Strategic Modeling for Future Agriculture in Asia

Asian Productivity Organization

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APO Members

Bangladesh, Cambodia, Republic of China, Fiji, Hong Kong, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkiye, and Vietnam.

STRATEGIC MODELING FOR FUTURE AGRICULTURE IN ASIA

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Strategic Modeling for Future Agriculture in Asia

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FOREWORD

Agriculture has been the foundation of livelihoods for millions across Asia and the Pacific, ensuring not only food security but also acting as a driver of economic prosperity, providing jobs and a sense of stability for rural communities. Over the past few decades, the region has experienced significant growth in agricultural productivity and made advances in reducing hunger. However, recent global challenges, including climate change, economic disruptions, rising costs, and the aftermath of the COVID-19 pandemic, have tested our resilience, highlighting vulnerabilities within food systems which threaten to reverse hard-won progress.

In this context, the Asian Productivity Organization (APO), in partnership with the International Food Policy Research Institute (IFPRI), is proud to present this report on *Strategic Modeling for Future Agriculture in Asia*. The study, prepared by IFPRI experts, uses advanced scenario modeling to explore what the future might hold for agriculture up to 2050, particularly under different investment scenarios focusing on R&D initiatives, expanding irrigation infrastructure, and making water use more efficient.

The findings are both timely and instructive. They clearly show that targeted investments in agricultural research, irrigation, and water management can boost productivity, improve dietary quality, lift 45 million people out of hunger by 2050, and reduce pressure on critical water resources. These benefits apply across multiple APO member economies with notable gains in water-stressed areas like Bangladesh, India, and Pakistan and significant productivity improvements in countries such as Indonesia, Thailand, and Vietnam, which are covered in this report.

Moreover, the report highlights that socioeconomic factors such as population growth, income dynamics, and technology adoption often have a greater impact on agriculture than climate change in the longer term among APO members in which the strategic simulation was done. However, the acute effects of climate change over the shorter term, such as extreme weather events, still pose a threat to livelihoods that needs to be addressed by building up resilience. Projections indicate that strategic economic growth, international cooperation, and technological advances could significantly boost agricultural productivity, helping APO economies such as Indonesia, Lao PDR and I.R. Iran come closer to meeting the UN target of eradicating hunger by 2030, as outlined in SDG 2.1. However, for several countries, such as India, Bangladesh, Pakistan, and Sri Lanka, this target may remain out of reach until well after 2050 unless we accelerate our efforts.

The APO extends gratitude and appreciation to the research team at IFPRI, particularly Nicola Cenacchi and Timothy B. Sulser, for their dedication and expertise. We also recognize the support from the CGIAR Initiative on Foresight, which played a key role in making this collaboration possible.

Both the challenges and opportunities are significant. By embracing the recommendations outlined in this report, such as investing in R&D, expanding irrigation, and focusing on efficient water use, APO member economies can build a more resilient, productive, sustainable future for agriculture. We invite all stakeholders to join us in leveraging these insights to work toward a more food-secure, prosperous Asia-Pacific region.

Dr. Indra Pradana Singawinata
Secretary-General
Asian Productivity Organization

PREFACE AND ACKNOWLEDGMENT

Despite enjoying strong economic growth in the last few decades, parts of Asia still face challenges to food security and productivity in their agrifood sectors. Agricultural production is likely to see important impacts from several global drivers. Climate change compounds pressures on food systems coming from the rapid developments in demographic, income, and technology trends.

In light of these challenges, in 2024, the Asian Productivity Organization (APO) and the International Food Policy Research Institute (IFPRI) entered an agreement to produce a technical report exploring longer-term projections of outcomes related to the agrifood sector in Asia. The aim of the report is to help inform decision-making by the APO and its members.

This work was undertaken by IFPRI with funding from the APO and support from the CGIAR Initiative on Foresight.

Nicola Cenacchi and Timothy B Sulser
Washington, DC

EXECUTIVE SUMMARY

Agricultural productivity and food security in Asian Productivity Organization (APO) member economies have faced significant setbacks since 2019 due to global conflicts, the COVID-19 pandemic, climate change, and rising food and input costs. After decades of progress, the number of undernourished people in the region has surpassed 300 million (back to 2010 levels). This troubling reversal of earlier gains, coupled with lack of proper investments, is slowing the necessary improvements in agricultural productivity.

Despite economic growth, parts of Asia continue to face challenges to agricultural productivity and food security. Growth in total factor productivity (TFP) for agriculture has slowed in several geographies, including India and Southeast Asia. Contributing factors include climate change, land degradation, reduced investment in agricultural research and development (R&D), and inefficiencies in the market. Water scarcity, exacerbated by groundwater depletion, pollution, and degradation of freshwater ecosystems, is a particularly pressing issue, with agriculture and urban demand placing increasing pressure on resources. Global drivers, especially climate change and population growth, will compound the current challenges and likely have complex effects on productivity and food security. This emphasizes the need for innovative strategies and targeted investments to support sustainable agricultural development.

This report examines various investments and policy interventions aimed at enhancing agricultural productivity, food security, and water use in low- and middle-income APO economies. Using scenario analysis, it projects outcomes for 2050 by different investments in R&D, irrigation, and water use efficiency (WUE). The goal is to provide insights that can help guide policymakers in crafting strategies for sustainable agricultural growth and productivity.

Key findings show that in a middle-of-the-road socioeconomic scenario, the total population across APO member economies is expected to increase by 21% between 2020 and 2050, with significant variations across countries. Pakistan, Mongolia, and the Philippines may see the largest population increases, while Thailand is projected to experience a population decline. Economic growth may result in a tripling of APO members' GDP by 2050, compared with 2020 levels. Crop production is projected to increase by over 40%, resulting in greater calorie availability and improved dietary quality across APO economies, characterized by a greater share of animal products and fruits and vegetables.

This report compares the impacts of socioeconomic factors and climate change on agriculture and finds that socioeconomic trends may have a larger influence on agricultural productivity by mid-century. A scenario with higher population growth, lower economic development, and reduced technological innovation (SSP3)[1] is projected to result in crop yields being 5% less by 2050 compared with the reference scenario. Conversely, a future with lower population growth, higher economic growth, stronger international cooperation, and more rapid technological development (SSP1) is expected to increase agricultural productivity by over 9% compared with the reference.

[1] SSP3 stands for Shared Socioeconomic Pathway 3.

In addition to the effects of population and income growth, this report explores different scenarios of increased investment in R&D, irrigation, and WUE. Results show that such interventions have the potential to increase farm productivity while enhancing food security, reducing hunger, and conserving natural resources. Under a comprehensive investment scenario (COMP) that combines investments in R&D, irrigation, and WUE, calorie availability per person could rise by 18% between 2020 and 2050. As a result, in 2050, COMP would lift 45 million people out of hunger compared with the reference scenario. COMP would also improve water management, saving over 60 billion cubic meters of water by 2050, compared with the reference, across the APO region, primarily in highly water-stressed areas like India. WUE investments could substantially reduce the water footprint of agriculture, thereby ensuring more sustainable use of limited resources.

Achieving Sustainable Development Goal 2.1 (ending hunger by 2030) remains a distant target for many APO economies. While some nations, such as Turkiye and Malaysia, are on track to meet this goal, others, including India, Bangladesh, and Sri Lanka, are not expected to reach the target until after 2050. However, targeted investments in agricultural productivity and water management could accelerate the progress, bringing many countries closer to achieving food security within the next few decades.

This analysis provides a roadmap for policymakers, emphasizing that strategic investments in agricultural productivity are essential for addressing future food security and ensuring sustainable agricultural development in the face of ongoing climate and socioeconomic challenges.

INTRODUCTION AND STATEMENT OF PURPOSE

APO low- and middle-income member economies[2] have made significant progress in reducing hunger. Between the year 2000 and 2019, the total number of undernourished people across all members decreased from 350 million to 230 million, mainly due to rapid economic and agricultural growth. Since 2019, long-run conflicts (e.g., the Russia–Ukraine war, and civil unrests in Myanmar and Afghanistan), the COVID-19 pandemic, worsening climate change, and rising prices of food, fuel, fertilizer, and livestock feed, have caused a backslide in hunger reduction. Food insecurity started increasing rapidly after 2019, and the number of undernourished people in 2021–23 was more than 300 million, back to the level similar to that in 2010 (FAO 2024).

Despite enjoying strong economic growth, parts of Asia still face challenges in agricultural production and food security. Agricultural productivity growth is slowing in several countries while agricultural R&D expenditures have declined. Agricultural productivity growth, as measured by TFP, slowed across much of Asia from 2010 to 2020, including in India and Southeast Asia (Fuglie et al., 2021). This decline is attributed to climate change, water scarcity, land degradation, reduced investment in agricultural R&D, and market inefficiencies (Fuglie et al., 2021). Water scarcity is a growing issue caused by increasing demand from agriculture, manufacturing, and urban areas; and is exacerbated by groundwater depletion, water pollution, and degradation of freshwater ecosystems (UN, 2023).

This reversal of progress underscores the urgency for policymakers, local and international non-governmental organizations, and regional development banks, to accelerate progress toward achieving multiple key food security goals in addition to reducing hunger. These goals include reducing poverty, ending hunger, achieving food and nutrition security, and promoting sustainable agriculture. Achieving these goals requires addressing several strategic food system challenges.

In the coming decades, agricultural production is likely to be affected negatively by many global drivers, including climate change, whose shocks may compound pressures on food systems in the wake of the rapid regional economic and demographic development. Therefore, it is important to study the future potential effects of such global drivers on agriculture productivity and food security across the APO region as well as the potential investment pathways to improve productivity and resilience of the sector.

The goal of this report is to help inform decision making in the agriculture sector across APO economies, by exploring the potential to offset the impacts of different global shocks through investments in enhanced productivity and in wider and more efficient use of water resources.

[2] This analysis focuses on developing APO member economies, those currently classified as low- and middle-income (LMIC) by the World Bank. High-income economies (Republic of China, Japan, Republic of Korea, and Singapore) are not included in this analysis. Hereafter, reference to APO economies implies LMIC members only.

Tackling current and future challenges will necessitate innovative strategies, along with targeted investments and policy interventions (Rosegrant, 2016), (Rosegrant, 2020). This report examines a diverse portfolio of investments and policies, focusing on their effects on agricultural productivity, food consumption, prices, hunger, and water scarcity. Using scenario modeling, it projects outcomes by 2050 under varying levels of investment in R&D, irrigation, and WUE. These investments are broadly defined in a stylized approach that provides direction toward classes of investment opportunities. Complementary to this analysis, specific implementation of investments under these broader approaches requires tailored assessments at the country and subnational levels to determine appropriate combinations of technologies for different commodities that work within regional food systems and production practices.

Research Objectives

The report will focus on the effects of climate and socioeconomic change on agricultural productivity and consumption and explore the potential of investments in R&D and water as adaptation measures across the agriculture sector. It will:

(1) explore different socioeconomic, climate, and technology scenarios in the agrifood sectors in APO low- and middle-income (LMIC) members;

(2) analyze and produce longer-term projections based on strategic modeling of the agrifood sector in the Asia-Pacific region; and

(3) recommend policies for enhancing agricultural productivity in the region to meet future needs.

METHODOLOGY

The IMPACT System of Models

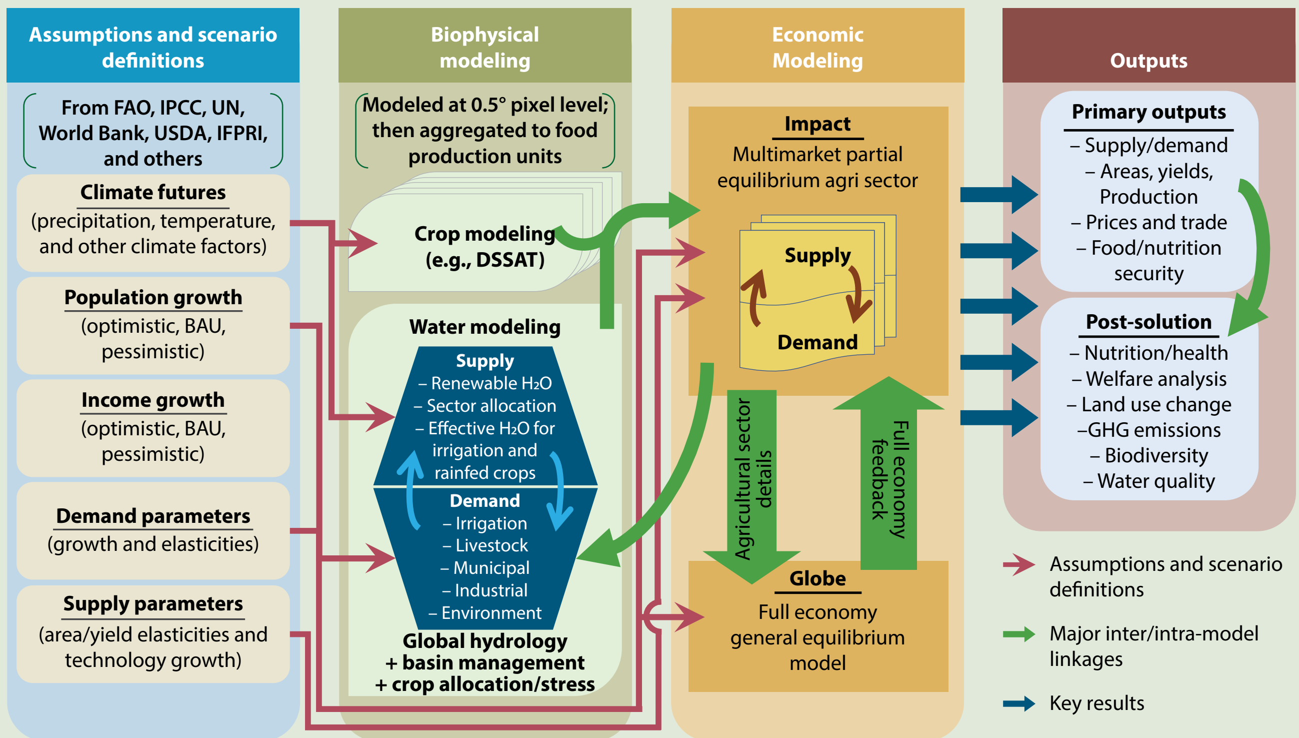
This research will use projections from the International Food Policy Research Institute (IFPRI)'s International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Robinson et al., 2015, Rosegrant et al., 2024) using a range of socioeconomic, climate, and technology/investment scenarios to explore the country- and regional-level dynamics in the agrifood sector out to mid-century.

IMPACT is a partial-equilibrium economic model that simulates national and global markets of agricultural production, demand, and trade. It was developed at IFPRI at the beginning of the 1990s to address a lack of long-term vision and consensus among policymakers and researchers on the actions necessary to feed the world in the future, reduce poverty, and protect the natural resource base. Over time, the model has been expanded and improved.

IMPACT is now an integrated system of models that links information from climate models, crop simulation models, and water models to a core global, partial-equilibrium, multimarket model focused on the agriculture sector (see Figure 1). Crop models use information on the geographical

FIGURE 1

IMPACT MODELING FRAMEWORK.

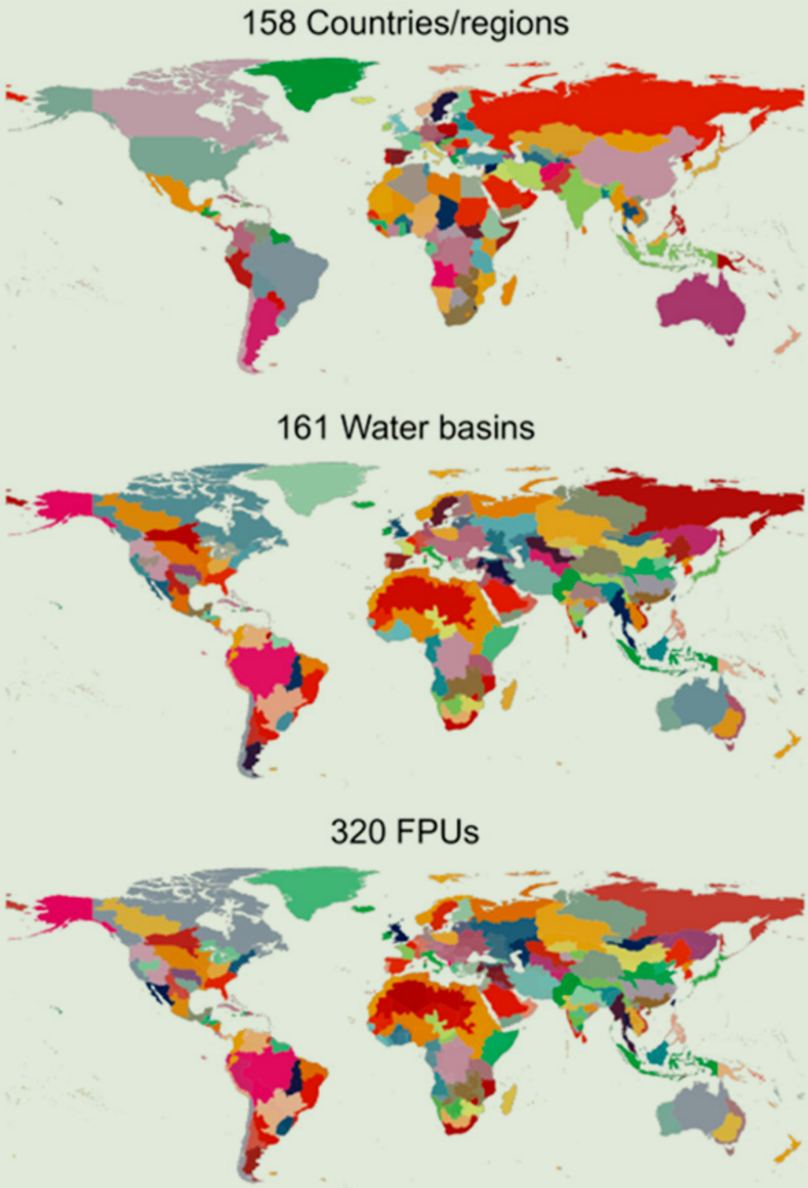


distribution of crops as well as their water management (rainfed or irrigated) from the Spatial Production Allocation Model.

IMPACT covers 62 commodities and 158 countries with subdivisions for 161 water basins that combine into a total of 320 production units (see Figure 2). IMPACT supports analysis of long-term challenges and opportunities for food, agriculture, and natural resources at global and regional scales. It has been employed in a wide range of analyses, ranging from assessing the potential effects of climate change on global food production and nutrition to exploring linkages between agriculture production and food security at the national and regional levels, to the assessment of economic effects of alternative mitigation policies and the global simulation of technology adoption.

FIGURE 2

IMPACT MODEL GEOGRAPHY.



IMPACT Simulations: Reference Suite of Scenarios

Assumptions on population and income growth are taken from the Shared Socioeconomic Pathways (SSP) database (Riahi et al., 2017) generated for the reports of the Intergovernmental Panel on Climate Change (IPCC). Climate shocks are obtained from climate scenarios produced by the Coupled Model Intercomparison Project – Phase 6 (CMIP6), (Eyring et al., 2016). For this analysis, we use the IPSL-CM6A-LR general circulation model (GCM).

The reference scenario (REF, Table 1) assumes population and income trends from SSP2, which is a middle-of-the-road socioeconomic scenario. Agricultural investments and productivity growth follow business-as-usual projections, while climate change shocks are derived from Representative Concentration Pathways (RCP) 7.0 as projected under the IPSL GCM. Optimistic and pessimistic climate change scenarios are constructed using lower (RCP2.6) and more severe (RCP 8.5) representative concentration pathways, respectively. More optimistic or pessimistic socioeconomic scenarios are built using the SSP1 and SSP3 shared socioeconomic pathways, respectively.

TABLE 1

LIST OF SCENARIOS.

Scenario grouping	Scenario name	Scenario description
Reference	REF	SSP2-RCP7.0-IPSL
	REF_NoCC	Reference scenario with constant 2020 climate
Optimistic climate change	REF_LowCC	SSP2-RCP2.6-IPSL
Pessimistic climate change	REF_HighCC	SSP2-RCP8.5-IPSL
Optimistic socioeconomic futures	SSP1	SSP1-RCP7.0-IPSL
Pessimistic socioeconomic futures	SSP3	SSP3-RCP7.0-IPSL
Investment in agricultural productivity growth	HIGHplus	Increase in R&D investment across international and national agricultural research systems plus increased research efficiency
Investment in irrigation expansion	IRREXP	Increased investment to expand irrigation
Investment in irrigation and water use efficiency	IRREXP+WUE	Increased investments to expand irrigation plus increased water use efficiency
Comprehensive investment	COMP	Combines HIGHplus and IRREXP+WUE

Investment Scenario Details

HIGHplus: This scenario focuses on increased investments in agricultural R&D and combines a few measures. We simulate increased investment in international agricultural research centers (IARCs), including CGIAR and other international research centers, which lead to accelerated yield gains. To this, we also add higher yield gains enhanced by the national agricultural research systems (NARS) extension work, which promotes technology adoption and localizes application of technologies developed elsewhere. We do not directly model extension services, but we use assumptions that reflect how extension and other policies are necessary to achieve full benefits of agricultural R&D. The final component covers investments in improving the spread and sharing of advanced research technologies across institutional and national boundaries. This reduces lag time from discovery to adoption, accelerating yield gains. Potential yield gains with research efficiency investments allow for investments to realize in-field yield increases within the first 10 to 15 years from the initial investment and peak in 20 to 25 years.

IRREXP: Projected irrigated area expansion rates vary across river basins and countries depending on recent trends, investments, and water availability. Priority is given to converting rainfed areas suitable for irrigation, up to 50% of initial rainfed area, followed by development of new lands for irrigation. Irrigated area under IRREXP is projected to be 8% higher by 2050 across the APO region compared with the reference scenario. Projected rainfed areas under the irrigation investment scenarios relative to reference scenario would decline because some rainfed areas would be converted to irrigation.

IRREXP+WUE: This scenario combines the expansion of the irrigated area from IRREXP with additional investment in irrigation modernization for advanced technologies and practices, enhancing WUE. WUE investments increase water available for irrigation (or decrease the amount necessary to maintain production levels). At the basin level, WUE is simulated as increasing basin efficiency by 12–35% in 15 years, varying by river basin. The improvements in efficiency are specific to each river basin and depend on available water resources and the potential improvement from initial WUE levels. In the reference scenario, it is assumed that 15% of the irrigated area in Asia–Pacific in 2020 will have investments in modernization, phased evenly from 2020 to 2050. Under the WUE scenario, it is assumed that 30% of the irrigated area will have investments in modernization. The average basin efficiency in 2050 under the IRREXP+WUE scenario is 0.68.

COMP: This scenario combines HIGHplus and IRREXP+WUE as described above.

RESULTS: EFFECTS OF BACKGROUND DRIVERS ON AGRICULTURE, DIETS, AND HUNGER

Effects of Population and Income

Results across three SSP scenarios (SSP1, SSP2 or the REF scenario, and SSP3) allow us to focus on the model assumptions for population and GDP and observe the projected effects of these drivers on the average diets and agricultural productivity across APO economies.

Projections under the REF scenario show population increasing by 550 million people (+21%) for the entire APO region between 2020 and 2050. At the country level, the largest increases in percentage are projected for Pakistan (65%); Mongolia (40%); and the Philippines (+39%). India is projected to become more populous than China by 2035. India's population may grow by 158 million (11%) by 2035, and 230 million (17%) by 2050. Thailand is the only APO member economy under consideration where population is projected to decrease, with a contraction of 3.5 million people by 2050 (–5%) (see Table 2). In accordance with the SSPs narratives, all APO economies have lower population growth in the SSP1 scenario and higher in the SSP3 scenario, compared with REF (SSP2).

Large changes are also expected for income under SSP2, with average GDP across APO economies tripling by 2050 compared with 2020. GDPs of Cambodia, Bangladesh, the Philippines, Pakistan, and India may grow four times by 2050. Under the pessimistic (SSP3) or optimistic (SSP1) scenarios, there is little change in the ranking of countries in terms of economic performance, but the overall magnitude of change does differ (see Table 2). Under SSP1, the average GDP across APO economies is estimated to be almost four times larger in 2050 compared with 2020, and only 2.8 times larger under SSP3.

The different expectations for income and technological development under the three alternative socioeconomic paths are associated with differences in the future of the agricultural sector. Average agriculture production for all crops is estimated to grow by between 38% and 55% between 2020 and 2050, with the lowest increase estimated under the SSP3 scenario and the highest growth under the SSP1 scenario. This expansion mainly originates from productivity growth (between 26% and 45%), rather than expansion of cropland (between 6% to 9%). Production in the livestock sector is projected to grow between 67% and 86%, with growing animal yields driving most of the increase (35% to 62%) with respect to the increase in animal numbers (19% to 25%). Similar to crop production, SSP3 and SSP1 provide the lowest and highest estimates, respectively, for the livestock sector.

TABLE 2

POPULATION AND GDP PROJECTIONS.

Region	Scenario name	GDP in billion USD			Population in million		
		2020	2035	2050	2020	2035	2050
Bangladesh	REF	1,000	2,564	4,645	166	190	199
	SSP1	1,000	2,642	5,305	166	186	191
	SSP3	1,000	2,486	3,723	166	194	212
Cambodia	REF	70	165	345	16	19	20
	SSP1	70	168	380	16	18	19
	SSP3	70	161	279	16	19	22
Fiji	REF	10	18	29	1	1	1
	SSP1	10	19	32	1	1	1
	SSP3	10	18	25	1	1	1
IR Iran	REF	1,260	1,833	2,317	87	97	103
	SSP1	1,260	1,837	2,453	87	96	102
	SSP3	1,260	1,839	2,153	87	98	105
India	REF	8,504	19,813	34,136	1,390	1,548	1,620
	SSP1	8,504	20,306	37,758	1,390	1,518	1,546
	SSP3	8,504	19,270	28,545	1,390	1,576	1,704
Indonesia	REF	3,160	5,964	9,027	271	299	311
	SSP1	3,160	6,103	9,881	271	294	299
	SSP3	3,160	5,806	7,652	271	303	324
Lao PDR	REF	56	102	180	7	9	9
	SSP1	56	104	197	7	8	9
	SSP3	56	101	154	7	9	10
Malaysia	REF	858	1,559	2,111	33	38	41
	SSP1	858	1,577	2,178	33	37	40
	SSP3	858	1,531	1,903	33	38	41
Mongolia	REF	38	68	111	3	4	5
	SSP1	38	69	123	3	4	4
	SSP3	38	66	93	3	4	5

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Region	Scenario name	GDP in billion USD			Population in million		
		2020	2035	2050	2020	2035	2050
Nepal	REF	110	223	431	29	33	35
	SSP1	110	229	503	29	32	33
	SSP3	110	217	333	29	34	38
Pakistan	REF	1,147	2,199	4,662	225	299	370
	SSP1	1,147	2,227	5,176	225	288	337
	SSP3	1,147	2,169	3,962	225	311	411
Sri Lanka	REF	284	372	546	22	23	23
	SSP1	284	382	627	22	23	22
	SSP3	284	362	439	22	23	25
Thailand	REF	1,205	1,808	2,378	71	72	68
	SSP1	1,205	1,840	2,545	71	71	67
	SSP3	1,205	1,762	2,041	71	72	68
The Philippines	REF	872	2,088	3,654	111	136	154
	SSP1	872	2,144	4,020	111	132	145
	SSP3	872	2,026	3,051	111	140	167
Turkiye	REF	2,375	4,395	6,079	84	92	96
	SSP1	2,375	4,472	6,377	84	92	95
	SSP3	2,375	4,321	5,796	84	94	101
Vietnam	REF	1,010	2,418	3,930	96	105	108
	SSP1	1,010	2,479	4,189	96	103	104
	SSP3	1,010	2,336	3,348	96	106	112

Source: SSP population and GDP per capita are from the SSP database (SKC et al., 2024).

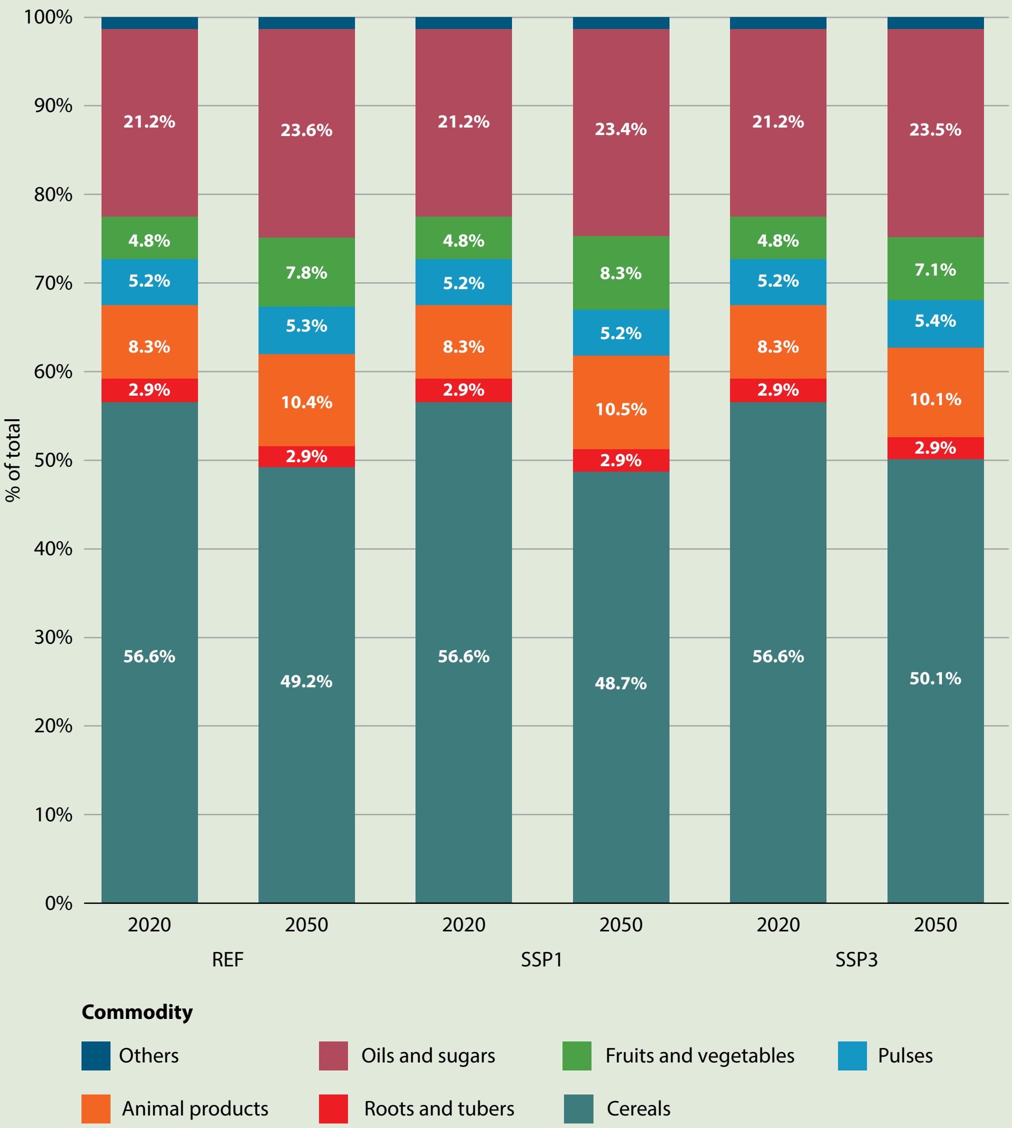
As production and incomes grow, total available kilocalories per day for an average person across APO economies are estimated to increase by 14% under REF, from 2,421 kcal in 2020 to 2,759 kcal in 2050. Under SSP1, the availability grows by 22%, whereas lower production growth and lower incomes mean that kilocalories only grow by 7% under SSP3. Consistent with the economic theory[3], IMPACT results show that consumption of staples like cereals (as a share of total kilocalories) decreases with growing availability of calories, and diets become richer in terms of

[3] IMPACT projections of food demand follow empirical patterns. One of these is Bennet's Law, which states that as income increases, the share of expenditure on staples (cereals and starchy roots and tubers) declines, such that the share of total calories coming from staples declines with diets diversifying and becoming richer.

animal products and fruits and vegetables (F&V) as well as in higher-value and processed foods, represented by oils and sugars (see Figure 3). Over time, these general trends hold true across the three SSPs, with minimal differences in the overall shares of food groups in 2050.

FIGURE 3

EVOLUTION OF DIETS ACROSS APO ECONOMIES; CHANGE IN COMPOSITION AS A SHARE OF TOTAL KILOCALORIES PER PERSON PER DAY.



The increase in calorie availability, especially from animal products, oils and sugars, and F&V contributes to lowering the total population at risk of hunger across all APO economies by between 55 and 265 million people, depending on the SSPs, which amounts to a reduction of up to 80% compared with 2020 (see Table 3). India, Pakistan, and Bangladesh see the largest changes in terms of the population at risk. India, in particular, may see a reduction of over 60% under REF and over 80% under an optimistic SSP1 path.

TABLE 3

CHANGES IN POPULATIONS AT RISK OF HUNGER BETWEEN 2020 AND 2050, IN MILLION.

Region	REF	SSP1	SSP3
APO	–184.1	–265.4	–54.8
Bangladesh	–10.0	–16.9	–0.9
Cambodia	–0.5	–0.8	–0.1
Fiji	0.0	0.0	0.0
IR Iran	–0.4	–3.2	3.2
India	–143.4	–192.3	–65.6
Indonesia	–7.5	–12.3	–0.7
Lao PDR	0.0	–0.2	0.2
Malaysia	–0.6	–0.7	–0.6
Mongolia	–0.1	–0.1	0.1
Nepal	–1.3	–1.4	–0.6
Pakistan	–12.8	–25.9	10.3
Sri Lanka	0.1	–0.5	0.7
Thailand	–3.0	–3.4	–1.3
The Philippines	–3.0	–5.0	0.4
Turkiye	0.5	0.5	0.7
Vietnam	–2.1	–3.2	–0.6

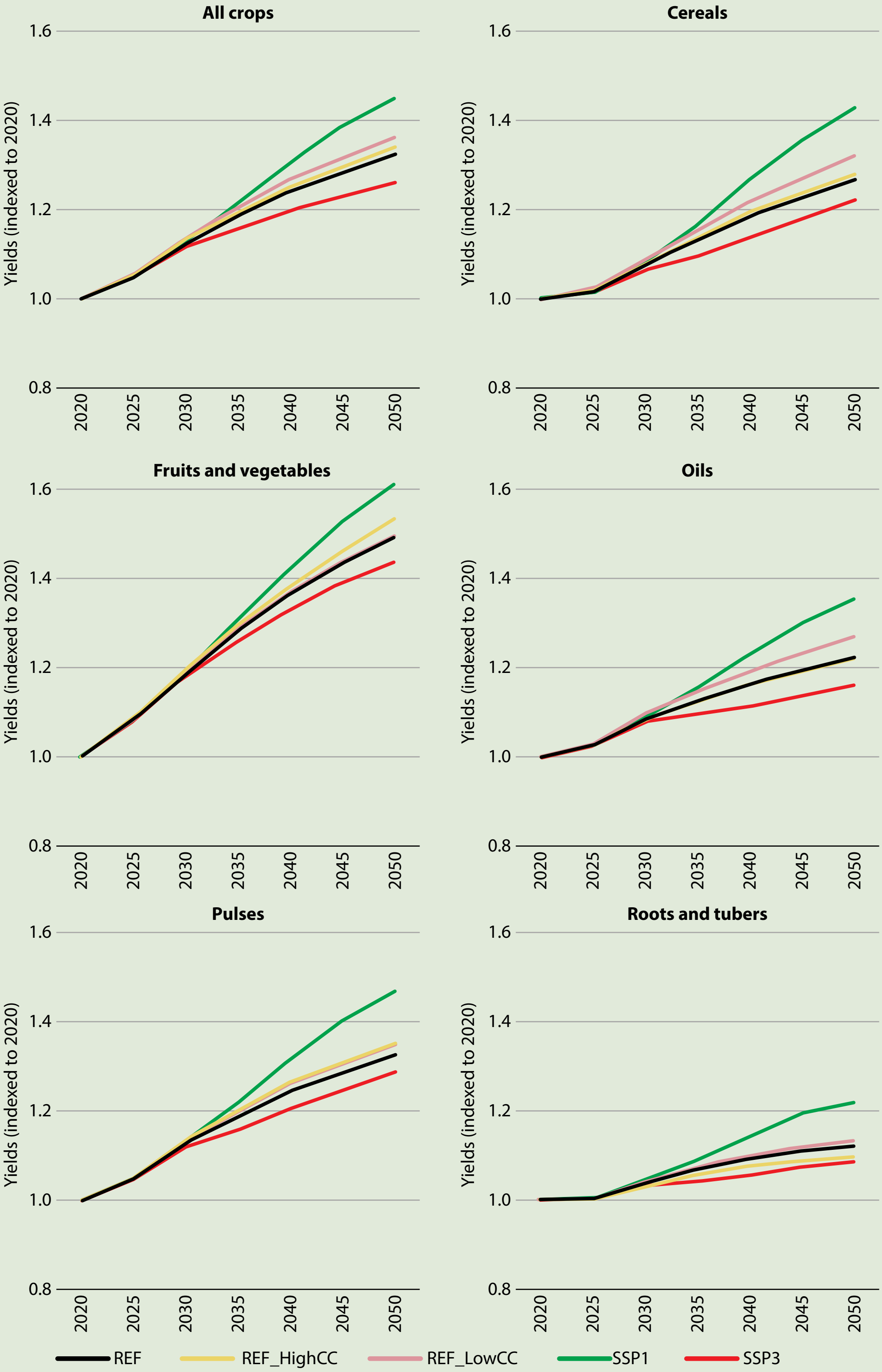
Comparing the Effects of Socioeconomics and Climate on Production and Food Security

Projections show that the range of climate futures may have a smaller impact on crop yields compared with the effects of alternative socioeconomic trends. On an average, across all crops, RCP7.0 and 8.5 (REF and REF_HighCC, respectively) are estimated to lead to similar growths in yields (see Figure 4). The picture is more mixed when looking at specific crop groups. For instance, yields of pulses and F&V appear to benefit from climatic change as represented in the REF_HighCC scenario. As expected, a lower warming trajectory (RCP2.6 or REF_LowCC) may see increased yield growth across APO economies compared with REF, with average yields across all crops being around 3% higher, while yields for cereal and oil crops each being around 4% higher than they would be under REF.

Putting the region on different socioeconomic paths appears likely to produce effects on agricultural productivity of a greater magnitude compared with climate shocks. Moving from a middle-of-the-road socioeconomic path (SSP2, in the REF scenario) to a scenario with higher population growth, lower economic growth, and low technological development (SSP3), (see Riahi et al., 2017) may depress productivity growth and generate average crop yields in 2050 that are nearly 5% lower compared with the yields achieved under REF as well as under the high climate change scenario (REF_HighCC – or SSP2-RCP8.5) (see Figure 5). While the more severe climate change scenario is projected to have a negative yield effect only for oil crops and roots and tubers, a switch to SSP3 is estimated to depress productivity across all food groups (see Figure 5). Oil crops, F&V, and cereals would suffer the most, with a loss of between 4% and 5% compared with REF by 2050. In the same year, the higher warming scenario (REF_HighCC) under SSP2 would reduce yields for oil crops by less than 1%, while it may increase yields for cereals by about 1% and for F&V by almost 3%. Roots and tubers would suffer the most from an RCP8.5 future with an estimated 2% decline by 2050 compared with REF.

FIGURE 4

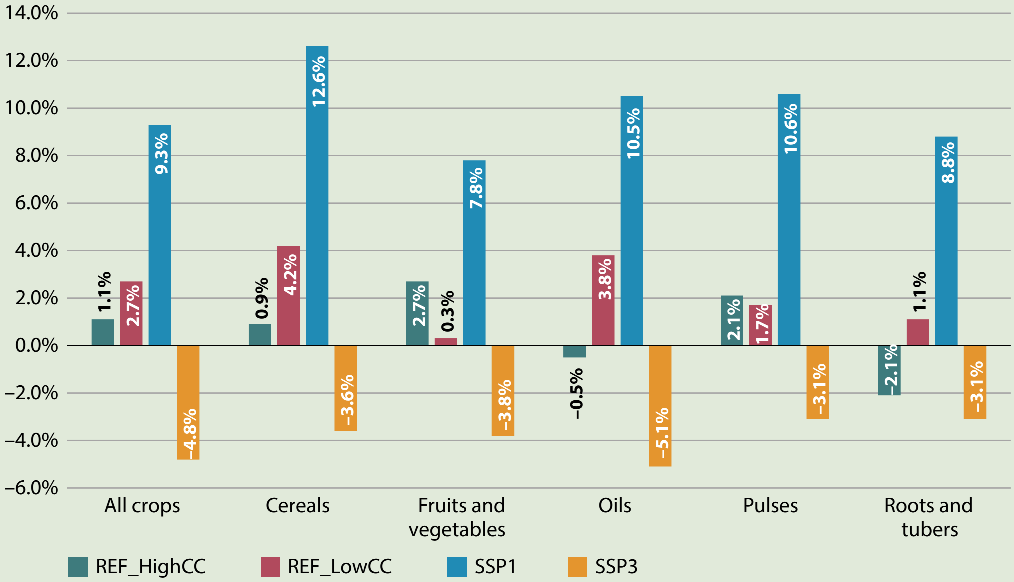
AVERAGE YIELDS ACROSS APO ECONOMIES FOR SELECTED CROP GROUPS.



Source: IMPACT simulations.

FIGURE 5

PERCENT CHANGE IN AVERAGE CROP YIELDS FROM REF IN 2050 FOR ALL CROPS AND SELECTED CROP GROUPS.



Source: IMPACT simulations.

While these results highlight the potential large changes resulting from alternative socioeconomic pathways, our projections do not imply that climate change will have little bearing on agriculture productivity across APO economies. The model estimates that the climatic change projected under the REF scenario (SSP2-RCP7.0) may cause around 3% reduction in yields across all crops compared with a scenario without climate change (NoCC). For the APO region, conditions under RCP7.0 may produce worse effects compared with RCP8.5 (see Table 4). Averages hide some of the projected effects across APO economies. Thailand, Malaysia, and Vietnam are estimated to see the largest reduction in average crop yields under REF, compared with NoCC (between –7% and –9%), while IR Iran, Pakistan, and Turkiye may see some improvements (see Figure A1 in Appendix).

TABLE 4

PERCENT CHANGE IN YIELDS FOR ALL CROPS AND MAJOR COMMODITY GROUPS IN 2050 COMPARED WITH NOCC.

CC Scenarios	All crops	Cereals	Fruit and vegetables	Oils	Pulses	Roots and tubers
REF	–2.7%	–5.6%	5.6%	–6.8%	–0.6%	–4.9%
REF_HighCC	–1.6%	–4.7%	8.4%	–7.2%	1.4%	–6.9%
REF_LowCC	–0.1%	–1.6%	5.9%	–3.3%	1.0%	–3.8%

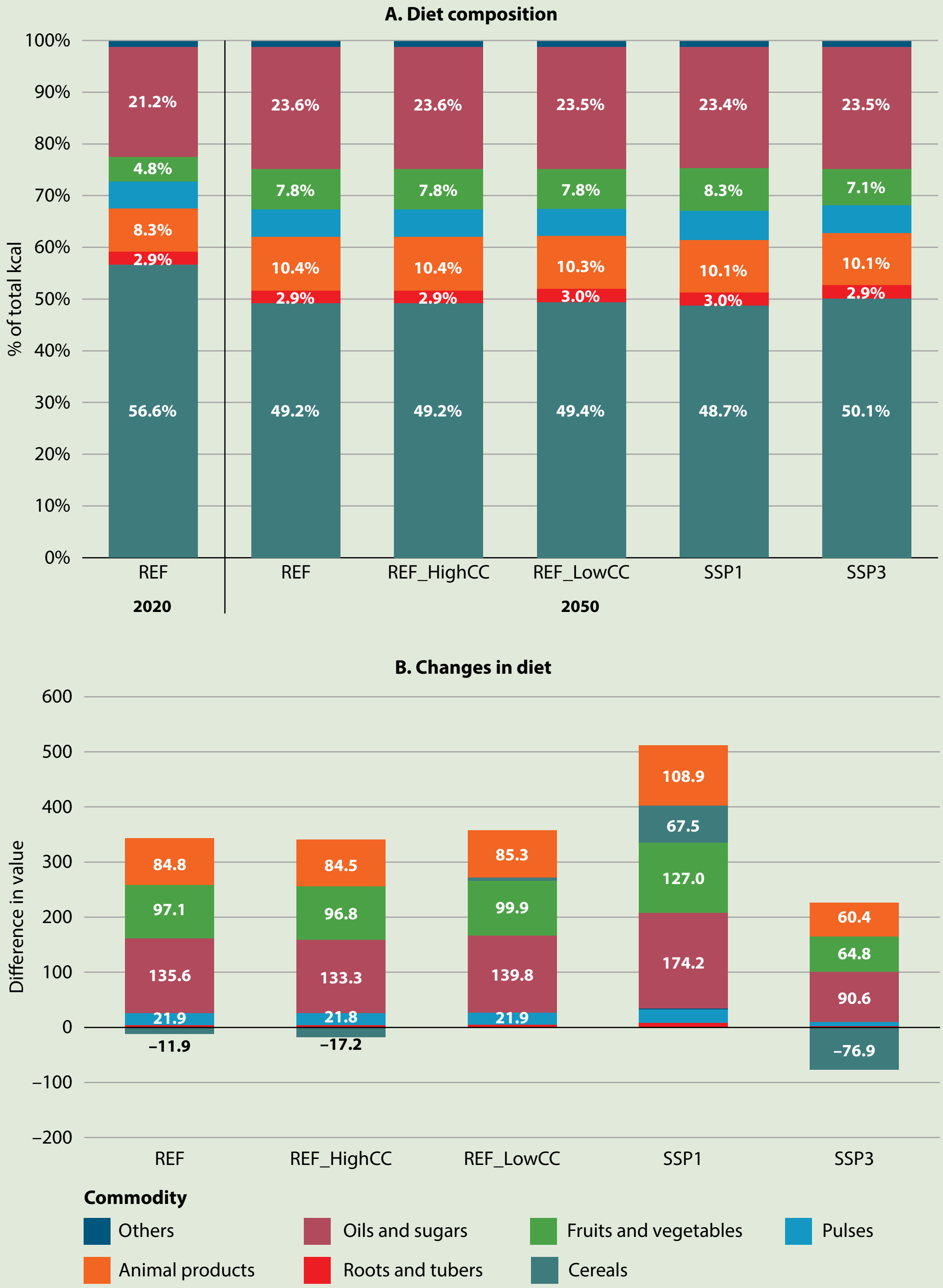
Source: IMPACT simulations.

As a counterpoint to SSP3, the socioeconomic path described by SSP1 is characterized by lower population growth and higher economic growth. It also includes higher levels of international cooperation and higher technological development (Riahi et al., 2017). If APO economies were to follow a SSP1 trajectory, the model estimates that the benefits to agricultural productivity would far exceed those of a low CC scenario (see Figure 5). In this scenario, by 2050, average yields across all crops could be over 9% higher compared with REF, and production could increase up to over 7%.

Focusing on the proportion of kilocalories in the diet for the main food groups, the diet composition in 2050 looks similar across the alternative socioeconomic and climate scenarios (see panel A in Figure 6). This broader picture hides substantial differences across the scenarios (see panel B in Figure 6). REF, REF_HighCC, and SSP3 in particular, show a net decrease in kilocalorie availability

FIGURE 6

DIET COMPOSITION (PANEL A) AND CHANGES IN DIET COMPOSITION (PANEL B) BETWEEN 2020 AND 2050 FOR REF, CLIMATE, AND SOCIOECONOMIC SCENARIOS.



from cereals. On the other hand, SSP1, characterized by the largest increases in income and agricultural production, shows a growth in calorie availability from cereals, as well as the largest increases in kilocalories from all the other food groups. Most APO economies are projected to experience an improvement in food security between 2020 and 2050, regardless of scenario. However, Turkiye is estimated to experience an increase in population at risk of hunger across all the scenarios, including SSP1, while hunger may be worsening in several countries under an SSP3 pathway, especially in Sri Lanka, IR Iran, and Lao PDR (see Figure 7).

FIGURE 7

PERCENT CHANGE IN POPULATION AT RISK OF HUNGER BETWEEN 2020 AND 2050 UNDER CLIMATE AND SOCIOECONOMIC SCENARIOS.

	REF	REF_HighCC	REF_LowCC	SSP1	SSP3
APO	–55.4%	–53.9%	–60.3%	–79.9%	–16.5%
Bangladesh	–49.7%	–47.5%	–57.8%	–84.2%	–2.7%
Cambodia	–58.8%	–57.3%	–66.2%	–92.0%	–8.5%
Fiji	–20.7%	–20.7%	–20.7%	–24.6%	–6.2%
IR Iran	–7.0%	–1.6%	–20.8%	–57.0%	58.3%
India	–6.7%	–61.5%	–66.9%	–84.1%	–28.7%
Indonesia	–44.3%	–46.9%	–50.6%	–67.2%	–4.4%
Lao PDR	–10.1%	–7.9%	–12.0%	–52.6%	46.4%
Malaysia	–57.4%	–57.4%	–57.4%	–57.4%	–57.3%
Mongolia	–27.6%	–25.9%	–32.1%	–69.2%	28.3%
Nepal	–83.9%	–83.0%	–85.9%	–92.9%	–37.9%
Pakistan	–34.2%	–38.2%	–38.2%	–69.2%	27.6%
Sri Lanka	7.0%	9.9%	–2.5%	–3.6%	60.0%
Thailand	–72.7%	–70.0%	–81.1%	–83.4%	31.2%
The Philippines	–51.6%	–49.4%	–59.8%	–85.5%	7.0%
Turkiye	15.0%	15.0%	13.9%	13.9%	20.2%
Vietnam	–41.1%	–39.3%	–47.2%	–62.8%	–11.1%

% Difference

–92.9% 60.0%

RESULTS: SCENARIOS OF INVESTMENTS IN R&D, IRRIGATION, AND WATER USE EFFICIENCY

In the period 2010–20, agricultural productivity growth has slowed across most of Asia, including in India and Southeast Asia. Climate change, land degradation, and water scarcity are some of the root causes, but importantly, there has also been a slowing of growth in expenditure on agricultural R&D (Fuglie et al., 2021).

In this section of the report, we explore the potential effects of increased investments in R&D and improved resource management on agricultural productivity, food consumption and dietary change, food prices, hunger, and water scarcity. The scenarios include different levels of investment in agricultural R&D, irrigation expansion and modernization, and water use efficiency (WUE). We construct these scenarios starting from REF; therefore, we assume for all a trajectory of population and income growth across APO economies that follows the SSP2 middle-of-the-road pathway along with climate shocks from RCP 7.0.

Production, Prices, and Land

Across all crops, and for most crop groups, investment scenarios increase yields in comparison to the REF scenario in 2050. The COMP and High scenarios provide the largest positive effects on productivity, with F&V benefiting the most, followed by cereals (see Table 5). On an average, irrigation expansion (IRREXP) appears to lead to some small declines in yields for cereals and F&V, but some small increases are projected for the other crop groups. The negative effects on cereal yields are reverted to positive when WUE is added to the expansion of irrigation (IRREXP+WUE). Country-level results confirm the regional picture (see Table A1 in Appendix)

TABLE 5

AVERAGE YIELDS ACROSS APO ECONOMIES; PERCENT CHANGE FROM THE REF SCENARIO IN 2050.

	All Crops	Cereals	Fruits and vegetables	Oils and sugars	Pulses	Roots and tubers
COMP	22.5%	38.2%	46.0%	11.1%	21.2%	27.4%
HIGHplus	21.4%	34.2%	46.3%	8.0%	20.7%	27.3%
IRREXP	−0.5%	−0.6%	−0.2%	0.9%	0.6%	0.3%
IRREXP+WUE	1.0%	2.8%	−0.2%	2.9%	0.5%	0.2%

The increase in productivity leads to greater agricultural production in 2050, compared with REF (see Table A2 in Appendix). Production also increases where yields are slightly decreasing, e.g., for cereals and F&V under irrigation expansion. In these cases, a modest increase in the harvested area (see Table 6) makes up for the small shortfall in yields.

TABLE 6

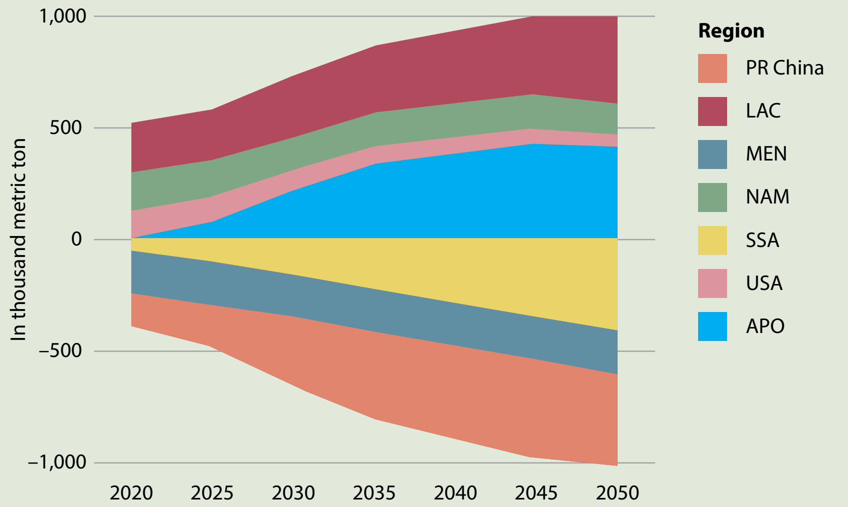
AVERAGE HARVESTED AREA ACROSS APO ECONOMIES; PERCENT CHANGE COMPARED WITH REF IN 2050.

	AllC	Cereals	Fruits and vegetables	Oils and sugars	Pulses	Roots and tubers
COMP	3.2%	7.9%	6.0%	–4.6%	–1.7%	3.3%
HIGHplus	0.6%	3.4%	5.0%	–4.7%	–2.1%	1.3%
IRREXP	2.6%	4.1%	0.9%	1.2%	0.2%	2.3%
IRREXP+WUE	2.6%	4.5%	1.0%	0.3%	0.3%	2.0%

A small increase in the harvested area compared with REF is observable across most combinations of crop groups and investment scenarios (with the exceptions of oils, sugars, and pulses), even when yields are increasing, e.g., for cereals and F&V under the COMP and HIGHplus scenarios. The increase in area is the result of global market effects. As a first observation, under REF, the demand for agricultural commodities grows by almost 60% between 2020 and 2050 across APO members. At the same time, a 50% increase in demand is projected for Latin America and for the Middle East and North Africa region, while a much larger 90% increase is estimated for Sub-Saharan Africa (see Table A3 in Appendix), where population is expected to grow at higher rates than in APO economies. Concurrently, yields of agricultural products (especially of cereals and F&V) across APO members under the COMP and HIGHplus scenarios are projected to grow the most compared with other regions of the world. This, along with high prices (see Figure A2 in Appendix) creates a competitive advantage for APO economies and thus conditions for some modest area expansion under the investment scenarios, compared with REF, to further increase exports from APO economies to the rest of the world. In fact, under COMP and HIGHplus scenarios, the APO region quickly becomes a net exporter of agricultural products, while other regions of the world grow more dependent on imports or export less (see Figure 8).

FIGURE 8

CHANGE IN NET TRADE VOLUME BETWEEN 2020 AND 2050 IN COMP SCENARIO.



As mentioned, one of the contributing factors for increase in production even when yields decrease is that socioeconomic and climate pressure across the globe cause substantial growth in global prices of agricultural products (see Figure A2 in Appendix). Between 2020 and 2050, under REF, world prices grow by 54% for roots and tubers, 36% for cereals, and over 5% for animal products. All the modeled investment scenarios across APO economies have some effect on world prices. Although the overall growth trend remains, the increase in prices slows down with increasing scope and intensity of the investment. As an example, APO is by far the largest producer and consumer of pulses and projected to remain so by 2050. Therefore, strong comprehensive investments plans (COMP and HIGHplus) bring down the world price of pulses considerably compared with REF (see Table 7).

TABLE 7

PERCENT CHANGE IN WORLD PRICES OF SELECTED CROPS AND OTHER PRODUCTS BETWEEN INVESTMENT SCENARIOS AND REF IN 2050.

	All crops	Animal products	Cereals	Fruits and vegetables	Oils and sugars	Pulses	Roots and tubers
COMP	−14.6%	−1.9%	−11.1%	−18.9%	−3.4%	−12.0%	−8.9%
HIGHplus	−13.0%	−1.5%	−8.4%	−17.8%	−2.6%	−11.0%	−7.9%
IRREXP	−1.0%	−0.2%	−1.6%	−0.7%	−0.6%	−0.6%	−0.9%
WUE	−0.5%	−0.2%	−1.1%	−0.3%	−0.2%	−0.3%	−0.1%
IRREXP+WUE	−1.6%	−0.4%	−2.8%	−1.1%	−0.9%	−1.0%	−1.0%

Food Security

Under the reference scenario, rapid increase in per capita income between 2020 and 2050 raises the average kilocalorie availability in APO economies by 339 kcal per person per day. All investment scenarios lead to an increase in production and lower prices, thus improving access to per-capita calories in 2050 (compared with REF). The largest boost takes place under COMP and HIGHplus across South Asian countries (see Table 8). Under COMP, the average availability in 2050 grows by 436 kcal per person per day (up 18% from 2020).

TABLE 8

PERCENT CHANGE IN KILOCALORIES PER CAPITA BETWEEN INVESTMENT SCENARIOS AND REF IN 2050.

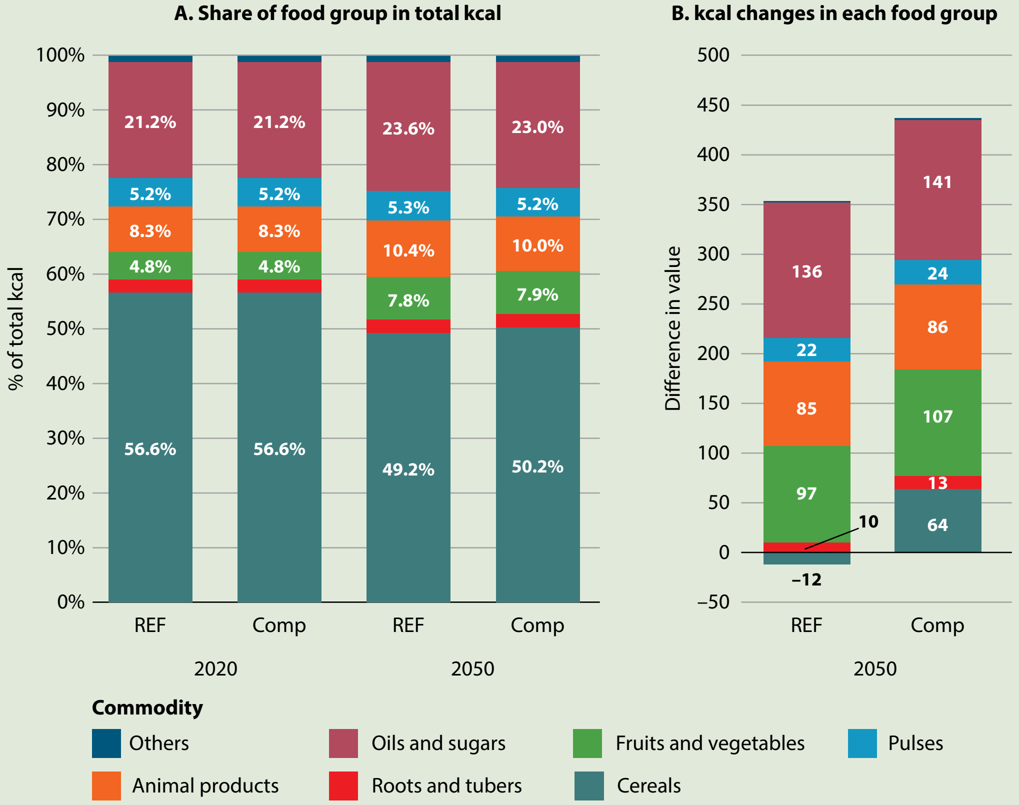
Region	COMP	HIGHplus	IRREXP	IRREXP+WUE
Bangladesh	5.2%	3.9%	0.8%	1.2%
Cambodia	4.3%	3.2%	0.7%	1.0%
Fiji	2.5%	1.8%	0.4%	0.6%
India	3.9%	3.0%	0.4%	0.7%
Indonesia	4.5%	3.4%	0.6%	1.0%
IR Iran	2.3%	1.7%	0.3%	0.5%
Lao PDR	4.9%	3.8%	0.7%	1.0%
Malaysia	1.2%	0.9%	0.2%	0.3%
Mongolia	2.1%	1.5%	0.2%	0.4%
Nepal	3.6%	2.7%	0.4%	0.7%
Pakistan	2.0%	1.4%	0.2%	0.5%
The Philippines	3.4%	2.5%	0.5%	0.8%
Sri Lanka	4.4%	3.2%	0.7%	1.1%
Thailand	2.1%	1.5%	0.3%	0.5%
Turkiye	1.7%	1.3%	0.2%	0.4%
Vietnam	3.7%	2.7%	0.6%	0.9%

Figure 9 shows how diets change across APO economies between 2020 and 2050 under the Reference scenario and the comprehensive investment scenario (COMP). In 2020, cereals provide more than half of the total available kilocalories. Diets diversify rapidly and achieve a similar composition under the two scenarios. By 2050, cereals contribute less to total kilocalories, down from around 56% to 50%. The contribution of fruits and vegetables grows from 5% to 8%, and that of animal products from 8% to 10% (Figure 9A). Similar shares across REF and COMP hide a key difference between the two futures. Under REF, calories contributed by cereals decrease between 2020 and 2050 while they still increase under COMP (Figure 9B). This difference is possible even if shares remain similar between REF and COMP because of the faster growth in total kilocalories under COMP.

The increase in kilocalories from cereals under COMP in 2050 drives the population at risk of hunger lower compared with REF by around 45 million people. As shown in Figure 10, investment scenarios start diverging from the reference early on. Looking only at the 2050 results misses some of the effects that additional investments may have on hunger, as millions of people are being lifted out of hunger earlier compared with the REF. A different metric, "hunger years" helps account for this different pace in reducing hunger. Hunger years are the cumulative number of years that people go hungry from 2020 to 2050, based on the number of people at risk of hunger. For instance, if a country were populated by only two people and one of them went hungry in 2025, 2026, and 2027, the total hunger years between 2025 and 2027 would be three. Table A4 in Appendix summarizes

FIGURE 9

SHARES OF FOOD GROUPS IN OVERALL DIETS IN 2020 AND 2050, AND PROJECTED CHANGES IN KILOCALORIES PER CAPITA PER DAY UNDER REF AND COMP SCENARIOS.



hunger years by scenario and shows that COMP and HIGHplus have the lowest values. The COMP scenario, for example, is faster than REF in reducing the population at risk of hunger, which indicates a substantial cumulative effect in reducing hunger over time. The "difference" in Figure 11 shows how many million people COMP lifts out of hunger every year compared with REF.

FIGURE 10

POPULATION AT RISK OF HUNGER ACROSS APO ECONOMIES UNDER ALL SCENARIOS.

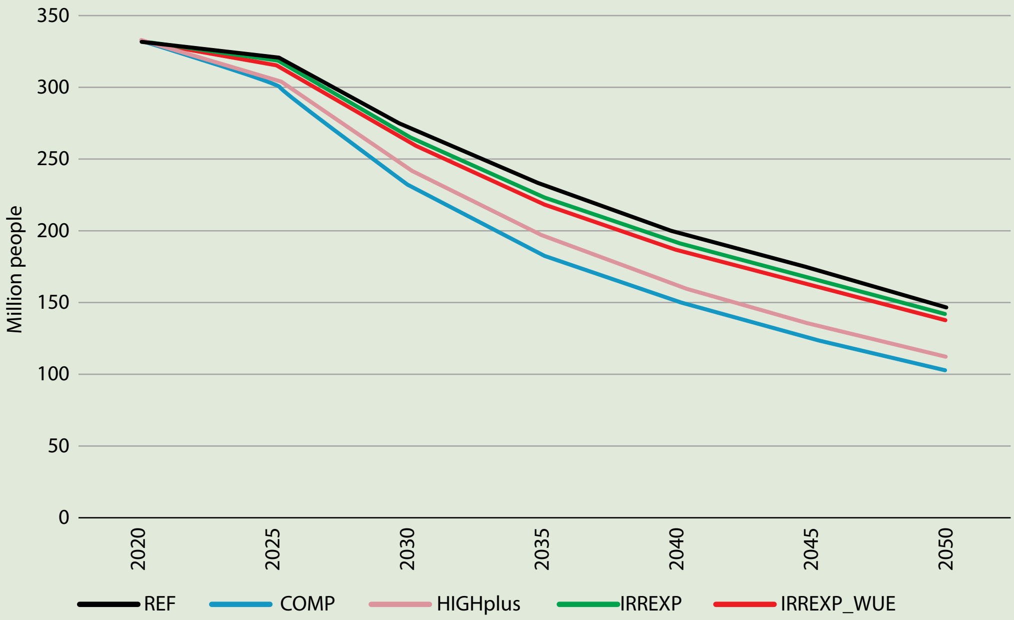
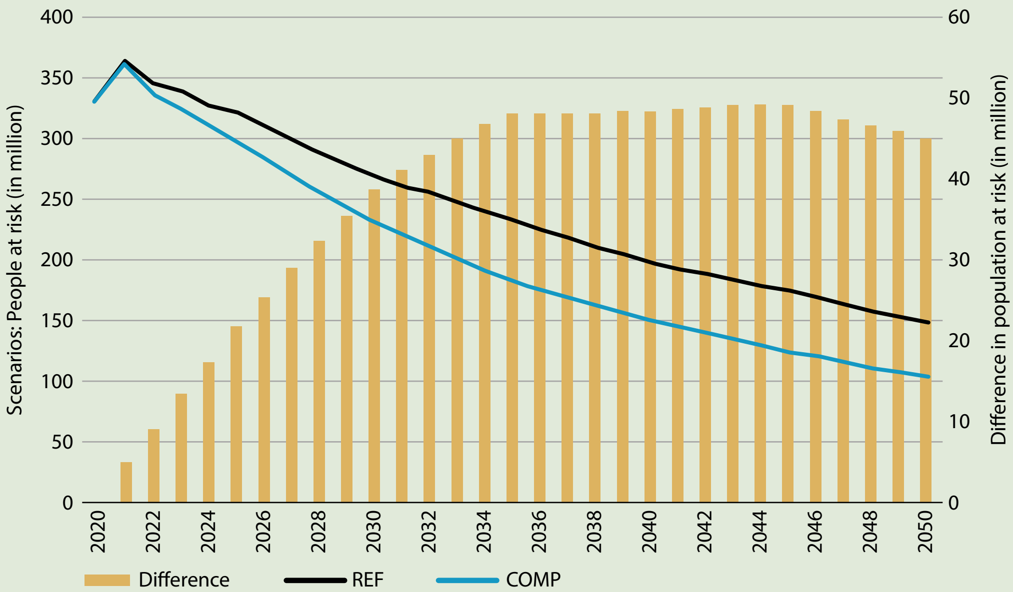


FIGURE 11

YEARLY APO POPULATION AT RISK OF HUNGER, AND THEIR DIFFERENCES, UNDER COMP AND REF SCENARIOS.

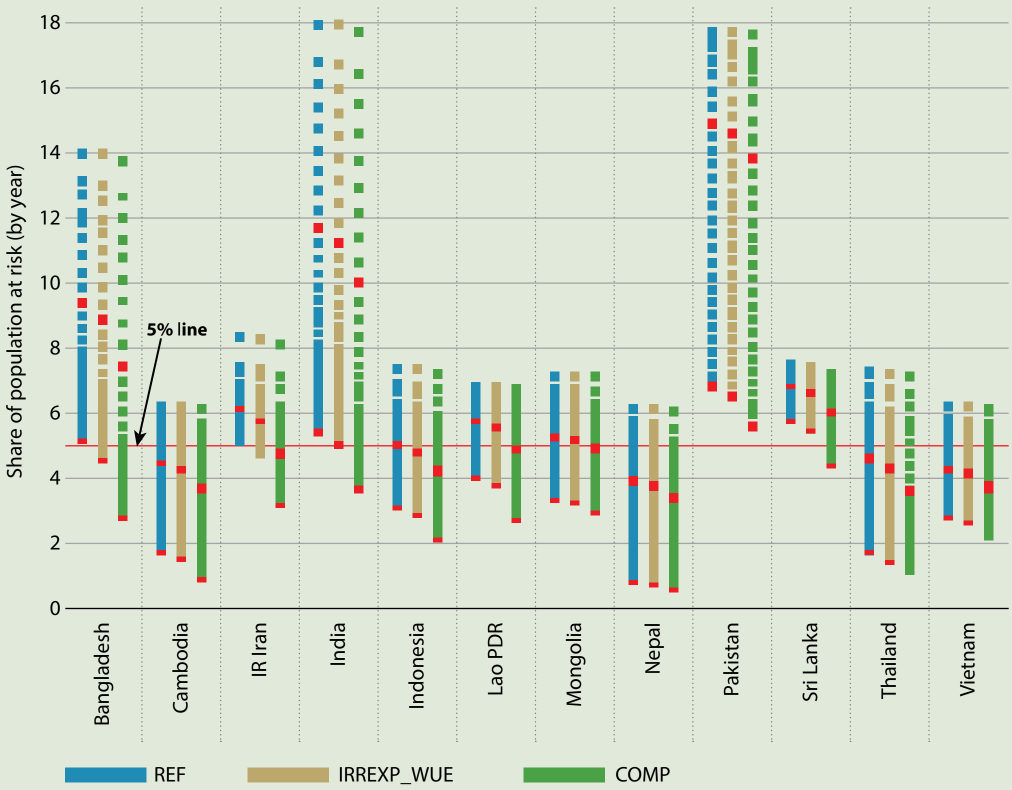


Achieving Sustainable Development Goal 2.1

Some investments are projected to help APO economies make substantial progress in reducing hunger. However, not all APO economies seem poised to achieve the Sustainable Development Goal 2.1 (SDG 2.1) to end hunger by 2030. The target of ending hunger is defined as the reduction of hunger to 5% share of the population by 2030. Turkiye, Malaysia, the Philippines, and Fiji appear to have already hit the mark. Under REF, Cambodia, Nepal, Thailand, and Vietnam appear on track to achieving SDG 2.1, whereas Indonesia, Lao PDR, and Mongolia, may reach the goal in or shortly after 2030 (see Figure 12). Bangladesh, India, IR Iran, Pakistan, and Sri Lanka may reach the 5% threshold only after 2050. Investments have the potential to speed up the progress, with the target getting closer as investments become more comprehensive (e.g., COMP in Figure 12).

FIGURE 12

SHARE OF POPULATION AT RISK OF HUNGER OVER TIME FOR SELECTED APO ECONOMIES UNDER REF, IRREXP+WUE, AND COMP.



Note: Dots show each year from 2020 to 2050 from top to bottom. The red dots identify 2030 and 2050. The red horizontal line shows the 5% threshold.

Change in Water Use for Irrigation

Under REF, water use for irrigation (blue water) is projected to grow between 2020 and 2050, both as an average for the APO economies and across most member economies (see Table 9). Indonesia, Malaysia, Nepal, and Sri Lanka are exceptions. Average blue water use across APO economies also increases under the investment scenarios. Irrigation expansion (IRREXP) produces the largest increases in blue water use, followed by HIGHPlus. The impact of irrigation expansion can be limited through investments in WUE. In fact, both IRREXP+WUE, and WUE in combination with investments in R&D (i.e., the COMP scenario) can reduce the growth in water use triggered by irrigation expansion alone (see Table 9). As a share of water resources, Sri Lanka appears to benefit the most with up to 45% reduction in water use both under COMP and IRREXP+WUE scenarios.

TABLE 9

CHANGE IN BLUE WATER USE BY ALL CROPS ACROSS APO AND ITS MEMBER ECONOMIES IN BILLION CUBIC METER BETWEEN 2020 AND 2050.

Region	COMP	HIGHplus	IRREXP	IRREXP_WUE	REF
APO	46.5	107.0	129.9	42.5	102.8
Bangladesh	–3.7	0.8	2.2	–3.8	0.8
Cambodia	0.5	0.8	1.0	0.5	0.8
Fiji	0.0	0.0	0.0	0.0	0.0
IR Iran	–1.1	7.4	9.7	–1.8	6.7
India	28.9	57.3	65.0	27.2	55.6
Indonesia	–4.9	–1.6	–0.7	–6.3	–3.1
Lao PDR	–0.1	0.1	0.2	0.0	0.1
Malaysia	–0.2	–0.1	–0.1	–0.2	–0.1
Mongolia	0.1	0.1	0.1	0.1	0.1
Nepal	–1.5	–0.3	–0.1	–1.7	–0.6
Pakistan	32.1	31.9	31.7	32.1	31.9
Sri Lanka	–3.2	–2.3	–2.0	–3.2	–2.3
Thailand	1.4	6.4	11.9	1.3	6.4
The Philippines	–0.1	1.6	2.8	0.0	1.7
Turkiye	0.5	4.0	4.8	0.4	4.0
Vietnam	–2.2	0.8	3.3	–2.2	0.8

Bangladesh, IR Iran, Indonesia, Lao PDR, Nepal, Sri Lanka, the Philippines, and Vietnam are all countries where IRREXP-WUE and COMP reduce water use below 2020 levels (see Table 9), and in doing so, they also consume less blue water compared with REF (Table 10). In 2050, adding investments in WUE to irrigation expansion (IRREXP+WUE) would save over 65 billion cubic meter (bcm) of blue water across APO economies, compared with REF, with COMP delivering an effect of similar magnitude (see Table 10). Investing only in irrigation expansion would increase water use by over 27 bcm.

The bulk of the water savings from IRREXP+WUE and COMP originate in India, with reductions in blue water use of around 30 bcm compared with REF (see Table 10). This is significant given the high-water stress in the region and the fact that under those two scenarios irrigated areas are projected to grow by over 30 million hectare.

TABLE 10

CHANGE IN BLUE WATER USE FROM REF IN 2050, IN BCM.

Region	COMP	HIGHplus	IRREXP	IRREXP_WUE
APO	−61.2	4.2	27.1	−65.3
Bangladesh	−4.9	0.1	1.4	−5.0
Cambodia	−0.3	0.0	0.2	−0.3
Fiji	0.0	0.0	0.0	0.0
IR Iran	−8.6	0.7	3.0	−9.2
India	−28.2	1.7	9.4	−29.9
Indonesia	−2.3	1.5	2.4	−3.7
Lao PDR	−0.2	0.0	0.1	−0.2
Malaysia	−0.1	0.0	0.0	−0.1
Mongolia	0.0	0.0	0.0	0.0
Nepal	−1.0	0.3	0.5	−1.2
Pakistan	0.3	0.0	−0.1	0.3
Sri Lanka	−1.1	0.0	0.3	−1.1
Thailand	−5.6	0.1	5.5	−5.7
The Philippines	−2.0	−0.1	1.1	−1.9
Turkiye	−3.8	0.0	0.9	−3.9
Vietnam	−3.5	0.0	2.5	−3.5

DISCUSSION

The results in this report show that accelerated economic development and a concurrent slowdown in population growth, along with investments in technology (SSP1), would bring considerable benefits to APO members. Higher incomes and large improvements in agricultural productivity could potentially lead to critical improvements in food security. Moreover, a focus on socioeconomic development appears to be a robust climate adaptation strategy, effective for building resilience against a range of potential climate futures.

Similar positive effects could originate from measures designed to specifically target some of the challenges that are currently afflicting the agriculture sector across APO economies. Increased investments in agricultural R&D, irrigation, and WUE can have important positive impacts on key goals for agrifood systems across APO member economies. They can help achieve much needed improvements in agricultural productivity and help bring the region closer to ending hunger while improving nutrition and reducing water use.

Specific investments in WUE may not produce large effects on yields per se but can lead to large water savings, thereby sparing resources for use outside the agriculture sector. Conversely, comprehensive investments combining support to R&D, efficient irrigation, and better WUE may generate both large changes in yields as well as substantial advances in food security and large water savings. Thus, such investments would strengthen key components of APO food systems, especially on-farm productivity and resource-use efficiency. Effective extension services from the government, NGOs, and the private sector are some of the key enabling conditions for ensuring the correct implementation and success of these investments, along with a broader use of technology (e.g., cellphones) to bring timely market information to farmers.

This report shows that there are opportunities for policy makers and their development partners across APO members to deploy investments that can address the challenges facing food systems. Targeted investment can improve food security and resilience in a world characterized by stronger demand and competition over land and water resources and a rapidly changing climate.

APPENDIX

TABLE A1

AVERAGE CROP YIELD; PERCENT CHANGE BETWEEN INVESTMENTS AND REF IN 2050 IN APO ECONOMIES.

	Scenarios	AllC	Cereals	Fruits and vegetables	Oils and sugars	Pulses	Roots and tubers
Bangladesh	COMP	29.2%	23.6%	51.1%	0.7%	27.6%	19.0%
	HIGHplus	28.9%	23.7%	51.0%	1.2%	27.8%	18.7%
	IRREXP	0.2%	0.1%	0.3%	–0.4%	0.1%	0.2%
	IRREXP+WUE	0.4%	0.0%	0.2%	–0.6%	0.0%	0.3%
Cambodia	COMP	32.9%	20.2%	49.4%	8.5%	37.1%	38.0%
	HIGHplus	32.7%	19.3%	45.3%	7.0%	37.4%	38.1%
	IRREXP	0.3%	0.9%	2.7%	1.5%	–0.1%	0.0%
	IRREXP+WUE	0.3%	0.7%	2.7%	1.3%	–0.2%	–0.1%
Fiji	COMP	4.2%	19.3%	39.6%	0.8%	–0.8%	25.0%
	HIGHplus	3.4%	20.0%	38.7%	–0.1%	–0.6%	25.0%
	IRREXP	0.9%	–0.4%	0.9%	0.9%	–0.2%	0.0%
	IRREXP+WUE	0.8%	–0.6%	0.9%	0.8%	–0.2%	0.0%
India	COMP	27.0%	44.3%	43.9%	6.5%	20.1%	19.7%
	HIGHplus	25.4%	39.5%	45.3%	2.0%	19.6%	19.6%
	IRREXP	–0.7%	–1.3%	–0.8%	0.9%	0.6%	0.2%
	IRREXP+WUE	1.6%	3.6%	–0.9%	4.8%	0.5%	0.2%
Indonesia	COMP	17.7%	24.4%	42.9%	18.6%	38.0%	37.6%
	HIGHplus	16.6%	22.7%	42.4%	16.5%	38.0%	38.2%
	IRREXP	1.3%	1.4%	0.4%	1.9%	0.1%	–0.4%
	IRREXP+WUE	1.3%	1.3%	0.3%	1.9%	0.0%	–0.4%
IR Iran	COMP	33.9%	23.3%	56.7%	–1.1%	44.6%	31.3%
	HIGHplus	32.6%	22.6%	54.2%	0.2%	42.8%	31.2%
	IRREXP	0.2%	0.8%	1.6%	–1.0%	1.1%	0.1%
	IRREXP+WUE	0.3%	0.5%	1.6%	–1.3%	1.2%	0.1%
Lao PDR	COMP	19.8%	20.8%	40.4%	2.2%	23.3%	15.3%
	HIGHplus	21.0%	20.2%	40.5%	2.4%	23.7%	15.8%
	IRREXP	–0.4%	0.6%	0.0%	0.3%	–0.1%	0.2%
	IRREXP+WUE	–0.4%	0.5%	–0.1%	–0.1%	–0.2%	0.2%

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	Scenarios	AllC	Cereals	Fruits and vegetables	Oils and sugars	Pulses	Roots and tubers
Malaysia	COMP	16.8%	21.1%	47.4%	19.1%	−0.5%	34.2%
	HIGHplus	16.9%	20.1%	47.9%	19.0%	−0.3%	34.5%
	IRREXP	−0.1%	1.0%	−0.3%	0.1%	−0.1%	−0.2%
	IRREXP+WUE	−0.1%	0.8%	−0.4%	0.1%	−0.1%	−0.2%
Mongolia	COMP	30.6%	52.9%	42.1%	−1.4%	−0.5%	7.8%
	HIGHplus	29.1%	48.9%	42.3%	−1.2%	−0.3%	8.4%
	IRREXP	−0.4%	−0.3%	−0.1%	0.0%	−0.2%	−0.5%
	IRREXP+WUE	0.7%	2.7%	−0.2%	−0.2%	−0.2%	−0.5%
Nepal	COMP	30.6%	39.6%	51.0%	3.2%	40.6%	17.2%
	HIGHplus	30.5%	38.7%	51.4%	0.7%	41.4%	18.0%
	IRREXP	−0.1%	0.9%	0.0%	0.2%	−0.2%	−0.6%
	IRREXP+WUE	0.2%	0.6%	−0.1%	2.2%	−0.3%	−0.6%
Pakistan	COMP	15.7%	61.7%	55.2%	8.9%	19.8%	16.9%
	HIGHplus	11.8%	50.8%	54.4%	0.2%	17.4%	17.3%
	IRREXP	−4.4%	−2.2%	0.4%	−4.4%	2.5%	−0.7%
	IRREXP+WUE	1.6%	6.8%	0.5%	6.9%	2.1%	−0.4%
The Philippines	COMP	17.1%	20.7%	35.6%	2.8%	21.9%	37.1%
	HIGHplus	17.1%	20.7%	35.4%	1.2%	21.8%	37.3%
	IRREXP	0.2%	0.1%	0.3%	1.8%	0.2%	−0.1%
	IRREXP+WUE	0.2%	0.0%	0.3%	1.6%	0.2%	−0.1%
Sri Lanka	COMP	23.1%	27.1%	47.9%	1.2%	13.0%	35.8%
	HIGHplus	22.9%	27.1%	48.2%	0.7%	13.3%	36.0%
	IRREXP	0.2%	0.0%	0.1%	0.6%	−0.1%	−0.1%
	IRREXP+WUE	0.3%	−0.2%	0.0%	0.5%	−0.2%	−0.1%
Thailand	COMP	12.3%	21.9%	45.2%	5.3%	16.4%	37.4%
	HIGHplus	11.8%	20.6%	43.4%	4.4%	15.4%	37.5%
	IRREXP	0.8%	1.2%	1.3%	1.0%	0.9%	−0.1%
	IRREXP+WUE	0.8%	1.0%	1.3%	0.9%	0.8%	−0.1%
Turkiye	COMP	32.2%	17.2%	51.5%	1.9%	34.0%	37.8%
	HIGHplus	31.0%	16.9%	50.1%	1.6%	32.9%	38.1%
	IRREXP	0.7%	0.3%	1.1%	0.8%	0.8%	−0.1%
	IRREXP+WUE	0.7%	0.2%	1.1%	0.3%	0.8%	−0.1%
Vietnam	COMP	23.4%	19.9%	46.5%	3.7%	20.3%	39.9%
	HIGHplus	25.5%	20.3%	44.3%	2.3%	20.4%	38.8%
	IRREXP	−1.7%	−0.5%	1.6%	1.7%	0.0%	0.8%
	IRREXP+WUE	−1.6%	−0.3%	1.5%	1.5%	−0.1%	0.8%

TABLE A2

AVERAGE PRODUCTION; PERCENT CHANGE ACROSS APO ECONOMIES FROM REF IN 2050.

Scenario	AllC	Animal products	Cereals	Fruits and vegetables	Oils and sugars	Pulses	Roots and tubers
COMP	24.2%	0.7%	49.2%	54.7%	6.5%	19.1%	31.6%
HIGHplus	20.2%	0.6%	38.8%	53.7%	3.7%	18.1%	28.9%
IRREXP	2.1%	0.1%	3.6%	0.7%	2.0%	0.8%	2.5%
IRREXP+WUE	3.4%	0.1%	7.4%	0.8%	3.0%	0.8%	2.3%

TABLE A3

PERCENT CHANGE IN TOTAL DEMAND FOR ALL AGRICULTURAL PRODUCTS BETWEEN 2020 AND 2050 UNDER REF SCENARIO.

Region	2050
APO	59.0%
PR China	10.1%
EUR	9.5%
FSU	15.0%
LAC	47.9%
MEN	51.8%
NAM	21.6%
SSA	90.0%

Note: EUR=Europe; FSU=former Soviet Union; LAC=Latin America and the Caribbean; MEN=Middle East and Northern Africa; NAM= North America; SSA=Africa south of the Sahara.

TABLE A4

HUNGER YEARS ACROSS APO MEMBERS BY SCENARIO, FROM LOWEST TO HIGHEST.

Scenario	Value, in million
COMP	6,317.7
HIGHPlus	6,610.0
IRREXP+WUE	7,200.0
IRREXP	7,322.1
REF	7,487.8

FIGURE A1

AVERAGE CROP YIELDS; PERCENT CHANGE BETWEEN REFERENCE AND NOCC IN 2050 ACROSS APO ECONOMIES.

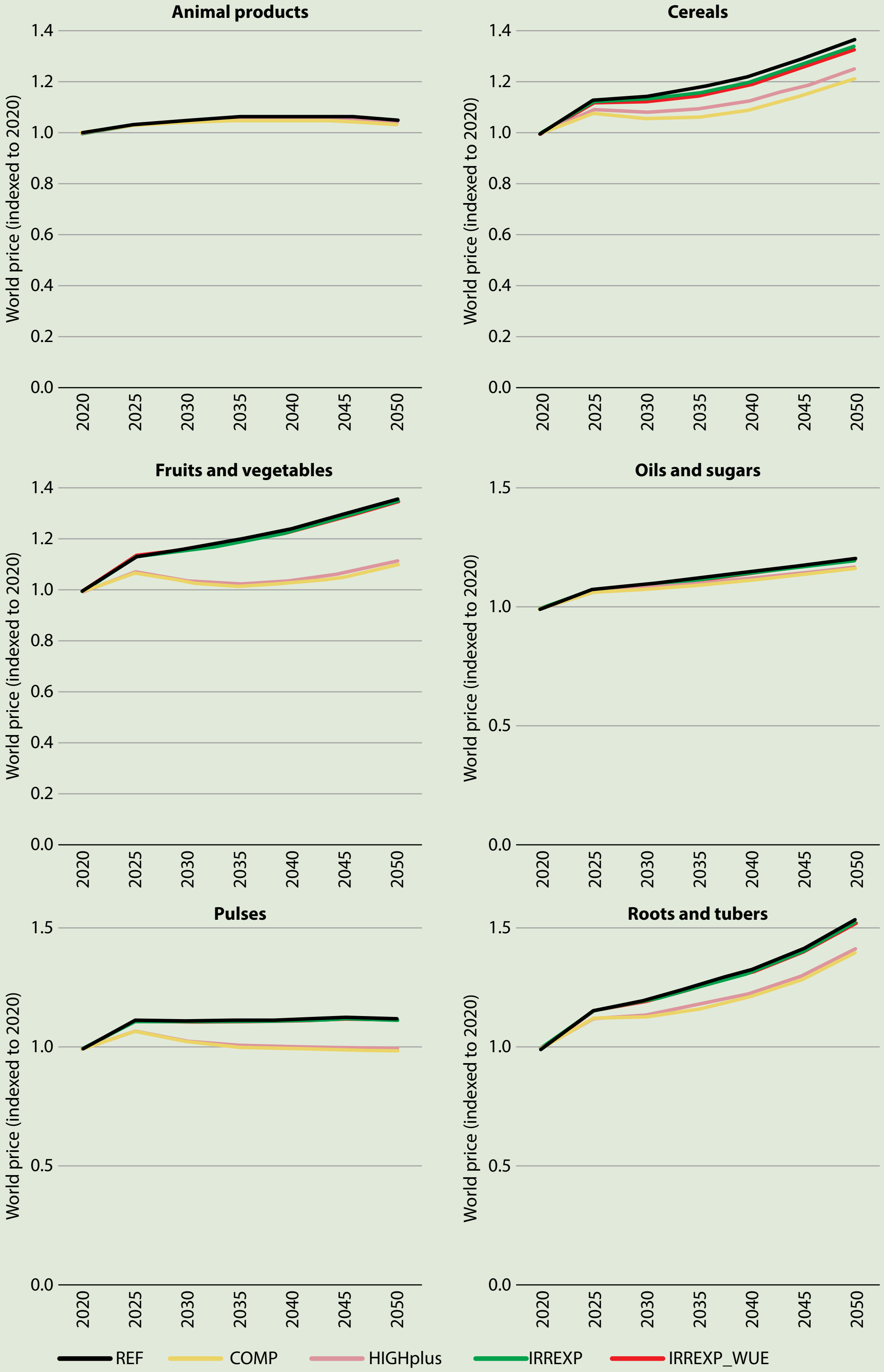
	All crops	Cereals	Fruits and vegetables	Oils	Pulses	Roots and tubers
Bangladesh	–2.8%	–10.1%	9.3%	–3.8%	8.1%	2.4%
Cambodia	–4.2%	–10.1%	–5.7%	–6.7%	–6.7%	0.0%
Fiji	4.2%	–1.9%	5.1%	–0.6%	–3.3%	0.0%
India	–2.6%	–8.6%	8.7%	–7.3%	3.6%	–9.2%
Indonesia	–5.1%	–8.4%	–6.7%	–5.5%	–1.0%	–2.4%
IR Iran	10.0%	11.8%	11.6%	8.4%	0.2%	–0.1%
Lao PDR	–0.7%	–7.3%	3.9%	1.4%	–0.6%	2.0%
Malaysia	–7.7%	–9.6%	1.4%	–8.1%	–0.2%	2.0%
Mongolia	0.8%	–3.5%	–2.3%	–0.1%	14.6%	0.3%
Nepal	–3.6%	–6.0%	0.2%	–3.3%	–7.1%	–4.0%
Pakistan	4.6%	–1.1%	–5.7%	–3.5%	–3.5%	–13.2%
The Philippines	–5.4%	–2.9%	–7.9%	–7.1%	–1.0%	–9.0%
Sri Lanka	–4.4%	–2.6%	3.9%	–6.7%	–1.8%	–9.7%
Thailand	–9.0%	–11.8%	–6.7%	–6.7%	–7.6%	–8.6%
Turkiye	6.7%	7.0%	7.4%	–3.3%	–7.6%	–8.6%
Vietnam	–7.0%	–9.9%	–6.7%	–6.7%	–4.5%	–3.6%

% Difference

–13.2% 14.6%

FIGURE A2

WORLD PRICES BY COMMODITY GROUPS FOR REF AND INVESTMENT SCENARIOS.



Note: Values are indexed to 1.0 in 2020.

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ABBREVIATIONS

AllC	all crops
CER	cereals
F&V	fruits and vegetables
OLS	oils
PUL	pulses
R&T	roots and tubers
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IFPRI	International Food Policy Research Institute
R&D	research and development

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