What do we know about THE FUTURE OF FOOD DEMAND, PRODUCTION, AND FOOD SECURITY BASED ON IMPACT MODEL PROJECTIONS?

Nicola Cenacchi (IFPRI), Timothy B. Sulser (IFPRI), and Abhijeet Mishra (IFPRI)

Key messages

- Global food demand is projected to increase as incomes rise, and diets will continue shifting toward more nutrient-dense foods, especially in low- and middle-income countries (LMICs).
- IMPACT model projections indicate that global production for all agricultural commodities will increase by over 40 percent between 2020 and 2050, driven by innovation and productivity growth, but resource constraints and climate change pose challenges. As with demand, production is projected to grow fastest in LMICs.
- In the coming decades, food demand is projected to outpace production in most LMIC regions. As a result, most of these regions, with the exception of Latin America and the Caribbean (LAC), are expected to increase their reliance on imports.
- Increases in production and trade are expected to enhance food availability, but most LMIC regions are not on track to achieve Sustainable Development Goal 2.1 on ending hunger by 2030.
- Strengthening model integration and incorporating socioeconomic disaggregation will enhance IMPACT's ability to provide more comprehensive insights for decision-making to address these challenges.

RECENT TRENDS AND CHALLENGES

As global population and incomes continue to rise, demand for food, water, and other essential resources increases, placing significant pressure on agricultural systems and natural ecosystems. Rising temperatures, shifting precipitation patterns, and more frequent extreme weather events will also affect food production and global supply chains, with different magnitudes of effects across regions and latitudes. Making the food security picture even more complex, geopolitical dynamics, shifts in trade policies, and related government interventions will influence access to markets, input costs, and the stability of the food supply.

Given these complex and interconnected challenges and uncertainty, scenario analysis using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) provides a crucial tool for assessing the potential scale and severity of future food system challenges and opportunities to address them. IMPACT is a system of models in which water, land use, crop, and value chain models are all linked to a core partial equilibrium multimarket economic model of global production, trade, demand, and prices for agricultural commodities. The modeling system also integrates projections of future changes in technology (drawing on the expertise of CGIAR scientists and other experts around the world) as well as in climate, population, and gross domestic product (Robinson et al. 2015; Eyring et al. 2016; K.C. et al. 2024).

By simulating different futures under alternative socioeconomic, environmental, and policy conditions, the model helps researchers, policymakers, and stakeholders: identify vulnerabilities; evaluate adaptation strategies by weighing their synergies and trade-offs; and develop informed, evidence-based policies to enhance resilience and guide the sustainable transition of global food systems.

The results presented here (and in the other chapters in this volume) are based on IMPACT release v3.4 (Rosegrant et al. 2024). They show the model projections for agriculture demand, production, net trade, and food security under a business-as-usual scenario characterized by middle-of-the-road population and income growth (SSP2) taken from the Shared Socioeconomic Pathways (SSP) database (Riahi et al. 2017) and a radiative forcing coded in the Representative Concentration Pathway 7.0 (RCP 7.0) downscaled using the IPSL-CM6A-LR global circulation model from climate scenarios produced by the Coupled Model Intercomparison Project–Phase 6 (CMIP6) (Eyring et al. 2016).

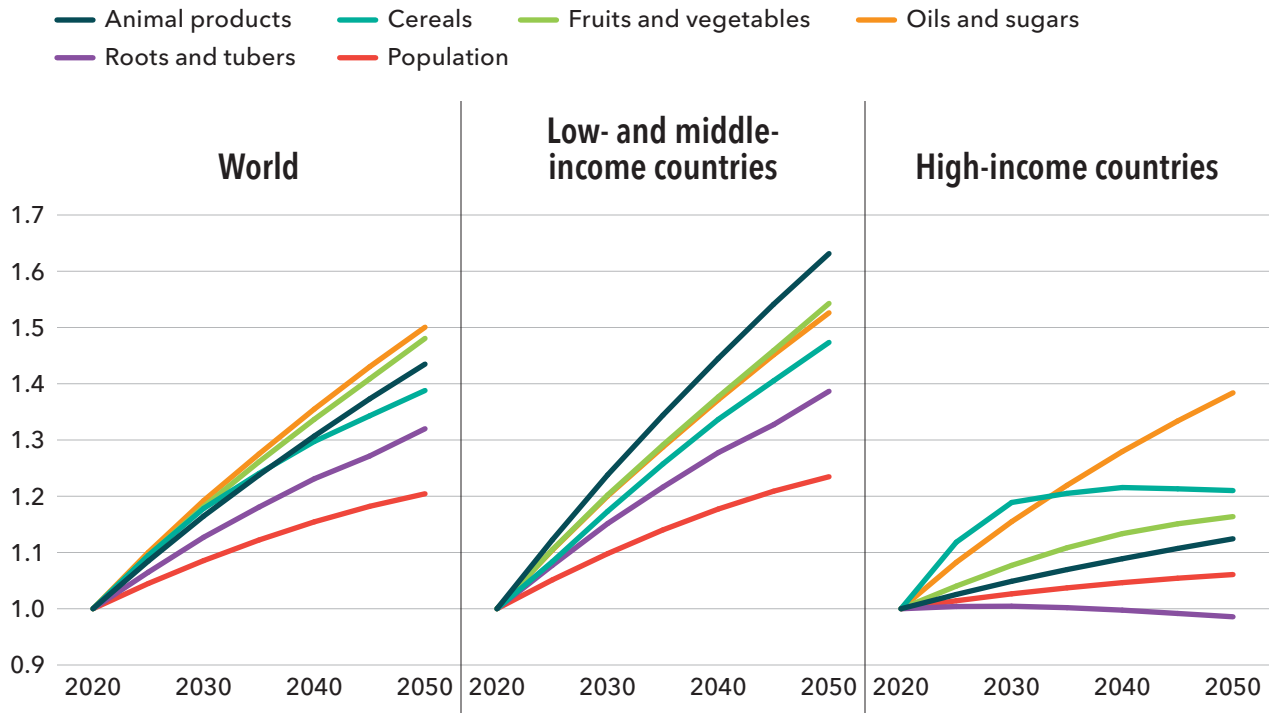
Baseline projections like these provide a starting point for analysis of the possible alternative policy and investment scenarios noted above and also underlie some of the findings in the other chapters of this volume. While we touch on growing demand, trade, nutrition, climate, and agricultural investments below, more details can be found in the corresponding chapters on animal-source foods, trade, diets and nutrition, and innovation. Similarly, dedicated chapters on LMIC regions add nuance and clarification to the regional results illustrated here.

LATEST FORESIGHT RESEARCH

Based on IMPACT projections, global demand for food commodities is expected to grow faster than population between 2020 and 2050, with a more rapid increase in LMICs compared to HICs (Figure 1). Incomes are projected to grow at about 3 percent per year, and — in accordance with Bennet's law — diets shift toward nutrient-dense foods, including more fruits and vegetables, processed foods, and animal-source foods. Cereals as a share of total average diet are projected to decrease by 4 percentage points globally by 2050, and by 5 percentage points across LMICs, due to slower demand growth. Demand for animal products is projected to grow by over 60 percent in LMIC regions,[1] a growth rate five times faster than in the rest of the world. Meat production is projected to double in East and Southern Africa (ESA), West and Central Africa (WCA), and South Asia (SA) by 2050; however, per capita consumption levels in LMICs will remain less than one-half of those in high-income countries (HICs). In HICs, demand for cereals is saturated by 2050, but not for oils and sugar, highlighting concerns about health impacts.

1 The names and acronyms used here for LMIC regions follow the CGIAR classification (https://www.cgiar.org/research/cgiar-regions/).

FIGURE 1 Population growth and demand growth (by food group) between 2020 and 2050, world and aggregated LMICs and HICs



Source: Extended results from Rosegrant et al. (2024).

Note: Indexed values, 2020 = 1. LMICs = low- and middle-income countries; HICs = high-income countries.

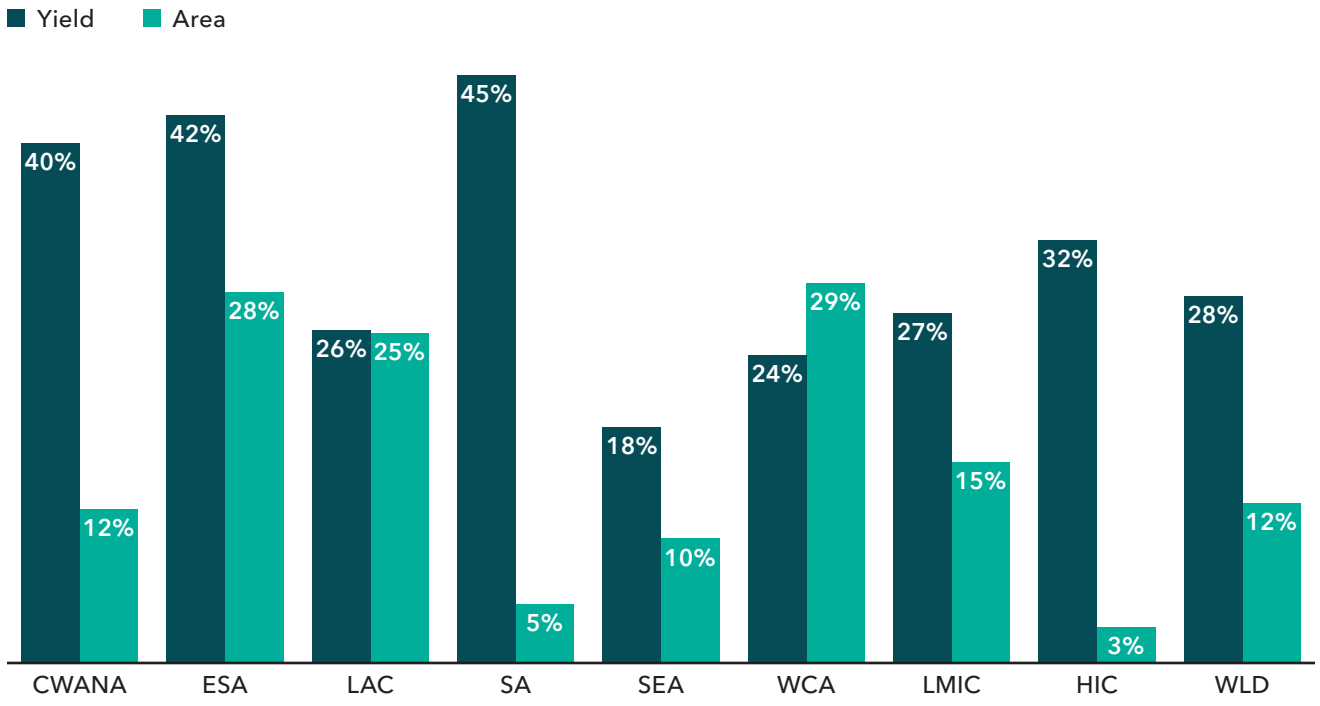
On average, demand for fruits and vegetables and oils and sugars will also grow by close to 50 percent, globally as well as across LMIC regions. In particular, the growing demand for processed foods is revealed by the increase in production of oil crops: by 2050, production is expected to grow by more than 80 percent in WCA and by 70 percent in Southeast Asia and the Pacific (SEA). Production of fruits and vegetables is projected to double in SA and ESA, while WCA and Central and West Asia and North Africa (CWANA) are projected to see increases of over 70 percent by 2050.

Baseline projections indicate that aggregate global food production will grow by about 44 percent over 2020 levels by 2050 to keep up with demand. Production and demand are projected to grow more rapidly in LMICs, particularly in Africa, than in HICs. By 2050, the baseline scenario shows crop production over 80 percent greater in ESA, 60 percent greater in WCA, and more than 50 percent higher in LAC and CWANA. In comparison, crop production in HICs is expected to grow by about 30 percent on average between 2020 and 2050.

In most regions, productivity growth is expected to be the primary driver of increased agricultural production, driven by investments in R&D, efficiency gains, and mechanization (Figure 2). However, when accounting for water constraints and the projected rise in weather variability and extreme events—particularly affecting crop production in equatorial regions (Heikonen et al. 2025) – the agriculture sector is expected to require an additional 170 million hectares of cropland globally to meet demand by 2050. Notably, 95 percent of this cropland expansion is projected to take place in LMICs, especially in ESA, LAC, and WCA.

Despite the increase in production, demand for food commodities is estimated to be larger and grow faster than production across LMIC regions. As a result, all regions except LAC will rely increasingly on imports, and LMICs as a group will be a net importer for all major food groups (Figure 3) (see additional details in the trade chapter). A greater volume of trade is essential to respond to geographic shifts in production and demand, while also adapting to the impacts of shifting weather patterns as well as demographic and income changes. Global trade

FIGURE 2 Percentage change in yields and harvested area between 2020 and 2050, by world, LMIC region, and aggregated LMICs and HICs



Source: Extended results from Rosegrant et al. (2024).

Note: CWANA = Central and West Asia and North Africa; ESA = East and Southern Africa; LAC = Latin America and the Caribbean; SA = South Asia; SEA = Southeast Asia; WCA = West and Central Africa; LMIC = low- and middle-income countries; HIC = high-income countries; WLD = world.

volumes are projected to more than double by 2050, but subject to considerable uncertainty, depending on changes in trade policies.

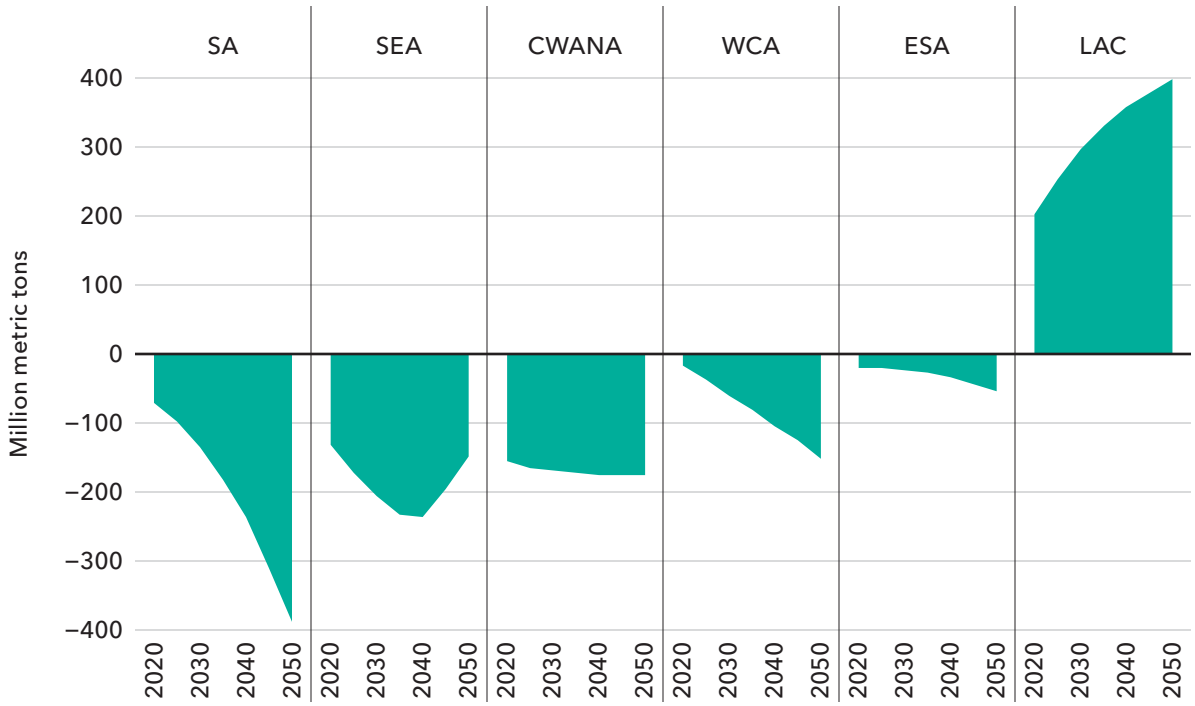
Larger trade volumes, along with greater production, are projected to increase food availability and raise the average per capita calorie availability across LMICs by 265 kilocalories (kcal) between 2020 and 2050, an increase of 10 percent. Globally, average dietary energy consumption is projected to increase by about 8 percent, to nearly 3,000 kcal per capita per day. As a result, the global population at risk of hunger is projected to decline by over 200 million (over 30 percent from 2020 levels). A decrease is projected across all regions except CWANA, with the largest improvements in SA, where over 130 million fewer people will be at risk by 2050 (Figure 4). The share of population at risk also declines for the group of LMICs, but not fast enough to reach the 5 percent threshold in 2030 and achieve SDG 2.1.

Despite progress, a business-as-usual trajectory under moderate climate change is projected to leave almost 450 million people at risk of hunger by 2050, with about one-half of that total equally distributed between ESA and SA. The challenge will be to find affordable and more efficient and equitable ways of increasing access to food worldwide.

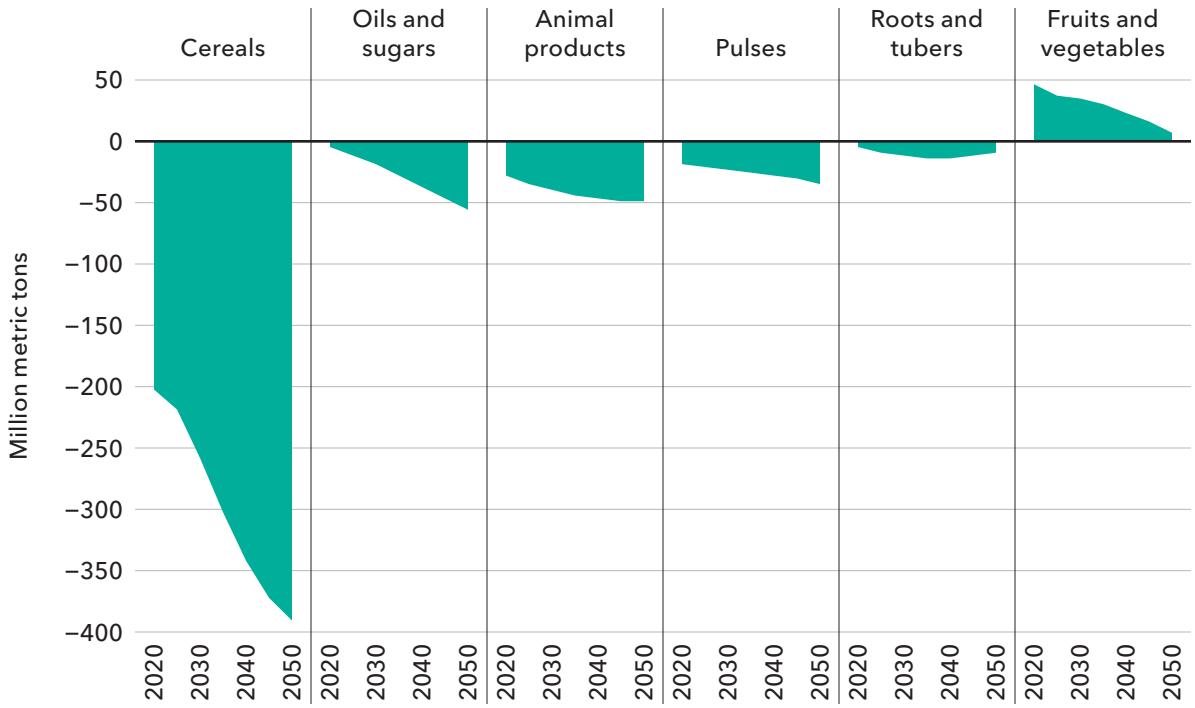
At the same time, improving the nutritional content of diets will be essential to counteract current trends in obesity as well as micronutrient deficiency (Costlow et al. 2025; Beal et al. 2017). While our projections suggest a decline in micronutrient deficiency, the availability of different nutrients is expected to be influenced by changing dietary preferences, fluctuating prices and incomes, and the rising concentrations of atmospheric carbon dioxide (Beach et al. 2019) (see the chapter on diets and nutrition). Healthier diets are also likely to be less "tradable," as they require greater consumption of foods that may be more expensive, perishable, and harder to transport or store. Therefore, agricultural investments focused on boosting local productivity are going to be critical. Additional agricultural investments in infrastructure and R&D have the potential to speed up the progress (Sulser et al. 2021).

FIGURE 3 Net trade between 2020 and 2050

A Net trade - LMIC regions - all commodities

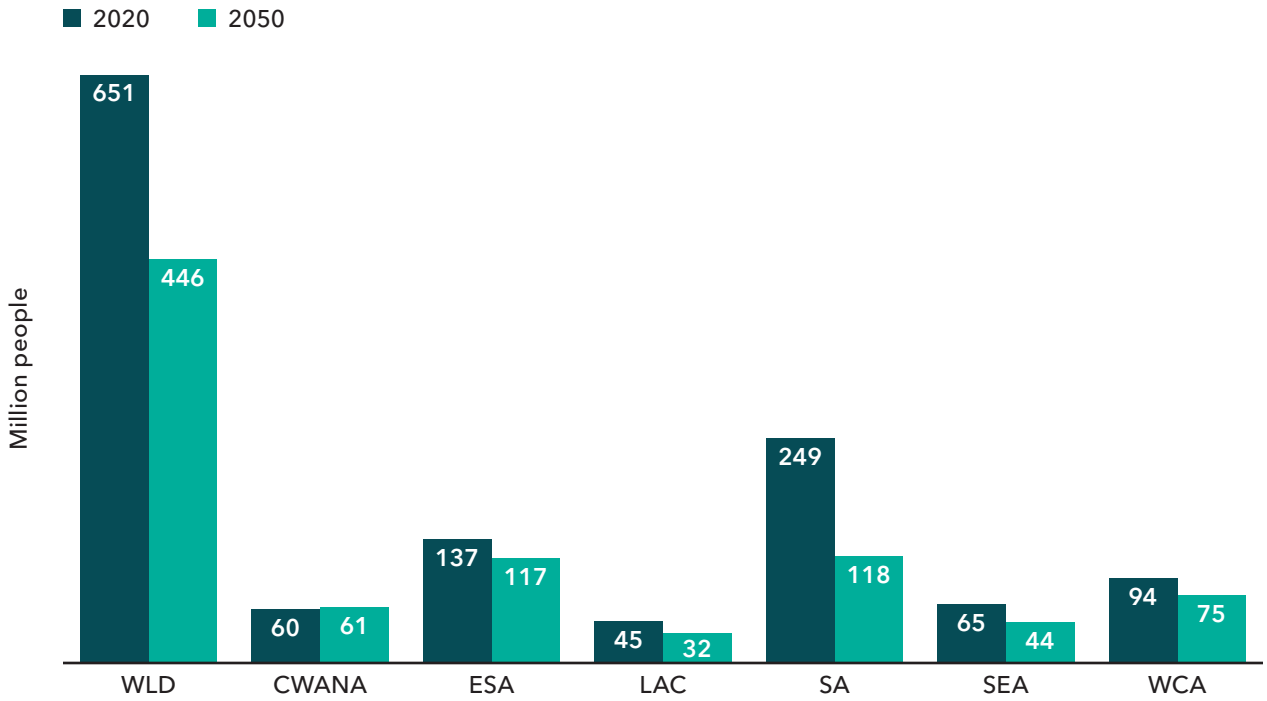


B Net trade - LMICs - by food group



Source: Extended results from Rosegrant et al. (2024).

FIGURE 4 **Population at risk of hunger, by world and LMIC region, in 2020 and 2050**



Source: Extended results from Rosegrant et al. (2024).

Note: WLD = world; CWANA = Central and West Asia and North Africa; ESA = East and Southern Africa; LAC = Latin America and the Caribbean; SA = South Asia; SEA = Southeast Asia; WCA = West and Central Africa.

KEY GAPS AND OPPORTUNITIES FOR FORESIGHT RESEARCH

The IMPACT modeling system links climate, water, and crop models to support the integrated study of future changes in population, income, diets, technology, natural resources, and climate, allowing for in-depth analysis of a variety of critical issues of interest to policymakers. IMPACT has been adapted over time to augment its capacity to address different issues of interest, such as water, climate change, and biofuels, among others. We highlight here a few themes currently in focus for the modeling framework, though many other topics are under development. Links between IMPACT and the global dynamic computable general equilibrium (CGE) model (GLOBE) further enhance analyses by allowing researchers to explore how investments or shocks in the agriculture sector may influence broader economic outcomes at national and regional levels and how that feeds back on incomes, an important driver in IMPACT. The interlinkage between these two modeling frameworks (partial equilibrium and general equilibrium, respectively) can be increased in a number of ways. For example, labor markets and other factors of production (such as inputs like fertilizer) are heavily influenced by the broader economy, as modeled by GLOBE, and are crucial for agriculture sector dynamics, as modeled by IMPACT.

The rising demand for protein highlights the need for a deeper understanding of livestock and fish production, as well as an exploration of future demand dynamics. Direct climate effects on animal-source foods are relatively understudied compared to crops, and developing a globally consistent knowledge base for the effects of climate change on animal productivity is crucial. Advancing this area will require both enhancements to the IMPACT modeling framework and stronger linkages with other analytical approaches, particularly for assessing herd dynamics, economic implications, and nutritional outcomes under different management strategies.

The recent link with a novel land-use model has expanded IMPACT's capacity to evaluate how the global food system

and shifting weather patterns influence the distribution of cropland and natural habitats. While this allows exploration of questions around agricultural expansion and encroachment on specific natural habitats, full feedback between the land use model and IMPACT is still under development.

Relatedly, increasing efforts are being directed toward disentangling the impacts of weather variability and extremes alongside long-term climate trends. Further work is envisioned to disaggregate results by income class, gender, and rural and urban populations, as well as to conduct more granular subnational analyses. These refinements will not only improve our ability to explore alternative futures but will also strengthen the evidence base for policymaking, fostering more informed dialogues about productive, sustainable, and resilient solutions.

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The authors of this chapter are **Nicola Cenacchi**, a Senior Research Analyst in the Foresight and Policy Modeling Unit at the International Food Policy Research Institute (IFPRI); **Timothy B. Sulser**, a Senior Scientist in the Foresight and Policy Modeling Unit at IFPRI; and **Abhijeet Mishra**, an Associate Research Fellow in the Foresight and Policy Modeling Unit at IFPRI.

Related chapters on the future of food system drivers and impacts, regional and national perspectives, food commodities, and foresight tools are available in our Table of Contents.

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1201 Eye St, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info

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