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Prepared by Diogo Baptista, Mai Farid, Dominique Fayad, Laurent Kemoe, Loic Lanci, Pritha Mitra, Tara Muehlschlegel, Cedric Okou, John Spray, Kevin Tuitoek, and Filiz Unsal

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Acronyms and Abbreviations

AI	Artificial Intelligence
CCDR	Country Climate and Development Reports
CMAP	Climate Macroeconomic Assessment Program
COP26	The United Nations Climate Change Conference in Glasgow
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gas
GSMA	Global System for Mobile Communications Association
IFC	International Finance Corporation
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
SDG	Sustainable Development Goals
SSA	Sub-Saharan Africa
WFP	World Food Programme
UN	United Nations

Executive Summary

Climate change is intensifying food insecurity across SSA with lasting adverse macroeconomic effects, especially on economic growth and poverty. Successive shocks from Russia's war in Ukraine and the COVID-19 pandemic have increased food insecurity in SSA by at least 30 percent since early 2020—IMF (2022a) examines these near-term issues. Complementing that paper, this departmental paper is the first IMF policy paper to address the longer-term issue of climate change and food insecurity, with SSA-specific considerations. In 2022, 12 percent of the population is suffering from high malnutrition and unable to meet basic food consumption needs. The rising frequency and intensity of droughts, floods, cyclones and higher temperatures and sea levels are set to exacerbate this number by hampering agricultural production and food distribution. After each major climate event, people die of hunger and the survivors are less productive. Over the longer term, poor nutrition hurts early childhood development, educational attainment, and earnings potential. Consequently, increased food insecurity could jeopordize the hard-earned improvements in incomes and education and health outcomes across SSA in recent decades. These and other serious humanitarian and economic implications could also fuel conflict and large-scale migration.

Addressing the lack of resilience to climate change, critically underlying chronic food insecurity in SSA, will require careful policy prioritization against a backdrop of financing and capacity constraints. Implementing multiple measures amid high debt levels, competing development needs, and capacity limitations is extremely extremely challenging. However, many reforms can be implemented without raising fiscal pressures. These include crucial changes in trade, regulatory, market structure, and financial sector policies—which can also catalyze sizeable private sector investment in resilience building. While the optimal policy mix will vary across countries, policy considerations (tradeoffs and complementarities) result in key findings that include the following:

- Fiscal policies focused on social assistance and efficient public infrastructure investment can improve poorer households' access to affordable food, facilitate expansion of climate-resilient agricultural production, and support quicker recovery from adverse climate events. Critical infrastructure areas include irrigation systems, telecommunications, transport, storage facilities, and renewable electricity. In cases where agricultural subsidies are present, the subsidies should be redesigned to ensure better targeting and reduce economic costs.

- Improving access to finance and digitalization is key to stepping up private investment in agricultural resilience and productivity as well as improving the earning capacity and food purchasing power of poorer rural and urban households. To this end, critical steps will be advancing property rights, expanding telecommunications infrastructure for mobile banking and enlarging access to early warning systems and up-to-date market and weather information that support agricultural production, distribution, and sales. Reduced informational asymmetries and improved financial literacy would support greater use of insurance. These reforms would also support micro finance or public-private partnerships that can jump start private finance.

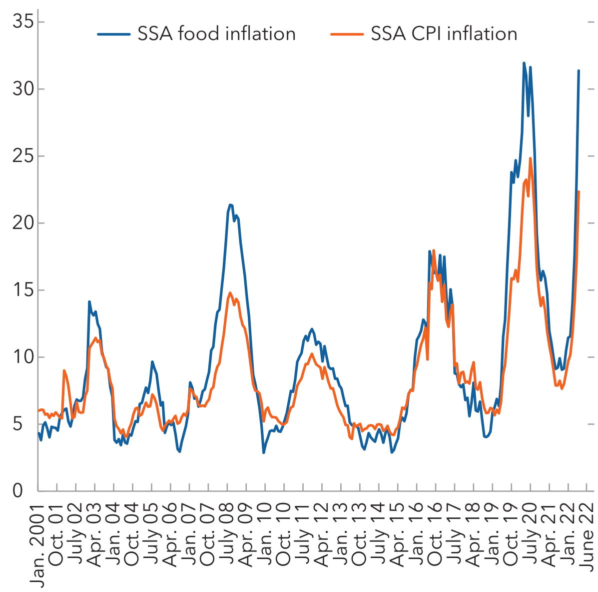
- Greater regional trade integration and resilient transport infrastructure enable sales of one country's bumper harvests to its neighbors facing shortages. Tariff reduction and regional alignment of agricultural and product market laws and regulations (especially with respect to water, seeds, and fertilizer) will all be elemental. Expansion of producer organizations can facilitate adoption of new technologies, scale up food production and distribution, and support price stability.

The international community can help with financial assistance, capacity development, and facilitating transfers of technology and know-how. For example, climate funds could play a critical role through grants and concessional financing; and development partners can support research in a host of areas such as irrigation technology and climate-resilient seeds, while also helping expand climate and financial literacy. The IMF is supporting SSA countries in these efforts through technical assistance, capacity development, and financial support including through climate-oriented public financial management advice and lending facilities such as the Extended Credit Facility and, once operational, the Resilience and Sustainability Trust.

1. Climate Change and SSA's Intensified Food Insecurity

Food insecurity is escalating across sub-Saharan Africa (SSA) countries. In 2022, at a minimum, 123 million people (12 percent of SSA's population) are projected to be acutely food insecure—suffering from high malnutrition and unable to meet minimum food consumption needs.[1] At least 28 million of these people became acutely food insecure over the past two years due to successive shocks raising food prices (Figure 1) and depressing incomes, especially for the most vulnerable. Most recently, the war in Ukraine has resulted in global cereal shortages and fuel price hikes inflating food import bills (adding 2 million people, Box 1).[2] Meanwhile, challenges induced by the COVID-19 pandemic continue, especially rising unemployment, falling incomes, and the lasting adverse impact on food supply chains from lockdowns in 2020–21 (contributing 26 million people).[3,4] These events are compounding mounting pressures from rapid population growth and a lack of resilience to climate change that have already contributed to food insecurity in SSA rising faster than in the rest of the world (Figure 2, panels 1 to 3).

Figure 1. Sub-Saharan Africa: Food Inflation and CPI Inflation, 2001–22
(Percent)



Sources: IMF World Economic Outlook database; and IMF staff calculations.
Note: CPI = consumer price index. The cyclicality in food inflation reflects transitory food market supply/demand mismatches. Negative food production shocks (adverse climate conditions, sharp increases in inputs costs) and transport bottlenecks can severely constrain supply and push food prices up. Similarly, excessive or pent-up demand of foodstuffs can feed food inflation. Once food inflation peaks, it is typically followed by a period of negative food price growth. These bouts of inflation tend to be short-lived and self-correcting (Gavin and Mandal 2022). However, protracted inflationary pressures require monetary and/or fiscal policy responses.

Climate change is set to further intensify food insecurity and potentially jeopardize hard-earned development gains. Increased food insecurity could weigh on child nutrition and educational attainment, unravelling decades of improvements in SSA health and education outcomes (Figure 2, panel 4). Already, the 2030 UN Sustainable Development Goal 2 (SDG2) on food security will be difficult to reach amid the "new normal" of frequent and recurring droughts, floods, cyclones, and rising temperatures and sea levels. For example, one-third of global droughts occur in SSA. Currently, Eastern Africa (including Ethiopia and Kenya) is suffering one of the most severe droughts in recent history while Angola is undergoing a fifth consecutive year of drought. A single such weather event can significantly raise food insecurity, especially for these countries where agricultural productivity is already less than half the global average.[5] In Ethiopia, Malawi, Mali, Niger, and Tanzania, food insecurity increases by

1 Acute food insecurity is defined as the number of people in IPC/CH (Integrated Phase Classification) Phase 3 or above, where populations are classified in five different phases of food insecurity with Phase 1 being the least severe and Phase 5 the most severe; WFP (2022).

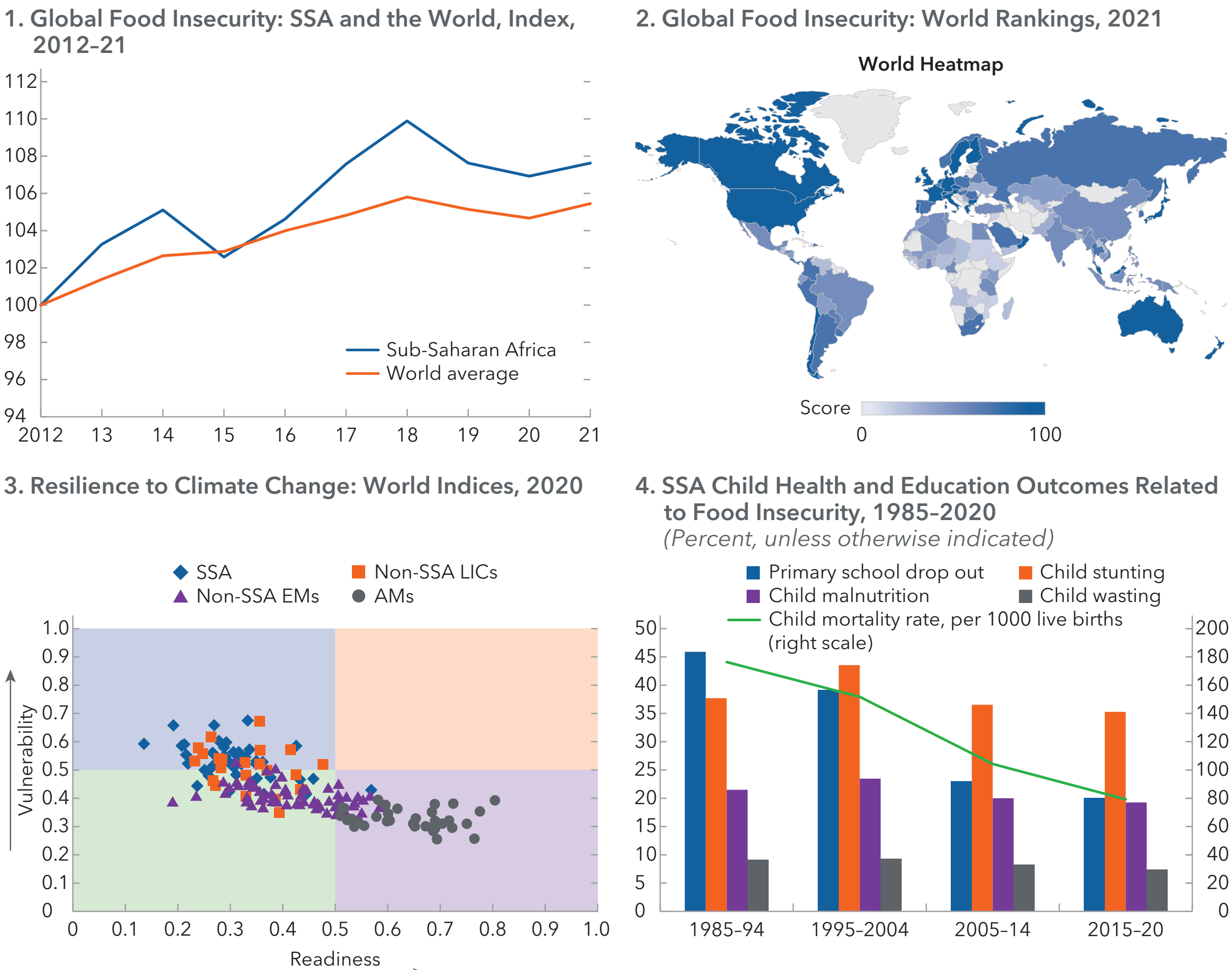
2 IMF (2022b).

3 IMF (2021a).

4 World Bank (2020a).

5 Fuglie and others (2020), Ritchie (2022).

Figure 2. Global Food Insecurity, Resilience to Climate Change, and SSA Development Outcomes



Sources: Global Food Security Index 2021; Notre Dame Global Adaptation Initiative, 2020; World Development Indicators; World Health Organization; and IMF staff calculations.
Note: In panels 1 and 2, the Economist Impact Global Food Security Index assesses countries' food security outlook based on official data, expert judgement, and surveys. It includes 28 SSA countries and measures performance across four pillars of the food security metric: availability, affordability, quality and safety, and natural resources and resilience. In panel 2, the most food-insecure countries correspond to the lightest shades. In panel 3, readiness measures a country's relative ability to leverage investments and convert them to adaptation actions on a scale 0 to 1 (higher is better); and vulnerability measures a country's relative exposure, sensitivity, and capacity to adapt to the negative effects of climate change on a scale of 0 to 1 (lower is better). In panel 4, child mortality rates are based on data spanning 1990–2020.

5 to 20 percentage points with each drought or flood.[6] Looking ahead, a similar or stepped-up frequency and intensity of adverse weather events will further hamper food production and distribution (including damaging effects on transport routes)—exacerbating food shortages originating within a given country or from import-sourcing countries—and fuel food inflation with severe cascading consequences for the economy (elaborated in the next chapter), conflict, and migration.

Higher temperatures, rising sea levels, droughts, floods, storms (especially severe ones such as cyclones), and acidification weigh on agricultural yields and weaken the nutritional value of food.

[6] IMF (2020a).

- A one degree Celsius temperature increase in developing countries is associated with a 3 percentage point reduction in agricultural output, leading to a 1.3 percentage point decline in growth.[7] In SSA, crop yields are projected to decline by 5 to 17 percent by 2050, especially in key staples.[8] Notably, rising temperatures and rainfall volatility are key contributors to the shrinking of growing seasons and arable land, resulting in reduced productivity from overuse—impeding total factor productivity in agriculture.[9]

- Rising temperatures and water levels are causing insects and weed seeds to migrate into SSA.[10] The 2019–20 locust infestations in Ethiopia, Kenya, and Somalia affected 1.25 million hectares of land, and the infestation response increased the region's financing needs by about $70 million.[11,12]

- Ocean acidification and rising temperatures are shrinking ecosystems, resulting in shortages of fish, meat, and dairy through diminished fishing yields, livestock grazing areas, animal lifespans, and impaired embryonic development and reproductive efficiency. The current drought in the Horn of Africa has already killed more than 1.5 million livestock and drastically cut cereal production.[13] By 2050, fish production in Coastal West Africa is projected to decline by 21 percent with a 50 percent decline in fisheries-related jobs; and it is expected to decline in Lake Tanganyika by almost 30 percent with adverse consequences across East Africa (Burundi, Democratic Republic of Congo, Tanzania, and Zambia).[14,15]

- Rising temperatures, CO2 emissions, and toxin levels disrupt grain development resulting in low protein content.[16] For example, based on actual outcomes during varied growing seasons, it has been found that the edible portions of key staples (for example, wheat, rice, potato) decrease by 10 to 14 percent.[17]

The pronounced vulnerability to climate change of SSA's food production, quality, and distribution reflects a lack of agricultural resilience. Reliance on rainfed crop production prevails across SSA. Less than 1 percent of arable land area is equipped for irrigation, leaving most farming and livestock areas prone to volatile rainfall, rising temperatures, and droughts.[18,19] Drainage systems for flood protection are also lacking. Poor storage capacity of households and warehouses results in significant food loss, averaging 9 percent a year in SSA.[20] This reflects both a lack of physical storage structures and access to electricity (less than half the population has access), where temperature control is critical, especially for perishables. Food distribution and supply of agricultural inputs (for example, fertilizers, equipment) are hampered by poor quality and coverage of transport infrastructure.[21] Consider roads, bridges, train tracks, and ports that are easily damaged or destroyed by severe weather. This hinders not only trade across countries within SSA but also transport of food imports from other parts of the world. Conversely, reliance on imported food is susceptible to weather events in other parts of the world that derail the transit of food imports or damage agricultural production in countries sourcing SSA food imports.

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7 Dell, Jones, and Oklen (2012).

8 Across SSA, the projected mean yield reduction by key staple is −17% wheat, −5% maize, −15% sorghum and −10% millet. Knox and others (2012).

9 Garcia-Verdu and others (2019), Jones and Thornton (2009), Zhang and Cai (2011), Lobell and others (2011).

10 Cannon (1998), Hellman and others (2008), FAO (2020a).

11 Cotter, de la Pena-Lavander, and Sauerborn (2012).

12 FAO (2020b)

13 Bloomberg (2022).

14 Lam and others (2012).

15 O'Reilly and others (2003).

16 Erda and others (2005); Ainsworth and McGrath (2010); Hatfield and others (2011); Miraglia and others (2009); Ceccarelli and others (2010).

17 Taub, Miller, and Allen (2008).

18 Economist Impact (2021).

19 Local temperatures rising from 2°C to 5°C can reduce wheat yields by 50 percent.

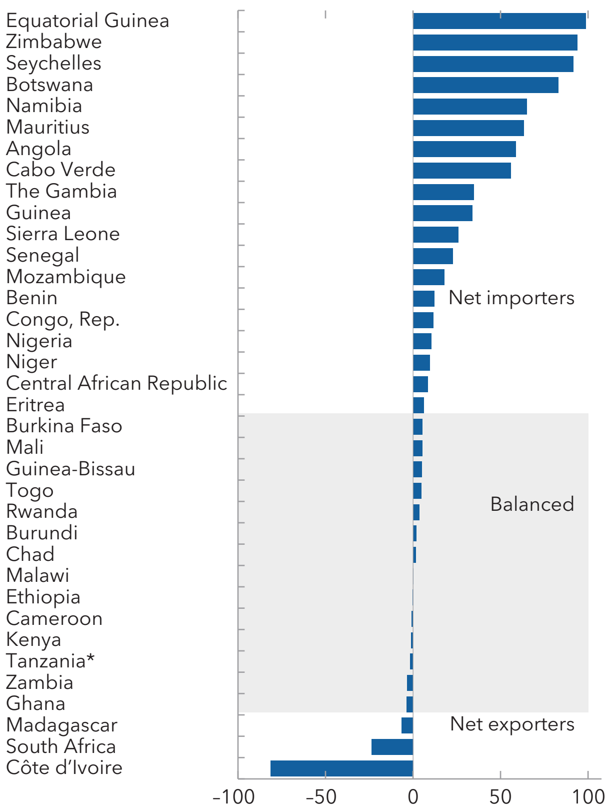
20 Adam and others (2012) presents different channels through which better storage can dampen food price volatility.

21 Port, air, and rail infrastructure are 28 percent below potential, and roads fall short by 22 percent.

2. Macroeconomic Consequences

The wide-ranging macroeconomic consequences of food insecurity brought on by climate change usually begins with shortages of food or agricultural inputs that raise food prices. Consider a weather shock that (1) reduces agricultural inputs (for example, fertilizers, seeds) or outputs in a given country (2) depresses food or agricultural input production in the country sourcing imports of these items or (3) physically obstructs the transport of food within a country or across countries, resulting in higher transit costs. As many SSA countries are net food importers (Figure 3 and Box 1) and have significant exchange rate pass-through, they are particularly sensitive to fluctuations in the prices of imported food and agricultural inputs as well as transit costs. Higher food prices typically spillover into higher overall inflation given the large weight of food products in most SSA countries' CPI baskets.[22,23]

Figure 3. Food Import Dependency Ratio, 2020
(Percent of total imports)



Sources: FAOSTAT; and IMF staff calculations.
Note: * indicates application of 2018 data.

Food shortages and inflation disproportionately affect poorer households through declines in incomes and purchasing power—exacerbating inequalities. On average, in SSA, 40 percent of households' spending is on food and this number rises to 60 percent for the poorest households, where half of SSA's population already lives below the poverty line.

- The majority of SSA's population lives in rural areas and depends on weather-sensitive activities such as rain-fed agriculture, herding, and fishing for their livelihoods (Figure 4). When adverse weather depresses agricultural production, subsistence farmers have less to eat for themselves and high food prices prohibit them from purchasing food elsewhere. Farmers that typically sell significant parts of their harvests could potentially gain from higher food prices. However, the negative impact of reduced production and often higher input prices (for example, fertilizer and seed demand can increase after a negative agricultural output shock) can dominate. In addition, agents purchasing food from farmers for sale in urban markets may not pass on the gains from higher market prices to farmers.

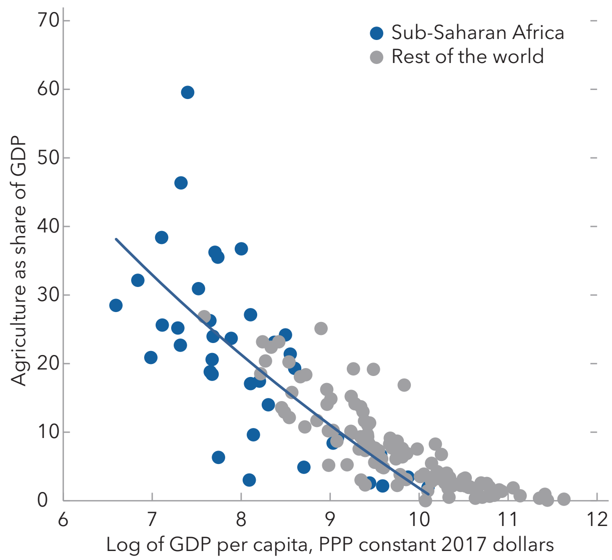
- In urban areas, higher food prices result in households spending a larger share of their income to buy food—where lower-income households tend to allocate a much greater share of their income toward food than higher-income households. Domestic food shortages can be partially offset through food imports but they are often expensive and do not substantially reduce food inflation. In addition to a loss of purchasing

[22] Godfray and others (2010), Parfitt, Barthel, and MacNaughton (2010).

[23] Rural households that produce and consume their own food or barter with their neighbors are less affected by higher food import costs.

power, the urban poor may also face greater competition for jobs and housing if the rural poor migrate to urban areas in search of food and replacement incomes.

Figure 4. Sub-Saharan Africa: Share of Agriculture and GDP per Capita, 2020



Sources: World Bank, World Development Indicators; and IMF staff calculations.

Increased food insecurity can have lasting adverse effects on economic growth and poverty. Rising death tolls shrink the workforce and, for those who survive, food insecurity weighs on near-term productivity. Hungry people are less able to concentrate and have diminished physical strength. The long-term impact is even more severe. Reduced food supply and higher food prices undercut child nutrition, early childhood development, and educational attainment (including through absenteeism).[24] This has lasting effects on the population's earning potential and human capital development, which is critical for long-term economic growth. Chronic malnutrition has already resulted in serious stunting and wasting challenges in SSA (Table 1), with irreversible cognitive and physical damage.[25] Food insecurity can also erode physical capital if households are forced to sell their assets (for example, parts of their homes, farms, equipment) in order to buy food.

A novel conceptual economic model illustrates the food insecurity and overall welfare impact of a climate shock in an average low-income SSA country (Figure 5, Box 2).[26] When a large climate shock hits and depresses agricultural production, rural households' food consumption declines rapidly.[27] As these households are already food insecure, the shock pushes them toward severe food insecurity. To meet a minimum food consumption requirement, these households are forced to sacrifice productive capital—leaving them with insufficient capital to operate their farms. Subsequently, these rural households migrate to urban areas. This causes a permanent decline in agricultural output and, notwithstanding an increase of food imports, food prices increase in rural and urban areas. Overall, food consumption declines and the number of permanently food insecure rises with a permanent scarring effect on growth and productivity. As a result, there is a significant reduction of aggregate welfare. The model is calibrated to meet parameters for a typical SSA country but the model results should be considered qualitative due to the stylized nature of the approach.[28]

External economic balances can also deteriorate. Higher food import bills weigh on trade balances. This can be the result of various factors including increased volumes of food imports (to compensate for domestic food shortages), higher import prices due to weather events in the import sourcing country resulting in food

[24] Bloem, Semba, and Kraemer (2010); Nikoloski, Christiaensen, and Hill (2015).

[25] WFP (2021).

[26] The model is conceptual to highlight mechanisms for large food security impacts from climate shocks and the relative efficacy of different policy responses. This work, elaborated in Baptista, Spray, and Unsal (2022a), will be complemented by a more quantitative approach in Baptista, Spray, and Unsal (2022b).

[27] The model considers a large temporary one-time shock to agricultural yields (for example, a year with particularly low rainfall or floods that damages crops for just one period). The choice of shock and magnitude are flexible and could be calibrated to effect multiple periods, different magnitudes, different variables, or different regions. Inequality is defined as the difference in per capita consumption between rural and urban areas. The model can be generalized to allow heterogeneity within each region as well as adding regions.

[28] The model calibration captures common key features of SSA countries with the objective of highlighting qualitative results. On an ongoing basis, the model is being adapted and applied to specific country cases, facilitating the analysis of policy tradeoffs on quantitative as well as qualitative dimensions. Quantification of the near and long term impact of climate events on economic growth (including through the food insecurity channel) is elaborated in IMF (2020a), Pondi, Choi, and Mitra (2022), and Yao (2021).

Table 1. Wasting and Stunting in Children, 2015–20
(In percent of children under 5 years)

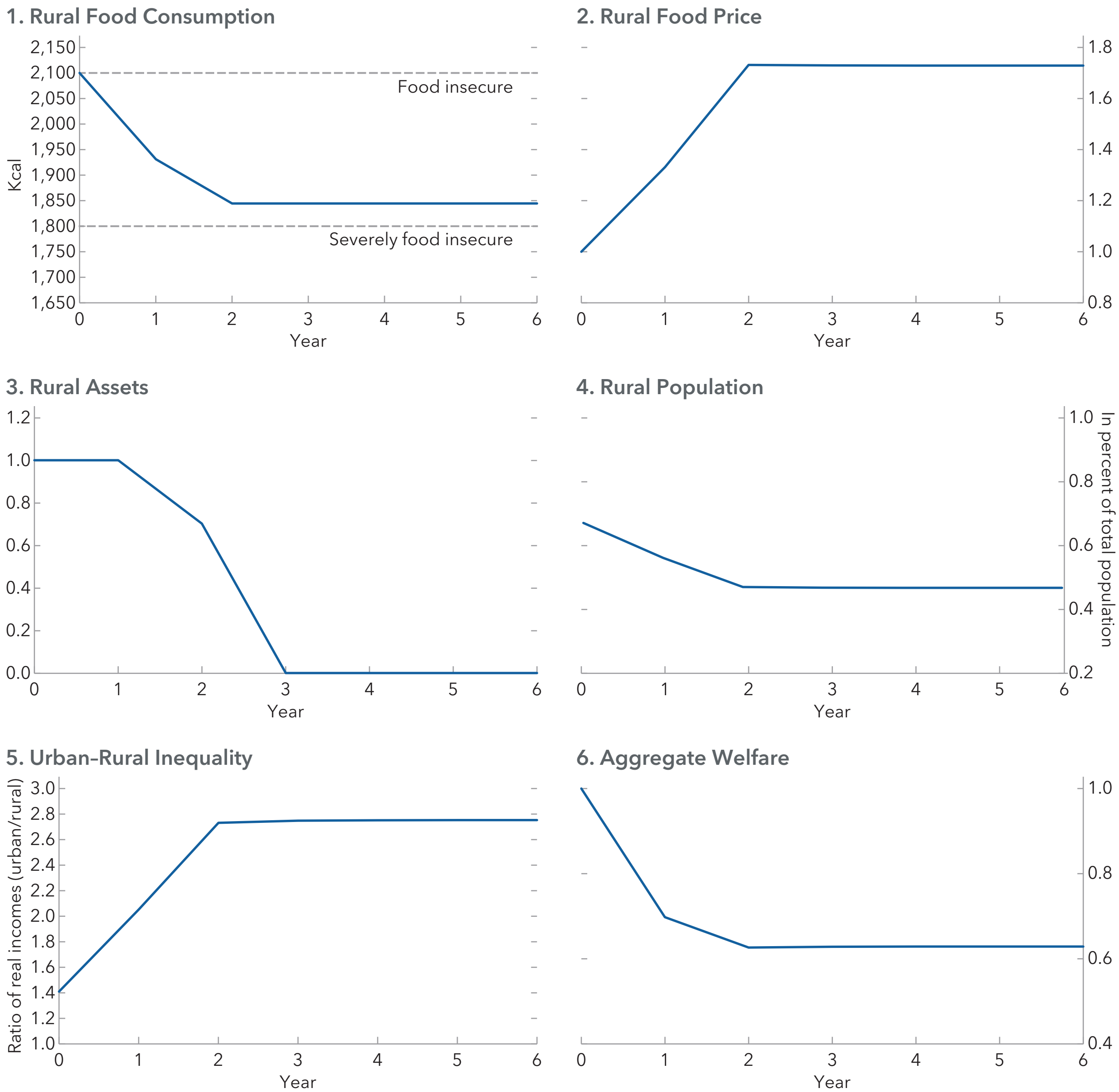
Country	Wasting	Stunting
Angola	8.2	37.6
Burkina Faso	9.1	24.9
Burundi	6.1	52.2
Central African Republic	5.2	37.5
Chad	10.0	30.5
Cote d'Ivoire	6.1	21.6
Democratic Republic of Congo	6.5	42.0
Eswatini	1.5	26.3
Ethiopia	7.2	36.8
The Gambia	6.0	13.6
Guinea	9.2	30.3
Madagascar	6.4	41.6
Mali	7.2	23.9
Mozambique	4.4	42.3
Niger	12.7	41.5
Nigeria	6.8	36.8
Republic of Congo	7.1	37.6
Senegal	8.1	18.8
Sierra Leone	5.4	29.5
South Sudan	15.8	15.6
Togo	5.7	23.8
Zambia	4.2	34.6
Zimbabwe	2.9	23.5

Source: WFP (2021).
Note: A child being too thin for his or her height as a result of rapid weight loss or the failure to gain weight is a sign of acute malnutrition (wasting) which, although treatable, can lead to illness, disability, or death. A child being too short for his or her age (stunting) is considered chronically malnourished.

or agricultural input shortages, or weather events impeding import transit routes. Weather events can also hamper production of agricultural exports. Overall, a worsened trade balance can put pressure on gross international reserves and exchange rates, where the balance of payments needs in many SSA countries is already large.

Fiscal pressures rise as governments seek to help populations cope with food insecurity and its consequences. Spending to address food insecurity, elaborated in the next chapter—spanning subsidies, social spending (social assistance, health), capital spending, and post-disaster relief—can crowd out other development spending in the face of limited fiscal revenues and debt sustainability considerations. The impact of

Figure 5. Impact of Climate Shock on Key Macroeconomic Variables
(Unless otherwise indicated variables are in percent deviation from value in period 0)



Source: IMF staff calculations.
Note: The figure demonstrates the impact of a temporary 30 percent decline in rural agricultural productivity from year 1, where the model is parametrized to match an average sub-Saharan African country based on available data. Variables in panels 2, 3, and 6 are normalized to express values relative to the initial period in the baseline scenario.

food insecurity on tax revenues can be mixed. Higher import bills often translate into higher revenues from customs duties and tariffs. However, in efforts to contain inflation, governments may reduce these duties and tariffs. In addition, slower economic growth and lower incomes could lower other tax revenues (such as income tax and VAT).

A host of other pressures can be spurred as well. Climate change events resulting in food shortages feed political and physical conflict over arable land and water access, which, in turn, impede food production and distribution—ultimately, weighing on economic growth. As a parallel, the example of food insecurity being a key driver of the Arab Spring could be considered.[29] Even absent conflict, the loss of stable food sources, income, and assets can push rural workers to migrate to cities in search of shelter and jobs (as mentioned above), which raises pressures on SSA cities already struggling to accommodate high population densities. The migration can also be to another country or continent with similar effects there.

[29] Soffiantini (2020).

3. Policies

A lack of resilience to climate change critically underlies food insecurity in SSA. Addressing this challenge, largely through more robust food production and distribution within SSA, is fundamental to reducing the population's vulnerability to shocks in food prices and supply—be it climate-induced shocks or ones like the ripple effects of the current war in Ukraine.[30]

Policymakers have been actively upgrading their strategies to reduce food insecurity in the face of climate change. This includes within countries' climate strategies, national development plans, and risk management strategies. Translating these strategies into action and results will require careful consideration and prioritization across policies—especially in the context of high debt levels, competing demands, and capacity limitations.[31]

The optimal policy mix will vary across countries but would typically include concerted efforts and coordination across fiscal, monetary and financial policies, and a host of structural reforms including in trade, agriculture, regulations, and digitalization—many of which are needed to address market failures (such as distortive agricultural input subsidies, under-provision of public goods, informational asymmetries). Key considerations in each of these areas and some examples of tradeoffs and complementarities across policies are raised in this paper. Importantly, policies in many of these areas (aspects of trade, laws and regulations, financial sector) do not require fiscal spending. Whatever policy mix is ultimately chosen, clear and broad communication of these policies, their sequencing, and socio-economic impact will be critical.

A. Fiscal Policy

Fiscal policy can help reduce food insecurity through an effective balance of subsidies, social assistance, and public investment. To address widespread food insecurity, in 2006, African Union countries committed to allocating at least 10 percent of total public spending on agricultural development, especially improving crop yields.[32] To this end, social assistance and agricultural input subsidies were stepped up but investment in climate resilient infrastructure has been slow. Accelerating such investments, coupled with more targeted social assistance, would improve poorer households' access to affordable food, support quicker recovery from adverse climate events, and facilitate farmers' access to technology and equipment supporting climate-resilient and green agricultural production (Box 3).

In the near term, a redesign of agricultural subsidies is needed. Against the backdrop of the current global food crisis and a lack of policy tools to address it, agricultural subsidies may need to be stepped up. However, especially where socio-political pressures around the current crisis are elevated, the effectiveness of subsidies must be enhanced through redesign that ensures those most in need benefit from the subsidies. Better targeting of the subsidies will also help reduce their high economic costs. SSA governments have favored these subsidies—especially for fertilizers, seed packs, and water—expecting they will reduce food insecurity and poverty. Instead of achieving these objectives, these subsidies have weighed on government budgets (Table 2); raised balance of payments pressures, through import reliance (for example, fertilizer imports); distorted market prices; created an uneven playing field by supporting state-owned enterprises (SOEs) or selected firms (for example, fertilizer manufacturers, distributers); resulted in input overuse (for

[30] The policies discussed in this paper focus on reducing food insecurity in the face of climate change. Policies to manage the impact of the war in Ukraine on food insecurity are discussed in IMF (2022a).

[31] The IMF Climate Macroeconomic Assessment Program and World Bank Country Climate and Development Reports will outline policy priorities for selected SSA countries in building resilience to climate change, including in food production and distribution.

[32] World Bank (2020b).

Table 2. Agricultural Subsidies, 2019–22
(In percent of GDP)

Country	Subsidy Type	2019	2020	2021	2022
Burundi	Guarantee on net agricultural lending by central bank	0.0	3.0	–0.4	0.0
Gambia[1]	Input subsidies for groundnut and other products	3.6	6.4	4.2	4.2
Guinea	Input subsidies across agricultural products	0.0	0.0	0.0	. . .
Malawi	Fertilizer and seed subsidies	0.5	0.4	1.4	1.3
Senegal	Subsidies on seeds, fertilizers, equipment	0.5	1.6	0.6	0.6
Sierra Leone	Agriculture, food, fisheries, and marine subsidies	. . .	0.0	0.1	0.1
Zambia	Fertilizer, food security packs, and strategic food reserves	2.0	3.6	3.0	2.9
Zimbabwe	Input subsidies for maize, wheat, and other grains	1.1	1.0	0.8	. . .

Sources: Country authorities; and IMF staff calculations.
[1]The Gambia has subsidies and transfers grouped together to state-owned enterprises, a primary one being input subsidies to the Gambia Groundnut Company for crop financing to support the rural poor population.

example, fertilizer, water) contributing to soil erosion and deforestation; supported hoarding of inputs and outputs; and reduced crop diversification through subsidized seed packs encouraging monoculture.[33,34,35,36] Consequently, crop yields fell short of their potential, the nutritional content of the population's diet suffered (with a focus on staples), and the region's carbon footprint grew (Box 3).

Guiding principles for the redesign of agricultural subsidies include the following:[37]

- Clearly defined objectives (productivity, equity) to facilitate assessment of the program's efficiency and cost effectiveness.
- Better targeting—including to small farmers and female-led households—as opposed to universal programs, would be more progressive and reduce the benefits captured by higher income groups and larger firms. For example, water subsidies seldom benefit poorer households with limited or no water access. Well-targeted fertilizer and seed electronic vouchers, in some cases, have proven effective in improving yields (net of input costs).[38]
- Reduced leakage through systems like electronic vouchers via a secure system such as a local agro-dealer—shrinking the secondary markets for benefits and improving governance and transparency.
- Gradually passing through international prices of inputs (for example, fertilizer, seeds) to consumers while protecting the most vulnerable households through targeted cash transfers (see elaboration on social assistance below).
- Careful timing of input delivery—given the seasonal nature of agriculture—and consideration for the quality of inputs (for example, climate-resilient seed packs).

[33] FAO, UNDP, and UNEP (2021).
[34] FAO (2021), Jayne and others (2018).
[35] Henderson and Lankoski (2019).
[36] FAO, IFAD, UNICEF, WFP, and WHO (2021).
[37] Morris and Rohrbach (2011).
[38] Wossen and others (2017), Kolapo and Kolapo (2021).

Over the longer term, redesign will also support eventual exit from agricultural subsidy programs. Given the politically charged nature of agricultural subsidies and how they are sometimes anchored in the expansion of strategic food reserves,[39] they will need to be phased out gradually. In some cases, it must also be recognized that well-targeted agricultural subsidies have merit.

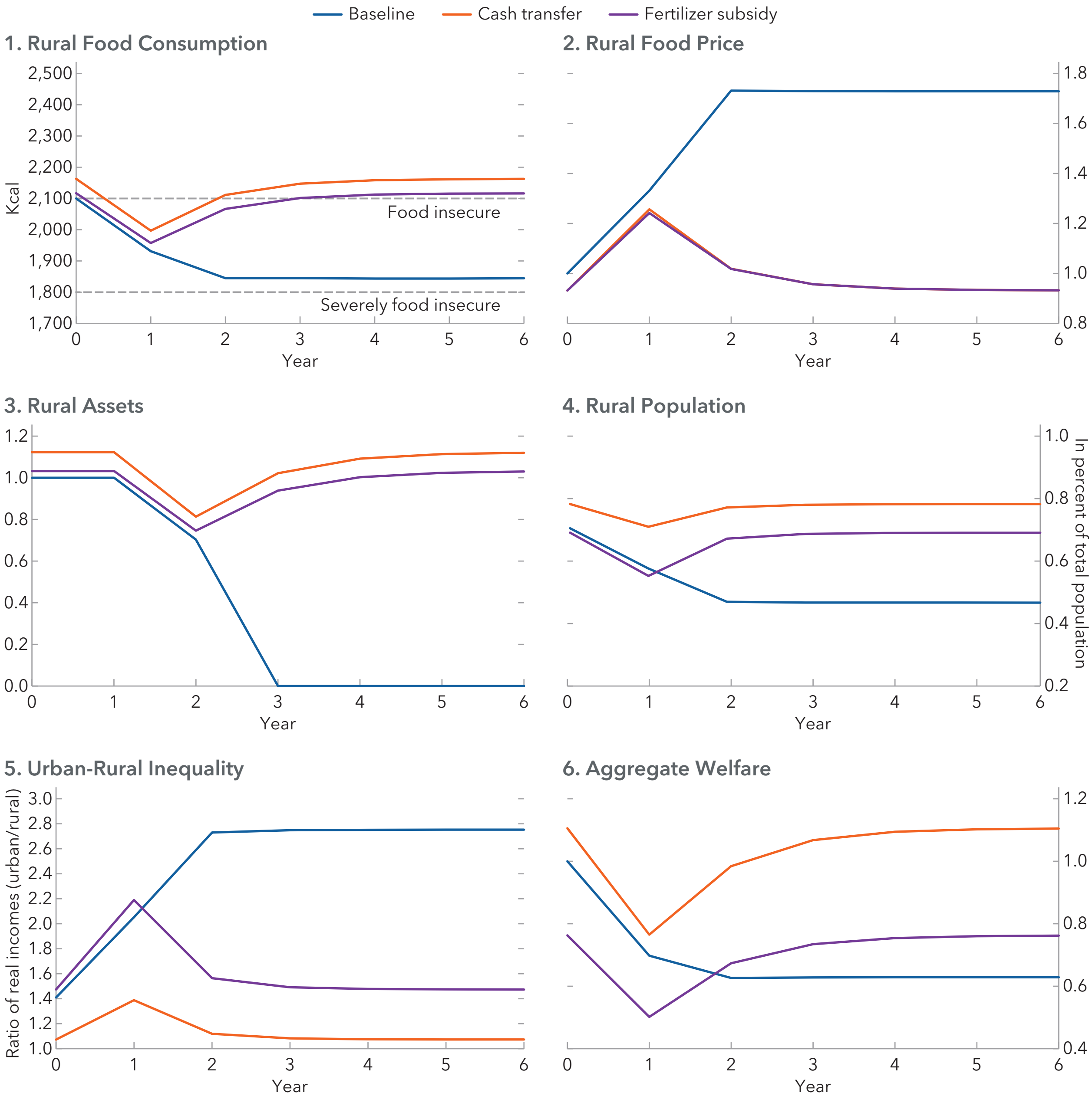
Well-designed social assistance systems can support food availability and affordability in the face of climate change. This is because targeted social assistance with far-reaching beneficiary coverage and ample financing (for example, cash transfers, school meals, food aid) is more effective at smoothing consumption and stimulating productive investment by poorer households—including through food purchases, rebuilding after climate shocks, and developing sustainable farms (for example, crop rotation, conservation tillage) and biodiversity.[40,41,42,43] Nearly all SSA countries have social assistance programs including food safety nets.[44] Many countries stepped up the reach of social assistance during the pandemic, including through mobile transfers and creation or expansion of national identity registries. Nevertheless, the funding, coverage, and operationality of most social assistance programs is still low.

Compared with equivalent spending on agricultural subsidies, social assistance such as cash transfers is more effective at safeguarding the welfare of rural and urban households (Figure 6). In response to agricultural shocks, policies often focus on mitigating the impact of the shocks on agricultural production through, for example, input subsidies. However, when households are food insecure, the decision between production and consumption are no longer separable as households may trade-off consumption today over production tomorrow. Many households and businesses rely on informal transfers, whose support is limited when the community is affected by the same climate event. Consequently, they revert to assets sales, which can curtail a household's long-term earnings and reduce human capital accumulation. Well-designed social assistance systems can support food availability and affordability in the face of climate change and avoid such draw down of capital whilst also being economically efficient. Consequently, compared with equivalent spending on efficient agricultural subsidies, social assistance such as cash transfers is more effective at safeguarding the welfare of rural and urban households.

Infrastructure is critical to resilient food production and distribution. To this end, Climate Change, Agriculture, and Food Security (CCAFS, the research arm of the Consultative Group on International Agricultural Research) suggests a three-pronged approach—focusing on infrastructure that increases agriculture productivity, enhances resilience to climate change, and reduces emissions.[45] In this context, quality and coverage of infrastructure across a broad range of areas will be key. This includes infrastructure such as irrigation and flood barriers that support production and infrastructure that reduces inequalities across rural and urban areas—lowering the cost of imported food in rural areas (Box 1)—as well as broader barriers to food distribution within a country. Some examples of such infrastructure are transport and storage facilities. More broadly, telecommunications and access to electricity generated from renewable sources (for example, geothermal, solar, and wind power) are critical in supporting the entire food supply chain. For instance, diversified electricity generation is amenable to innovations such as solar-powered irrigation that would reduce reliance on drought-vulnerable hydroelectricity (generating one-fifth of SSA's electricity).

[39] EC (2018).
[40] WRI (2018).
[41] Helpful guiding principles in designing social assistance are provided in IMF (2020b, 2019b).
[42] FAO (2021).
[43] Fisher and others (2017).
[44] WRI (2018).
[45] CSA Country Profiles.

Figure 6. Cash Transfers vs. Fertilizer Subsidy: Impact of Climate Shock on Key Macroeconomic Variables
(Unless otherwise indicated variables are in percent deviation from value in period 0)



Source: IMF staff calculations.
Note: The figure demonstrates the impact of a temporary 30 percent decline in rural agricultural productivity from year 1. Variables in panels 2, 3, and 6 are normalized to express values relative to the initial period in the baseline scenario. The cash transfer and fertilizer subsidy are provided on an annual basis and are fiscally equivalent policies that are financed by income taxes (10 percent of annual income). Specifically, policies are budget neutral and raised through consumption taxes. In order to capture challenges with raising government revenue, inefficiencies could be added to the model to make all government policies less effective (to varying degrees). Nevertheless, this is not expected to change the model's qualitative results.

This, in turn, will facilitate water access and management as well as temperature control for food storage.[46] Infrastructure that raises resilience to climate change is also associated with improved quality, large spending multipliers, and sustainable job creation.[47]

Together, infrastructure and social assistance can be powerful policy tools. Consider Figure 7 as an example, wherein the individual impacts of cash transfers and public investment in irrigation are compared. Better irrigation infrastructure mitigates the impact on yields from a climate shock. Consequently, food prices rise less and normalize sooner, and less migration occurs from rural to urban areas. Consumption also declines by less but normalizes more slowly than with cash transfers. Similarly, asset values, inequalities, and aggregate welfare fluctuate less with better irrigation infrastructure but return to their pre-shock values sooner with cash transfers. When both policies are applied together, fluctuations in key macroeconomic variables and welfare would be substantially reduced and normalized sooner. In the same vein, investment in relevant research and development (for example, new climate resilience building technologies discussed below) and in ecosystem-based approaches can help reduce food insecurity and improve welfare.[48,49]

Capacity and financing constraints can limit the pace at which large scale infrastructure investments, and to a lesser extent social assistance, can be stepped up. SSA policymakers will have to balance trade-offs across these and other development-supporting investments while facing financing constraints from limited revenues and debt sustainability considerations.

- Public investment management that applies climate change impacts and cost-benefit analysis in their assessment criteria will be critical to prioritizing across investment projects.[50] Climate-sensitive public investment practices, such as integration of these projects in long-term budget planning, will enable timely project implementation and, ultimately, coordination across the projects to support improved food security.[51,52] More broadly, good public financial management and procurement practices are basic criteria for accessing external financing.
- Substantial external financing will be required despite domestic revenue mobilization efforts and channeling of savings from gradually phasing out subsidies (in agriculture or other areas such as fuel).

Stepped up financing from the international community will be critical, be it direct budget or project support, financing channeled through climate funds, or debt relief. Financing resilience to climate change, especially infrastructure, is much more cost effective (for example, 3 times as much for drought) than frequent disaster relief.[53] At COP26, African leaders indicated that $1.3 trillion through 2030 is necessary to address the region's climate-related needs, with a substantial concentration on building agricultural resilience. In contrast, during 2015–19, climate finance to SSA amounted to only $65 billion (Figure 8). However, the trend is positive. So far, the bulk of climate finance for SSA has been grants and concessional loans in agriculture, water, and sanitation by the World Bank, the African Development Bank, and bilateral donors; and the

[46] IMF (2020a).

[47] Batini and others (2021), find spending on clean energy, such as solar, wind, or nuclear, has an impact on GDP that is about two to seven times stronger—depending on the technology and the horizon under consideration—than spending on non-eco-friendly energy sources such as oil, gas, and coal or building back non-resilient infrastructure.

[48] IFPRI (2021).

[49] IPCC (2021) finds ecosystem-based approaches (for example, pest control, pollination, buffering extreme temperatures) can support food security, nutrition, livelihoods, biodiversity, and sustainability but face substantial challenges such as high costs of establishment and access to inputs and viable markets.

[50] IMF (2021b), Mitra and Vu (2021).

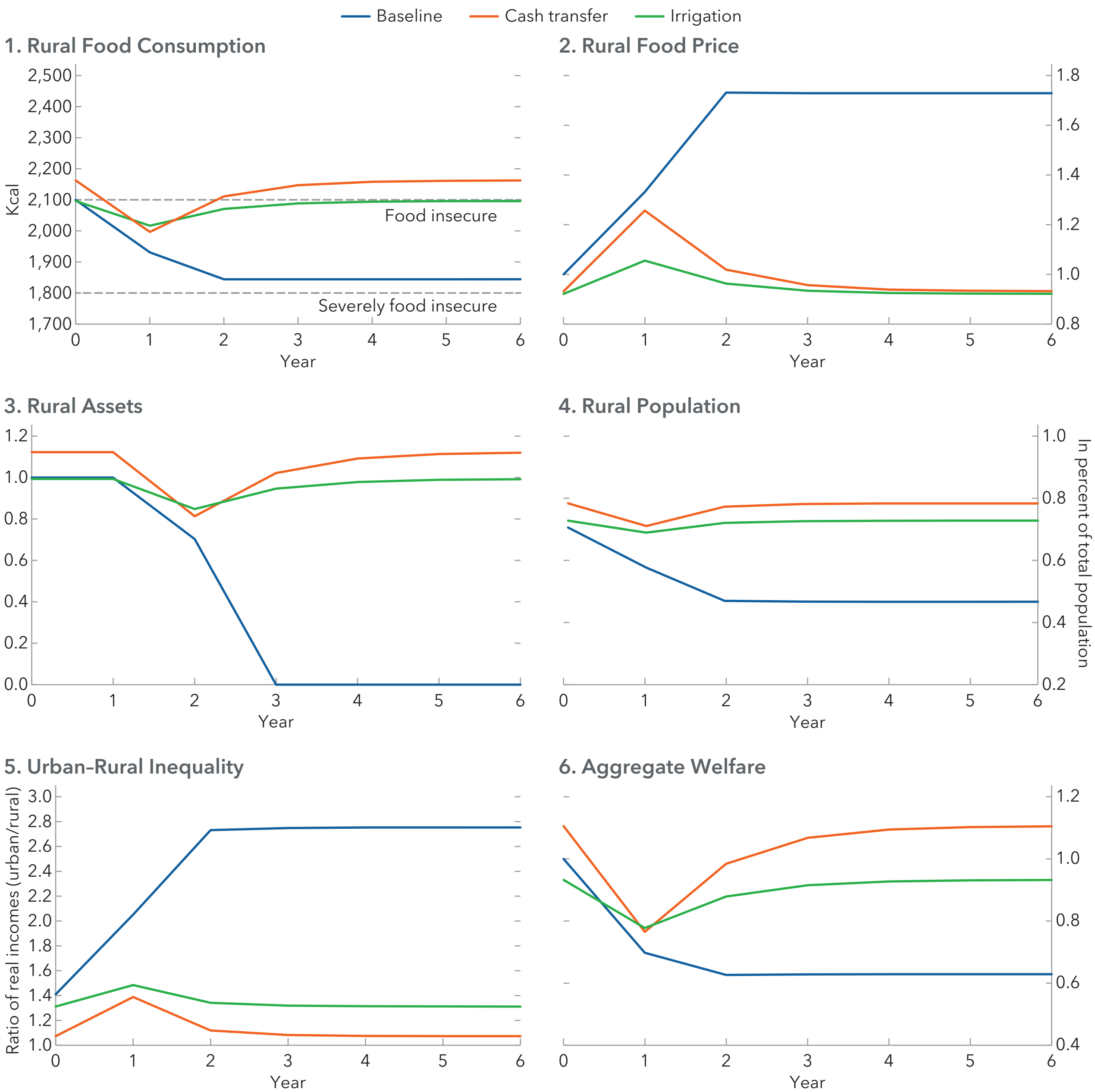
[51] World Bank (2020c).

[52] Gonguet and others (2021).

[53] IMF (2020a).

Figure 7. Irrigation Investment and Cash Transfers: Impact of Climate Shock on Key Macroeconomic Variables

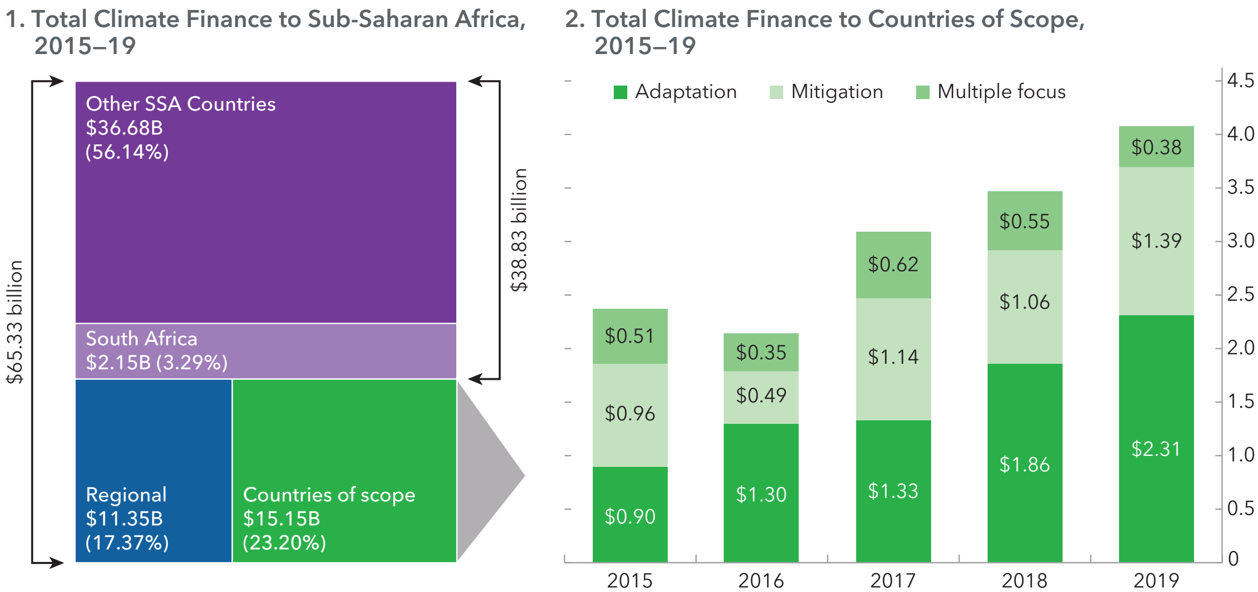
(Unless otherwise indicated variables are in percent deviation from value in period 0)



Source: IMF staff calculations.

Note: The figure demonstrates the impact of a temporary 30 percent decline in rural agricultural productivity from year 1. Variables in panels 2, 3, and 6 are normalized to express values relative to the initial period in the baseline scenario. Investment in irrigation is financed by government borrowing in year 0, which is repaid with an annual income tax of 8.5 percent over 10 years. The cash transfer, provided on an annual basis, is financed by an annual 10 percent income tax. The magnitude of the initial shock response changes with the amount of financing (or taxes) but the response pattern of each variable is robust to these changes. Generally, policies in this model are budget neutral and raised through consumption taxes. In order to capture challenges with raising government revenue, inefficiencies could be added to the model to make all government policies less effective (to varying degrees). Nevertheless, this is not expected to change the model's qualitative results.

Figure 8. Climate Finance Flows to Sub-Saharan Africa, 2015-19
(Billions of US dollars)



Source: Climate Finance Advisors (2021).
Note: The countries of scope are Angola, Central African Republic, Chad, Democratic Republic of the Congo, Guinea-Bissau, Liberia, Madagascar, Mozambique, Niger, Nigeria, Tanzania, Zimbabwe.

financing has been steadily growing often in line with improvements in public financial management and procurement practices.[54] Reforms in these two areas combined with better debt management are critical to accelerating climate finance, especially from climate funds, and could encourage debt relief.[55]

Overall, the IMF is supporting SSA countries in these efforts through a variety of channels. Targeted technical assistance and capacity development in public debt management, public financial management—including the Climate-Public Investment Management Assessment—and procurement are being provided. Broader balance of payments and fiscal support is available. Several SSA countries currently avail of the IMF's lending facilities, such as the Extended Credit Facility and, once operational, the Resilience and Sustainability Trust is expected to explicitly support countries' efforts to address climate change.[56]

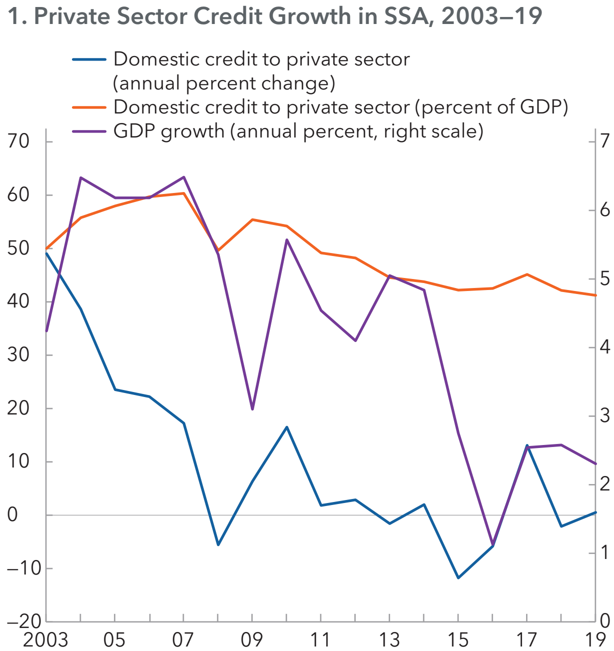
B. Monetary and Financial Sector Policies

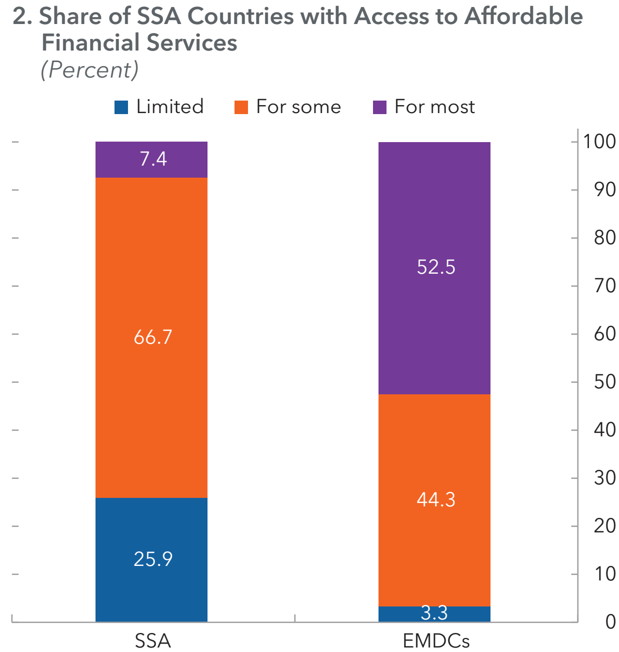
Monetary and financial sector polices can reduce the impact of climate change on food affordability and availability through multiple channels. Monetary policy can influence prices of domestically produced goods, including food, and anchor inflation expectations (Box 1). For instance, when inflationary pressures are rising, tightened monetary policy can reign in prices (including through exchange rate appreciation). In contrast, when inflationary pressures are contained, accommodative monetary policy can support fiscal policy in moderating the impact of climate shocks.

Given weak monetary policy transmission across SSA, increased financial inclusion and greater exchange rate flexibility (as explained below) coupled with regional trade integration could have strong near- and long-term benefits to food security. In practice, private sector credit in SSA has not kept pace with the last

[54] Climate Finance Advisors (2021).
[55] Prasad and others (2022).
[56] IMF (2022c).

Figure 9. Access to Finance





Sources: World Bank Databank; and IMF, International Financial Statistics.

decade's GDP growth and, for most of the population, access to affordable formal financial services in SSA is limited (Figure 9). Consequently, informal money lenders are frequently resorted to by poor households and small businesses, including farmers—notwithstanding serious concerns such as risk of fraud and high interest rates reflecting high default risks and monopoly-premiums.

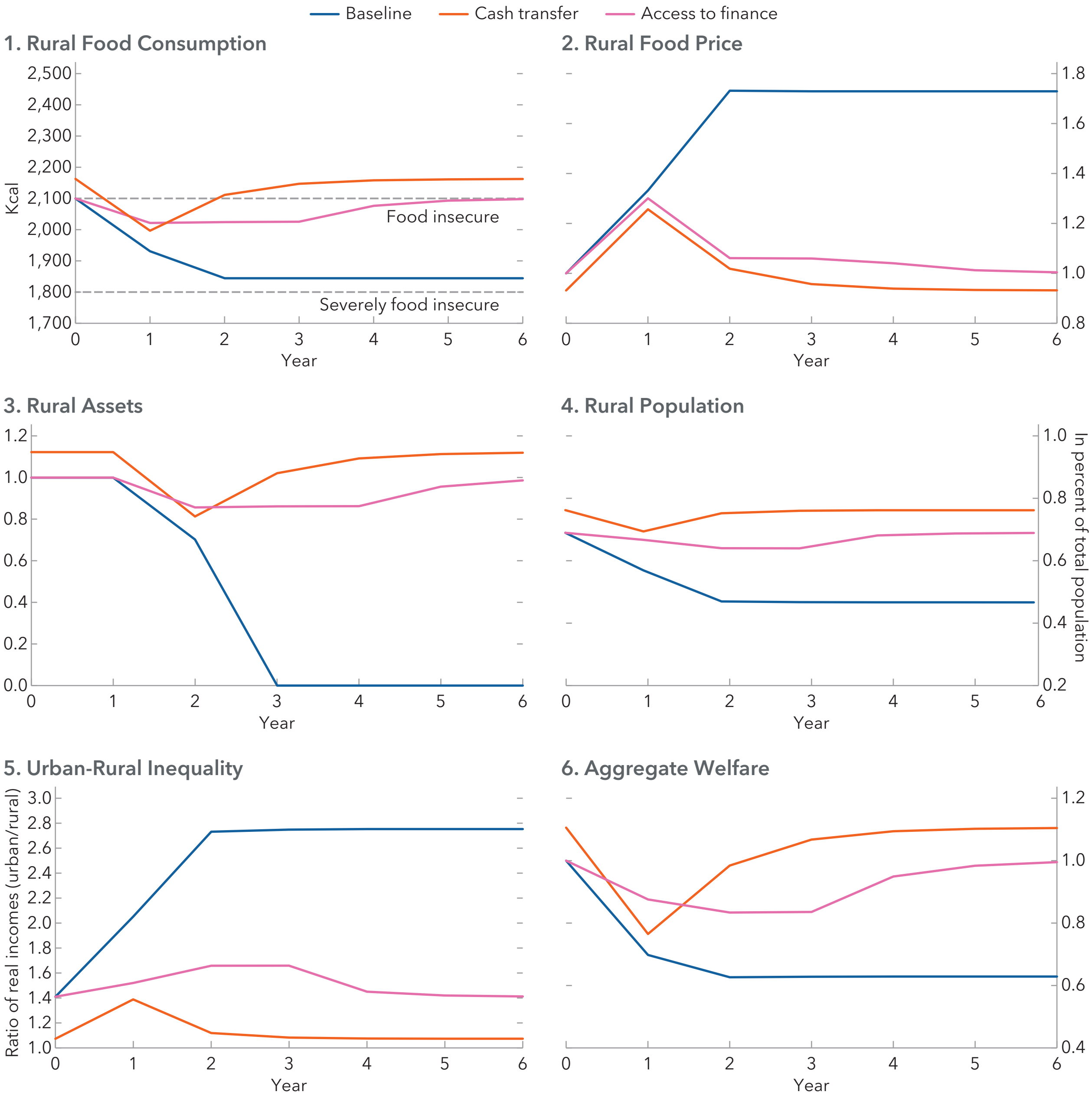
Efforts to jump start private finance could include (1) micro financing (or, where effective, public development bank financing) and capacity development that can help farms and agri-businesses get started, build a track record of financial performance, and demonstrate investment readiness; (2) public-private partnerships (PPPs)—accompanied by appropriate regulatory, accounting, and governance frameworks—that can reduce risks for private sector investment[57]; and (3) attracting impact investment—an emerging approach which provides an opportunity to channel private investment in SSA toward development sectors addressing social or environmental needs, where most of the funds have so far been directed to microfinance, agriculture, and forestry.[58] Each of these efforts, however, carry risks which can be partially addressed with improvements in project selection and planning.[59]

Higher access to finance through credit market deepening would enable private investment in agricultural resilience and productivity while also improving monetary policy transmission. The impact is similar to that of social cash transfers—in that it allows agents to smooth post-shock income and spend on food and rebuilding assets in support of a recovery that avoids lasting negative effects (Figure 10)—but does not require fiscal spending.

Ensuring digitalization efforts support further growth of mobile banking will be key to extending financial sector services to those who currently lack access. Mobile banking facilitates opening of bank accounts and access to digital financial services in rural areas where the physical presence of banks is lacking—helping

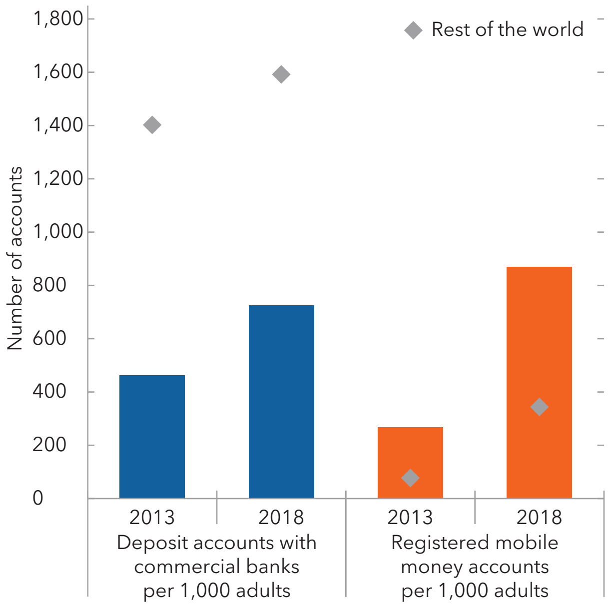
[57] IMF (2021d).
[58] IMF (2021e).
[59] Prasad and others (2022).

Figure 10. Access to Finance and Cash Transfers: Impact of Climate Shock on Key Macroeconomic Variables
(Unless otherwise indicated variables are in percent deviation from value in period 0)



Source: IMF staff calculations.
Note: The figure demonstrates the impact of a temporary 30 percent decline in rural agricultural productivity from year 1. Variables in panels 2, 3, and 6 are normalized to express values relative to the initial period in the baseline scenario. Once the shock hits, rural households receive a two-year loan (from the private sector, which is repaid in year 3) corresponding to 15 percent of their pre-shock income. The cash transfer is financed by an average 10 percent income tax in year 0; and it is budget neutral, raised through consumption taxes. In order to capture challenges with raising government revenue, inefficiencies could be added to the model to make all government policies less effective (to varying degrees). Nevertheless, this is not expected to change the model's qualitative results. Overall, the magnitude of the initial shock response changes with the amount of financing but the response pattern of each variable is robust to these changes.

Figure 11. Sub-Saharan Africa: Deposit Accounts and Mobile Money Accounts, 2013–18



Source: IMF (2020).
Note: Data availability covers 31 and 23 sub-Saharan African countries in 2013 and 2018, respectively.

to reduce poverty and increase economic growth (Box 4).[60] SSA mobile money accounts already outnumber traditional deposit accounts, with 21 percent of adults in the region having a mobile money account (Figure 11).[61] Further growth of mobile money will depend on expanding telecommunications infrastructure and implementing appropriate financial and telecommunications regulations.

Advancing insurance and other financial products could significantly offset the impact of climate events on households and businesses—as is the case in many other regions of the world.[62] Currently, only 0.5 percent of the world's agricultural insurance is offered in SSA—mainly in Mauritius, Nigeria, and South Africa—and this insurance often depends on government subsidies. Broadening the reach and viability of private insurance across SSA will require, as a start, reducing informational asymmetries (for example, through credit registries) and advancing financial literacy.[63] As insurance markets develop in SSA, further challenges such as risk diversification, replication, and scalability will also need to be addressed. At a sovereign level, the World Bank's Catastrophe Deferred Drawdown Option (CATDDO) and African Risk Capacity provide financing to governments through sovereign insurance instruments related to extreme weather events and natural disasters.

The impact of global food inflation on domestic food prices can be lower in fixed exchange rates countries with adequate international reserves. This is particularly the case for net food importers (Figure 3), where a fixed exchange rate allows them to contain exchange rate pass-through effects on food inflation. In contrast, flexible exchange rates can increase food price volatility. Estimates suggest that pass-through of world food inflation and exchange rates are 26 and 23 percent for low- and middle-income countries as opposed to 14 and 8 percent for high-income countries. Higher food commodity prices during 2020–21 are expected to translate into a 7 percent real increase in domestic food prices by end-2022.[64]

Over the longer term, however, exchange rate flexibility that boosts competitiveness and external buffers can support food availability, affordability, and quality. More competitive exports, including in agriculture, increase incomes and purchasing power.[65] International reserves buffers facilitate additional food imports when domestic production is compromised. As such, their targeted levels should account for food import dependency, the likelihood of adverse climate events and their impact on food insecurity, imports related to building climate-resilient agricultural infrastructure, debt carrying capacity, and access to post-disaster

[60] IMF (2020a).
[61] IMF (2019b).
[62] von Peter and others (2012).
[63] Giné and Yang (2009), Mobarak and Rosenzweig (2013), Cole and others (2013), Hill, Hoddinott, and Kumar (2013), Hallegatte and others (2017).
[64] IMF (2022b).
[65] Berg and Kpodar (2019).

relief. Greater regional trade integration, especially for agriculture, would reduce vulnerabilities to exchange rate pass-through, where regional currencies often fluctuate less against one another than with the rest of the world.

C. Regional Trade Integration

In the context of climate change, greater regional trade integration can enhance food availability and affordability. Combined with resilient storage and transport infrastructure (for example, better coverage and quality of roads, train lines, and ports), it can facilitate sales of one country's bumper harvests—that may have gone to waste—to a neighboring country facing shortfalls.[66] In turn, prices in both countries will remain stable, incentivizing longer-term agricultural investment. By the same token, increased regional trade could open new markets for farmers and agri-businesses and contribute to developing production networks and value chains across SSA.[67] The resulting knowledge transfers, including for adaptation (for example, optimizing drought-resistant crops, best-suited equipment for a given terrain and training on its use, energy-efficient agricultural practices), as well as the competition could boost productivity. Figure 12 illustrates the welfare benefits from reduced transport costs and import tariffs (each considered separately), where high transport costs or tariffs prohibit households from buying imported food and accelerate food insecurity. While the two policies naturally complement each other, a comparison across polices indicated that lower transport costs support a slightly faster rebound from climate shocks.

Currently, only 15 percent of the food imports are intra-regional, where food-related trade restrictions and export bans rose in reaction to the COVID-19 pandemic.[68] For example, Zambia's ban on maize exports represented 8 percent of maize imports by the other SSA countries; and Cameroon's cereal export ban to Nigeria represented 15 percent of Nigeria's rice import share, though the ban has since been lifted. Both net food importers and exporters stand to benefit from all of the potential gains listed here, especially when viewed from the perspective of individual agricultural products.

The Africa Continental Free Trade Agreement (AfCFTA), which came into force in May 2019, is a positive step forward with a potential market size of $3½ trillion in GDP and 1.3 billion people.[69] The World Trade Organization (WTO) describes the agreement as helping "…African countries establish trade corridors for essential goods, reduce duties on essential products, establish regional value chains, reconfigure supply chains, establish local pharmaceutical production facilities, and increase access to medication."[70]

Food trade in SSA would also benefit from reducing sizeable global trade restrictions (Figure 13). For example, the WTO estimates full implementation of the WTO Trade Facilitation Agreement (TFA) and its commitments would reduce trade costs of the Central African region (globally one of the highest) by an average of 16–17 percent. Additionally, more transparent regulation of commodity markets could help avoid speculative bubbles in food markets and contribute to food security—notwithstanding measures related to health and environmental protection that promote sustainable agriculture.

D. Agricultural Market Structure and Government Intervention

Producer organizations (for example, agricultural cooperatives) and competition amongst them can reduce the adverse consequences of climate change on food production, prices, and quality, without impacting national budgets. Key actions include:

[66] UN WFP (2019); The East African (2017).

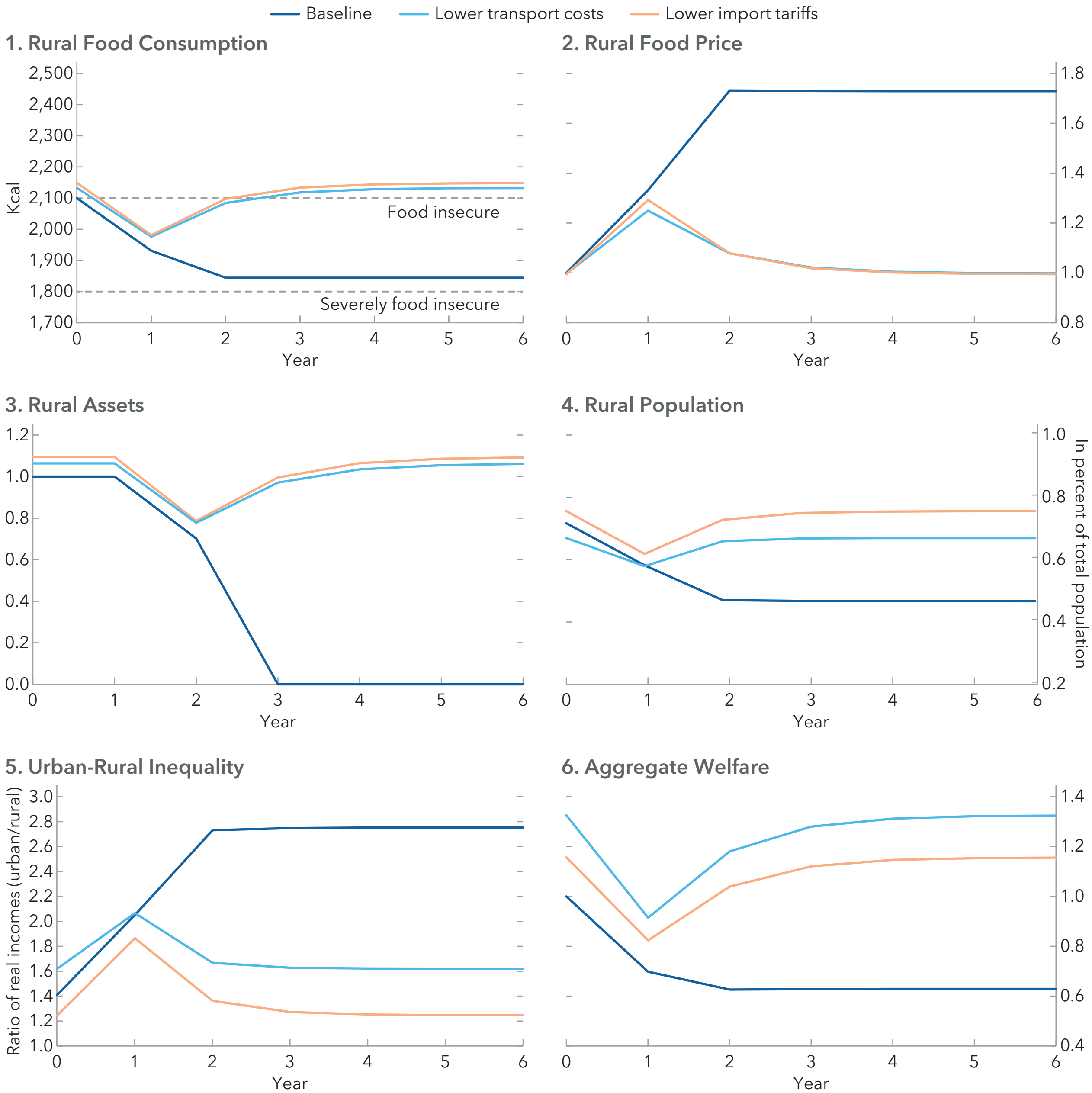
[67] FAO (2016a).

[68] Unsal and others (2020); UNCTADstat and IMF staff calculations; latest data are for 2018.

[69] IMF (2021c).

[70] WTO (2021).

Figure 12. Transport Costs and Import Tariffs: Impact of Climate Shock on Key Macroeconomic Variables
(Unless otherwise indicated variables are in percent deviation from value in period 0)

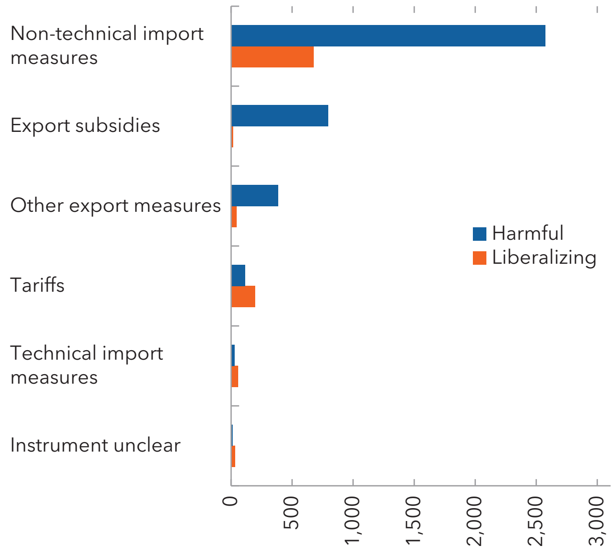


Source: IMF staff calculations.
Note: Note: The figure demonstrates the impact of a temporary 30 percent decline in rural agricultural productivity from year 1. Variables in panels 2, 3, and 6 are normalized to express values relative to the initial period in the baseline scenario. In this example, transport costs and tariffs are both reduced to zero. The magnitude of the initial shock response changes with the amount of transport cost or tariff reduction, but the response pattern of each variable is robust to these changes.

- Facilitating adoption of new technologies. For example, producer organizations can promote digital pest management technologies, distribution of climate-resistant seeds, and climate adaptation training.[71] Resource pooling allows these organizations to reach remote farmers and marginalized communities, who are especially vulnerable to climate change. The international community can also help by facilitating technology transfer and know-how shared with producer organizations as well as other stakeholders.

- Scaling up food production and distribution. Producer organizations can reduce market and information asymmetries and leverage economies of scale (by aggregating members' production) to negotiate lower input costs, affordable storage facilities, higher margins on product sales, more reliable distribution chains, and reach new markets—all benefiting farmers' profitability and ability to expand production.

Figure 13. Global Trade Interventions for Food Products, 2016–20



Source: UNCTAD calculations based on Global Trade Alert (2021).
Note: Harmful interventions are defined as those that restrict trade or more generally cause economic harm (for example, raise prices or reduce availability). Liberalizing interventions do the opposite.

- Supporting price stability. Longer-term contracts and lower input prices, both negotiated by producer organizations, support price stability for agricultural products. Digitalization that puts producer organizations directly in touch with markets, eliminates the need for traders who can manipulate the price and quantity of sales to markets.

In contrast, heavy government involvement—such as subsidies, price controls, agricultural marketing boards, and other large SOEs involved in agriculture—can suppress production and innovation. Agricultural subsidies, especially poorly designed ones, distort prices and hurt crop yields (see above). Meanwhile, price controls can contribute to shortages by disincentivizing food production, storage, and trade (Table 3). Market liberalization in Ethiopia, Zambia, and Zimbabwe had positive effects on market-based competition, innovation, and agricultural productivity.[72] When agricultural inputs and food distribution networks are controlled by a small group of politically connected companies or SOEs (including agricultural marketing boards), the result can be higher agricultural input and consumer prices as well as reduced competition, research, and innovation. Overall, most countries' agricultural sectors will likely benefit from gradual phasing out of government involvement, with substantial budgetary savings. There are, however, some targeted exceptions—for example, in some countries, the building of strategic grain reserves when food prices are low.

[71] FAO (2016b).
[72] Fuglie and others (2020).

Table 3. Price Controls in SSA

Country	Date	Subsidy Type
Ethiopia	2011	Introduction of price ceilings on 18 essential food items, incl. sugar, edible oil, bananas and spaghetti
	2014	Introduction of food subsidy and price intervention on wheat and products
Kenya	2009	Introduction of price ceiling on maize and products, wheat and products, rice, cooking fat/oil, sugar
	2011	Introduction of fixed price on maize and products and essential commodities
	2017	Maintenance of food subsidy and price intervention on maize and products
Mozambique	2010	Introduction of price intervention on rice and products
Nigeria	2016	Release of food stock and introduction of price intervention on wheat and products
Senegal	2008	Introduction of fixed prices on rice and products (later price ceiling) and milk and products
	2009–10	Introduction of fixed price on wheat and products
	2012	Decrease of price intervention on rice, sugar and oil
	2013	Introduction of fixed price on rice, granulated sugar; introduction of price cap on edible oil
Tanzania	2009	Introduction of price stabilization on agricultural commodities
Zambia	2015–16	Decrease of price intervention on maize and products
	2016	Increase of price intervention on maize and products

Source: Unsal and others (2020).

E. Legal and Regulatory Environment

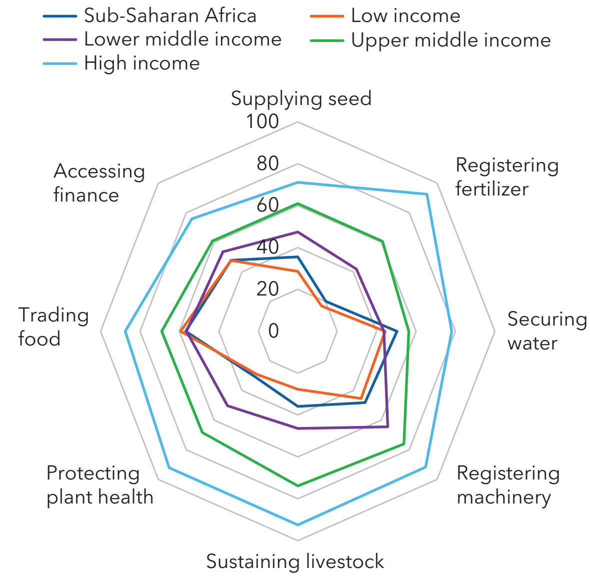
Well-designed and implemented laws and regulations enable growth of climate-resilient agriculture. In particular, those governing inputs, property rights, and bringing products to markets are most impactful and don't raise fiscal pressures (Figure 14).[73] In addition, to the points highlighted below, lifting restrictions against women's involvement in each of these areas will be important for reducing gender bias, expanding the agricultural sector, and adding innovation in resilience-building.

- Water regulations can be instrumental in reducing SSA's reliance on rain-fed agriculture. Regulations governing farmers' access to water (for example, complying with water use permit rules) can encourage farmer-led irrigation and protect from pollution and depletion. For instance, Burkina Faso introduced a progressive tariff grid based on the volume of use, with higher tiers subsidizing the lowest tier as well as part of sanitation activities.[74] From a safety perspective, it is also important to have strong rules surrounding management of runoff of water with excess fertilizer, chemicals, or salinity from agricultural fields.
- Fertilizer testing, labeling, and registration requirements are essential to ensure appropriate fertilizers are accessible to farmers, including those that are best suited for the type of climate change impact that the soil and crops are facing. Regulations can also ensure fertilizers are free of heavy metals, which can pollute

[73] World Bank (2019).
[74] IMF (2015).

surface and groundwater, posing a threat to human and animal health. More broadly, the quality control provided by appropriate regulations and their proper implementation can enhance agricultural productivity and farmers' profitability.[75]

Figure 14. Regulations and Laws Enabling Business and Agriculture, 2019



Source: World Bank, Enabling Business in Agriculture Database.
Note: The indicators, based on official data and expert judgement, assess laws and regulations in agriculture across 101 countries.

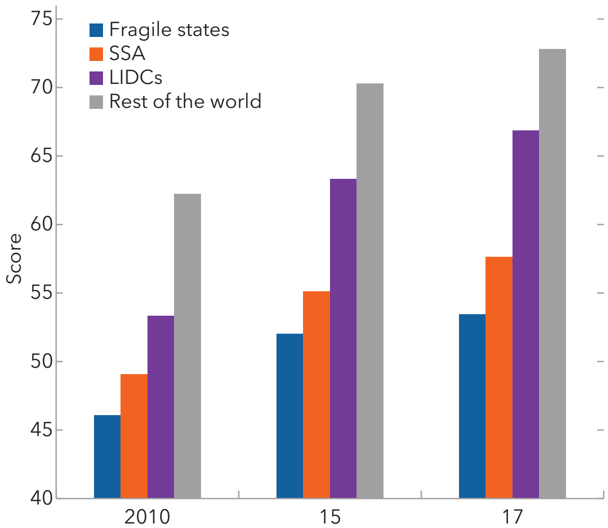
- Seed quality certification and regional agreements can help encourage use of climate-resilient seed as well as ensuring high-quality crops that meet market standards. For example, Economic Community of West African States regional agreements allow free circulation of new seed varieties; and in Kenya efficient seed registration has multiplied seed supply and access to foreign seed varieties.
- Animal feed and veterinary medicinal products that are properly regulated ensure high-quality inputs for livestock and reduce the chances of pests and disease outbreaks, which are increasingly frequent with climate change.
- Registering machinery ensures safety but should be streamlined to encourage farmers to invest in agricultural machinery (for planting, tending, and harvesting) that will increase yields and flexibility in types of crops grown—reducing vulnerabilities to climate events.
- Trade regulations and procedures that are streamlined can facilitate higher-volume agricultural sales at lower cost.
- Property rights that are legally established can allow farmers to use land as collateral in accessing finance and to use warehouse receipts to both gain access to working capital and to extend sales periods of perishable products beyond the harvesting season when prices are usually low—stabilizing long-term market prices. To this end, with World Bank support, Mozambique and Tanzania are expanding title and survey registers and developing digital land administrative services; and a pilot project is underway in Ghana that applies blockchain technology for land digitalization—addressing problems of poor record keeping, missing records, and multiple sales.[76] As these reforms progress, it will also be important for property taxation frameworks to keep pace.

F. Digitalization

Digitalization can improve access to finance, agricultural knowledge exchange, and more broadly, transparency and innovation. As discussed above, mobile phone technology is critical for farmers to access mobile banking and social assistance (mobile money). It also provides access to a much broader spectrum of services such as early warning systems and up-to-date market and weather information—both of which inform farmers' decisions on when to plant, irrigate, or fertilize—peer learning, and agriculture extension services.

[75] Bold and others (2017).
[76] Atlantic Council (2020).

Figure 15. Enhanced Digital Access, 2010–17



Source: IMF (2020a).
Note: SSA = sub-Saharan Africa; LIDCs = low-income developing countries.

SSA startups are using satellite, AI, and other technologies to empower farmers and policymakers by democratizing data.

- Machine-learning combined with satellite connections enabled Kenyan farmers to fight severe locust swarms in 2020. The Food and Agriculture Organization of the United Nations (FAO) estimates these efforts saved 34 million livelihoods and averted losses amounting to $1.5 billion throughout East Africa. Technology firms such as Plant Village in collaboration with the United Nations and FAO applied satellite connections and machine-learning ground teams to record images. This helped identify maturity and project swarm movements with up to 90 percent accuracy. Advice was disseminated to nearly 14 million farmers weekly through Shamba Shape and Mercy Corps. Plant Village also uses mobile spectrophotometry to allow farmers to gain insight into crop health of cassavas.
- Remote sensing allows Astra Aeriel Agroservices (a Kenya-based startup) to use drone technology in supporting irrigation management, crop spraying, and crop inspection. While this startup is currently the only licensed drone company in Kenya, others are in the pipeline. Having mapped nearly 2,500 farms, the company has digitized data on farm ownership and gender, farm distribution, crop, and livestock value chains. This data can then be used to project potential flooding vulnerabilities and provide targeted responses that reduce scouting times.

Accelerating broad-based digitalization in SSA requires investment and appropriate regulatory frameworks. Digital access has already grown markedly across SSA (Figure 15). Further growth will hinge on infrastructure investment—expanding access to electricity, ensuring global network connectivity, data centers, and data storage and management structures. An appropriate regulatory environment and digital strategies will also be key, where the focus should be on (1) digitally enabled businesses, new entrants, and ensuring equal access to critical digital infrastructure (competition policy, mainstreaming gender policies) and (2) lowering entry barriers (cost, information asymmetries, licensing, etc.). Investing in digital and financial literacy as well as risk management frameworks to ensure business continuity and address cyber-risks will be equally important.[77]

[77] IMF (2020a).

Box 1. Drivers of Staple Food Prices in Sub-Saharan Africa

Rising staple food prices is a major stressor of food security—as is becoming evident from the ripple effects of the war in Ukraine combined with the COVID-19 pandemic's adverse impact on food prices. Together, they have resulted in a more than 50 percent surge in global food prices since 2019.

Monthly market food prices reveal that this global price spike coincided with the sharpest increase (19.3 percent) in the relative prices of staple foods in local SSA markets since the global financial crisis. The steepest real price increases were seen for cassava (83.2 percent), wheat (18.6 percent), and maize (11.3 percent). The average price changes for rice and palm oil have been more muted, at less than 4 percent. When local prices are combined with the consumption share of each staple across countries, there is an 8.5 percent real increase in the cost of a typical food consumption basket in SSA.

The five most consumed staples (maize, rice, cassava, wheat, and palm oil) make up nearly 55 percent of average daily consumption in 15 SSA countries.[1] Maize accounts for 19.7 percent of the daily caloric intake in the region and is the top staple in Eastern and Southern Africa, while rice (11.4 percent) is widely consumed in Western Africa. The consumption of cassava (10.5 percent), wheat (8.3 percent), and palm oil (3.5 percent) is broadly more homogeneous across the region (Box Figure 1.1, panel 1).

The majority of the top staples are highly imported from outside SSA. Russia is the dominant source for wheat (34.7 percent), whereas palm oil and rice mainly come from Malaysia (47.8 percent) and India (36.3 percent), respectively. While net imports of wheat, palm oil, and rice are high in the region (81.9, 80, and 52.9 percent of net import dependence), maize and cassava are mainly domestically sourced (with low net import dependence ratios of 8.5 and 8 percent). Uganda and Tanzania account for 33.8 and 41.2 percent of SSA countries' imported maize and cassava.

Staple foods, in particular highly imported ones, are on average cheaper in urban than rural areas. The average cost of staple foods is 2.4 percent lower in large cities and the urban-rural price gap is wider (3 percent) for highly imported staples. Costs of wheat and rice—mostly imported staples—have continued to be relatively cheaper in urban than rural local markets (Box Figure 1.1, panel 2). However, the relative prices of maize and cassava—predominantly produced domestically in rural areas—have grown more in urban than rural areas. These price differentials can largely be explained by acute infrastructure gaps and binding transport bottlenecks (unreliable roads, deficient electricity grids, and weak irrigation systems) within countries, which raise transport and market access costs.[2]

Global staple food price increases could bring near one-to-one increases in the SSA sales prices of highly imported staples (nearly one-quarter of the daily SSA caloric intake), albeit often with lags. The pass-through is estimated at 0.97 in countries that import at least 75 percent of their staples' consumption (Angola, Côte d'Ivoire, Ghana, Kenya, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Senegal, and Tanzania) and much smaller (0.19) in countries with a higher share of domestic production (Box Figure 1.1, panel 3). Because highly imported staples account for a quarter of daily caloric consumption, a strong pass-through of global food price spikes to local staple food prices will likely hamper access and consumption of nutritious staple foods for many households. To put things in perspective, global wheat prices rose 55 percent (year-on-year) in May 2022 following Russia's invasion of Ukraine and, in turn, pushed staple food prices to record highs in domestic SSA

[1] The panel data sample (n = 98, T = 116) cover the top five staple foods (cassava, maize, palm oil, rice, wheat) across 68 local markets in 15 SSA countries (Angola, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Uganda, United Republic of Tanzania, and Zambia), from January 2012 to September 2021.

[2] Gollin and Rogerson (2016).

Box 1. Drivers of Staple Food Prices in Sub-Saharan Africa *(continued)*

markets.[3] Wheat prices on international markets eased back to pre-war levels in late July following an agreement to resume Ukrainian grain exports but higher fertilizer prices are expected to prevail in the coming months.

Overall, the consumption share of each staple has the largest price effect. A 1 percent increase in the consumption share of a staple food is expected to raise its relative price by about 0.6 percent. Similarly, local staple food prices are expected to rise by 1.7 and 0.2 percent when net import dependence and global food prices edge up by 1 percent, respectively (Figure 1.1, panel 3). The price effects of consumption shares and global food prices are larger for highly imported staples than locally sourced staples (Box Figure 1.1, panel 4). For example, 1 percent depreciation in real effective exchange rates would increase the price of highly imported staples by an average 0.3 percent.[4] The estimated effects should be interpreted with care as conditional correlations rather than pure causal impacts from exogenous factors.

Natural disasters and wars often lead to staple food price spikes, albeit with varying effects depending on the nature of the event. Staple food prices typically rise sharply by an average 4 percent in the wake of wars and 1.8 percent after natural disasters. While the food price effects of natural disasters taper off after three months, the effects of wars last longer and remain statistically significant after two years.[5] Similarly, the effects of the drivers on staple food prices were larger during the COVID-19 crisis with adverse knock-on effects; a 1 percent depreciation in the real effective exchange rate would have raised the real cost for highly imported staples by an average 0.7 percent more during the pandemic. However, different types of natural disasters—for example, droughts versus floods—or wars—for example, internal versus external—could imply different impacts, depending on their definition, magnitude, frequency, duration, and location.[6] By increasing the frequency and severity of natural disasters, climate change is exacerbating food insecurity, as evidenced by the loss of arable land to desertification (for example, in the Sahel region).

Policy and structural conditions shape differences in staple food prices between countries. Across the region, differences in monetary policy frameworks, fiscal management, per capita income, and geographic challenges (for example, terrain such as mountains that increase transport costs) explain a large share of the cross-country variation in the changes in relative staple food prices. The real change in the cost of staple food is about 2.5 percentage points lower for countries above the median of the monetary policy framework index (Box Figure 1.1, panels 5 and 6). Better monetary policy frameworks imply more effective monetary policy, where banks with sound policies and communications are more likely to be able to curb food price inflationary pressures, especially second round impacts; they also have better transmission mechanisms, making monetary policy more effective, and in turn increasing its potency to control general inflation. On the fiscal side, a 1 percent uptick in the debt-to-GDP ratio would raise the real cost of staple foods by 0.1 percentage point above the regional average. In addition to a heavy debt burden, elevated debt-to-GDP can reflect weak fiscal management, which could weaken the domestic currency, raising the domestic price of imported food. Relative food prices tend to decline by about 1.2 percentage points below the SSA average when per capita income rises by 1 percent, suggesting that households spend a smaller fraction of

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3 FAO (2022).

4 Okou, Spray, and Unsal (2022).

5 Similar food price spikes are reported after natural disasters by McGuirk and Burke (2020) and armed conflicts by van Weezel (2016).

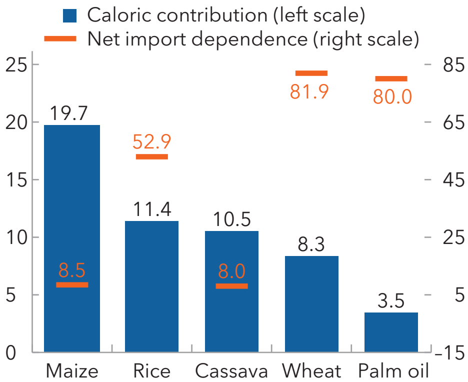
6 Dieppe, Kilic Celik, and Okou (2020).

Box 1. Drivers of Staple Food Prices in Sub-Saharan Africa *(continued)*

Box Figure 1.1. Consumption Share, Import Dependence, and Estimated Price Effects of Drivers

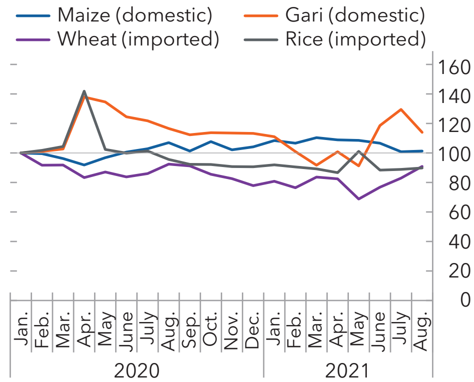
Among the top five staples in SSA, contributing more than half the average daily caloric intake, wheat, palm oil, and rice are highly imported.

1. Daily Caloric Contribution and Net Import Dependence of Top Five Staples
(Percent)



Lower mobility and binding transport disruptions coincide with growing urban-rural price differentials for imported and domestic food.

2. Urban-Rural Staple Price Ratio, 2020–21
(Urban–rural price ratio, percent)



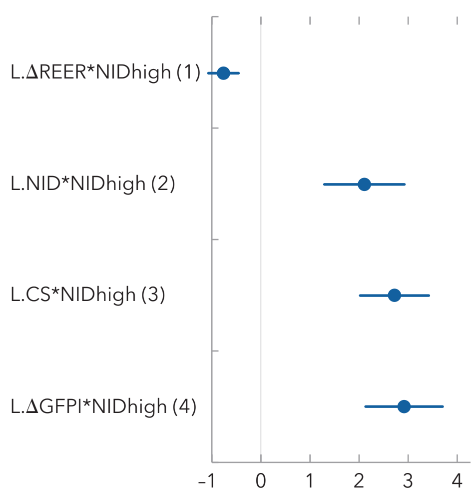
The estimated pass-through from global to local staple food prices is almost one for highly imported staples.

3. Estimated Effects for Highly Imported Staples
(Unscaled coefficients)

Dependent variable: relative food price change	(1)	(2)	(3)	(4)
L.NID	0.168***	0.120**	0.0968**	0.184***
	(0.0446)	(0.0490)	(0.0491)	(0.0470)
L.CS	0.564***	0.540**	0.522**	0.571***
	(0.215)	(0.215)	(0.215)	(0.216)
L.ΔGFPI	0.180***	0.182***	0.182***	0.189***
	(0.0378)	(0.0378)	(0.0378)	(0.0391)
High food price increase (dummy)	93.16***	93.22***	93.26***	93.01***
	(1.522)	(1.521)	(1.520)	(1.522)
L.ΔREER*NIDhigh	–0.335***	–0.130**	–0.0305	–0.262**
	(0.0695)	(0.0551)	(0.0536)	(0.109)
L.NID*NIDhigh		0.0998***		
		(0.0207)		
L.CS*NIDhigh			0.726***	
			(0.0955)	
L.ΔGFPI*NIDhigh				0.777***
				(0.107)
Country-market-item FE	Yes	Yes	Yes	Yes
Observations	6313	6313	6313	6263
Adj. R^2	0.569	0.570	0.570	0.569

Global food prices have the largest effects on highly imported staple food prices.

4. Estimated Effects for Highly Imported Staples
(Rescaled by the standard deviations of regressors)



their incomes as they become richer.[7] Finally, the real costs of staples are on average 2.5 percentage points higher in a country with one-point higher geographic challenge index, reflecting higher logistical costs.[8]

[7] As income increases, households' demand for food increases less than proportionally; Calderón and Schmidt-Hebbel (2010).

[8] A one-point increase in the geographic challenge index corresponds to 100 meters terrain elevation, for example, from Zambia (0.5) to Ethiopia (1.6).

Box 1. Drivers of Staple Food Prices in Sub-Saharan Africa *(continued)*

Box Figure 1.1 (continued). Consumption Share, Import Dependence, and Estimated Price Effects of Drivers

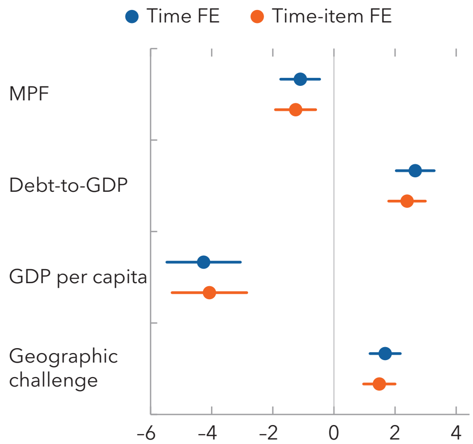
Policy and structural variables affect staple prices.

5. Estimated Effects of Country Characteristics
(Unscaled coefficients)

Dependent variable: deviation of relative food price change	(1)	(2)
L. Monetary policy framework (dummy)	-2.210***	-2.504***
	(0.664)	(0.686)
L. Government gross debt (% of GDP)	0.126***	0.113***
	(0.0151)	(0.0149)
L.ΔGDPPC	-1.253***	-1.200***
	(0.181)	(0.188)
Geographic challenge	2.850***	2.532***
	(0.440)	(0.453)
High food price increase (dummy)	67.21***	67.86***
	(1.483)	(1.486)
Time FE	Yes	Yes
Item FE	No	Yes
Observations	4968	4968
Adj. R^2	0.454	0.457

Local staple food prices are higher in countries with larger debt-to-GDP ratios.

6. Estimated Effects of Country Characteristics
(Rescaled by the standard deviations of regressors)



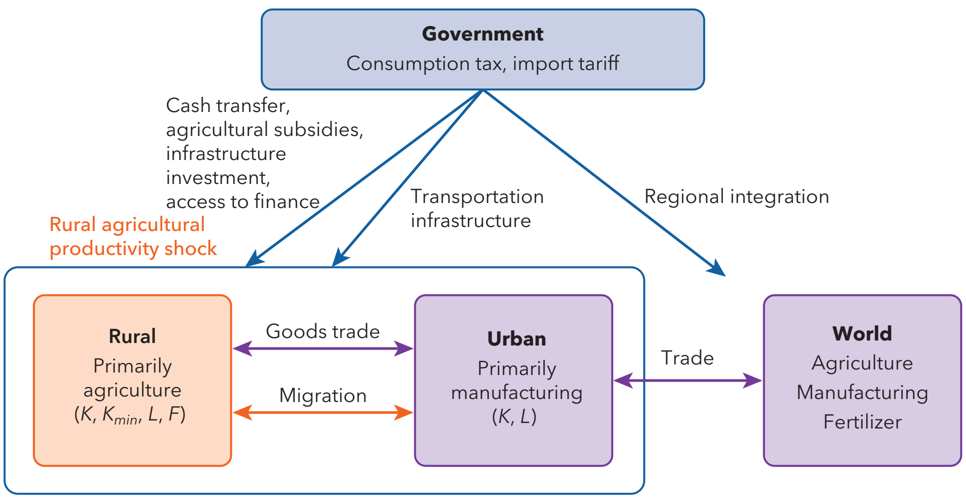
Sources: Food and Agriculture Organization of the United Nations Food Price Monitoring and Analysis and food balance sheets; Okou, Spray, and Unsal (2022); World Bank World Development Indicators; IMF, *World Economic Outlook*; and IMF staff calculations.
Note: The sample includes panel data on 15 sub-Saharan African countries (Angola, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Uganda, United Republic of Tanzania, Zambia) from January 2012 to September 2021.
For Figure 1C-D: The dependent variable is the percent change in real food price (monthly, y-o-y). Explanatory variables include lagged net import dependence in percent (NID), consumption share in percent (CS), the percent change in the real global food price index (ΔGFPI), high food price increase dummy (1-if food price increase > 50%, 0-otherwise), percent change in real effective exchange rate (Δ REER) interacted with a dummy for highly imported staples (NIDhigh=1–if NID>75%, 0–otherwise), largest city dummy, and interaction terms between largest city dummy, highly imported staples dummy and geographic challenge proxied by a country's terrain ruggedness index (hundreds of meters of terrain elevation, Nunn and Puga 2012).
For panels 3 and 4: The dependent variable is the monthly deviation (in percentage points) of real food price change from the group average of 15 sub-Saharan African (SSA) countries. Regressions include lagged dummy for the Independence, Accountability, Policy and Operational Strategy, and Communications (IAPOC) index of monetary policy frameworks (1–if IAPOC index > median IAPOC index, 0–otherwise), government gross debt (percent of GDP), GDP per capita growth (ΔGDPPC), geographic challenge proxied by a country's terrain ruggedness index (hundreds of meters of terrain elevation, Nunn and Puga 2012), high food price increase dummy (1–if food price increase > 50%, 0–otherwise), and control for time and item fixed effects (FE). Clustered robust standard errors in parentheses. *p < .10; **p < .05; ***p < .01.

Box 2. A Spatial Multisector Open Economy Model of Food Insecurity

A dynamic quantitative open economy spatial multisector macroeconomic model (Baptista. Spray, and Unsal 2022) can be used to analyze the macroeconomic consequences of food insecurity in SSA.

The model captures both rural and urban locations. Food is produced in the rural areas on household-operated farms using labor, imported fertilizer, and accumulated capital. Urban locations specialize in manufacturing but, more broadly, this sector can be viewed as a non-farm sector capturing services, industry, and other output. Agents can trade and migrate across regions (with relative wages declining in the region agents are migrating to) subject to frictions and can import from the outside world.

Box Figure 2.1.



Source: IMF staff.

Four frictions, prevalent in low-income countries, are featured: subsistence consumption on food (which implies that households spend relatively more on food as incomes fall), limited access to finance (which introduces a trade-off between consumption today and production later), transportation costs and import tariffs (which brings limited labor and goods mobility across regions and countries), and a capital threshold in the agricultural production function (which means that farm output is positive only if a certain level of capital is reached).

Incorporating these frictions in a dynamic setting with important sources of spatial and income heterogeneity allows the model to consider the macroeconomic implications of food insecurity, including a food-insecurity-driven poverty trap. Climate change shocks are modeled as a temporary one period decline in agricultural productivity. The model is, however, flexible and could accommodate multiple period shocks or permanent shocks. In order to simulate the impact of climate change on food insecurity, the model's output is linked directly to calorie consumption.

If hit by a negative agricultural shock, households may sell productive capital to meet a minimum food consumption requirement. If the shock is small and an isolated event, the economy adjusts. Rural households only temporarily migrate to urban areas and work in manufacturing; and these adjustments are easier when trade and migration frictions are small. If the shock is sufficiently large

Box 2. A Spatial Multisector Open Economy Model of Food Insecurity *(continued)*

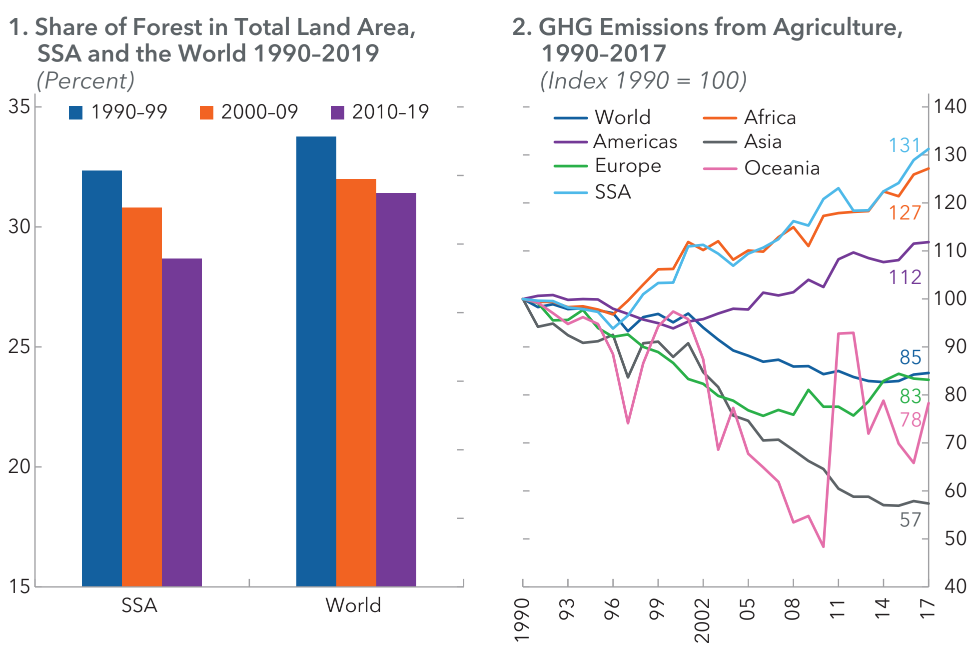
(or there are successive smaller shocks), the household will give up productive capital to meet the subsistence (or minimum) food requirement and capital falls below a minimum threshold. In which case, the household will not have enough capital to operate a farm and instead must earn a fixed wage in the manufacturing sector. A household leaving the agricultural sector causes an aggregate "food price" externality as countrywide food shortages and higher prices increase the chance other households will also become food insecure. The result is a permanent decline in agricultural output, increase in food prices, lower food consumption, migration to the urban area, increased regional inequality, lower economic growth and productivity.

Box 3. Agricultural Practices and Climate Change

Poor agricultural practices exacerbate the impact of climate change on food insecurity in SSA. Deforestation hampers forests' CO_2 capture and exposes agricultural lands to inclement weather (for example, leading to erosion, landslides, desertification). The share of SSA's forests in total land has been declining, with substantial deforestation in Côte d'Ivoire, The Gambia, and Niger (Box Figure 3.1), often motivated by the need to expand agricultural production. Soil erosion in Africa by 2070—particularly in Cameroon, Ethiopia, Kenya, and West Africa—is projected to be much higher than the global average.[1] In addition, GHG emissions are created from increased land use, residue burning, enteric fermentation, and certain types of fertilizer, where the latter two have more devastating climate effects than CO_2 emissions. Ecosystem-based agricultural management and preserving biodiversity can play a critical role in overcoming some of these challenges.[2]

Regionally, the positive impact on crop yields from these agricultural practices is more than offset by the negative yield impact from increased GHGs stemming from agriculture[3]—where SSA's agriculture-sourced GHG emissions are steadily rising (Box Figure 3.1). To keep things in perspective, SSA's total GHG emissions (from all sources, including agriculture) is slightly more than half that of US emissions and, excluding Nigeria and South Africa, SSA's emissions are slightly more than two-fifths of those from the United States.[4] More broadly, food demand patterns and food production systems are among the top contributors to GHG emissions in low-income countries.[5]

Box Figure 3.1. Agriculture, Deforestation, and GHG Emissions



Sources: FAOSTAT; and IMF staff calculations.

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1 Borrelli and others (2020).

2 IPCC (2021).

3 Van Dingenen and others (2009) estimates a 10 percent loss in wheat and soybean yields due to elevated O3 (Ozone) since preindustrial times.

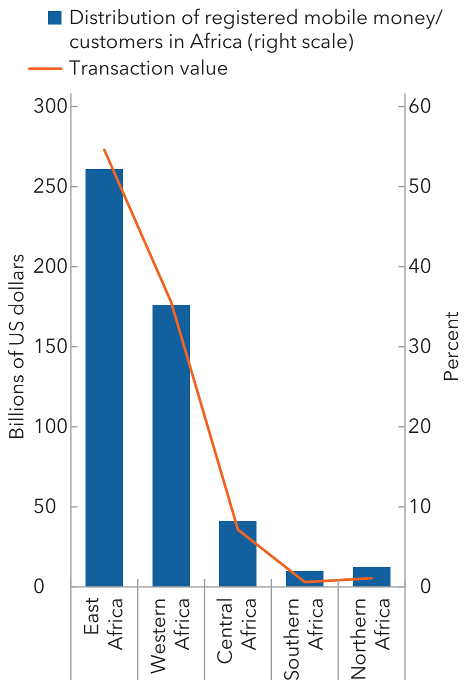
4 2018 data from https://ourworldindata.org/.

5 Batini (2021).

Box 4. Mobile Money

Financial inclusion in SSA, though growing, still excludes the bulk of smallholder farmers. Cash remains the dominant payment platform by cooperatives and agribusinesses. Many smallholder farmers are still unbanked with limited access to formal financial platforms.

Box Figure 4.1. Mobile Money in Africa, 2020



Source: Global System for Mobile Communications Association.

Mobile banking is key to addressing this challenge. GSMA estimates that Africa had 562 million registered mobile accounts in 2020 (47 percent of global accounts) with 12 percent annual growth and that mobile money agents have 58 and 26 times the reach of traditional banks and ATMs. In response, leading banks are adopting mobile-based and cashless transactions to access more clients.

Households' access to social assistance, remittances, and banking is rising. Mobile banking has lowered cash transfer costs and made it possible for governments to quickly and easily assist the most vulnerable. This was especially important during the COVID-19 pandemic, where the contact-free nature of these transactions supported public safety as well. To encourage this format of social assistance, the WFP disbursed $2.1 billion in 2019 to 64 countries in cash transfers with a component involving mobile money. Women, who are generally underbanked in SSA despite their leading role in agriculture, are also benefiting—with improved options for saving, borrowing, and investing. Mobile money has also played an integral role in facilitating receipt of remittances in rural areas across SSA.

Mobile platforms also broaden smallholder farmers' access to agricultural markets. Farmers can use mobile money to purchase fertilizers, seeds or farm labor, while receiving payment for produce sold. A striking example is that of Twiga Foods, an East African agri-based business-to-business food supply platform.[1] Twiga facilitates transactions between rural farmers and small- to large-scale vendors via a mobile-based cashless platform. Currently, more than 4,000 suppliers and 35,000 vendors use it. Replacing the traditional "middleman," this platform results in lower prices for vendors and higher prices for farmers, as well as reliable access to buyers, limiting post-harvest losses. According to the International Finance Corporation, a key initial financier, Twiga's post-harvest losses are 5 percent—substantially lower than the 30 percent average losses in Kenya's widely used informal market. Consumers also benefit from fresher produce. By 2019, the platform had expanded farmers' annual access by 600 percent.

[1] IFC (2018).

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