovery from the swine flu epidemic, and the use of subsidies by many governments in Asia to alleviate the shock from high global oil prices have kept inflation relatively lower in the Asia region compared with other parts of the world (International Monetary Fund (IMF), 2022). Nevertheless, global supply chain disruptions following the Coronavirus (COVID-19) pandemic and widespread inflation posed challenges to combating food insecurity in 2022, which is expected to remain high in 2023 relative to pre-pandemic levels. In 2023, the prevalence of food insecurity in the Asia region is estimated at 21.8 percent, which translates to a total population of 537.3 million people unable to consume 2,100 kilocalories per day (table 10). The estimated prevalence of food insecurity in 2023 ranges from a high of 79.1 percent in Afghanistan to a low of 7.9 percent in Vietnam (table 10).

The per capita Gross Domestic Product (GDP) in 2023 for each of the countries in Asia included in the assessment is estimated to be higher from Asia's 2022 values (except for Afghanistan), with a regional average per capita GDP of $2,440 in 2023, reflecting estimated growth of 4.7 percent over the 2022 estimate (table 10). Despite the overall projected economic progress in the Asia region, both Afghanistan (58.2 percent) and the Democratic People's Republic of Korea (47.9 percent) are projected to have a significant proportion of their population considered food insecure in 2033 (table 10).

Although the short-term food security situation in the Asia region is estimated to improve relative to 2022, the lingering impact of COVID-19, worsening global economic conditions, and the high food and energy prices observed in 2021 and 2022 compounded by the effects of the war in Ukraine will all pose a challenge to the speed of Asia's economic recoveries (Asian Development Bank (ADB), 2022; Zereyesus et al., 2022; Bhowmick, 2023). Russia's military invasion of Ukraine poses a threat to the 2023 global commodity supply due to a reduction in planting area and uncertainty in the exportability of stored grains in Ukraine (AMIS, 2023). The difficulty in transporting agricultural products goes beyond Ukraine and affects global availability and prices of food items (Food and Agriculture Organization of the United Nations (FAO), 2022). The spike in global commodity prices due to the war lasted for several months, thereby propelling inflation higher in the Asia region (IMF, 2022). The impact of the Russian military invasion of Ukraine is expected to persist as Ukraine is one of the major suppliers of commodities to the global market and the war has damaged agricultural lands, farm machinery and equipment, crops, livestock, and storage facilities (FAO, 2022).

In addition, the global energy crisis (intensified by the war in Ukraine) is expected to impact several nations in the Asia region, leading to food security concerns because of a spike in fuel prices (Bhowmick, 2023). While many countries have policies to support vulnerable households, these supports may not be able to offset the direct impact of inflation on household income (IMF, 2022), leading to an increase in poverty. The average food gap for the Asia region in 2023 is estimated to be 316 kcal per capita per day (table 10).

Spikes in global food prices imply that lower income households spend more of their disposable income on food or the households reduce the amount of food purchased. Income will continue to be a major driver of the region's food security situation. Growth forecasts for low- and middle- income countries in the Asia region are lower due to the uncertainty of the global economy (ADB, 2022). Afghanistan and Sri Lanka are estimated to be adversely affected by the hike in food prices amidst their worsening economies. In 2023, Afghanistan is estimated to have the highest prevalence of food insecurity in the Asia region, with 79.1 percent (31.0 million people) of its population estimated to be food insecure in 2023 (table 10). The country is currently included in the World Food Programme (WFP) and Food and Agriculture Organization of the United Nations' (FAO) highest alert risk level of food security deteriorating to catastrophic conditions (WFP & FAO, 2022).

The South Asia sub-region, which includes India, has the highest number of food insecure people in Asia with 22.9 percent of the population estimated to be food insecure in 2023, totaling 426.5 million people (table 10). Because of the high population of India that is classified as food insecure, the South Asia sub-region is estimated to account for 79.3 percent of the people classified as food insecure in the Asia region in 2023 and 37.5 percent of the total population of food insecure people covered by the IFSA report (table 10).

Several government interventions are in place to combat food insecurity across India. Currently, India's Government has one of the largest food-based safety nets that reaches about 1.0 billion vulnerable people monthly (WFP, 2023a). Monthly grain distribution during the pandemic has continued and is authorized until the end of 2023, under the National Food Security Act (NFSA). Food distribution has been reported to reduce income inequality in India (State Bank of India Research, 2023), thereby reducing the severity of food insecurity. Despite the relative improvements in food security, 18.8 percent of India's population (about 253.7 million people) is estimated to be food insecure in 2023 (table 10).

Extreme weather poses a significant risk to food security globally, especially in the South Asia sub-region, including in Afghanistan, Pakistan, and India. Natural hazards from weather events, including La Niña and El Niño, are impacting agricultural activities thereby reducing food availability through crop and livestock losses (WFP & FAO, 2022). The combination of extreme weather events and the ongoing Russian military invasion of Ukraine also led to changes in trade policies across countries, including bans, taxes, and quota restrictions on the export and import of agricultural products, thereby affecting food availability. The rise in the domestic price of rice in India led to the introduction of an export tax on broken rice by India's Government in September 2022 to prevent rising prices in the poultry sector in which broken rice is used as feedstock[17] (Government of India, 2022). Prices of commodities are also projected to increase sharply, due to the risk of export bans on main staples like wheat from Kazakhstan, Pakistan, and Tajikistan to Afghanistan (Integrated Food Security Phase Classification (IPC), 2022).

Pakistan is another important contributor to the high number of food insecure people in the South Asia sub-region, with 103.0 million people estimated to be food insecure in 2023 (table 10). In 2022, after a shortage of water due to drought, an unprecedented flood in Pakistan led to the destruction of farmlands, the displacement of millions of citizens, and caused $15.2 billion in economic damages, which pushed between 8.4 to 9.1 million people below the poverty line (World Bank, 2022). Per capita GDP in Pakistan is estimated to grow 1.0 percent in 2023, relative to 2022, the second lowest in the Asia region and below the South Asia sub-regional average of 4.8 percent (appendix C).

In the last 2 years, Sri Lanka has also had significant food security challenges and is estimated to have 25.3 percent of its population considered food insecure in 2023, a 31.1-percent increase from the 2022 estimate (table 10; appendix B). The food crisis is likely to worsen amid ongoing economic problems, food price inflation, and poor agricultural production (FAO & WFP, 2022). Sri Lanka is a predominantly agriculture-based economy, with about 30.0 percent of its population employed in agriculture and about 80.0 percent of food producers in the country practicing on a small scale (Gunaratne et al., 2021). The severe macroeconomic crisis has led to acute shortages of major agricultural inputs like fertilizer, thereby significantly impacting the production of major food crops like paddy rice, maize, vegetables, fruits, and other export-oriented crops (FAO & WFP, 2022). Prices of food items have steadily risen since 2021, mostly due to the worst economic crisis Sri Lanka has faced since 1948 as the country is unable to pay import bills for food, gas, and other essential imported commodities (Relief Web, 2022). Price spikes for major food staples contributed to a political crisis in 2022 and these spikes are expected to continue throughout 2023. Along with high food inflation and severe macroeconomic crisis, rising temperatures and extreme heat are major threats to food security in

[17] About 60–65 percent of input cost for poultry feed in India comes from broken rice (Government of India, 2022)

Sri Lanka because of the potential impact on agricultural yields. About 80 percent of land in Sri Lanka faces frequent water shortages (WFP, 2023b). In 2022, the Government of Sri Lanka introduced its National Food Security Programme, which allocates 10,000 Sri Lankan Rupee (LKR) per food-insecure family (equivalent to $27.27 per family), as well as providing 400 million LKR ($1.1 million) towards seeds and planting materials for farmers, and 40 billion LKR ($110 million) for fertilizer for rice cultivation (Wanigasinghe, 2022).

In the South East Asia (SEA) sub-region, Burma's food security situation continues to worsen compared with other countries in the sub-region with 22.9 percent of the population of Burma is estimated to be food insecure in 2023 (table 10). Major contributors to the food insecurity situation in Burma are conflict, inflation, international sanctions, and plunging crop yields (Bloomberg, 2022). Per capita GDP in Burma is estimated to grow by 1.5 percent in 2023 relative to 2022, far below the SEA sub-regional average of 4.6 percent (appendix C).

Almost half of the SEA sub-region's 575.8 million population live in Indonesia. The country's food insecure population is projected to decline from 44.6 million (16.3 percent) in 2023 to 5.6 million (1.9 percent) in 2033, driving the significant improvement in food security projections in the SEA subregion.

In the East Asia sub-region, the Democratic People's Republic of Korea (DPRK) is estimated to have the highest number of food insecure people, with 59.8 percent of its population considered food insecure in 2023 (table 10). Major threats to food security in the DPRK are economic constraints and inconsistency in agricultural production due to lack of inputs, harsh weather patterns, low soil and fertilizer quality, and outdated machinery (FAO, 2023). In the DPRK, the agriculture sector employs about 36.0 percent of the workforce and generates about 20.0 percent of the GDP (FAO, 2023).

Table 10
Food Security results in the Asia region, 2023 and 2033

Region/ sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
Asia	**Region total**	**2,466.8**	**2,690.6**	**537.3**	**102.4**	**21.8**	**3.8**	**316**	**293**
East Asia	**Sub-region total**	**29.4**	**30.1**	**16.2**	**12.8**	**55.1**	**42.4**	**424**	**379**
	Democratic People's Republic of Korea	26.2	26.6	15.6	12.7	59.8	47.9	430	379
	Mongolia	3.3	3.5	0.6	0.0	17.2	0.7	279	175

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Region/ sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
South Asia	**Sub-region total**	**1,861.7**	**2,033.7**	**426.5**	**71.5**	**22.9**	**3.5**	**316**	**294**
	Afghanistan	39.3	48.3	31.0	28.1	79.1	58.2	509	394
	Bangladesh	167.3	181.7	28.5	5.8	17.0	3.2	268	200
	India	1,353.2	1,451.4	253.7	10.5	18.8	0.7	265	163
	Nepal	31.0	33.0	4.4	0.1	14.1	0.4	257	159
	Pakistan	247.7	294.8	103.0	25.7	41.6	8.7	403	266
	Sri Lanka	23.3	24.6	5.9	1.1	25.3	4.6	277	195
South East Asia	**Sub-region total**	**575.8**	**626.8**	**94.7**	**18.1**	**16.4**	**2.9**	**294**	**228**
	Cambodia	17.5	19.1	3.1	0.2	17.7	1.3	280	185
	Indonesia	274.3	292.8	44.6	5.6	16.3	1.9	284	201
	Laos	7.8	8.7	1.7	0.3	21.8	3.3	266	186
	Burma	58.0	61.8	13.3	5.1	22.9	8.2	300	239
	Philippines	115.7	133.7	23.9	6.6	20.7	4.9	330	249
	Vietnam	102.5	110.7	8.1	0.3	7.9	0.3	253	171

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

Table 11

Inflation-adjusted per capita Gross Domestic Product (GDP) in the Asia region, 2023 and 2033

Region/sub-region	2020–2022 (average)	2023	2033	Annual growth rate	
				(2022–2023)	(2023–2033)
	U.S. dollars, 2015			Percent	
Asia	**2,225**	**2,440**	**3,821**	**4.7**	**4.6**
East Asia	1,454	1,518	1,934	2.1	2.5
South Asia	1,916	2,116	3,385	4.8	4.8
South East Asia	3,266	3,533	5,325	4.6	4.2

Note: Values are expressed in 2015 U.S. dollars. Regions include only countries that covered by the International Food Security Assessment. For full country statistics, see appendix C.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

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Latin America and the Caribbean

Food insecurity differs across countries in the Latin America and Caribbean (LAC) region due to their economic conditions, food production, and government policies to benefit vulnerable populations. Some of the significant developments in 2022—including advances in the region's economic recovery, high prices of food commodities, a high degree of labor informality, and any recurrence of the Coronavirus (COVID-19)—remain influential to the LAC 2023 economic outlook. Countries with significant informal sector economies and with large shares of the population lacking formal occupations are more vulnerable to low-income and food insecurity conditions. Other key drivers of food insecurity in the LAC region include migration, conflicts, and extreme weather events, which have the potential to reduce incomes, agricultural production, and food availability. The prevalence of food insecurity in all countries in the LAC region is estimated to decline from 2022 with a regional average prevalence of food insecurity of 22.6 percent in 2023. The estimated prevalence of food insecurity for 2023 ranges from a high of 60.8 percent in Haiti to a low of 8.0 percent in the Dominican Republic (table 12).

Over the coming 10 years, food insecurity in the LAC region is projected to fall to 6.9 percent in 2033. This reduction implies that the number of food insecure people in the region will decline from an estimated 40.3 million in 2023 to 13.3 million in 2033. The population of the LAC region in 2023 is estimated at 178.1 million and is projected to reach 191.9 million by 2033 (table 12).

Between 2020 and 2022, the economies of the LAC region rebounded from the Coronavirus (COVID-19) pandemic-induced Gross Domestic Product (GDP) contraction. The region benefitted from a surge in commodity prices driven by strong global demand and, as a result, the region's GDP grew by 7.0 percent in 2020–22 (appendix C). Countries leading this overall LAC region recovery include Colombia, Peru, and the Dominican Republic, which experienced better post-pandemic recovery than the rest of the LAC region and are projected to drive much of the regional growth through 2033. The growth of these countries is supported by stronger economies, investment, diversified agricultural exports, and tourism. For 2023, the GDP growth estimate for the LAC region is expected to slow to 2.9 percent due to a mix of continued inflationary pressures, restrictive fiscal and monetary policies that will impact domestic consumption, and slower demand for export commodities—all of which are creating significant headwinds in the short term. GDP in the LAC region is projected to grow at a subdued pace between 2023 and 2033, averaging 3.5 percent per year—one of the lowest among the five IFSA regions (appendix C). Per capita income is projected to reestablish growth rates that continue their pre-pandemic pattern and average 2.7 percent in 2023–2033, rising from $5,636 in 2023 to $7,364 in 2033 (table 13).

The economies of the Central America sub-region have been simultaneously affected by the COVID-19 pandemic and adverse weather-related shocks. Stronger storms, increased flooding, and landslides in 2022 led to partial losses of crop and livestock production, interruptions in services that affect supply chains, and reductions in agricultural exports. These events have exacerbated the dire economic and food insecurity conditions, especially of low-income, rural smallholders in the region. In 2023, 28.0 percent of the population in Central America is estimated to be food insecure, equivalent to 11.4 million people (table 12). The Central America sub-region has high under-employment conditions tied to a significant informal sector economy (World Bank, 2023b; Economic Commission for Latin America and the Caribbean (ECLAC), 2022) and has the lowest per capita GDP in the LAC region, estimated at $3,681 in 2023 (table 13). With a population of 40.5 million in 2023, the Central America sub-region is projected to have the fastest population growth rate in the LAC region (1.0 percent) in 2023–2033, but the lowest per capita GDP growth rate (2.1 percent) in the LAC region (table 13; appendix C).

Honduras' economy has partially rebounded from the COVID-19 pandemic and the detrimental impacts of Hurricanes Eta and Iota in 2020. Remittances have increased and the post-hurricane reconstruction of roads, infrastructure, and recovery of tree crops strengthened Honduras' agricultural exports, especially for bananas, coffee, and palm oil. Remittances are an important component of Honduras' economy, accounting for 25.3 percent of GDP and equivalent to the income of the lowest 40 percent of the population (World Bank, 2022). Real GDP growth is expected to decelerate in 2023, as COVID-19 pandemic support is phased out. For the 2023–2033 period, Honduras is projected to register a GDP growth rate of 3.4 percent per year (appendix C). Beginning in 2019, Honduras was able to expand its conditional cash transfer program to households living in extreme poverty in urban and rural areas with funding from the World Bank and the Inter-American Development Bank, which helped provide a social safety net during the COVID-19 pandemic (World Bank 2023a; Inter-American Development Bank (IADB), 2022). However, the country still faces high levels of poverty and food insecurity, with 26.8 percent of its population experiencing food insecurity in 2023 (table 12).

Prior to the COVID-19 pandemic, Guatemala was experiencing economic stability and higher real GDP growth rates compared with other economies in the Central America sub-region. Agriculture is one of Guatemala's largest economic sectors, and the participation of multinational companies in the sector ensured less disruptions to supply chains during the COVID-19 pandemic (United Nations Conference on Trade and Development (UNCTAD), 2011). Per capita GDP in Guatemala is also the highest in the Central America sub-region, which is estimated at $4,478 in 2023 and it is projected to grow to $5,590 in 2033. However, this economic growth has not translated into a narrowing of the income gap, as reflected by the Gini index of income inequality, which has remained above 0.48 for the past decade (World Bank, 2023b). Indigenous people make up more than half of Guatemala's population and are affected most by persistent income inequality and poverty (World Bank, 2023b). In 2023, 29.8 percent of Guatemala's population is estimated to be food insecure (table 12).

Nicaragua, Central America's smallest economy, is the second-highest food insecure country in the LAC region after Haiti. About 32.4 percent of Nicaragua's 6.4 million people are estimated to be food insecure in 2023 (table 12). Nicaragua's economy, which experienced a prolonged recession in 2018–20, was able to recover in 2021 to ultimately attain a 6.8 annual average GDP growth in 2020–22 (appendix C). The country's GDP is projected to grow 2.2 percent per year on average during the 2023–2033 period, driven by agricultural goods and remittances. Annual remittances account for about 15.3 percent of Nicaragua's GDP (World Bank, 2022).

The Caribbean sub-region, which includes the Dominican Republic, Haiti, and Jamaica for this assessment, is widely diverse in terms of economic performance, population, and the prevalence of food insecurity. Strong economic growth in the Dominican Republic and Jamaica drove an estimated 7.2 percent GDP growth in the sub-region between 2020–22. The sub-region has an estimated population of 25.1 million in 2023 and is projected to increase to 27.3 million by 2033. Nearly two-thirds of this population increase is the result of projected population growth in Haiti (table 12).

Haiti is considered one of the most food-insecure nations in the world and the poorest country in the LAC region. The country has been recurrently afflicted by high levels of food insecurity from acute food and fuel shortages and soaring inflation, weather-related shocks, and conflict (WFP & FAO, 2023). The economy has been sustained by increased inflows of international aid (Haiti is the second largest recipient of U.S. aid in the region, after Colombia) and remittances, which account for 20.0 percent of GDP (Food and Agriculture Organization of the United Nations (FAO), Global Information Early Warning Systems (GIEWS), 2022; World Bank, 2022). In 2023, Haiti's per capita GDP is estimated at $764 (appendix C) with 7.0 million people (60.8 percent of the country's total population) estimated to be food insecure. Haiti is projected to

make the least progress in terms of its food security metrics in the LAC region, despite a projected drop to 49.8 percent in the prevalence of food insecurity by 2033. Haiti also has the highest estimated per capita food gap of 721 kcal per capita per day in the LAC region (table 12).

South America stands out as being the sub-regional leader in LAC in terms of absolute GDP and is projected to have 2.8 percent annual growth in per capita GDP over the next decade (table 13). The South America sub-region includes Colombia and Peru, which collectively account for 58.4 percent of the GDP of the LAC region in 2023 (appendix C). The South America sub-region has an estimated population of 112.5 million and per capita income estimated at $6,479 in 2023 (table 12; table 13). About 18.3 percent of the population in the South America sub-region is estimated to be food insecure in 2023 (table 12).

Although Venezuelan migration has been taking place since the mid-2000s, beginning in 2019 the deteriorating economic conditions in the country triggered a more rapid pace of migration of Venezuelan nationals into neighboring countries—which, in turn, aggravated host countries' food security situations. An estimated 6.1 million Venezuelan migrants and refugees reside throughout LAC, but the majority reside in IFSA countries including Colombia (2.48 million), Peru (1.52 million), Ecuador (502,200), Dominican Republic (115,300), and Bolivia (15,700) (World Bank, 2023c; Inter-Agency Coordination Platform for Refugees and Migrants from Venezuela (R4V), 2023).

Colombia—the most populous of the LAC countries (50.4 million people in 2023)—is projected to gain an additional 2 million people by 2033 (table 12); a large share of the projected increase is driven by migrants and refugees from Venezuela. Despite the signing of a peace accord with the Revolutionary Armed Forces of Colombia (FARC) guerrilla group in 2016, the country continues to be affected by armed conflict and insecurity by dissident FARC (non-state armed guerrillas), which has impacted agriculture, a key driver of the economy. Labor shortages, due to internal displacements, and social unrest blockades significantly impair the country's marketing and distribution of food, which adds to food price inflation (World Bank, 2023c). The prevalence of food insecurity in Colombia is estimated at 9.3 percent in 2023, which is significantly below LAC's regional average of 22.6 percent (table 12). Colombia is the region's fifth-largest exporter of agricultural products and the continued depreciation of Colombia's currency and increased coffee prices—the country's principal export—continue to boost export revenues. However, the depreciated exchange rate severely affects corn and wheat, which account for 40 percent of Colombia's agricultural imports.

Bolivia has the smallest population among South America countries (12 million people) and is estimated to have 34.3 percent of its population experiencing food insecurity in 2023 due to the socioeconomic impacts of the COVID-19 pandemic, reduced aid, and a decline in remittances (table 12). Per capita GDP is projected to grow by 2.4 percent per year during the 2023–2033 period. Annual remittances account for about 3.5 percent of GDP in Bolivia (World Bank, 2022). The real domestic price of wheat in Bolivia rose an average of 6.7 percent annually between 2020 and 2022 due to inflation, supply chain issues, and roadblocks set up during protests (appendix D).

Table 12

Food Security results in the Latin America and Caribbean region, 2023 and 2033

Region/ sub-region	Country	Population		Population food insecure		Share of population food insecure		Food gap (per capita)	
		2023	2033	2023	2033	2023	2033	2023	2033
		Million		Million		Percent		Kilocalories per day	
Latin America and the Caribbean	**Region total**	**178.1**	**191.9**	**40.3**	**13.3**	**22.6**	**6.9**	**372**	**430**
Caribbean	**Sub-region total**	**25.1**	**27.3**	**8.3**	**6.5**	**32.9**	**23.8**	**643**	**639**
	Dominican Republic	10.8	11.7	0.9	0.1	8.0	0.6	213	155
	Haiti	11.5	12.8	7.0	6.4	60.8	49.8	721	649
	Jamaica	2.8	2.8	0.4	0.1	15.1	1.9	233	167
Central America	**Sub-region total**	**40.5**	**44.9**	**11.4**	**3.5**	**28.0**	**7.7**	**352**	**267**
	El Salvador	6.6	6.7	1.4	0.3	20.7	4.4	282	209
	Guatemala	18.0	20.6	5.4	1.6	29.8	7.8	356	260
	Honduras	9.6	10.6	2.6	0.7	26.8	6.6	344	253
	Nicaragua	6.4	6.9	2.1	0.9	32.4	12.6	397	310
South America	**Sub-region total**	**112.5**	**119.8**	**20.6**	**3.4**	**18.3**	**2.8**	**275**	**195**
	Bolivia	12.0	13.2	4.1	0.9	34.3	6.6	307	206
	Colombia	50.4	52.6	4.7	0.4	9.3	0.7	244	175
	Ecuador	17.5	19.3	4.7	0.9	27.1	4.7	262	180
	Peru	32.6	34.8	7.1	1.2	21.7	3.6	286	203

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections to 2032* long-term projections report OCE-2023–1.

Table 13

Inflation-adjusted per capita Gross Domestic Product (GDP) in Latin America and Caribbean region, 2023 and 2033

Region/sub-region	2020–2022 (average)	2023	2033	Annual growth rate	
				(2022–2023)	(2023–2033)
	U.S. dollars, 2015			Percent	
Latin America and the Caribbean	**5,266**	**5,636**	**7,364**	**2.0**	**2.7**
Caribbean	4,640	5,015	6,840	3.0	3.2
Central America	3,471	3,681	4,544	2.0	2.1
South America	6,045	6,479	8,540	1.9	2.8

Note: Values are expressed in 2015 U.S. dollars. Regions include only countries that covered by the International Food Security Assessment. For full country statistics, see appendix C.

Source: USDA, Economic Research Service estimation using the International Food Security Assessment model and *USDA Agricultural Projections* to 2032 long-term projections report OCE-2023–1.

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Special Article: Projecting Long-Term Staple Grain Production for the International Food Security Assessment: A Time Series Cross-Validation Approach

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Introduction

The USDA, Economic Research Service's (ERS) International Food Security Assessment (IFSA) model was developed to help USDA and its stakeholders evaluate the food security status of low- and middle-income countries. The model analyzes the gap between projected food demand, which is a function of per capita income and food prices, and a consumption target of 2,100 calories per capita per day for the low- and middle-income countries included in the IFSA report. Each country's food security status is estimated and projected for the next 10 years (Zereyesus et al., 2022a). The IFSA model also provides an estimate of total food demand and domestic food production, and the gap between domestic food production and demand is used to estimate the Implied Additional Supply Required (IASR) for each of the 83 countries included in IFSA, which is an indication of potential import needs, including food aid.

Therefore, it is important to have the most accurate agricultural production estimates possible for the IFSA countries, especially when facing a changing climate, as shortfalls in output may have global trade repercussions (Jagermeyr et al., 2020). The importance of international markets for the supply of stable and affordable agricultural commodities will be increasingly critical as sources of nutrition for the world population (Hertel et al., 2020; Smith & Glauber, 2020).

The current IFSA production model aggregates a panel of agricultural production data for the countries to provide model-based estimation and projection of yield, area, and production values (Zereyesus et al., 2022b). Zereyesus et al. (2022b) improved the IFSA food production model's performance by disaggregating staple cereal yield estimates, using regional or sub-regional specifications in place of the aggregate IFSA yield model. The authors developed a model-based performance evaluation criterion to select the best performing specification, using a method called a Cross-Validation (CV) technique.[18]

Because the CV method is applied using observed yield data, prediction performance for more than 1 year becomes challenging without data. The model applied by Zereyesus et al. (2022b) only uses model-based yield changes and assumes a predefined area adjustment over time. The existing IFSA food production module does not include weather information in the projection, which is problematic in the face of changing weather conditions and their impact on agricultural production. This report attempts to fill this research gap by (1) developing time series models that account for the unique and dynamic nature of yield, as well as area (acreage) dynamics for each country over the 10-year projection period; and (2) incorporating weather variables (temperature and precipitation) into the models to capture the influence of observed weather trends on grain production dynamics. The new model specification is also compared with the existing IFSA method to project global food production based on the criteria outlined in this report.

[18] The authors assume that the best performing model specification based on the approach will also result in the best prediction performance in each of the next 10 years covered by IFSA.

Projecting Staple Cereal Production

The availability of cereal grains is critical to food security in low- and middle-income countries, making the factors influencing output a key component of the IFSA production module. The IFSA model projects grain production using crop yield and area equations that incorporate parameters estimated from a pooled panel dataset of the 83 low- and middle-income countries included in the IFSA report (Zereyesus et al., 2022a; Zereyesus et al., 2022b).

Grain production can be defined as the area harvested (hectares) times the yield (production per hectare) (Zereyesus et al., 2022a; Zereyesus et al., 2022b). We developed models to project area and yield separately and then multiplied them together to obtain an estimate of production. The general model is specified as follows:

$$Y_{it} = f(\theta_i, t) + \boldsymbol{\beta}'_i \boldsymbol{X_{it}} + \alpha_i + \epsilon_{it} \quad (1)$$

Where $\boldsymbol{Y_{it}}$ denotes the dependent variable: area (hectares), or yield (million metric tons per hectare); $f(\theta_i, t)$ denotes a trend that could either be linear or nonlinear; $\boldsymbol{X_{it}}$ are the independent variables (price, temperature, and precipitation); and ϵ_{it} are the residual elements.[19] The regression model estimates the parameters θ_i,$\boldsymbol{\beta}_i$, and α_i.

Several alternative model specifications are considered as variants of equation (1) for projecting area (hectares) or yield (million metric tons per hectare). We considered including linear versus flexible nonlinear trends, estimating a single coefficient for all countries versus country-specific coefficients, and using a linear versus exponential functional form.

Time Series Cross Validation

Cross Validation (CV) provides an objective and data-driven approach to compare the predictive value of the different model specifications that are considered. Furthermore, CV approaches have been an important part of the literature related to crop yield distribution modeling and insurance rates (e.g., Norwood et al., 2004; Lanoue et al., 2010).[20]

Model-based projection performance is assessed in terms of how well the specified model can be expected to perform on an independent out-of-sample dataset (i.e., a dataset that is not part of the model estimation), often assessed by the actual estimate of the out-of-sample evaluation criteria (e.g., Mean Absolute Error, Mean Squared Error, and Root Mean Squared Error). When an independent out-of-sample dataset is not available, a CV approach can be used to choose the best model by estimating out-of-sample performance criteria using an in-sample dataset. The out-of-sample error—often referred to as the test-error—is the average error that results from using the regression method to predict the response on a new observation that was not used to estimate the regression model. The best model specification is determined as the model that gives the lowest prediction error in the test dataset (James et al., 2017). Time series cross validation is similar, except that the validation accounts for the time series nature of the projection. For example, the model is trained

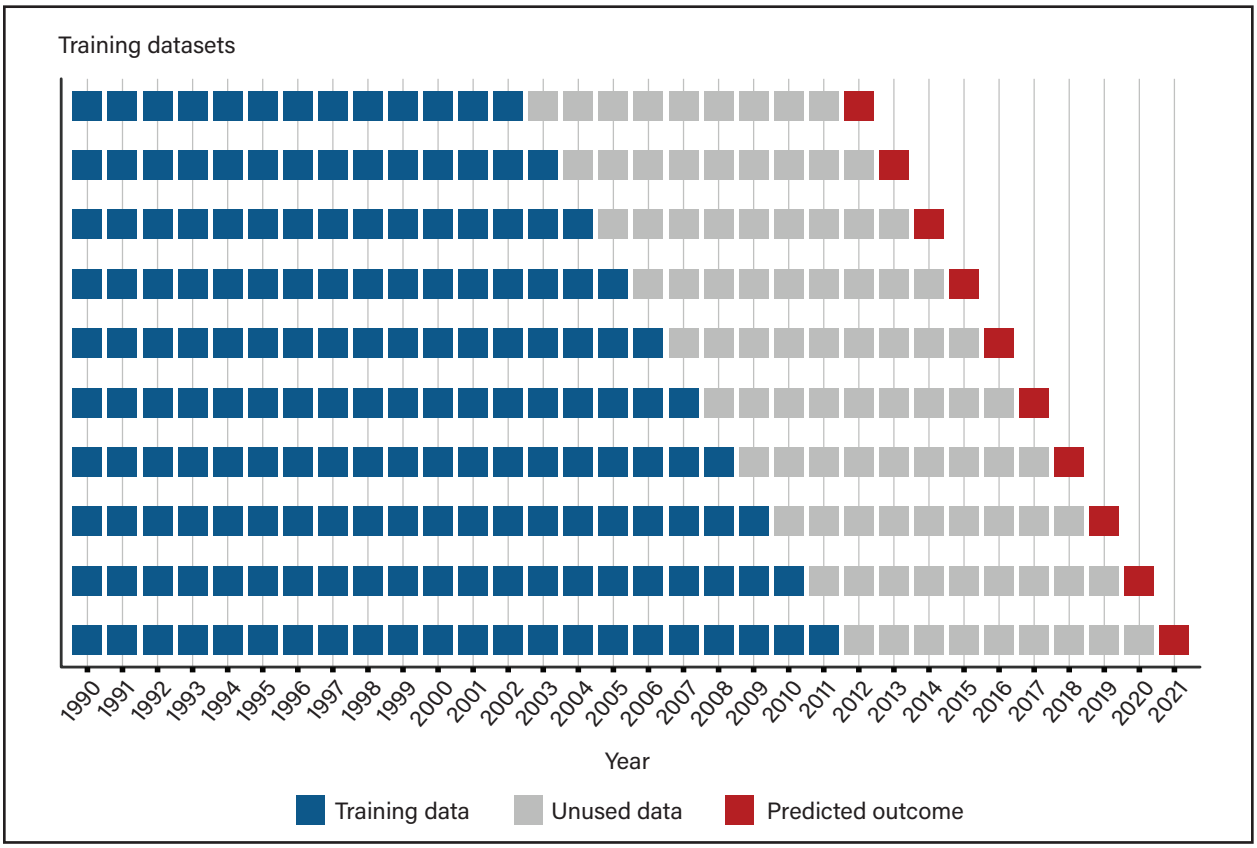
[19] Given that the main objective is to project the production variables, no causal analysis is implied in the specified model above, and hence no economic theory is imposed in the model.

[20] For example, Norwood et al. (2004) used a grouped cross-validation approach to evaluate the out-of-sample performance of six different yield densities for corn, soybeans, and wheat. The authors found that the flexible semiparametric model developed by Goodwin and Ker (1998) performed best using out-of-sample criteria.

with data up to a certain year and then the model is used to predict for a year in the future[21] (Hyndman & Athanasopoulos, 2021).

The time series CV method applied in this report is illustrated in figure 8. The primary objective is to create an accurate projection up to 10 years into the future. Considering the data for the assessment starts in 1990, the model is trained using data between 1990 and 2002 (the blue squares) to predict the outcome for 2012 (the red square). Next, the model is trained using data between 1990 and 2003 to predict the outcome for 2013. This process is repeated until the most recent observed data (i.e., 2021) is projected. This projection gives 10 different estimates of the 10-year out prediction error for each specification that are summarized as described in the next section.

Figure 8
Out-of-sample projection Cross Validation model assessment



Source: USDA, Economic Research Service model assessment calculations based on data from USDA, Foreign Agricultural Service, *Production, Supply and Distribution* database; World Bank's Commodity Database; International Financial Statistical Series; International Grain Council; and Climatic Research Unit (University of East Anglia).

Out-of-Sample Prediction Performance

The difference between the out-of-sample predicted outcome (area or yield) values and the real outcome values is calculated in the test dataset. This difference is referred to as the prediction error.

[21] Model performances are assessed using forecast and K-fold cross-validation. Both methods are designed to assess the out-of-sample predictive ability of a model and forecast cross-validation accounts for the time series nature of the data (Newell et al., 2021).

The prediction errors ($\widehat{\epsilon_{it}}$) are then used to calculate the Root Mean Squared Error (RMSE) for each country (James et al., 2017).

(1) $$RMSE_i = \sqrt{\frac{\sum_{t=\tau}^{T} \widehat{\epsilon_{it}}^2}{10}}$$

Where τ is the earliest year in the test data and T is the final year in the test data. Projections are done for 10 different years. The RMSE is the average squared prediction error. Squaring the prediction error means that it is always positive, whether the model under- or overestimated the outcome. Squaring the error also means that large differences from the true outcome are given relatively larger penalties in the RMSE metric, therefore RMSE is more sensitive to outliers in the data. An alternative metric of the prediction accuracy is the Mean Absolute Error (MAE) for each country, which is calculated as

(2) $$MAE_i = \frac{\sum_{t=\tau}^{T} |\widehat{\epsilon_{it}}|}{10}$$

The MAE calculates the average prediction error in absolute value, so large differences from the true outcome are given the same relative penalty in the MAE metric. To create a single measure of the predictive accuracy for each specification, the predictive accuracies for countries are averaged by country. The preferred specification is the one with the smallest RMSE or MAE. These performance criteria operate differently in evaluating the outcome models. For example, RMSE penalizes large actual and predicted discrepancies by more than MAE and MAE is always less than or equal to RMSE. Each of these values can be used to compare across models; however, comparing one performance criteria with another is not informative. Based on the best performing model specification, the projected values for the outcome variables for the immediate year and 10 years out (i.e., 2023 and 2033) are obtained.

Data and Analysis

The data used in this report come from various sources covering 1990–2021. Grain staples include corn, rice, wheat, sorghum, barley, and millet. The area harvested, yield, and production data come from USDA, Foreign Agricultural Service's Production, Supply and Distribution (PSD) database. Total grain production and area are aggregated across crops by adding tons of production or hectares. On average, about 3.2 hectares are allocated for staple grain production. The average aggregate grain yield is 1.5 tons per hectare (table 15).

Three different measures of crop prices are considered in the specifications. One measure uses futures prices from the Chicago Board of Trade. Daily futures prices were also obtained from the International Grain Council. A second measure is the local spot price obtained from the World Bank's commodity price database. A third measure is the world price index for each crop from the International Financial Statistical series. Farmers make most production decisions before planting a crop. Therefore, the relevant price to include in the model is the price before planting. However, planting dates differ across countries and crops. To account for this difference, we use the spot price 1 month before the average planting date of the respective crop. Crop-specific planting dates by country were obtained from the Food and Agriculture Organization of the United Nation's Statistical FAO-Global Information and Early Warning System (GIEWS). However, there are some countries in the database that do not have a specified planting date. We interpolated these missing planting dates spatially, using an inverse distance weighting (IDW) approach with the closest data points having more influence on the predicted planting dates.

Prices are aggregated across crops to give an average annual grain price for each country. The price data are aggregated using a simple and weighted average across crops. The weights used to estimate the weighted average represent the share of grain production for the specific crop. Weather data at the country level are obtained from the Climatic Research Unit (CRU) at the University of East Anglia. CRU creates monthly country-level data by averaging monthly gridded weather data within each country. For each year, we

calculated the cumulative precipitation—measured in millimeters (mm)—and the average temperature—measured in Celsius (°C). We calculated the annual average precipitation and temperature as 1,113.5 mm and 22.1°C, respectively[22] (table 15). The projections for 2023 and 2033 are based on average prices and weather variables observed during the most recent 5-year period.

Model Results

Figure 9 shows the RMSE across all linear models to predict area harvested. A lower RMSE indicates better model performance. The models were ranked in terms of RMSE, where the model with the lowest RMSE was ranked first. Similarly, figure 10 shows the RMSE across models to predict yield. We found that including country-specific trends and country fixed effects improves prediction accuracy.

Table 14
Summary statistics of data used in the analysis (1990–2021)

Variable	Unit	N	Median	Mean	Standard deviation
Area	Million hectares	4,610	0.9	3.2	10.1
Production	Million metric tons	4,610	1.1	5.7	19.9
Yield	Metric tons per hectare	4,610	1.2	1.5	0.9
Futures price (simple average)	Dollars per metric ton	3,444	319.9	402.7	199.1
Futures price (weighted average)	Dollars per metric ton	3,417	328.6	497.2	486.8
Spot price (simple average)	Dollars per metric ton	3,973	275.4	325.8	191.4
Spot price (weighted average)	Dollars per metric ton	3,938	4,898.8	7,169.7	7,167.2
World price index (simple average)	Index (base 2016)	2,615	169.8	179.9	70.8
World price index (weighted average)	Index (base 2016)	2,582	197.7	271.9	203.7
Precipitation	Millimeters per year	4,466	1,059.8	1,113.5	739.0
Temperature	Degrees Celsius	4,465	24.0	22.1	6.3

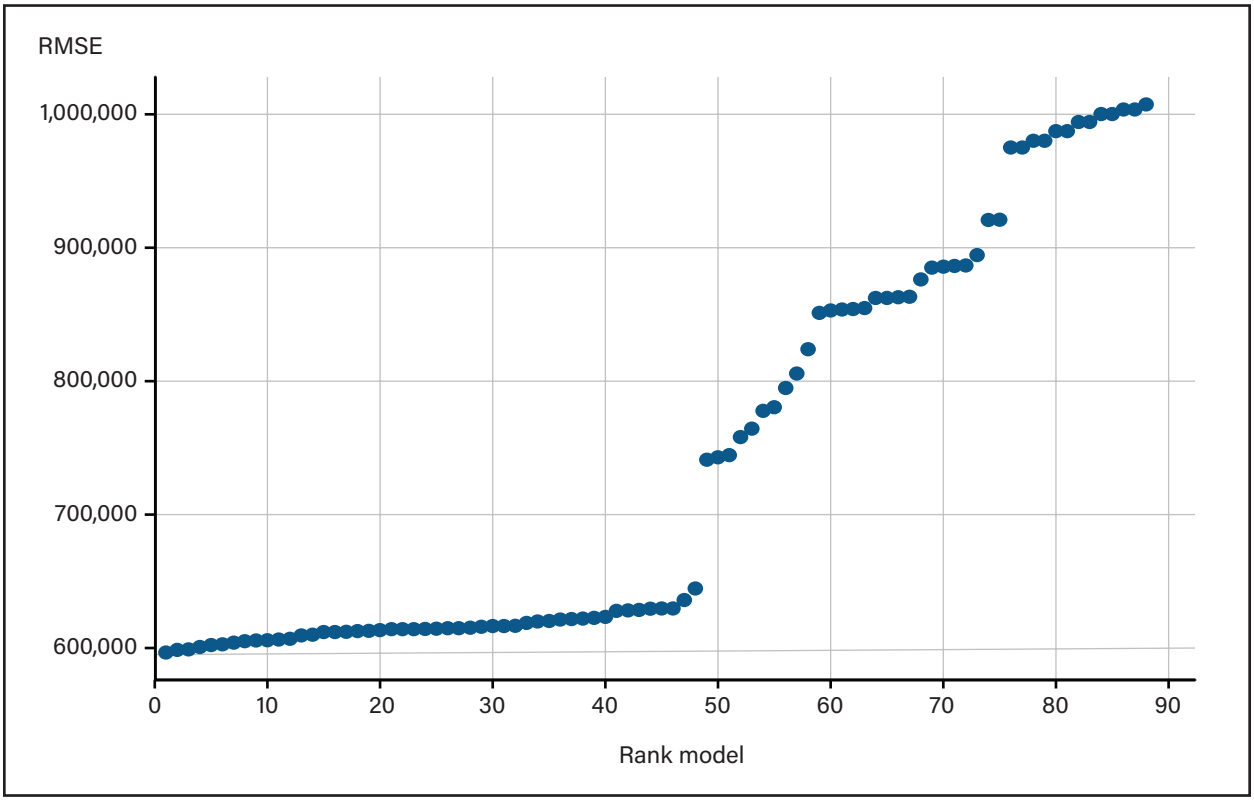
N = the sample size used to derive the summary statistics.

Source: USDA, Economic Research Service using data from USDA, Foreign Agricultural Service, *Production, Supply and Distribution* database; World Bank's Commodity Database; International Financial Statistical Series; and International Grain Council; and Climatic Research Unit (University of East Anglia).

Projections for production in 2023 and 2033 are obtained using the preferred area harvested and yield model specifications. Although overall cereal production is projected to increase in most countries, there are some countries where production is projected to decline in the next 10 years.

[22]All estimation and analyses of results are completed using the R statistical software (R Core Team, 2021), including glmnet, a regularization package for generalized linear models (Friedman et al., 2010) and boot—a bootstrapping package for the in- and out-of-sample cross-validation applications (Canty & Ripley, 2021).

Figure 9
Time series cross-validation RMSE for different specifications to predict area

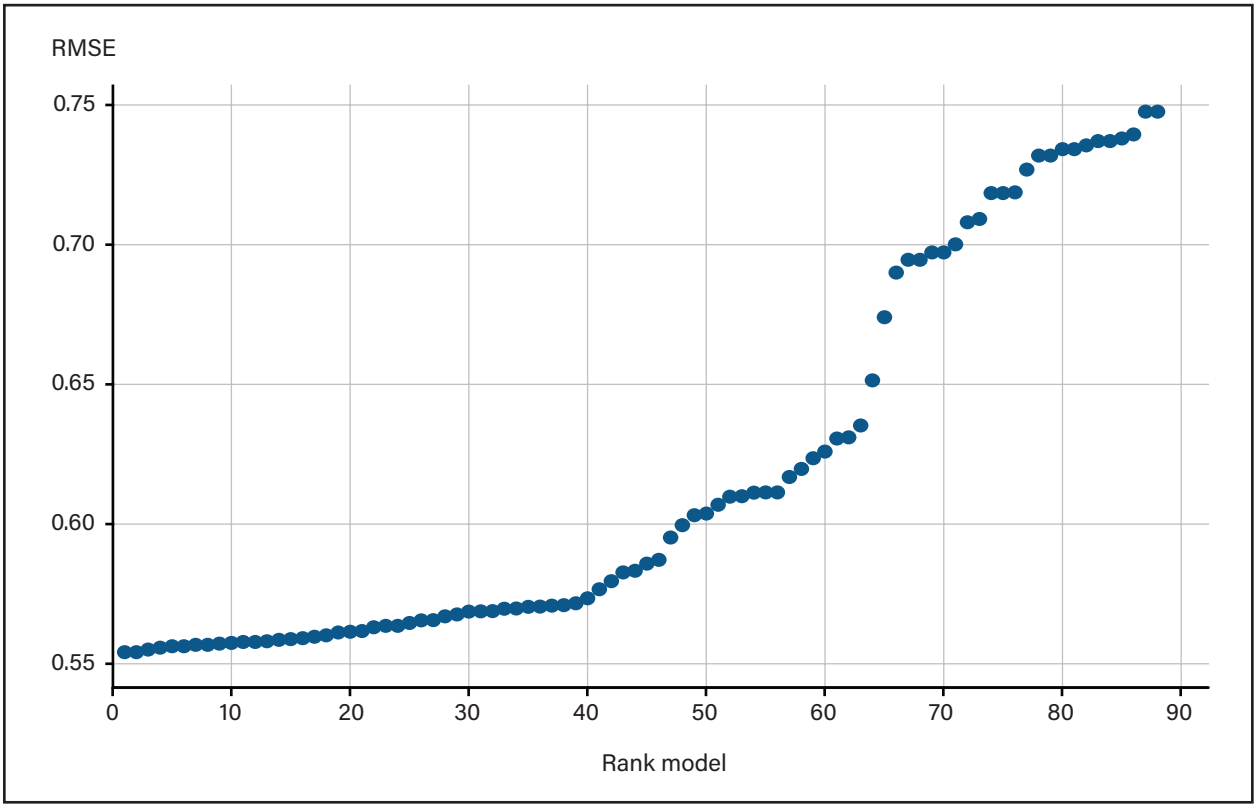


RMSE = Root Mean Squared Error.

Note: Rank model sorts the models in terms of their RMSE, where the model with the lowest RMSE is ranked first.

Source: USDA, Economic Research Service calculations based on data from USDA, Foreign Agricultural Service, *Production, Supply and Distribution* database; World Bank's Commodity Database; International Financial Statistical Series; International Grain Council; and Climatic Research Unit (University of East Anglia).

Figure 10
Time series cross-validation RMSE for different specifications to predict yield



RMSE = Root Mean Squared Error.

Source: USDA, Economic Research Service calculations based on data from USDA, Foreign Agricultural Service, *Production, Supply and Distribution* database; World Bank's Commodity Database; International Financial Statistical Series; International Grain Council; and Climatic Research Unit (University of East Anglia).

Evaluating IFSA's Current Grain Projection Model

Zereyesus et al. (2022b) applied recent CV approaches to examine the projection capabilities of the IFSA model. In terms of the new results compared with the previous approach, their findings indicated that the sub-regional model specification improved the yield prediction performance by 15 percent relative to the pooled IFSA model approach used in the past. In particular, the model improved the absolute difference between the observed and estimated yield (e.g., 0.159 tons per hectare and 0.188 tons per hectare for the sub-regional model and pooled IFSA model, respectively).

Zereyesus et al. (2022b) specified the yield prediction model as:

(6) $$Yield_{it} = \theta_r t + \beta_1 MA_{2,it} + \beta_2 MA_{5,it} + \alpha_i + \epsilon_{it}$$

Where $MA_{2,it}$ and $MA_{5,it}$ denote a 2-year and 5-year moving average of returns relative to yield, respectively. The α_i are country-specific intercepts and ϵ_{it} are the residuals.

The area equation is numerically calibrated to the base year average of the preceding 3 years of the report (e.g., 2017–19 for the 2020 report), using a predefined linear relationship for the price and lagged acreage responses and the ratio of domestic grain price to fertilizer price (Thome et al., 2019). Therefore, no model-based prediction comparisons were done for the area variable.

To compare the current time series CV approaches with the recent IFSA model assessments (Zereyesus et al., 2022b) for yield equations, we conducted time-series cross validation for a 10-year out project by applying both models. Since equation (6) uses a 5-year moving average, the training data starts in 1995, rather than 1990. Using this timeframe for both methods, we estimated accuracy metrics using RMSE and MAE metrics. Comparison results indicate that the current method outperformed the previous method (Zereyesus et al., 2022b) with respect to RMSE metrics, while MAE values are similar for both methods.

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Appendix A: Food Security Assessment Model: Definitions and Methodology

The International Food Security Assessment (IFSA) model[23] used in this report projects food consumption (food demand), food access, and food gaps in 83 low- and middle-income countries. Each country's food security metrics are estimated for 2023 and projected to 2033. Food is divided into four groups, covering 100 percent of food consumption: the 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 estimated domestic food consumption (food demand) and a caloric threshold necessary to sustain life at a moderate level of activity, set at 2,100 kilocalories (kcal) per capita per day. The modeling projections of food demand are expressed in a grain equivalent based on each food group's caloric content to allow aggregation across food groups, which allows this grain equivalent to be easily expressed in kilograms (kcal).

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 threshold; (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 threshold indicates the relative well-being of a country's population and helps to 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 model's specification and 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. (2015) introduced the methodology and Beghin et al. (2017) provided more detail on price transmission and food security projections.

Each country model comprises a price-independent generalized log-linear (PIGLOG)[24] demand system for each of the four food groups (Deaton & Muellbauer, 1980; Muellbauer, 1975). The demand system is calibrated on a 3-year-average of prices and incomes (2020–22), observed consumption levels, a measure of inequality, and income and price elasticities. Demand projections are based on projected prices and incomes; the model implicitly assumes that the demand system represents preferences and that the projections 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 this 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.

[23] The methodology used to estimate the IFSA model indicators was replaced in 2016. To understand the changes to the model and their impact on food security estimates, see Rosen et al. (2016).

[24] PIGLOG refers to a class of demand systems that provide flexible structure with a nonlinear income response and exact aggregation of individual demand into a representative consumer demand function of per capita income and, as shown later, the Theil entropy measure of income inequality.

Definition and Calibration

The demand q_i^h for a given food group i, for income-decile h is specified as:

$$(1) \qquad q_i^h = (\frac{x^h}{p_i})(A_i(p_i) + B_i(p_i)\ln(x^h))$$

Where p_i is the price (expressed in real local currency), and x_h is the decile-level income.[25] $A_i(p_i) = a_{i0} + a_{i1}p_i$ 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, as shown in (2).

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

The latter in equation (2) is a function of average per capita income $\bar{x}$ and Theil's entropy measure of income inequality z.

The average expenditure share for good category i is also defined as:

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

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

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

The own-price elasticity of the average demand is:

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

In each country, consumers at different income levels have similar underlying preferences over good 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

[25] The combined impacts of supply side factors (such as input and fertilizer prices, weather and climate changes, and uncertainties with agricultural production) are expected to drive prices and income.

income. A range of values of the free parameters allows can ensure these stylized facts are satisfied by the calibrated demand system. Here b_{i0} is pinned down 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 $\tilde{a}_{i0}$, $\tilde{a}_{i1}$, $\tilde{b}_{i0}$, 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 to be constant across the income distribution.

For each country, a demand system is calibrated for each of the four food groups—based on income, consumption levels, and prices from the 3 years preceding the projection period (2020–22). The "major grain" (which varies across countries) is determined, 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, domestic food prices are either observed (including the components of a price index for other grains that is weighted by caloric share), or synthetic prices are created.

For the food prices not observed in the calibration stage, a synthetic domestic price, p_i^{ds}, that is linked to the world price, p_i^w, is created and expressed in local currency. The parameter θ is the price transmission slope, which is assumed 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 are assumed 10 percent, and trc^{dom} are domestic trade costs, which are assumed $20 per ton in real terms:

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

At this stage, the calibration also includes a price transmission equation that links the domestic price p_i^{dom} (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, the intercept, $\hat{I}$, is solved in real terms and is held constant during the projection period.

Projection of Food Demand Calculation and Food Security Indicators

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

For each country, the demand parameters and projected income, x_t, and prices, p_{it}, are used to project food demand, q_{it}, for each of the four food groups i in each year t so that $q_{it} = \widehat{A}_i(x_t/p_{it})((p_{it}) + \widehat{B}_i(p_{it})\ln(x_t))$. The demand for the four food groups is aggregated into total food demand expressed in calories, so that $\sum q_{it} = Q_t$, which is also referred as food or calorie consumption. This measure of total demand is used to calculate food security indicators.

The Food and Agriculture Organization of the United Nations (FAO) (2019) is followed 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 $CV = (\sqrt{v}/m)$.[26]

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

Given the CV and the projected mean caloric consumption (Q_t), the variance (v) of the empirical distribution for a given year t can be recovered.

Assuming food consumption Q_t is distributed lognormal, then $ln\ (Q_t)$ is distributed $N\ (\mu, o^2)$ 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 o^2 are computed, the proportion of the population that falls below the calorie threshold (2,100 kcal per capita per day) is recovered using the standard normal CDF, Φ: $\Phi^{insecure} = \Phi\left(\left(\frac{\ln(2{,}100-\mu)}{\sigma}\right)\right)$. Here, $\Phi^{insecure}$ indicates the share of the population that is food insecure. Using this share and total population in the respective country, the total number of food insecure people in this country is calculated.

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 threshold (2,100 kcal), which is calculated as $q_{cal}^{food} = e^{\mu-\sigma/\Phi\text{^}2100[\phi((\ln(2100)-\mu)/\sigma]}$, where ϕ is the standard normal density function.

The food gap is the difference between the caloric threshold of 2,100 kcal and the average calorie availability for food insecure people. This gap provides a measure of the food gap in kcal per day per food insecure person. 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.

Data

The model is calibrated for each of the four food groups based on average prices and income from 2020–22. Prices are expressed in real local currency units. Quantities are expressed in grain-equivalent units.

Calibrated Parameters and Variables

Demand parameters ($\tilde{a}_{i0}$, $\tilde{a}_{i1}$, $\tilde{b}_{i0}$, and $\tilde{b}_{i1}$), price intercepts, and domestic prices (synthetic) projections are based on data from the USDA, Economic Research Service (ERS) International Macroeconomic Data Set and the *USDA Agricultural Projections to 2032* report. They 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:

- Average consumption per capita–Food and Agriculture Organization (FAO) of the United Nations Food Balance Sheet (most recent available)[27]
- Grain shares: FAO Food Balance Sheet[28]

[27] Food Balance Sheets (FBS) are from 2019. There are no current FBS for Somalia, South Sudan, and Eritrea. In order to generate per capita consumption for each food group, grain consumption levels and share of grains in total calories were used, as reported in the Food Agriculture Organization of the United Nations (FAO) Global Information Early Warning Systems (GIEWS) Cereal Supply and Demand Balance for Sub-Saharan African Countries from February 2023. The reported consumption of all food groups uses information from FAO's grain supply data and changes in caloric intake.

[28] For Somalia, an FBS from the original FAO Statistical Database was used, which is no longer maintained. The FBS of neighboring countries used (Burundi–Rwanda; Democratic Republic of Congo–Congo; Eritrea–Ethiopia) to approximate the shares of grains and roots and tubers in total calories for the other countries.

- Elasticities of price and income calculations: 2011 International Comparison Program (ICP) data, following the methodology in Muhammad et al. (2011)[29]
- 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)[30]
- Exchange Rates and Consumer Price Indices (CPIs): USDA, ERS's International Macroeconomic Data Set[31]
- Population: U.S. Department of Commerce, Bureau of the Census.
- World prices: *USDA Agricultural Projections to 2032* report[32]
- Per capita income: generated using GDP and population from USDA, ERS's International Macroeconomic Data Set[33]
- Income distribution: World Bank Data Bank.[34]
- Coefficient of variation (CV) of food consumption: FAO State of Food Insecurity (FAO, 2019)[35]

[29] Elasticities are not available for all countries. Estimates are used from neighboring countries (Somalia, Eritrea, Djibouti, and South Sudan–Ethiopia; Lebanon–Jordan; Syria–Iraq; Algeria—average Tunisia and Morocco; Afghanistan—average Tajikistan and Pakistan; Turkmenistan—average Tajikistan, Kyrgyzstan, Kazakhstan; Uzbekistan-average Tajikistan, Kyrgyzstan, Kazakhstan). Less elastic values were used for major grain in Vietnam, Philippines, Indonesia, India, Pakistan, and Bangladesh, and for other grain in India.

[30] Tariff rates are available through 2021. Tariff rates are not available for Somalia, Turkmenistan, Eritrea, and North Korea. For Eritrea, the Common Market for Eastern and Southern Africa (COMESA) average was used. Somalia has imposed a 12.3 percent tariff on commercial imports (LCS Logistics). Turkmenistan has no tariffs but imposes excise taxes that have historically been 10 percent. North Korea does not import on the open market, so calculations assume there are zero tariffs and do not quantify other trade frictions.

[31] Ecuador and El Salvador are modeled in the currency of U.S. dollars (instead of local currency), as in the USDA, ERS International Macroeconomic Data Set, which is based on data from the International Monetary Fund (IMF) and Oxford Economics. Projections are constructed for South Sudan, Somalia, North Korea, and Zimbabwe using data from the International Monetary Fund, IHS Markit, and Oxford Economics.

[32] The world price series include the following: corn (U.S. gulf #2 yellow); rice (Thai, B, free on board (FOB) Bangkok, Thailand); sorghum (U.S. Gulf, #2 yellow); wheat (U.S. Gulf, #2 Hard Red Wheat); barley (E.C., Rouen, France); Oats (U.S. farm); roots and tubers (cassava; tapioca, hard pellets, FOB, Rotterdam, Netherlands); other food (represented by soybean oil, Dutch FOB, ex-mill Rotterdam, Netherlands). World price projections are not available for all cereals represented in the Food and Agriculture Organization of the United Nations (FAO) Food Balance Sheets and the FAO Global Information Early Warning System (GIEWS) price database. The world price of wheat to represent rye; and sorghum to represent all other cereals (e.g., millet, teff, fonio) was used.

[33] Projections were constructed using information from the International Monetary Fund, Oxford Economics, and IHS Markit for Zimbabwe, South Sudan, Somalia, and North Korea.

[34] Income distributions are not available for all countries. Report used Djibouti, Eritrea, South Sudan, and Somalia–Ethiopia; Zimbabwe–Zambia; North Korea–Mongolia; and Afghanistan—average Uzbekistan, Pakistan, Tajikistan.

[35] The coefficient of variation and the income distribution parameters are assumed to be constant throughout the projection period.

Modeling Staple Cereal Production

The current production module of the IFSA model aggregates a panel of agricultural production data for all 83 countries in the assessment to provide a model-based estimation for the current year and a projection for 10 years out for yield and area dynamics. 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 2022–32, based on producer price projections in local currency units and world price projections from the *USDA Agricultural Projections to 2032* report.

Yield

Yield parameters are estimated econometrically using panel data consisting of observations for each country and are calibrated to observed yields for the immediate past 3 years (e.g., 2020–22 yields). The calibration procedure involves in-sample prediction using observed yield data and consensus estimates for the expected return ratio, an indicator of the relative profitability of fertilizer use. 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—revenue from yield divided by the price of fertilizer—$RR_{ct} = (yp_{ct} * Y_{ct})/fp_{ct}$), where yp and fp are yield and fertilizer prices, respectively. The expected return ratios include a current-year component and a long-term expectation component, expressed in the real local currency unit. In these calculations, the *USDA Agricultural Projections to 2032* prices for superphosphate and the major grain by production volume (for grain) were used.

The domestic price for each grain is linked to its world reference price, expressed in real local currency unit, through the following price transmission equation:

$$p^{domestic} = 0.7 \times pworld + 0.3 \times I$$

The expected domestic price is a weighted average of 70 percent of the current-year world price $(pworld)$ and 30 percent of the mean domestic price (*I*) over the analysis time period. The grain production data used in the estimation come from USDA, Foreign Agricultural Service's *Production, Supply and Distribution* (*PSD*) database and from the Food and Agriculture Organization of the United Nations (FAO). The intercept, *I*, is the mean of the price over the regression time period (1985–2021).

Modeling Area

Crop area, AR_{ct}, is modeled with the widely used Nerlovian specification—in which lagged area, expected crop and fertilizer prices, and a time trend—enter into the equation as follows:

$$AR_{ct} = f(yp_{ct}, fp_{ct}, AR_{ct-1}, T)$$

The expected prices are averages of contemporaneous and lagged relative prices. A time trend is included in the area equation to capture non-price factors in area, and a country fixed effect. The area equation is numerically calibrated to the base year average of the preceding 3 years of the report (e.g., 2018–20), using consensus estimates for price and lagged acreage responses. Regional and sub-regional models are fitted to allow for

heterogeneity among diverse countries included in the IFSA model. The regional specification disaggregates the estimation of area and yield by the five regional classifications of the IFSA countries: Sub-Saharan Africa (SSA), Asia, Latin America and the Caribbean (LAC), Middle East and North Africa (MENA), and the Former Soviet Union (FSU). The sub-regional specification disaggregates the model to 13 sub-regions of the IFSA countries: Central Africa, East Africa, Southern Africa, West Africa, North Africa, Middle East, Central America, South America, the Caribbean, the Former Soviet Union, South Asia, South East Asia, and East Asia.

A model-based projection performance is assessed in terms of how well the specified model can be expected to perform on an independent (out-of-sample) data set, often assessed by the actual estimate of the out-of-sample Mean Squared Error (MSE). When an independent out-of-sample dataset is not available, a Cross-Validation (CV) approach (used in this report) can be used to choose the best model by estimating the out-of-sample MSE using an in-sample dataset. The out-of-sample error (often referred to as the test error) is the average error that results from using the regression method to predict the response on a new observation that was not used in regression estimation. Given an in-sample dataset, the choice of a particular specification (e.g., in this report, the regional and sub-regional model specifications) is warranted if the model results in a low test error (James et al., 2017). The models are assessed with a "leave-one-out-cross-validation" (LOOCV) to simulate their out-of-sample prediction performance (James et al., 2017). The performances of regional and sub-regional model specifications are assessed using the overall out-of-sample MSE scores. The model with the smallest out-of-sample MSE is selected for estimation.

Modeling Implied Additional Supply Required

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: $IASR = TD - PR$.

The demand for grain for processing, seed, and other uses is assumed to grow at the same rate as production. The demand for grain feed grows at the average rate was observed during 2006–21.

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Appendix B: Food Security Measures for International Food Security Assessment (IFSA) Countries, 2023–2033

Country	Food insecure (percent)				Population insecure (million)				Food gap (kcal per capita per day)			
	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033
Total IFSA countries	**25.4**	**32.3**	**26.6**	**7.9**	**1,056.2**	**1,366.5**	**1,137.6**	**385.9**	**369**	**400**	**387**	**357**
Asia region	**21.3**	**26.4**	**21.8**	**3.8**	**515.5**	**646.8**	**537.3**	**102.4**	**298**	**333**	**316**	**293**
East Asia sub-region	51.3	64.2	55.1	42.4	15.0	18.7	16.2	12.8	408	397	424	379
Democratic People's Republic of Korea	55.9	68.6	59.8	47.9	14.5	17.8	15.6	12.7	412	475	430	379
Mongolia	14.5	28.2	17.2	0.7	0.5	0.9	0.6	0.0	268	319	279	175
South Asia sub-region	22.5	27.7	22.9	3.5	410.6	514.0	426.5	71.5	295	340	316	294
Afghanistan	49.3	81.0	79.1	58.2	18.5	31.1	31.0	28.1	359	524	509	394
Bangladesh	20.2	22.3	17.0	3.2	33.2	36.9	28.5	5.8	280	288	268	200
India	20.2	24.7	18.8	0.7	270.2	333.5	253.7	10.5	271	286	265	163
Nepal	14.7	19.6	14.1	0.4	4.5	6.0	4.4	0.1	259	278	257	159
Pakistan	33.7	42.0	41.6	8.7	80.3	101.9	103.0	25.7	371	404	403	266
Sri Lanka	17.2	19.3	25.3	4.6	4.0	4.5	5.9	1.1	250	257	277	195
South East Asia sub-region	15.9	20.0	16.4	2.9	89.9	114.0	94.7	18.1	293	306	294	228
Cambodia	20.3	23.7	17.7	1.3	3.5	4.1	3.1	0.2	290	303	280	185
Indonesia	15.4	18.3	16.3	1.9	41.6	49.9	44.6	5.6	280	292	284	201
Laos	31.5	34.6	21.8	3.3	2.4	2.7	1.7	0.3	298	308	266	186
Burma	17.6	24.3	22.9	8.2	10.0	14.0	13.3	5.1	280	305	300	239
Philippines	21.4	29.4	20.7	4.9	23.9	33.0	23.9	6.6	332	365	330	249
Vietnam	8.4	10.2	7.9	0.3	8.5	10.4	8.1	0.3	256	265	253	171
Former Soviet Union region	**9.9**	**14.6**	**15.2**	**1.2**	**11.6**	**17.1**	**17.8**	**1.4**	**236**	**261**	**258**	**256**
Armenia	5.8	8.4	6.1	0.1	0.2	0.3	0.2	0.0	194	207	196	124
Azerbaijan	3.8	8.0	3.7	0.3	0.4	0.8	0.4	0.0	168	189	167	128
Georgia	10.9	13.5	10.2	0.4	0.5	0.7	0.5	0.0	235	246	232	155
Kyrgyzstan	18.7	33.4	9.7	0.9	1.1	2.0	0.6	0.1	265	315	230	166
Moldova	9.5	30.5	8.1	0.0	0.3	1.0	0.3	0.0	195	261	189	107
Tajikistan	28.7	63.3	39.4	11.8	2.6	5.8	3.7	1.2	342	490	383	273
Turkmenistan	9.8	16.5	10.3	0.7	0.5	0.9	0.6	0.0	222	248	224	157
Ukraine	9.4	4.5	21.7	0.0	4.1	2.0	9.4	0.0	195	172	235	98
Uzbekistan	5.8	11.5	7.2	0.1	1.8	3.6	2.3	0.0	195	220	202	127

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Country	Food insecure (percent)				Population insecure (million)				Food gap (kcal per capita per day)			
	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033
Middle East and North Africa region	**17.4**	**21.2**	**17.4**	**7.5**	**59.0**	**73.3**	**60.9**	**29.2**	**375**	**331**	**425**	**357**
Middle East sub-region	25.8	25.6	23.1	12.9	36.6	37.0	34.0	21.3	421	356	520	397
Iran	10.7	6.1	2.9	0.0	9.2	5.2	2.5	0.0	251	227	204	134
Lebanon	21.1	21.8	19.3	7.6	1.1	1.2	1.0	0.4	283	286	277	228
Syria	21.3	20.0	20.0	6.7	4.4	4.3	4.6	1.8	284	279	279	223
Yemen	72.0	84.8	81.8	51.0	21.9	26.3	25.9	19.0	526	633	603	418
North Africa sub-region	11.4	18.0	13.3	3.5	22.4	36.3	26.9	7.9	299	306	305	250
Algeria	5.9	19.3	8.1	1.1	2.6	8.5	3.6	0.6	249	314	262	202
Egypt	15.3	19.7	16.4	5.2	16.2	21.4	18.0	6.5	315	335	320	259
Morocco	8.2	12.9	11.9	1.9	3.0	4.7	4.3	0.7	271	295	290	220
Tunisia	5.4	13.5	8.1	0.9	0.6	1.6	1.0	0.1	238	281	254	191
Sub-Saharan Africa region	**39.0**	**50.9**	**41.2**	**15.9**	**432.1**	**578.5**	**481.2**	**239.5**	**458**	**477**	**468**	**380**
Central Africa sub-region	49.6	70.7	48.8	25.5	86.5	127.2	90.5	63.1	586	590	580	451
Burundi	80.9	84.6	85.2	64.4	9.9	10.7	11.2	11.2	594	631	638	482
Cameroon	20.9	30.7	21.5	10.2	6.0	9.0	6.5	4.0	302	338	304	257
Central African Republic	72.7	82.7	76.2	31.0	4.3	5.0	4.7	2.3	547	628	572	350
Chad	51.3	68.9	59.1	35.7	8.9	12.4	10.9	8.9	517	622	559	443
Congo	56.3	68.5	69.7	27.3	3.0	3.8	4.0	1.9	400	459	465	295
Democratic Republic of the Congo	51.7	79.6	47.6	22.9	54.3	86.3	53.2	34.8	640	862	615	480
East Africa sub-region	44.1	56.1	47.3	15.2	173.4	225.7	195.5	79.8	444	516	470	365
Djibouti	20.5	22.8	20.2	3.0	0.2	0.2	0.2	0.0	320	329	318	225
Eritrea	60.4	80.7	68.4	19.4	3.7	5.0	4.3	1.4	432	558	473	277
Ethiopia	32.7	43.4	36.2	4.8	36.3	49.3	42.1	7.0	335	374	348	219
Kenya	45.8	60.1	54.8	9.2	25.1	33.6	31.2	6.4	371	431	407	236
Madagascar	70.4	71.5	70.8	41.0	19.4	20.2	20.4	14.5	516	523	519	377
Rwanda	40.1	57.8	41.0	3.6	5.2	7.6	5.5	0.6	408	489	412	238
Somalia	81.2	88.5	85.7	62.7	13.9	14.9	15.5	15.2	696	786	747	555
South Sudan	60.4	81.5	81.1	23.6	6.5	8.9	9.0	3.1	489	634	630	332
Sudan	32.4	46.4	23.1	10.2	15.1	22.3	11.4	6.5	366	423	330	274
Tanzania	39.2	48.7	42.6	12.5	23.8	30.5	27.4	10.4	480	527	496	350
Uganda	54.2	71.9	59.6	22.6	24.2	33.2	28.4	14.6	495	601	524	356

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Country	Food insecure (percent)				Population insecure (million)				Food gap (kcal per capita per day)			
	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033
Southern Africa sub-region	48.2	62.9	51.8	29.9	59.9	80.4	67.9	50.8	493	501	503	410
Angola	40.9	53.9	44.2	34.5	13.8	18.8	15.9	17.2	400	456	414	374
Eswatini	26.2	41.9	31.0	9.5	0.3	0.5	0.4	0.1	291	345	307	229
Lesotho	48.7	55.9	56.2	12.4	1.0	1.1	1.2	0.3	395	426	427	259
Malawi	28.7	50.4	32.6	2.1	6.1	10.9	7.2	0.6	362	453	378	222
Mozambique	56.2	66.2	62.0	37.7	17.4	21.0	20.1	15.8	506	563	537	420
Namibia	30.9	48.5	38.3	10.6	0.8	1.3	1.1	0.4	285	343	308	217
Zambia	50.6	78.0	56.6	29.6	9.1	14.5	10.8	7.4	559	752	593	453
Zimbabwe	77.5	81.5	72.8	48.1	11.5	12.3	11.2	9.0	630	667	593	454
West Africa sub-region	27.0	34.1	29.1	8.2	112.2	145.3	127.4	45.9	362	397	367	277
Benin	19.9	24.7	22.2	4.0	2.6	3.4	3.2	0.8	317	336	326	235
Burkina Faso	31.9	36.9	35.8	9.6	6.8	8.1	8.0	2.7	465	489	483	347
Cabo Verde	32.5	41.0	19.4	2.4	0.2	0.2	0.1	0.0	323	353	277	192
Cote d'Ivoire	21.3	26.0	21.9	6.2	6.0	7.5	6.4	2.2	404	427	407	316
Gambia	32.8	30.5	19.9	2.7	0.7	0.7	0.5	0.1	335	327	289	202
Ghana	8.5	14.2	10.5	1.1	2.6	4.4	3.3	0.4	249	275	258	188
Guinea	20.7	24.2	20.0	7.7	2.7	3.2	2.7	1.4	348	363	345	283
Guinea-Bissau	48.8	54.3	48.7	26.9	1.0	1.1	1.0	0.7	408	432	408	325
Liberia	58.0	61.9	51.8	19.5	3.0	3.3	2.9	1.4	613	638	577	412
Mali	18.3	27.1	24.4	6.0	3.7	5.6	5.2	1.7	319	355	345	257
Mauritania	18.3	25.1	16.2	2.6	0.7	1.0	0.7	0.1	310	338	302	221
Niger	34.7	40.0	31.8	4.4	8.2	9.8	8.1	1.6	438	462	425	280
Nigeria	29.4	37.9	32.7	10.0	64.6	85.3	75.5	29.6	334	365	346	256
Senegal	21.7	28.0	20.5	2.6	3.5	4.6	3.5	0.6	276	297	271	188
Sierra Leone	45.7	49.4	48.0	26.0	3.1	3.4	3.4	2.3	500	519	512	409
Togo	30.8	39.9	31.6	3.2	2.7	3.6	2.9	0.4	339	373	342	214
Latin America and the Caribbean region	**21.8**	**28.7**	**22.6**	**6.9**	**38.1**	**50.9**	**40.3**	**13.3**	**368**	**360**	**372**	**430**
Caribbean sub-region	32.7	37.8	32.9	23.8	8.1	9.4	8.3	6.5	635	412	643	639
Dominican Republic	8.7	13.5	8.0	0.6	0.9	1.4	0.9	0.1	217	237	213	155
Haiti	60.2	65.4	60.8	49.8	6.7	7.4	7.0	6.4	716	755	721	649
Jamaica	14.3	18.7	15.1	1.9	0.4	0.5	0.4	0.1	230	246	233	167
Central America sub-region	26.9	37.3	28.0	7.7	10.7	14.9	11.4	3.5	348	384	352	267
El Salvador	19.2	30.5	20.7	4.4	1.2	2.0	1.4	0.3	276	316	282	209
Guatemala	28.3	37.5	29.8	7.8	4.9	6.6	5.4	1.6	350	386	356	260
Honduras	27.3	37.1	26.8	6.6	2.5	3.5	2.6	0.7	346	385	344	253
Nicaragua	30.7	43.9	32.4	12.6	1.9	2.8	2.1	0.9	391	447	397	310

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Country	Food insecure (percent)				Population insecure (million)				Food gap (kcal per capita per day)			
	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033	2020–22*	2022**	2023	2033
South America sub-region	17.5	23.7	18.3	2.8	19.4	26.6	20.6	3.4	269	298	275	195
Bolivia	30.6	47.3	34.3	6.6	3.6	5.7	4.1	0.9	295	351	307	206
Colombia	10.4	14.8	9.3	0.7	5.2	7.5	4.7	0.4	250	269	244	175
Ecuador	23.4	33.6	27.1	4.7	4.0	5.8	4.7	0.9	251	282	262	180
Peru	20.4	23.5	21.7	3.6	6.6	7.6	7.1	1.2	281	292	286	203

Kcal = Kilocalories.

*These are the estimated calibrated average results for 2020, 2021, 2022.

**The sub-regional, regional, and total averages for 2022 are imputed based on reported 2022 values for countries included in the 2022 IFSA report and estimates for the six additional countries.

Source: USDA, Economic Research Service based on results from the International Food Security Assessment model.

Appendix C: Macroeconomic Measures for the International Food Security Assessment (IFSA) Countries, 2023–2033

Country	Population (million)		Population annual growth rate (percent)	GDP (million 2015 USD)			GDP: Annual growth rate (percent)			Per capita GDP (2015 USD)			Per capita GDP: Annual growth rate (percent)		
	2023	2033	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33
Total IFSA countries	**4,279.8**	**4,895.6**	**1.4**	**9,372,197**	**10,333,661**	**16,584,183**	**5.1**	**5.2**	**4.8**	**2,253**	**2,415**	**3,388**	**3.6**	**3.7**	**3.4**
Asia region	**2,466.8**	**2,690.6**	**0.9**	**5,387,273**	**6,018,326**	**10,280,362**	**5.9**	**5.7**	**5.5**	**2,225**	**2,440**	**3,821**	**4.9**	**4.7**	**4.6**
East Asia sub-region	29.4	30.1	0.2	42,426	44,658	58,189	2.7	2.5	2.7	1,454	1,518	1,934	2.3	2.1	2.5
Democratic People's Republic of Korea	26.2	26.6	0.2	28,728	29,914	34,194	3.2	1.1	1.3	1,106	1,143	1,285	2.8	0.7	1.2
Mongolia	3.3	3.5	0.7	13,698	14,744	23,995	1.8	5.6	5.0	4,282	4,528	6,903	0.9	4.7	4.3
South Asia sub-region	1,861.7	2,033.7	0.9	3,502,342	3,939,518	6,884,704	6.9	5.7	5.7	1,916	2,116	3,385	5.8	4.8	4.8
Afghanistan	39.3	48.3	2.1	17,996	14,869	19,147	-16.1	-1.3	2.6	481	379	396	-18.0	-3.5	0.5
Bangladesh	167.3	181.7	0.8	289,029	325,852	572,584	6.5	6.2	5.8	1,760	1,948	3,152	5.5	5.2	4.9
India	1,353.2	1,451.4	0.7	2,747,178	3,122,477	5,554,593	7.8	6.0	5.9	2,058	2,308	3,827	7.0	5.3	5.2
Nepal	31.0	33.0	0.6	26,879	29,274	48,318	3.3	5.2	5.1	882	946	1,466	2.5	4.4	4.5
Pakistan	247.7	294.8	1.8	332,079	353,212	550,116	3.7	2.9	4.5	1,394	1,426	1,866	1.7	1.0	2.7
Sri Lanka	23.3	24.6	0.5	89,181	93,836	139,946	-1.3	8.5	4.1	3,871	4,023	5,700	-2.0	7.8	3.5
Southeast Asia sub-region	575.8	626.8	0.9	1,842,505	2,034,149	3,337,469	4.2	5.6	5.1	3,266	3,533	5,325	3.1	4.6	4.2
Cambodia	17.5	19.1	0.9	23,725	26,139	47,899	3.6	5.9	6.2	1,387	1,496	2,514	2.4	4.8	5.3
Indonesia	274.3	292.8	0.7	1,070,364	1,177,063	1,911,700	4.3	5.3	5.0	3,964	4,291	6,528	3.4	4.5	4.3
Laos	7.8	8.7	1.2	19,407	20,697	35,018	2.8	3.6	5.4	2,566	2,665	4,020	1.4	2.2	4.2
Burma	58.0	61.8	0.6	80,599	79,265	99,406	-5.3	2.3	2.3	1,413	1,367	1,608	-6.1	1.5	1.6
Philippines	115.7	133.7	1.5	380,214	430,024	695,750	6.3	6.3	4.9	3,396	3,716	5,205	4.4	4.6	3.4
Vietnam	102.5	110.7	0.8	268,196	300,962	547,696	4.2	7.1	6.2	2,666	2,935	4,947	3.2	6.1	5.4

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Country	Population (million)		Popula-tion annual growth rate (percent)	GDP (million 2015 USD)			GDP: Annual growth rate (percent)			Per capita GDP (2015 USD)			Per capita GDP: Annual growth rate (percent)		
	2023	2033	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33
Former Soviet Union region	**117.3**	**119.5**	**0.2**	**354,428**	**363,130**	**583,730**	**-2.5**	**8.1**	**4.9**	**3,037**	**3,095**	**4,885**	**-2.8**	**7.9**	**4.7**
Armenia	3.0	2.8	-0.5	12,443	13,148	18,803	3.7	2.6	3.6	4,132	4,399	6,604	4.1	3.0	4.1
Azerbaijan	10.4	11.0	0.5	53,983	58,447	72,526	5.2	3.2	2.2	5,250	5,609	6,602	4.4	2.5	1.6
Georgia	4.9	4.9	-0.1	17,883	19,464	26,642	6.2	3.9	3.2	3,625	3,943	5,430	6.2	3.9	3.3
Kyrgyzstan	6.1	6.6	0.7	7,380	7,710	10,474	0.9	4.4	3.1	1,226	1,259	1,592	0.0	3.6	2.4
Moldova	3.3	2.9	-1.2	9,256	9,975	15,178	6.9	3.2	4.3	2,782	3,064	5,256	8.1	4.4	5.5
Tajikistan	9.3	10.5	1.2	11,425	11,849	16,298	3.4	2.2	3.2	1,269	1,280	1,557	2.0	0.8	2.0
Turkmenistan	5.7	6.2	0.8	48,522	52,665	72,028	4.9	4.0	3.2	8,688	9,247	11,697	3.8	3.0	2.4
Ukraine	43.3	41.2	-0.5	84,753	71,679	170,941	-25.1	30.3	9.1	1,937	1,655	4,152	-24.7	30.9	9.6
Uzbekistan	31.4	33.5	0.7	108,783	118,193	180,838	5.1	4.3	4.3	3,527	3,770	5,398	4.2	3.4	3.7
Middle East and North Africa region	**350.1**	**390.8**	**1.1**	**1,219,041**	**1,342,490**	**1,892,612**	**4.0**	**5.7**	**3.5**	**3,595**	**3,834**	**4,843**	**2.3**	**4.0**	**2.4**
Middle East sub-region	147.5	164.8	1.1	458,212	516,946	701,956	3.9	8.2	3.1	3,224	3,506	4,260	2.1	6.1	2.0
Iran	87.6	94.4	0.8	390,723	448,460	600,178	5.1	9.0	3.0	4,550	5,121	6,356	4.0	8.0	2.2
Lebanon	5.3	5.6	0.5	32,501	32,455	45,734	-5.3	3.0	3.5	6,076	6,082	8,128	-3.8	2.3	2.9
Syria	22.9	27.4	1.8	18,365	19,829	29,508	4.5	3.5	4.1	898	864	1,076	-0.9	-2.6	2.2
Yemen	31.6	37.3	1.7	16,622	16,202	26,536	-3.9	1.8	5.1	546	512	711	-5.7	-0.1	3.3
North Africa sub-region	202.6	226.0	1.1	760,828	825,544	1,190,656	4.0	4.2	3.7	3,862	4,074	5,268	2.5	2.8	2.6
Algeria	44.8	49.6	1.0	175,131	187,754	231,892	4.3	2.7	2.1	4,017	4,193	4,678	2.8	1.3	1.1
Egypt	109.3	124.5	1.3	433,464	477,370	743,909	4.4	5.2	4.5	4,100	4,366	5,973	2.5	3.5	3.2
Morocco	36.6	39.4	0.8	108,883	115,267	156,639	2.8	3.6	3.1	3,032	3,152	3,971	1.9	2.7	2.3
Tunisia	12.0	12.5	0.4	43,350	45,153	58,216	2.6	1.8	2.6	3,670	3,770	4,663	1.8	1.1	2.1

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Country	Population (million)		Population annual growth rate (percent)	GDP (million 2015 USD)			GDP: Annual growth rate (percent)			Per capita GDP (2015 USD)			Per capita GDP: Annual growth rate (percent)		
	2023	2033	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33
Sub-Saharan Africa region	**1,167.4**	**1,502.8**	**2.6**	**1,489,548**	**1,605,645**	**2,414,248**	**3.8**	**3.9**	**4.2**	**1,345**	**1,375**	**1,607**	**1.1**	**1.2**	**1.6**
Central Africa subregion	185.5	247.8	2.9	108,419	118,629	190,051	4.2	4.9	4.8	621	639	767	1.1	1.8	1.8
Burundi	13.2	17.4	2.8	3,259	3,457	5,231	2.7	3.2	4.2	266	263	300	-0.8	-0.5	1.3
Cameroon	30.1	39.2	2.7	37,045	40,216	59,748	3.8	4.5	4.0	1,298	1,334	1,525	1.0	1.7	1.3
Central African Republic	6.2	7.3	1.7	2,047	2,194	2,921	2.6	4.0	2.9	345	357	401	0.8	2.2	1.2
Chad	18.5	24.8	3.0	10,611	11,089	15,283	1.8	2.5	3.3	609	599	616	-1.3	-0.6	0.3
Congo	5.7	7.1	2.3	7,613	7,922	10,340	0.9	2.7	2.7	1,405	1,395	1,449	-1.4	0.3	0.4
Democratic Republic of the Congo	111.9	152.0	3.1	47,843	53,752	96,528	5.7	6.3	6.0	455	481	635	2.4	3.0	2.8
Eastern Africa subregion	413.5	523.8	2.4	413,948	453,072	743,132	4.5	4.9	5.1	1,053	1,096	1,419	1.9	2.3	2.6
Djibouti	1.0	1.2	1.7	3,246	3,604	6,091	4.9	5.7	5.4	3,452	3,685	5,252	2.8	3.7	3.6
Eritrea	6.3	7.1	1.3	5,248	5,645	7,748	3.7	3.5	3.2	854	901	1,088	2.7	2.4	1.9
Ethiopia	116.5	145.8	2.3	100,804	113,033	193,594	5.8	6.2	5.5	909	971	1,328	3.2	3.6	3.2
Kenya	57.1	69.4	2.0	84,102	92,496	151,492	5.6	4.5	5.1	1,537	1,621	2,183	3.4	2.3	3.0
Madagascar	28.9	35.3	2.0	12,840	13,903	21,799	4.0	4.0	4.6	465	482	618	1.6	1.7	2.5
Rwanda	13.4	15.7	1.6	11,925	13,750	28,355	8.8	7.0	7.5	921	1,026	1,810	6.9	5.2	5.8
Somalia	18.1	24.3	2.9	1,622	1,708	2,420	2.4	3.0	3.5	95	94	100	-0.7	-0.1	0.6
South Sudan	11.1	13.3	1.9	11,903	12,961	19,166	4.9	4.0	4.0	1,106	1,169	1,438	3.4	2.4	2.1
Sudan	49.2	63.6	2.6	74,782	76,658	95,754	0.5	2.0	2.2	1,600	1,558	1,506	-2.1	-0.6	-0.3
Tanzania	64.3	83.6	2.7	66,393	73,582	137,293	5.0	5.6	6.4	1,091	1,145	1,643	2.1	2.7	3.7
Uganda	47.7	64.7	3.1	41,082	45,732	79,419	4.8	6.1	5.7	918	958	1,228	1.4	2.7	2.5

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Country	Population (million)		Population annual growth rate (percent)	GDP (million 2015 USD)			GDP: Annual growth rate (percent)			Per capita GDP (2015 USD)			Per capita GDP: Annual growth rate (percent)		
	2023	2033	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33
Southern Africa sub-region	131.1	169.6	2.6	193,996	205,678	291,992	2.5	3.4	3.6	1,560	1,569	1,721	-0.3	0.7	0.9
Angola	36.0	50.0	3.3	105,143	111,184	153,248	1.8	3.4	3.3	3,125	3,090	3,064	-1.5	0.0	-0.1
Eswatini	1.1	1.2	0.6	4,178	4,326	5,342	1.6	1.9	2.1	3,751	3,826	4,438	0.8	1.2	1.5
Lesotho	2.1	2.2	0.8	2,379	2,522	3,241	2.5	3.2	2.5	1,173	1,225	1,455	1.8	2.5	1.7
Malawi	22.1	27.2	2.1	7,554	8,048	12,112	2.4	4.0	4.2	358	364	446	0.0	1.6	2.0
Mozambique	32.5	42.0	2.6	18,345	19,330	29,307	2.3	3.0	4.2	594	595	698	-0.3	0.4	1.6
Namibia	2.8	3.3	1.7	10,528	10,981	14,614	2.3	2.0	2.9	3,930	3,954	4,428	0.5	0.2	1.1
Zambia	19.1	25.1	2.8	24,346	26,131	38,680	3.5	4.0	4.0	1,350	1,367	1,543	0.5	1.0	1.2
Zimbabwe	15.4	18.6	1.9	21,522	23,155	35,448	4.7	3.2	4.4	1,451	1,502	1,902	2.7	1.2	2.4
Western Africa sub-region	437.3	561.5	2.5	773,185	828,266	1,189,072	3.8	3.4	3.7	1,862	1,894	2,118	1.1	0.8	1.1
Benin	14.2	19.6	3.2	15,354	16,932	29,031	5.6	5.0	5.5	1,153	1,191	1,483	2.1	1.6	2.2
Burkina Faso	22.5	28.0	2.2	16,254	17,871	26,985	5.6	4.6	4.2	760	795	963	2.9	2.0	1.9
Cabo Verde	0.6	0.7	1.1	1,726	1,909	3,093	5.5	5.1	4.9	2,922	3,156	4,602	4.2	3.8	3.8
Cote d'Ivoire	29.4	36.0	2.1	64,959	72,183	110,367	5.6	5.5	4.3	2,311	2,459	3,069	3.3	3.2	2.2
Gambia	2.3	2.9	2.0	1,592	1,743	2,934	3.8	5.5	5.3	710	743	1,026	1.4	3.1	3.3
Ghana	31.7	38.8	2.1	64,832	70,730	109,316	4.8	4.4	4.4	2,140	2,234	2,815	2.4	2.1	2.3
Guinea	13.6	17.8	2.7	13,525	14,761	21,840	4.6	4.4	4.0	1,050	1,085	1,224	1.8	1.6	1.2
Guinea-Bissau	2.1	2.7	2.6	1,302	1,397	1,920	3.0	4.2	3.2	658	672	715	0.5	1.6	0.6
Liberia	5.5	7.2	2.7	3,201	3,465	5,123	4.0	4.1	4.0	614	629	716	1.2	1.3	1.3
Mali	21.4	28.3	2.8	16,514	17,362	24,592	2.8	2.4	3.5	820	813	869	-0.2	-0.6	0.7
Mauritania	4.3	5.1	1.8	7,312	8,526	12,842	6.7	9.0	4.2	1,789	2,006	2,515	4.6	6.9	2.3
Niger	25.4	36.4	3.7	13,318	15,829	30,749	6.0	12.0	6.9	564	623	845	2.2	8.0	3.1
Nigeria	230.9	296.2	2.5	518,664	546,360	749,845	3.2	2.3	3.2	2,362	2,366	2,532	0.6	-0.3	0.7
Senegal	17.1	21.4	2.3	24,093	27,628	41,733	5.0	9.3	4.2	1,485	1,618	1,947	2.3	6.6	1.9
Sierra Leone	7.2	8.8	2.1	5,149	5,542	7,885	3.5	3.9	3.6	755	773	891	0.9	1.4	1.4
Togo	9.3	11.7	2.3	5,390	6,029	10,818	5.2	6.2	6.0	610	650	925	2.6	3.6	3.6

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Country	Population (million)		Popula-tion annual growth rate (percent)	GDP (million 2015 USD)			GDP: Annual growth rate (percent)			Per capita GDP (2015 USD)			Per capita GDP: Annual growth rate (percent)		
	2023	2033	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33	2020–22*	2023	2033	2020–22*	2022–23	2023–33
Latin America and the Caribbean region	**178.1**	**191.9**	**0.7**	**921,908**	**1,004,070**	**1,413,232**	**7.0**	**2.9**	**3.5**	**5,266**	**5,636**	**7,364**	**6.0**	**2.0**	**2.7**
Caribbean sub-region	25.1	27.3	0.8	114,208	125,814	186,525	7.2	3.9	4.0	4,640	5,015	6,840	6.1	3.0	3.2
Dominican Republic	10.8	11.7	0.8	91,456	101,888	157,238	8.2	4.5	4.4	8,626	9,442	13,491	7.2	3.5	3.6
Haiti	11.5	12.8	1.1	8,667	8,762	11,198	-0.2	1.1	2.5	774	764	877	-1.4	-0.1	1.4
Jamaica	2.8	2.8	0.1	14,086	15,163	18,089	5.3	2.1	1.8	5,000	5,375	6,348	5.2	2.0	1.7
Central America sub-region	40.5	44.9	1.0	137,299	149,201	203,911	6.4	3.2	3.2	3,471	3,681	4,544	5.0	2.0	2.1
El Salvador	6.6	6.7	0.2	25,448	27,164	32,812	6.0	2.2	1.9	3,899	4,114	4,887	5.3	1.7	1.7
Guatemala	18.0	20.6	1.4	73,930	80,545	115,321	5.9	3.6	3.7	4,240	4,478	5,590	4.2	2.0	2.2
Honduras	9.6	10.6	1.1	24,233	26,672	37,300	7.9	3.5	3.4	2,591	2,786	3,507	6.5	2.3	2.3
Nicaragua	6.4	6.9	0.8	13,687	14,820	18,478	6.8	2.6	2.2	2,186	2,325	2,680	5.8	1.7	1.4
South America sub-region	112.5	119.8	0.6	670,401	729,056	1,022,796	7.1	2.6	3.4	6,045	6,479	8,540	6.3	1.9	2.8
Bolivia	12.0	13.2	0.9	36,669	39,399	54,894	4.6	3.2	3.4	3,118	3,276	4,172	3.4	2.1	2.4
Colombia	50.4	52.6	0.4	326,392	358,748	514,935	8.1	2.6	3.7	6,553	7,119	9,797	7.4	2.0	3.2
Ecuador	17.5	19.3	1.0	97,319	102,650	134,794	3.4	2.3	2.8	5,690	5,868	6,993	2.2	1.1	1.8
Peru	32.6	34.8	0.6	210,021	228,259	318,173	7.8	2.7	3.4	6,509	6,999	9,152	7.1	2.2	2.7

GDP = Gross Domestic Product. USD = U.S. dollars.

Source: USDA, Economic Research Service, International Macroeconomic Data Set.

Appendix D: Exchange Rate and Price Measures for the International Food Security Assessment (IFSA) Countries, 2023–2033

Country	Consumer Price Index: Annual growth rate (percent)			Real exchange rate: Annual growth rate (percent)			Real domestic price of major grain: Annual growth rate (percent)		Real domestic price of food groups: 2022–23 growth rate (percent)**			
	2020–22	2022–23	2023–33	2020–22	2022–23	2023–33	2020–22	2023–33	MG	OF	OG	RT
Total IFSA countries	**50.2**	**43.0**	**10.4**						**1.0**	**-9.0**	**1.0**	**1.0**
Asia region	**7.8**	**7.3**	**5.3**						**2.0**	**-4.0**	**10.0**	**8.0**
East Asia sub-region	8.5	9.5	4.4						10.0	-5.0	4.0	6.0
Democratic People's Republic of Korea	7.1	10.8	2.4	-3.2	3.4	4.8	-10.2	2.8	5.0	-4.0	13.0	12.0
Mongolia	9.8	8.3	6.1	0.4	1.9	-0.5	11.8	-3.4	10.0	-5.0	4.0	6.0
South Asia sub-region	10.5	8.9	6.3						8.0	-2.0	11.0	10.0
Afghanistan	20.1	18.9	10.2	-2.1	2.3	2.2	11.4	-2.5	11.0	-5.0	5.0	9.0
Bangladesh	6.2	6.0	5.5	0.5	3.5	1.9	-5.3	0.3	3.0	-4.0	12.0	11.0
India	5.8	5.5	4.8	1.3	0.5	-1.7	-6.0	-2.0	2.0	-5.0	8.0	5.0
Nepal	5.5	6.2	4.9	1.5	-1.2	-2.2	-6.4	-2.6	1.0	-7.0	7.0	7.0
Pakistan	10.9	9.2	5.2	2.2	0.1	-1.0	20.7	-5.6	13.0	-6.0	4.0	7.0
Sri Lanka	14.5	5.9	4.9	23.0	15.0	-0.2	6.1	-0.9	10.0	4.0	16.0	21.0
Southeast Asia sub-region	4.5	4.6	4.2						2.0	-4.0	10.0	9.0
Cambodia	3.8	3.1	3.2	1.7	0.1	-0.6	-6.1	-1.4	2.0	-6.0	13.0	7.0
Indonesia	2.9	4.3	4.0	2.0	5.0	-1.8	-2.5	-0.9	2.0	-3.0	10.0	13.0
Laos	4.9	5.0	4.1	8.1	2.7	0.7	-0.5	-0.2	1.0	-3.0	8.0	8.0
Burma	7.7	7.0	6.4	11.1	0.7	0.8	0.4	-0.4	2.0	-3.0	12.0	8.0
Philippines	4.2	3.4	2.8	3.6	-1.3	-1.0	-2.5	-0.8	0.0	-7.0	9.0	6.0
Vietnam	2.8	4.1	3.6	3.0	0.4	0.1	-5.3	-1.0	2.0	-6.0	11.0	7.0
Former Soviet Union region	**11.7**	**8.9**	**5.4**						**9.0**	**-8.0**	**2.0**	**4.0**
Armenia	7.6	5.7	3.4	-0.9	-3.0	-1.3	7.2	-2.4	5.0	-9.0	4.0	2.0
Azerbaijan	8.6	6.4	3.8	-3.0	-3.1	-0.2	6.0	-1.9	4.0	-9.0	4.0	2.0
Georgia	11.0	7.5	3.8	-3.3	-2.7	-1.6	4.8	-1.8	4.0	-9.0	5.0	3.0
Kyrgyzstan	13.0	9.7	6.0	-2.7	-2.3	1.1	6.3	-1.7	5.0	-7.0	4.0	3.0
Moldova	14.6	8.0	4.2	-3.1	-4.3	-2.4	12.5	-4.8	7.0	-8.0	3.0	3.0
Tajikistan	10.3	9.3	5.6	4.4	4.8	1.8	13.2	-2.6	11.0	-3.0	9.0	9.0
Turkmenistan	13.9	10.2	5.8	-7.4	-0.6	0.6	8.5	-3.1	9.0	-7.0	2.0	7.0
Ukraine	13.8	11.3	6.6	-0.7	-13.3	-4.1	21.8	-8.4	1.0	-15.0	-3.0	-4.0
Uzbekistan	11.5	10.0	6.8	-0.4	-2.1	0.1	16.4	-4.4	10.0	-8.0	2.0	4.0

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Country	Consumer Price Index: Annual growth rate (percent)			Real exchange rate: Annual growth rate (percent)			Real domestic price of major grain: Annual growth rate (percent)		Real domestic price of food groups: 2022–23 growth rate (percent)**			
	2020–22	2022–23	2023–33	2020–22	2022–23	2023–33	2020–22	2023–33	MG	OF	OG	RT
Middle East and North Africa region	**74.8**	**44.2**	**9.7**						**-1.0**	**-15.0**	**-3.0**	**-5.0**
Middle East sub-region	97.6	49.1	10.1						-1.0	-15.0	-3.0	-5.0
Iran	35.9	13.2	13.3	-17.8	-15.4	-4.5	3.2	-6.0	-1.0	-20.0	-3.0	-4.0
Lebanon	176.5	75.0	5.4	-22.0	-32.7	0.4	-0.1	-0.6	-3.0	-2.0	-5.0	-22.0
Syria	132.1	45.0	12.9	-17.6	-16.2	-2.5	0.7	-0.9	0.0	-5.0	-2.0	-2.0
Yemen	15.3	15.8	6.0	-2.8	4.6	3.2	7.9	-1.6	9.0	-3.0	6.0	5.0
North Africa sub-region	7.5	7.0	4.1						12.0	-7.0	5.0	6.0
Algeria	9.7	8.3	4.5	2.7	-1.1	-0.2	22.8	-5.4	13.0	-7.0	6.0	7.0
Egypt	8.9	8.4	5.0	5.4	-3.0	-0.9	13.2	-3.3	7.0	-8.0	2.0	3.0
Morocco	2.6	2.4	1.7	3.3	-0.5	0.6	20.0	-4.3	12.0	-7.0	7.0	7.0
Tunisia	7.1	7.2	3.7	0.6	1.2	0.2	22.1	-5.4	15.0	-5.0	6.0	5.0
Sub-Saharan Africa region	57.0	47.6	10.9						2.0	-4.0	3.0	6.0
Central Africa sub-region	6.8	6.1	3.8						4.0	-2.0	2.0	4.0
Burundi	9.5	7.9	4.9	-0.6	0.2	0.6	7.0	-1.7	3.0	-3.0	4.0	4.0
Cameroon	2.8	2.8	2.5	5.6	-0.7	-1.4	7.4	-1.9	3.0	0.0	2.0	5.0
Central African Republic	5.8	8.7	4.8	2.6	-6.0	-3.6	13.8	-4.2	2.0	-9.0	1.0	2.0
Chad	2.7	2.8	2.6	3.8	-1.1	-1.6	16.5	-3.8	4.0	-6.0	3.0	6.0
Congo	2.5	3.3	2.2	4.0	-1.6	-1.7	23.7	-6.4	12.0	-6.0	1.0	6.0
Democratic Republic of the Congo	10.1	7.4	4.1	-0.1	-1.7	1.6	7.8	-1.6	3.0	-7.0	1.0	3.0
Eastern Africa sub-region	54.8	60.9	12.7						2.0	-6.0	2.0	8.0
Djibouti	2.3	3.3	1.6	3.0	-0.2	0.8	9.0	-2.1	6.0	-4.0	1.0	8.0
Eritrea	4.2	2.5	2.0	1.1	0.6	0.3	20.4	-4.9	14.0	-6.0	7.0	8.0
Ethiopia	30.5	31.4	28.3	0.1	5.2	-1.3	10.8	-3.2	7.0	-3.0	6.0	13.0
Kenya	6.3	5.8	4.9	5.0	1.9	0.3	17.4	-3.5	7.0	-6.0	10.0	8.0
Madagascar	6.6	6.5	5.1	1.0	1.4	1.5	-7.0	0.1	3.0	-6.0	13.0	8.0
Rwanda	4.4	8.3	5.0	5.4	0.7	2.7	17.5	-2.4	6.0	-6.0	6.0	8.0
Somalia	24.3	17.1	8.5	-3.6	1.5	-0.8	0.0	0.0	0.0	-5.0	0.0	9.0
South Sudan	1.1	25.0	8.2	22.9	1.4	-2.1			35.0	-5.0	25.0	29.0
Sudan	251.9	85.0	13.8	-5.9	-33.6	-4.2	7.1	-2.0	-10.0	-24.0	-7.0	-19.0
Tanzania	3.9	4.0	3.3	2.1	0.7	1.3	16.3	-3.1	6.0	-5.0	3.0	8.0
Uganda	3.2	5.2	4.5	0.3	0.5	2.1	17.5	-3.1	7.0	-6.0	5.0	7.0

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Country	Consumer Price Index: Annual growth rate (percent)			Real exchange rate: Annual growth rate (percent)			Real domestic price of major grain: Annual growth rate (percent)		Real domestic price of food groups: 2022–23 growth rate (percent)**			
	2020–22	2022–23	2023–33	2020–22	2022–23	2023–33	2020–22	2023–33	MG	OF	OG	RT
Southern Africa sub-region	91.2	37.9	7.9						3.0	-6.0	3.0	3.0
Angola	23.9	6.2	7.1	-12.7	5.4	-0.9	2.5	-1.4	3.0	-1.0	5.0	5.0
Eswatini	3.9	4.6	4.2	-1.8	0.9	0.7	5.7	-1.5	3.0	-6.0	3.0	9.0
Lesotho	6.5	5.6	5.5	-4.1	-0.1	-0.6	18.0	-5.5	8.0	-7.0	11.0	8.0
Malawi	11.6	9.6	8.0	-1.0	-5.8	-5.2	16.7	-6.4	2.0	-11.0	1.0	1.0
Mozambique	7.0	6.4	4.7	-4.6	4.6	1.6	8.2	-2.1	6.0	-3.0	5.0	7.0
Namibia	4.7	4.7	4.5	-2.6	0.8	0.3	4.2	-1.3	4.0	-6.0	2.0	9.0
Zambia	17.3	6.4	5.1	-10.7	6.8	1.1	13.2	-4.9	15.0	-2.0	15.0	13.0
Zimbabwe	117.7	41.8	8.0	-25.7	-25.2	-4.9	-1.0	-1.6	-5.0	-3.0	-5.0	-10.0
Western Africa sub-region	8.8	8.3	6.8						1.0	-5.0	6.0	6.0
Benin	3.8	2.9	2.8	3.7	-0.8	-2.0	-2.3	-1.1	1.0	-6.0	5.0	3.0
Burkina Faso	4.4	2.5	3.4	4.0	-0.3	-2.3	20.4	-5.4	7.0	-6.0	4.0	7.0
Cabo Verde	3.3	2.2	1.3	0.0	0.5	0.6	-2.1	-0.1	1.0	-6.0	3.0	2.0
Cote d'Ivoire	5.0	5.7	2.4	3.4	-3.4	-1.3	-2.7	-1.0	0.0	-8.0	8.0	3.0
Gambia	8.1	8.8	8.2	-0.4	0.8	0.1	-3.5	-0.4	1.0	-4.0	6.0	6.0
Ghana	14.7	9.7	6.9	2.4	-0.7	0.1	-2.9	-0.5	1.0	-6.0	6.0	5.0
Guinea	11.5	11.4	9.8	-8.2	1.1	0.3	-6.1	-0.3	1.0	-4.0	6.0	7.0
Guinea-Bissau	6.0	5.6	2.5	1.6	-3.3	-2.4	-3.7	-1.4	0.0	-5.0	2.0	4.0
Liberia	10.0	11.2	9.6	-14.5	-5.7	-4.7	-14.8	-2.9	-2.0	-9.0	8.0	2.0
Mali	5.1	4.1	3.1	3.3	-1.9	-2.0	-3.3	-1.5	0.0	-7.0	5.0	6.0
Mauritania	5.1	4.7	5.8	-1.1	0.6	0.1	8.5	-2.5	7.0	-6.0	1.0	9.0
Niger	5.2	5.3	4.8	1.3	-3.5	-3.6	11.3	-3.3	2.0	-8.0	1.0	5.0
Nigeria	16.8	13.0	6.9	-2.4	-6.9	-2.3	-2.6	-0.6	-1.0	-10.0	2.0	1.0
Senegal	4.4	4.9	2.5	4.0	-2.6	-1.4	-3.3	-1.4	0.0	-8.0	5.0	4.0
Sierra Leone	13.8	15.0	11.7	-0.5	1.4	0.3	-3.2	-0.3	1.0	-5.0	12.0	6.0
Togo	5.1	3.1	2.8	-0.3	-0.2	-2.1	9.7	-3.0	4.0	-6.0	4.0	3.0

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Country	Consumer Price Index: Annual growth rate (percent)			Real exchange rate: Annual growth rate (percent)			Real domestic price of major grain: Annual growth rate (percent)		Real domestic price of food groups: 2022–23 growth rate (percent)**			
	2020–22	2022–23	2023–33	2020–22	2022–23	2023–33	2020–22	2023–33	MG	OF	OG	RT
Latin America and the Caribbean region	**9.1**	**7.8**	**4.3**						**-2.0**	**-10.0**	**2.0**	**1.0**
Caribbean sub-region	17.5	13.9	5.3						3.0	-4.0	3.0	5.0
Dominican Republic	8.7	5.1	3.4	-3.6	0.4	2.3	-4.5	0.3	1.0	-6.0	12.0	8.0
Haiti	27.3	21.0	6.3	-11.4	-9.1	-2.2	-3.5	-0.4	-1.0	-2.0	1.0	0.0
Jamaica	8.1	6.0	4.3	2.0	-0.5	-0.5	23.4	-5.9	14.0	-5.0	3.0	6.0
Central America sub-region	6.0	4.8	3.9						2.0	-6.0	6.0	7.0
El Salvador	4.9	2.9	2.1	0.0	0.0	0.0	6.9	-1.8	3.0	-7.0	4.0	8.0
Guatemala	4.8	4.3	3.9	0.3	-0.9	-0.9	9.0	-2.5	3.0	-7.0	8.0	6.0
Honduras	7.6	6.9	4.7	-2.2	-1.5	0.9	9.3	-2.3	4.0	-7.0	5.0	7.0
Nicaragua	6.5	4.5	4.5	1.1	1.6	0.0	-3.1	-0.4	1.0	-5.0	7.0	8.0
South America sub-region	3.7	3.6	3.1						-2.0	-11.0	2.0	1.0
Bolivia	1.4	3.5	4.0	3.9	4.3	0.2	6.7	-1.8	6.0	-3.0	3.0	6.0
Colombia	6.1	4.7	3.2	2.9	-7.7	-0.3	-2.6	-0.5	-2.0	-11.0	2.0	1.0
Ecuador	1.4	1.9	2.9	0.0	0.0	0.0	-2.7	-0.3	1.0	-6.0	7.0	5.0
Peru	5.4	4.0	2.1	4.2	1.8	0.4	-2.9	-0.4	2.0	-6.0	7.0	9.0

MG = Major grain. OG = Other grains. OF = Other foods. RT = Roots and tubers.

**Real domestic price in grain equivalents expressed per kilocalories is used to generate price indices for the four food groups (i.e., major grains, other grains, other food, and roots and tubers) used in the IFSA demand model.

Source: USDA, Economic Research Service, International Macroeconomic Data Set.