Building Stronger Food Systems in the Face of Global Shocks

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ABOUT THIS REPORT

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EXECUTIVE SUMMARY

Over the past few years, the world has faced a series of unprecedented shocks that have pushed farmers and our global food system to the breaking point. The COVID-19 pandemic, international and regional conflicts including the war between Russia and Ukraine, and extreme weather events caused by climate change have come together to create a true "polycrisis" – significantly impacting food, fertilizer, feed, fuel, and finance available to farmers. These challenges have been extremely difficult in their own right, but worst still, they have left humanity vulnerable to any future "black swan" moments that could have severe and far-reaching consequences for global food supplies.

Recent shocks have led to high food prices and worsening hunger and malnutrition around the world. This polycrisis has had a disproportionately negative impact on small-scale producers and people living in low-income, food-deficit countries who spend most of their incomes on food. Smallholders generally have low levels of agricultural productivity, high exposure to climate change and other threats, scarce assets, and poor access to information, technology, markets, and services – increasing their vulnerability to shocks.

Because Russia and Ukraine are major crop producers and suppliers of fertilizer, a key input to help smallholder farmers increase their crop yields, the war between the two countries has had significant impacts on global food and nutrition security. Trade bottlenecks, initially caused by the COVID-19 pandemic but compounded by the Russia-Ukraine war, have further exacerbated the crisis. Structural challenges to food systems in developing countries, including farmers' lack of access to markets and finance, poor storage and transportation infrastructure, which contribute to food loss and waste, and persistent disempowerment of women in agriculture, mean that countless farmers and food producers were already teetering on the edge of survival; additional burdens stemming from the polycrisis have pushed many into disaster. Consumers around the world have also faced enormous pressure, as disrupted agricultural supplies have led to rising food prices and lower availability and affordability of nutritious foods. New research has shown that even modest increases in the prices of staple foods leads rapidly to negative nutrition impacts from deteriorating diet quality, as low-income families shift away from more nutritious and expensive foods including vegetables, fish, and eggs, in order to afford the increased costs of rice, wheat, maize, or other dietary staples.

The U.S., through its whole-of-government Feed the Future initiative, has an important role to play in enabling farmers and food systems in developing countries to better withstand shocks. Supporting global food and nutrition security is in America's best interest both from an economic and national security standpoint. Studies show that U.S. investment in international agricultural development, research, and innovation benefits both developing countries and U.S. producers and consumers, far exceeding its costs.

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Key Recommendations

Agricultural research and development (R&D) can help developing countries address their own unique challenges and shore up local food systems to better withstand shocks. Unfortunately, there have been significant decreases in inflation-adjusted U.S. and multilateral investment in food systems R&D to countries and universities in recent years, and important institutions including CGIAR have seen fluctuations in research funding.

The U.S. government is uniquely positioned to lead investments in international agricultural research by virtue of its unparalleled capacity from the federal, university, private sectors, and to generate benefits that would simultaneously help smallholder farm families around the world and American farmers and ranchers. The U.S. can strengthen its portfolio by providing additional resources to initiatives such as CGIAR, U.S. Feed the Future Innovation Labs, and the Foundation for Food and Agriculture Research (FFAR), and by partnering with institutions with long histories of designing and delivering research for development overseas, such as the International Fund for Agricultural Development (IFAD).

Within this context, the U.S. should consider targeting additional research funding toward the following areas to increase impact:

1. **Climate change adaptation and mitigation:** The impact of climate change on agriculture is expected to intensify in coming years, and more investments are needed to improve smallholder resilience, productivity, and incomes. Areas that need increased research investment include drought-resistant crop varieties, better on-farm water management and improved irrigation, more precise fertilizer application, and additives to cattle feed to improve feed efficiency and/or reduce enteric methane emissions.

2. **Soil health and nutrient management:** More research is needed into solutions that can reduce global dependence on Russian fertilizer. The U.S. should consider investing in R&D and partnering with the private sector to develop and scale up green fertilizer, biofertilizers, fertilizer alternatives, and innovations that boost fertilizer efficiency and nutrient uptake.

3. **Crop diversity and nutrition:** Low productivity, high production risks, and insufficient diversification towards producing more nutritious foods are critical drivers of the elevated cost of healthy diets, especially in low-income countries. More research should focus on developing sustainable and scalable production methods for various crops, including fruits, vegetables, legumes, nuts, improved forages for climate-smart animal nutrition, and where appropriate, biofortification and fortification of crops and food. In addition, more research is needed to improve the affordability of animal-source foods, such as fish, eggs, and dairy, that would enhance both nutrition and livelihoods.

4. **Access to markets and finance, especially for women:** Research could focus on how to address barriers to smallholders' access to credit and market information, ways to develop new market linkages, innovative financing models, and partnerships with development banks to expand lending to farmers, and how to improve farmer organizations' capacity to negotiate with buyers.

5. **Supply chain infrastructure:** Inadequate food storage, poor road infrastructure, limited food preservation capacity, and the lack of physical access to food markets, especially for perishable foods, lead to significant food losses and inefficiencies along supply chains in many developing countries. Innovations focused on the infrastructure needs of small-scale producers, along with strategies developed to address those needs, could help attract additional investment on-farm and across the entire food system.

6. **Local capacity building:** Giving voice and agency to local producers allows for their participation and leadership in R&D funding and prioritization decisions. Without their engagement from the start, adoption of technologies and other R&D tools produced could be futile. It is also critical to ensure that R&D investments do not cause unintended negative consequences, burdens, or harms, particularly for women who already face significant hurdles.

WHAT IS THE GLOBAL FOOD AND NUTRITION SECURITY POLYCRISIS?

Climate change and the long tail of the COVID-19 pandemic have weakened global economic, food, and health systems (Barrett, 2020; Myers et al., 2022). With the additional shocks created by the Ukraine-Russia war, along with other ongoing conflicts such as in Afghanistan, Ethiopia, Sudan, Syria, and Yemen, many view the current global situation as having reached a tipping point of piling yet another crisis upon a collection of crises the world already faces, sparking a "polycrisis" (World Economic Forum, 2023). These "3C" drivers—climate, COVID-19, and conflict—have significant bearings on the "5F" inputs and outputs of the global agricultural system: food, fertilizer, feed, fuel, and finance. Insufficiencies in preventing, mitigating, and adapting to the 3C external drivers that have consequences on the 5Fs have amplified the downstream effects on people's food security, diets, health, and livelihoods for many actors and workers earning a living within food systems, as well as environmental sustainability (Hendriks et al., 2022).

These "3Cs" are systemic shocks that have created long-term chronic stress of food insecurity and malnutrition in the world, and at the same time, can lead to "black swan" (low likelihood, high impact) type events with extreme and far-reaching consequences (Hamilton et al., 2020). It is difficult to say whether we are nearing a tipping point of such an event, but the current trends and scenarios are not optimistic in the near- and long-term (Benton and Bailey, 2019; Webb et al., 2020). It should be noted that the world is not new to these types of crises. Historical food price crises in 1973-1978 and 2008-2011 resulted in lessons in responding to such events and as such, stronger public-sector safety nets (Tadesse et al., 2014). The latter global food price crisis led to the establishment of Feed the Future, the U.S. whole-of-government's global food security initiative, in 2010. The initiative works with partner countries to develop their agriculture sectors and local food systems to address the root causes of hunger, malnutrition, and poverty. By helping people feed themselves, Feed the Future has made tremendous progress in helping to lift millions of people out of poverty, hunger, and malnutrition. Yet, governments and the private sector have not invested enough in agricultural development and proven innovations, implementation systems, and leadership to help ensure resilient food systems (Barrett, 2022).

The Global Polycrisis: Causes and Effects

3C Drivers:

- Climate
- COVID-19
- Conflict

5F Inputs and Outputs:

- Food
- Fertilizer
- Feed
- Fuel
- Finance

These "3C" drivers have significant bearings on the "5F" outputs of the global agricultural system. Insufficiencies in preventing, mitigating, and adapting to the 3C external drivers that have consequences on the 5Fs have amplified the downstream effects on people's food security, diets, health, and livelihoods for many actors and workers earning a living within food systems, as well as environmental sustainability (Hendriks et al., 2022).

Even absent such crises, global agriculture has been volatile for some time, with some regions and countries having bumper crops while other areas face declining production of key crops and reduced fertilizer availability in other places. This volatility and uncertainty have increased food prices, contributing to significant rising food insecurity concerns. As Russia's invasion of Ukraine carries on, the war continues to constrain the global food supply, further spurring downstream effects on food and nutrition security. Prior to the war, both countries supplied wheat, maize, and sunflower seeds and oil to global markets. In 2020, they together accounted for approximately 29% of global exported wheat (Ukraine 9.0%, $4.6 billion USD; Russia 19.5%, $10.1 billion USD) and produced more than half of the world's sunflower oil. Nearly 60% of Ukraine's maize and wheat production is typically destined for export (Glauber and Laborde, 2022). Most of this production is purchased by lower-income countries, particularly in the Middle East and North Africa, Asia, and Sub-Saharan Africa.

Russia is a critically important exporter in the international fertilizer and energy markets, providing 13% of nitrogen-based fertilizers and 11% of crude-oil exports. Russia and its close ally Belarus supply 40% of the world's potash (potassium), an essential component of chemical-based fertilizers (Glauber and Laborde, 2022). However, war-related sanctions imposed on natural gas used to produce nitrogen-based fertilizers have driven up their costs. While data suggest that Russian grain exports somewhat recovered, Ukraine's volume of food exports remains below levels compared to 2021 (Glauber et al 2023). One study suggests that the war caused a 17% loss of winter wheat output in Ukraine in 2022 (Deininger et al., 2023).

Extreme weather events, such as floods and droughts, also significantly impact the productivity of crops and livestock across agricultural landscapes (Cogato et al., 2019; Cottrell et al., 2019; Marmai et al., 2022; Schmitt et al., 2022). For example, hot and drought-like conditions negatively affected wheat and maize harvests in Argentina, China, Europe, and the U.S. in the 2022/23 crop year. In addition, the price of rice increased in late 2022 and continues to be a concern for food security, especially in Asia where it is a staple food commodity. This price increase was partly driven by extreme weather in some significant rice-producing countries, including catastrophic heatwaves and monsoon floods in Pakistan, the world's fourth largest exporter of rice, as well as India's move towards protectionism with recent restrictions on rice exports. In addition, the extended COVID-19 lockdowns and flooding limited wheat and sugar production in China. Furthermore, because of the increased demand for animal-sourced foods in the country, China's aquaculture and beef industries have been impacted by the shortages of maize and soybean meal for livestock feed.

The COVID-19 pandemic had varied impacts and disruptions across food supply chains and trade, depending on the supply chain, infrastructure, and geographic area (Laborde et al., 2020). However, many food supply chains were surprisingly resilient. For some countries, trade restrictions and anticipated speculation regarding rising food insecurity caused food prices to increase (McDermott et al., 2022).

This situation has become a global food and nutrition security polycrisis creating significant global risk, with disproportionate impacts on poor, small-scale agricultural producers and those living in low-income, food-deficit countries, who spend most of their incomes on food and basic needs. These producers have low levels of agricultural productivity, high exposure to many types of risk, scarce assets, and poor access to information, technology, markets, and services. As a result, they are vulnerable to food insecurity, malnutrition, and loss of livelihoods (Davis et al., 2022). For example, as of 2022, the Food and Agriculture Organization of the United Nations (FAO) estimated that nearly 80% of Africans could not afford a healthy diet (FAO et al, 2022). Moreover, many of these small-scale actors live in countries facing overlapping crises and shocks, making it difficult for governments with limited resources to aid them. In this current context, small-scale agriculture producers are particularly disadvantaged.

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HOW THE POLYCRISIS IMPACTS SMALL-SCALE PRODUCERS IN DEVELOPING COUNTRIES

In this paper, we argue that there are five challenges that are increasingly disconcerting as the global food and nutrition crisis continues, further exacerbating the polycrisis. They are: (1) the cost of fertilizer and other inputs, (2) the cost and reliability of transport, (3) access to markets and finance, (4) food loss and waste, and (5) persistent disempowerment of women. Small-scale producers produce 35% of the world's food using 12% of agricultural land (Lowder et al., 2016). These five challenges will adversely impact small-scale producers' ability to play a crucial role in current and future food systems (Giller et al., 2021).

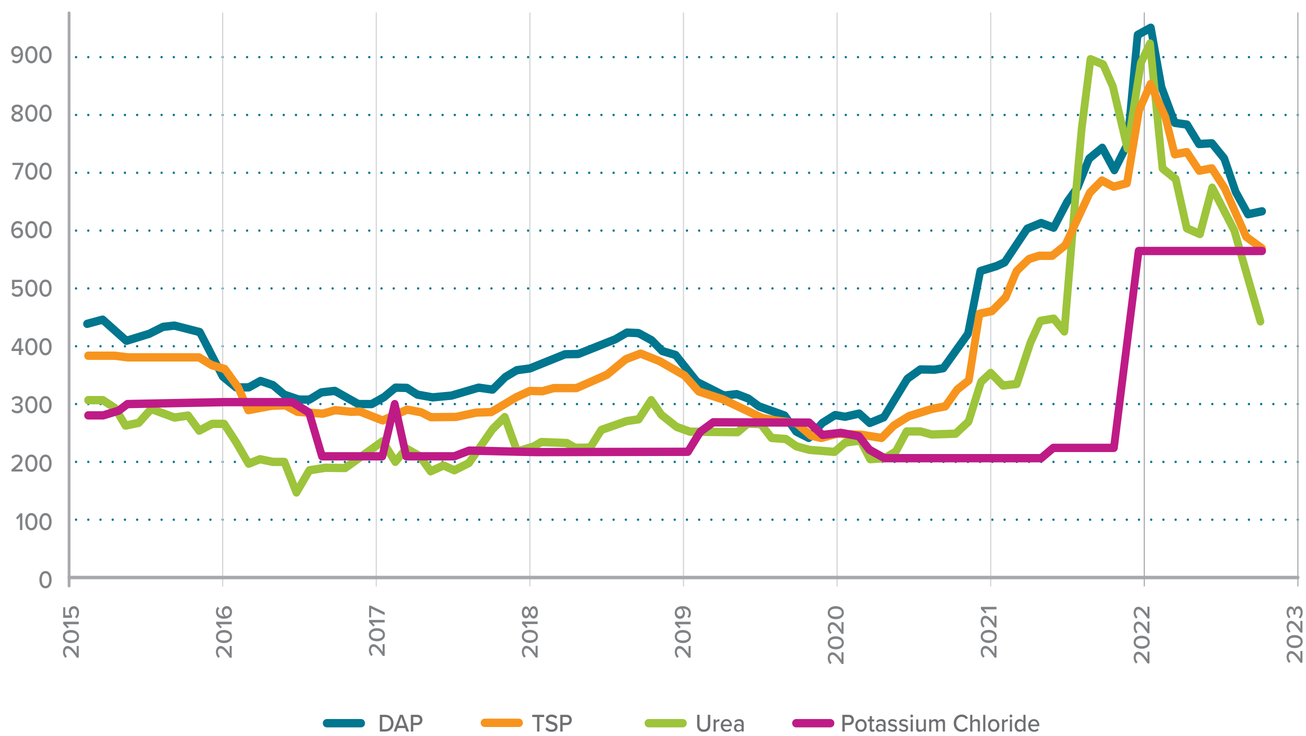
Cost of inputs and fertilizers

The Ukraine-Russia war and subsequent sanctions initially increased natural gas prices and decreased gas exports (used to make nitrogen fertilizer), limiting fertilizer production worldwide and making fertilizer costs volatile and high (up an average of 80% to 100% since 2020). Much of this rise was due to Russia cutting off natural gas supplies through pipelines to Central and Western Europe. This led to several European producers deciding to halt nitrogen-based fertilizer production. As of September

2022, fertilizer production in Europe had fallen by two-thirds (Kilic 2022). China is also a major exporter of fertilizer and imposed an export ban in 2021 in response to the COVID-19 pandemic, further shocking global markets (Hebebrand and Glauber, 2023). In addition, self-imposed export restrictions in Russia and Belarus, both major fertilizer suppliers, have limited global fertilizer availability. These factors reduce the production and flow of fertilizers worldwide, creating shortages and soaring prices. While the negotiated Black Sea Grain Initiative has eased some of the supply and trade issues, it remains tenuous, and the continuing high fertilizer cost has placed this input out of reach for many small-scale farmers.

Fertilizers are an essential input for crop production. Global fertilizer price increases started in 2021, and subsequently, resulted in sharp reductions in fertilizer use worldwide (Fig. 1) (Vos et al., 2022), which could reduce crop yields in upcoming harvests. For example, in Ukraine, shortages in fertilizer, along with land lost to Russian advances and labor shortages, have decreased wheat production, continuing to impact global wheat markets. For example, NASA Harvest has shown using satellite data that Russia occupied roughly 22% of Ukraine's arable land, leading to 29% and 21% reductions of winter crops (mainly wheat), and spring/summer planted crops (mainly maize) respectively in 2022. In total, Ukraine's wheat production decreased 28% from 2021-2022 to 2022-2023, with high fertilizer prices affecting farmers' planting decisions, as well as factors including weather, market prices, labor, conflict, and government policies. Because farmers frequently purchase fertilizer well in advance of planting season, this year's harvest may still be impacted by high prices over the last year.

Figure 1: International Fertilizer Prices



Source: IFPRI, based on World Bank data | https://www.ifpri.org/blog/russia-ukraine-war-after-year-impacts-fertilizer-production-prices-and-trade-flows

DAP = diammonium phosphate; TSP = triple super phosphate

If fertilizer prices remain high, this becomes a challenge for small-scale producers. For many, particularly in Sub-Saharan Africa, fertilizer prices were already persistently high, and demand is low due to poor infrastructure related to transportation costs. The continued high prices will make access difficult, resulting in hard choices to decrease the use of inputs, or decrease the hectares under cultivation, ultimately leading to declines in yields. These fertilizer trends suggest that food prices and inflation will remain high due to market speculation and fears of food shortages and failures over the next few years. Most food commodity prices have gone up and down. However, if energy prices and, as a result, fertilizer prices remain high, food prices will continue to follow.

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Transport and trade bottlenecks of food

The World Trade Organization (WTO) was created in the mid-1990s during a period of steadily falling food prices. Because its rules were negotiated during an era of falling prices, the WTO has focused on limiting governments' ability to "indulge domestic political pressure for protectionism around imports that lead to lower prices" (Barrett, 2022). Unfortunately, the WTO has little power to prevent or relieve domestic shortages of food nor the ability to constrain governments from restricting exports to mitigate against world market price volatility (Hopewell and Margulis, 2023). It is critical for the WTO to protect domestic food supplies when crops fail and food prices soar (Falkendal et al., 2021).

With the slowing of wheat and maize exports from Ukraine and Russia, models suggest that maize and wheat prices will increase 4.6% and 7.2%, respectively, in the coming year (Carriquiry et al., 2022). There was some ramping up of production for maize and wheat in other regions, but it was not enough to offset the price impacts entirely. As a result, by August 2022, global trade saw significant shortages of wheat, palm oil, corn, sunflower oil, and soybean oil. Currently, approximately 17% of traded food products are under export restrictions (Glauber and Laborde, 2022). Several countries have lifted or reduced export restrictions, but many export bans of commodities are still in place. For example, Indonesia banned palm oil exports, Argentina banned beef exports, and Turkey, Kyrgyzstan, and Kazakhstan banned grain product exports. With global trade flow contractions and export restrictions, the intricately connected structure of globalized food systems shows vulnerabilities.

The Black Sea Grain Initiative agreement in July of 2022 allowed shipments to resume out of three of the seven major ports of Ukraine. The deal helped move 3 million metric tons of wheat, maize, and sunflower seeds monthly. However, this volume is still less than 50% of what would typically be shipped out of those ports in previous years, leaving less space to fill silos with the incoming harvests. As a result, there are concerns that the global production forecast of coarse grains is estimated to be approximately 18 million tons lower or 1.8% down from 2021. In October 2022, Russian President Vladimir Putin suspended his country's participation in the agreement, halting any food from leaving ports. This decision resulted in a sharp spike in wheat prices. Then, in an about-face, he rejoined the deal a few weeks later, indicating that Russia's food would ship to the poorest countries. This rapid turnaround shows President Putin is using food, natural gas, and fertilizers as war-leveraging tools, resulting in extreme market volatility and potentially devastating consequences for food security, especially in food-importing LMICs. With the uncertainty of President Putin's ability to negotiate and manage the current crisis, it is not clear if the deal will be sustainable as the war marches on.

This chaos followed the COVID-19 pandemic, which weakened and disrupted food supply chains, showing their true fragility (Barrett, 2020; Zurayk et al., 2022). Much of those disruptions were due to rising freight costs, trade restrictions, abandoned shipping containers, port congestion, factory closures, disrupted "just in time" inventory systems, deficits in the labor force, and heightened demand. As a result, the Global Supply Chain Pressure Index reached an all-time high by December 2021, showing that delivery times, backlogs, and purchased stocks were all impacted (the index has now decreased to pre-pandemic levels) (New York Fed, 2022). In addition, where perishable foods are harvested, tighter border controls and air freight restrictions made international transport and trade of those goods more difficult and costly. These COVID-driven constraints on global food systems had adverse impacts on small-scale producer households' livelihoods and physical and economic access to food (Ghosh-Jerath et al 2022; Marsden et al 2023; Nchanji and Lutomia, 2021).

Poor access to markets and finance

For small-scale agricultural producers, fertilizers, seeds, finance, transport, extension, and other services are often lacking or not accessible at a reasonable price. Finance facilities are often not physically present near small-scale producers, or such producers are deemed too risky to receive loans without collateral. Small-scale producers cannot access new tools and technologies to grow their businesses without financing. This limits their ability to increase yields, further inhibiting production and income gains. Access to domestic and, even more so, international markets are limited due to insufficient basic infrastructure to compete in these markets. Small-scale producers are often unable to facilitate proper storage of crops, resulting in significant post-harvest losses. These challenges make it difficult for farmers to obtain the best price for their crops, resulting in increased pressure to sell as soon as they harvest. With the inability to access or sell food in markets, along with high food prices resulting from the polycrisis, small-scale producers are financially strained.

Food loss and waste

Globally, an estimated 14% of food is lost in the supply chain from post-harvest to wholesale (FAO, 2019), and 17% of food is wasted at the retail and consumer levels (United Nations Environment Programme, 2021). Food loss and waste is a challenge to the global food system that inhibits food security, nutrition, and environmental sustainability. Current estimates indicate that food loss and waste costs the global economy $1 trillion USD annually (Studi et al., 2019). In low-income countries, more food is lost across the various stages of the value chain, including agriculture production, post-harvest storage, and packaging. It is also important to note that food loss and waste equates to a loss of nutrients, which can have impacts on diets and subsequently nutrition outcomes (Spiker et al., 2017). If nutrients are wasted, that serves as a loss towards nutrient availability in diets.

Many small-scale producers lose crops, particularly those that are perishable and often, nutritious. Loss is high due to a lack of training on new post-harvest technologies, poor access to tools and facilities to help ensure crops are not lost, or in processing technology, and inadequate market access. It is already challenging for many populations in LMICs to meet nutrient needs, particularly for micronutrients such as iron and zinc (often found in perishable foods). With escalating food prices due to the polycrisis, food loss and waste will increasingly stress food insecure small-scale producer households. Reducing food loss and waste in low-income countries requires investments in improving infrastructure, including better roads for transport, cold chain storage and transport, and sustainable packaging. More can be done to increase knowledge on solutions for households, services, and retail to minimize waste through various innovations, including easy-to-understand labeling of use-by dates, creative recipe development, and access to inexpensive storage and handling solutions. It is also critical for food systems to better capture and utilize harvests, and for retail entities and households to utilize the food that is for sale and purchased particularly with countries being cautious in their participation of trade and exports following the pandemic.

Persistent disempowerment of women in agriculture

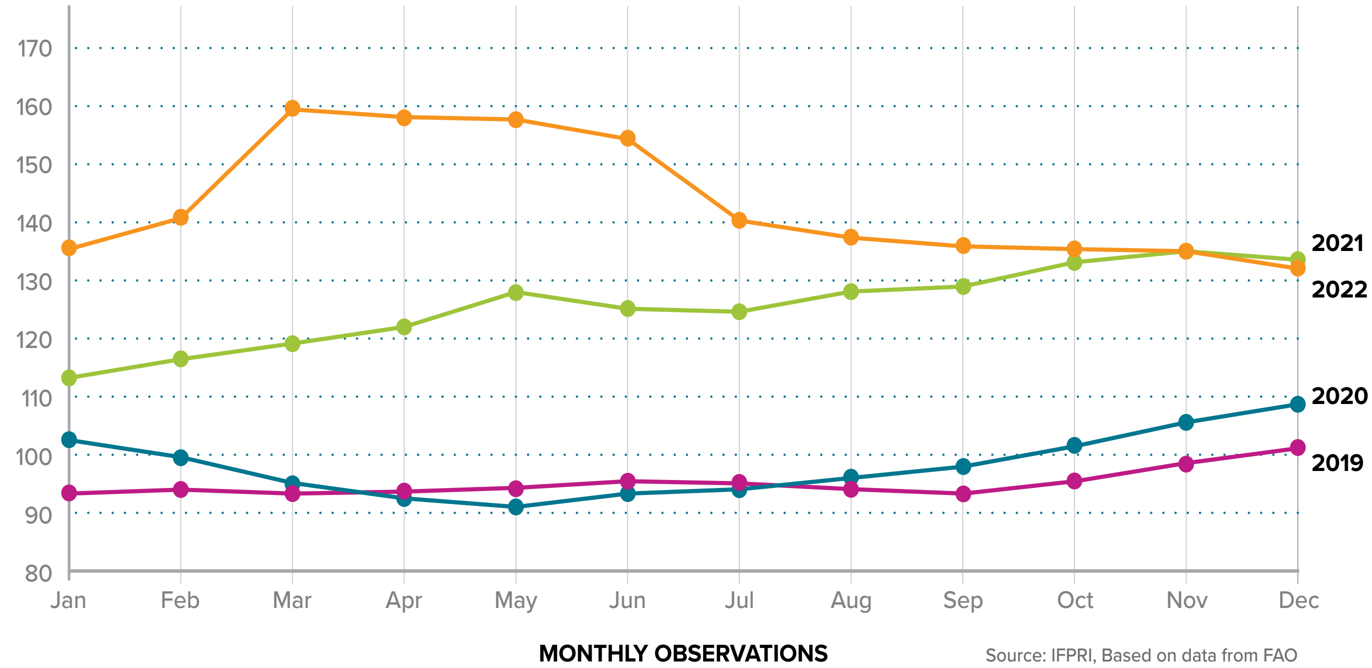
Women are critical for agriculture in LMICs. For example, 66% of women are employed in the food system and they make up 40% of the agriculture labor force in Sub-Saharan Africa (Palacios-Lopez et al., 2017; FAO 2023). In South Asia, 71% of women engage in the food system, as compared to 47% of men (FAO 2023). However, many women are more vulnerable to food insecurity and malnutrition than their male counterparts due to broader economic and social inequities (Fox et al., 2019). Women are burdened with unpaid care at the household, thus suffering from time poverty and the inability to seek out opportunities for education and employment (FAO 2023). In LMICs, women are mainly self-employed in the informal sector as subsistence farmers or as micro- and small entrepreneurs, doing in-home-based work (producing goods for sale), and wholesale or retail vending. They are also often employed as wage-earners in unskilled labor roles on farms or microenterprises. In addition, as small-scale producers, many women have limited access to land tenure rights and lack resources such as training, technology, finance, or credit to improve their businesses and incomes (Doss et al., 2018). As a result, it becomes harder to compete in local markets.

Women also often face gender-based violence within their households and communities, which makes it even more challenging to participate in markets and other agricultural activities. However, with investments through women-led initiatives to improve their incomes and livelihood, the payoffs at the household, particularly for child health and nutrition, are immense (Abreha and Zereyesus, 2021; Essilfie et al., 2020). The impacts of the pandemic and the current economic and food system crisis are intensifying the many inequities that women face on a day-to-day basis. Twenty two percent of women lost their jobs in food systems in the first year of the pandemic as compared to 2% of men (FAO 2023).

HOW THE POLYCRISIS IMPACTS ACCESS TO SUFFICIENT, SAFE, AND HEALTHY SUPPLIES OF FOOD FOR CONSUMERS

As a result of recent crises and Russia and Ukraine's importance as major breadbasket countries, the FAO Food Price Index of internationally traded food commodities increased to an all-time high in mid-March 2022. By the end of 2022, food prices had decreased but only to pre-war levels of late 2021. Food prices remain high for various reasons, including the continued supply chain constraints of the pandemic, extreme weather events, and the global economic downturn (Fig. 2) (Glauber and Laborde, 2022). This higher index level holds for all commodities, including cereal staples, meats, dairy, vegetable oils, and sugar.

Figure 2: Monthly nominal food price index: January to December 2019-2022
2014-2016 = 100



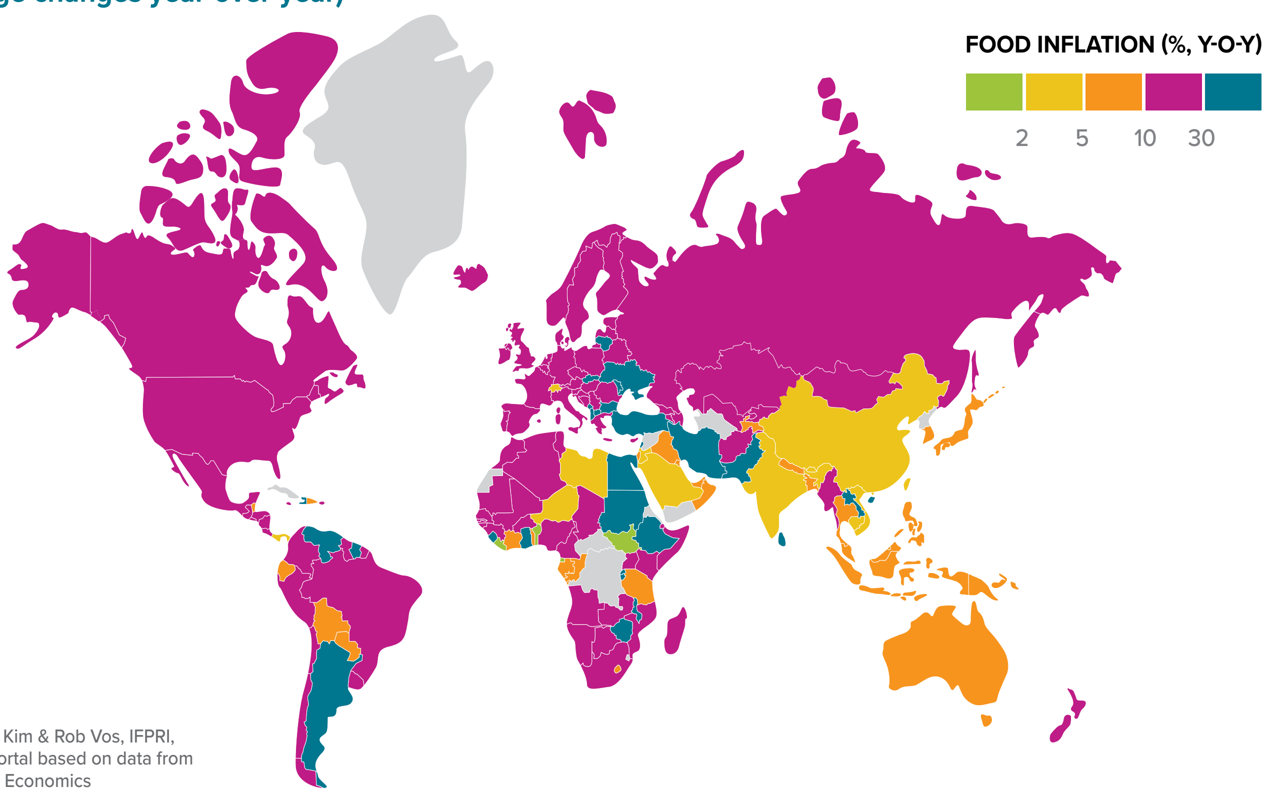
Source: IFPRI, Based on data from FAO

As the war in Ukraine carries into a second year second year and climate change continues to wreak havoc in places such as the Horn of Africa, 2023 is becoming another year of dire consequences for global food and nutrition security. There is also rising debt in many LMICs, partly due to the strong dollar, and the fact that international commodities are traded in the currency; thus, many countries struggle to import basic staples and energy needs. In addition, the volatility of domestic food prices is having devastating effects on food and nutrition security. For example, a recent study found that the urban poor in Egypt, Sudan, and Yemen—who are highly dependent on food imports—are likely to suffer from more food insecurity and malnutrition because of insufficient social protection measures put in place (Abay et al., 2023).

Already, between 691 to 783 million people, rising for the fourth consecutive year (FAO et. al, 2023), and many low-income households spend more than half of their entire incomes on food (HLPE, 2017). Food inflation is putting significant constraints on poor and vulnerable households. Food price inflation is alarmingly high worldwide, increasing from 10% to 30% since mid-2022. Most LMICs, particularly low-income food-deficit countries, are vulnerable. Countries such as Zimbabwe, Lebanon, and Venezuela are seeing annual food inflation of over 25% (Fig. 3), and in Western Europe, bread prices had almost doubled in some urban centers by late 2022.

High-income countries are not immune from food inflation pressures. The U.S. saw food inflation up 11.2% annually as of the fall of 2022. Even so, U.S. residents are more insulated due to their relatively strong purchasing power and local agricultural production. Other countries are faring much worse. A 2022 study examining the impacts of food inflation on child malnutrition in 44 LMICs shows that a 5% increase in the real price of food increases the risk of severe acute malnourishment, also known as severe wasting, by 14% (Headey and Ruel, 2022). Wasting has increased among male children, rural children, and children living in asset-poor landless households since 2021.

Figure 3: Consumer food price inflation rates around the world, November-December 2022 (percentage changes year-over-year)



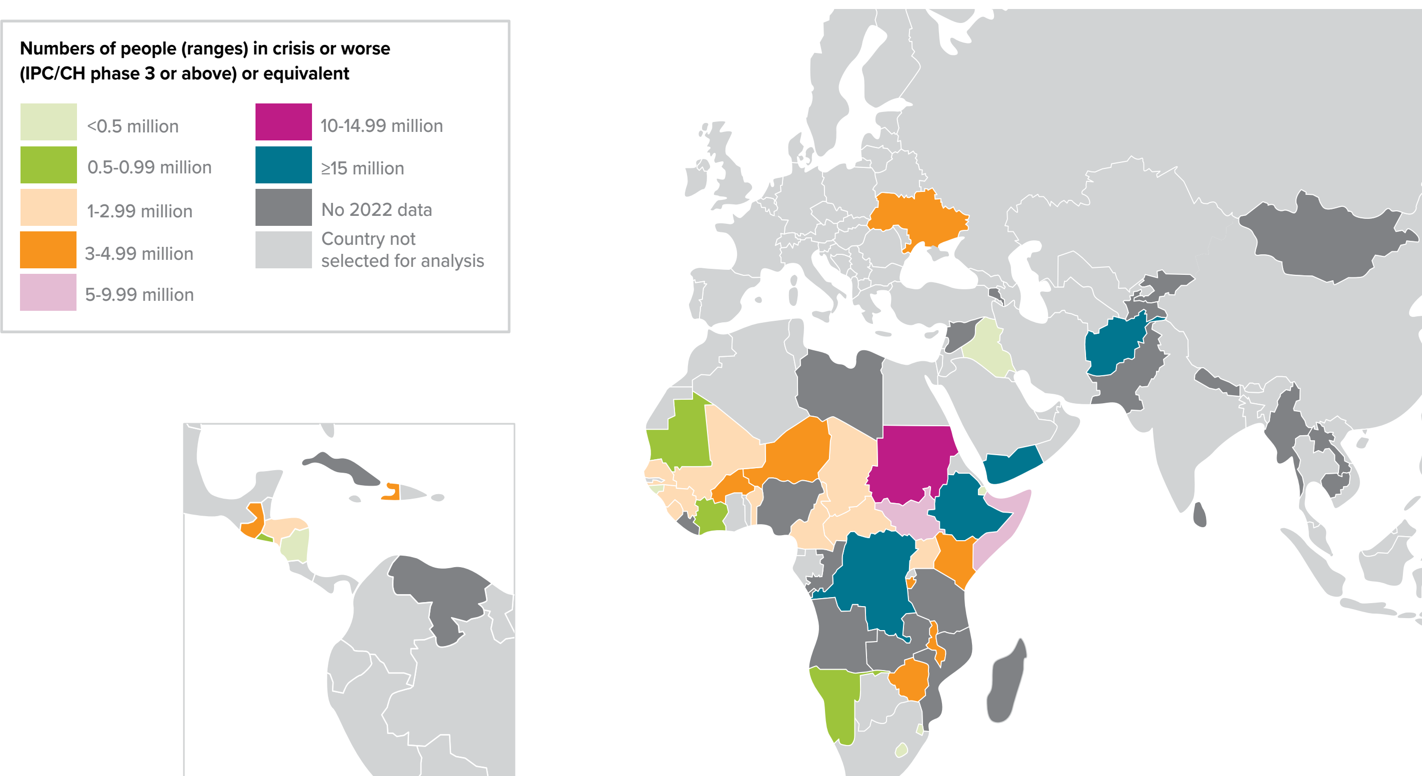
Source: Soonho Kim & Rob Vos, IFPRI, Food Security Portal based on data from IMF and Trading Economics

Even before the start of the Ukraine-Russia war and last year's food price inflation, a significant number of people around the world had difficulty accessing healthy, nutritious diets due to various factors such as poverty, inequality, lack of access to markets, and inadequate infrastructure. These factors significantly affect individual and societal health, including increased risk of chronic diseases and reduced productivity.

Forty-five countries, including 33 in Africa, nine in Asia, two in Latin America and the Caribbean, and one in Europe, currently need external food assistance (Fig. 4). Protracted crises and extreme weather events have exacerbated food insecurity and malnutrition, such that the total number of people facing crisis-level acute food insecurity increased from 155 million in 2020 to 193 million in 2021 to 258 million by mid-2022 (FSIN, 2022). In places such as Afghanistan, Ethiopia, Nigeria, South Sudan, Somalia, and Yemen, populations face or are at risk of starvation (some of the countries are categorized as falling within the catastrophic Integrated Phase Classification Phase 5) (GRFC 2023). Even in Ukraine, 17.7 million people out of an estimated 48.5 million population urgently need humanitarian assistance, including about 6.6 million internally displaced people due to the conflict.

Malnutrition is also a global and alarming problem exacerbated by high food prices, inflation, and the inability to access healthy diets. In particular, many women and children living in LMICs still suffer from undernutrition. For example, 149 million children are stunted (a marker of chronic undernutrition), and 45 million children suffer from wasting (a marker of acute malnutrition) as of 2021 (FAO et al., 2022). In addition, 56% of preschool aged children (372 million) and 69% of non-pregnant women of reproductive age (1.2 billion) are deficient in at least one essential micronutrient (Stevens et al., 2022).

Figure 4: Number of people with acute food insecurity, mid-2022



Source: FSIN 2022

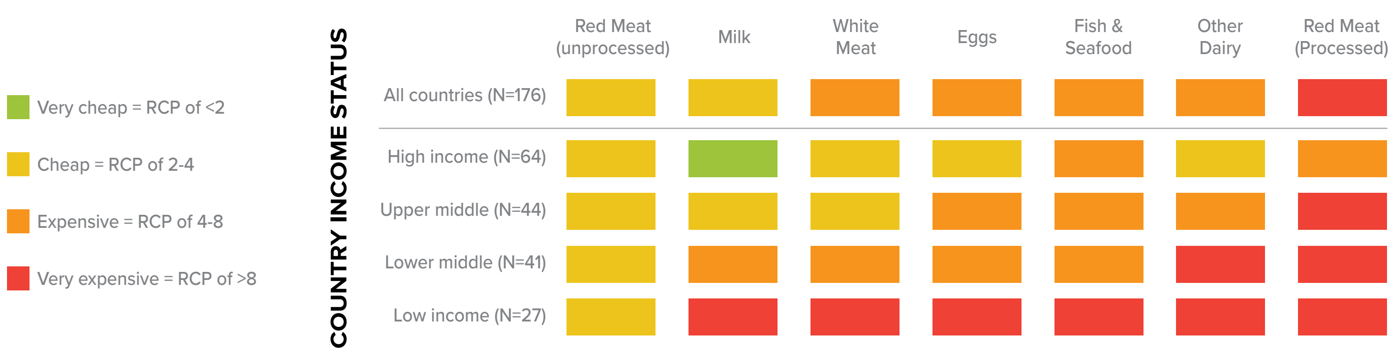
While the prevalence of undernutrition has been declining for several years, progress is beginning to wane or reverse due to overlapping shocks from the COVID-19 pandemic, climate-related extreme weather events, and conflict (Osendarp et al., 2021). Now, 13.6 million more children above previous levels are suffering from wasting, a 30% increase over the last three years. In addition, over 3.6 million more children are stunted (Osendarp et al., 2022). A modeling study examining the increased agricultural input costs and export restrictions from Russia and Ukraine estimated that this conflict could increase food costs by 60-100% in 2023 from 2021 levels, put an additional 61-107 million people at risk for undernourishment, and lead to an additional 416,000-1 million deaths (Alexander et al., 2022).

While the prevalence of undernutrition has been declining for several years, progress is beginning to wane or reverse due to overlapping shocks from the COVID-19 pandemic, climate-related extreme weather events, and conflict (Osendarp et al., 2021).

It should be noted that the growing concern of malnutrition does not just rest with food insecurity and undernutrition in LMICs. The burden of obesity and diet-related non-communicable disease has surpassed malnutrition in many countries, including developing countries (Popkin and Ng, 2021; Swinburn et al., 2019). In addition, rural and urban households are deeply impacted by the growing trends of overweight and obesity, with some households dealing with double burdens—in which some members are undernourished and others, overweight (Popkin et al., 2020). One of the primary reasons for this growth is the constrained physical and economic access to healthy diets (Carducci et al., 2021). These diets typically contain minimally processed fresh fruits, vegetables, legumes, nuts and seeds, whole grains, and animal-sourced foods. According to the FAO, 3 billion people globally cannot afford a healthy diet—a diet that meets nutrient needs and is health protective (Bai et al., 2022; Herforth et al., 2020). Populations, especially women and children, living in low-income countries and resource-constrained settings are particularly vulnerable to this problem.

While the polycrisis has made access to healthy diets, food insecurity and malnutrition worse, the status quo was not ideal for many living in LMICs. In fact, progress in reducing malnutrition (in line with the Sustainable Development Goals) was stagnate and slow. Much of this had to do with poor physical and economic access to healthy diets. One study examined the relative caloric price of foods across 176 countries and found that most non-cereal foods were relatively cheap in high-income countries, including sugar- and fat-rich foods. As shown in Fig. 5, healthy foods are expensive in lower-income countries, especially items such as animal-sourced foods. More specifically, the relative prices of dairy products, eggs, and white meat were strongly associated with income levels, relatively cheap in high-income countries but very expensive in most LMICs and Sub-Saharan Africa. Most of the high prices of animal-sourced foods are associated with supply constraints. Most animal-sourced foods are highly perishable, including milk and eggs, and because of

Figure 5: A heat map of relative caloric prices of animal-sourced foods in 176 countries, grouped by World Bank income levels



Source: Headey, D.D. and Alderman, H.H., 2019. The relative caloric prices of healthy and unhealthy foods differ systematically across income levels and continents. The Journal of Nutrition, 149 (11), pp.2020-2033.

poor productivity in the dairy and poultry sectors of low-income countries, prices for these foods are high. For those foods with higher relative caloric prices, there was less consumption among children. Further, higher milk prices are correlated with higher stunting levels among children, whereas higher priced sugar-sweetened beverages were associated with reduced overweight prevalence (Headey and Alderman, 2019).

In a related study examining the retail prices and nutrient composition of 671 foods and beverages in 177 countries around the world, the most affordable nutrient-adequate diet exceeds the cost of adequate energy by a factor of 2.66, costing $1.35 USD per day to meet median requirements of healthy adult women in 2011. Affordability is lowest in Sub-Saharan Africa. Among micronutrients, total diet costs are most sensitive to calcium requirements and vitamins A, C, E, B12, folate, and riboflavin. On average, only about 5% of dietary energy in the least-cost nutrient adequate diets is derived from animal-source foods, with small quantities of meat and fish. Over 70% of all animal products consumed in least-cost diets are eggs and dairy, but only in upper-middle and high-income countries. In lower-income countries where egg and dairy prices are significantly higher, the shortfalls in animal protein consumption are replaced by larger volumes of vegetal foods. When controlling for national income, diet costs correlate considerably with rural travel times and access to electrification (Bai et al., 2022). Seasonal fluctuations in food prices matter too. In Ethiopia, Malawi, and Tanzania, the price of nutrient-dense foods rose because of seasonal shortages of staple crops (Masters et al., 2018).

What people can usually access are ultra-processed food products. Ultra-processed foods are an extensive category of foods made from highly processed, industrialized ingredients not found in the home or restaurant kitchens that are designed to be hyper-palatable, often conveniently ready-to-eat, shelf-stable, transportable, heavily marketed, and, ultimately, highly profitable (Lawrence and Baker, 2019; Scrinis and Monteiro, 2022). Ultra-processed foods provide calories but do not contribute to nutritious diets in the way that unprocessed and minimally processed fresh fruits, vegetables, legumes, and whole grains do. The more ultra-processed foods eaten, the less room there is in diets for whole, healthy foods. Not only do ultra-processed foods typically lack the nutrients that whole foods do, but they also contain potentially harmful components, including salt, added sugar, unhealthy fats, synthetic additives, and chemical compounds from packaging.

Ultra-processed foods, such as sugar-sweetened beverages, chips, crackers, cookies, cakes, pies, pastries, and candy, make up a significant proportion of diets around the world, more than half of the energy consumed in many high-income countries and between 20% to 30% of the energy consumed in many middle-income countries, with this share growing by up to 10% per year (Monteiro et al., 2019). The Global Nutrition Report showed that residents of Europe, North America, and Oceania purchase the highest volumes of packaged, ultra-processed food; however, sales growth is stagnating or declining in recent years. In contrast, regions home to the bulk of the world's population – Asia and Africa – are experiencing significant growth in sales, albeit from a lower baseline. Globally, sales of total per capita volumes of packaged food rose from 67 kg per capita in 2005 to 77 kg per capita in 2017 (Fanzo et al., 2019).

While the trends in sales of packaged foods are relatively clear, a growing body of evidence suggests the adverse health effects of consuming these foods. Several studies, meta-analyses, and systematic reviews point to an association between consuming ultra-processed foods and obesity, dyslipidemia (high cholesterol), hypertension, gastrointestinal disorders, and some cancers, with increasing associations with various diseases (Beslay et al., 2020; Cascaes et al., 2022; Figueiredo et al., 2022; Hall et al., 2019; Hecht et al., 2022; Honicky et al., 2022; Schnabel et al., 2018; Smit et al., 2022; Werneck et al., 2022; Whatnall et al., 2022). It has been estimated that replacing half the ultra-processed foods consumed in the United Kingdom with minimally processed ones would result in a cumulative 14,235 fewer coronary deaths and 7,820 fewer stroke deaths by 2030 (Moreira et al., 2015).

KEY RECOMMENDATIONS: HOW TO STRENGTHEN FOOD SYSTEMS RESEARCH AND DEVELOPMENT TO BENEFIT SMALL-SCALE PRODUCERS AND CONSUMERS

As evidenced by this paper, the polycrisis has exacerbated existing and new challenges for small-scale producers and households in LMICs. Investing in agricultural R&D and innovation and the deployment of that innovation to small-scale producers is more critical than ever because of the global food and nutrition security crisis – it is a key intervention to ameliorate these impacts and improve food and nutrition security in low- and middle-income countries (LMICs) and, therefore, globally. A recent meta-analysis shows that past investments in agriculture R&D have yielded tenfold returns, with benefits accruing in LMICs, where most of the world's poor and food insecure reside (Alston et al 2021). A recent study by Jayne and colleagues encouraged the U.S. to invest in the capacity of public agricultural organizations, as well as universities and research institutes in Africa. This would allow for the continent to economically grow, bolstering stable and secure nations (Jayne et al 2021). For the United States, investing in agriculture R&D is important to ensure agriculture production and productivity as a means to reduce poverty and promote food security. A failure to invest in R&D could lead to future food failures in the context of growing populations and demand, further exacerbating food insecurity and malnutrition among some of the most vulnerable, small-scale producer families.

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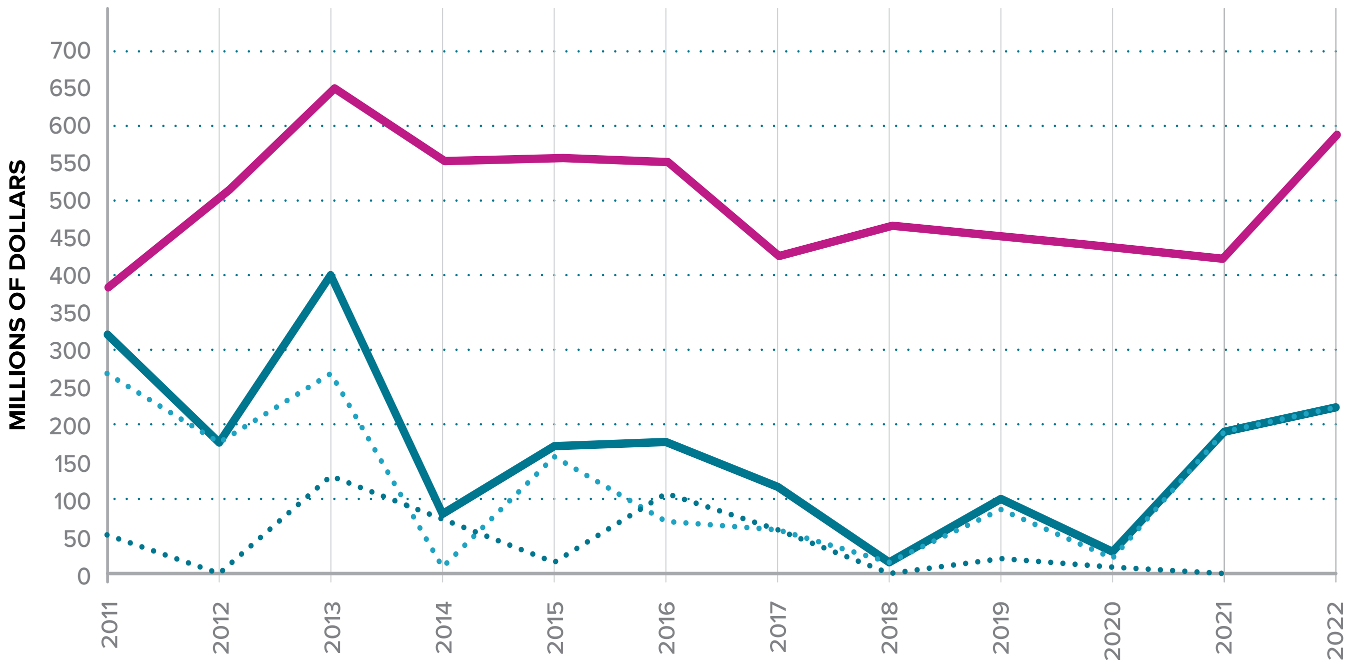
The U.S. is an important donor and investor in agriculture and food system research and development around the world. In fact, the U.S. is one of the largest donors to agricultural innovation projects in LMICs. The U.S. invests in LMIC food systems and specifically agriculture and nutrition through the whole-of-government Feed the Future initiative because U.S. foreign agricultural assistance contributes to global and national security, among other social and economic benefits to the United States (Price et al., 2023). The benefit of investment in agriculture R&D to both developing countries and U.S. producers and consumers far exceeds the costs and helps secure a better future for all (IFPRI 2019). In addition to the clear benefits in LMICs, investing in R&D also allows high income countries to develop technologies that reap benefits at home and abroad because of the adaptation of those technologies by industry.

Unfortunately, there have been significant decreases in inflation-adjusted U.S. and multilateral investment in food systems R&D to countries and to universities (Dalton and Fuglie, 2022; Fuglie et al., 2022). The CGIAR has seen its research funding decline in recent years, falling nearly 24% between 2016 and 2021, but the total rebounded in 2022. Funding for the Global Agricultural Food Security Program (GAFSP), a multilateral program to fund agricultural R&D in developing countries that is operated by the World Bank, has also fluctuated considerably since it was established in 2010 (Fig. 6). Both institutions have recently engaged in a series of reforms to try to better align donor wants to impact (Leeuwis et al., 2018). However, if agricultural R&D is left entirely to intergovernmental institutions (e.g., UN agencies such as IFAD, World Bank), progress on genetic, mechanical, and digital advances needed for small-scale actors will not keep pace with the dynamic nature of climate change, the natural evolution of pathogens and pests, and demand growth for food in the Global South (Barrett et al., 2020, 2021). Bilateral institutions, including U.S. government agencies like the U.S. Agency for International Development (USAID), Millennium Challenge Corporation (MCC), and others, must step in.

The U.S. government could fill gaps and strengthen its portfolio to address supply chain constraints and continue to improve food and nutrition security in LMICs. This can be done by working in collaboration with or providing additional resources and building capacity with institutions and programs, including the CGIAR, the Borlaug and Cochran fellowship programs (run by USDA's Foreign Agricultural Service), and other academic and research institutions

Figure 6. Funding for CGIAR and the World Bank's Global Agricultural Food Security Program



Source: CGIAR and the World Bank's Global Agriculture and Food Security Program

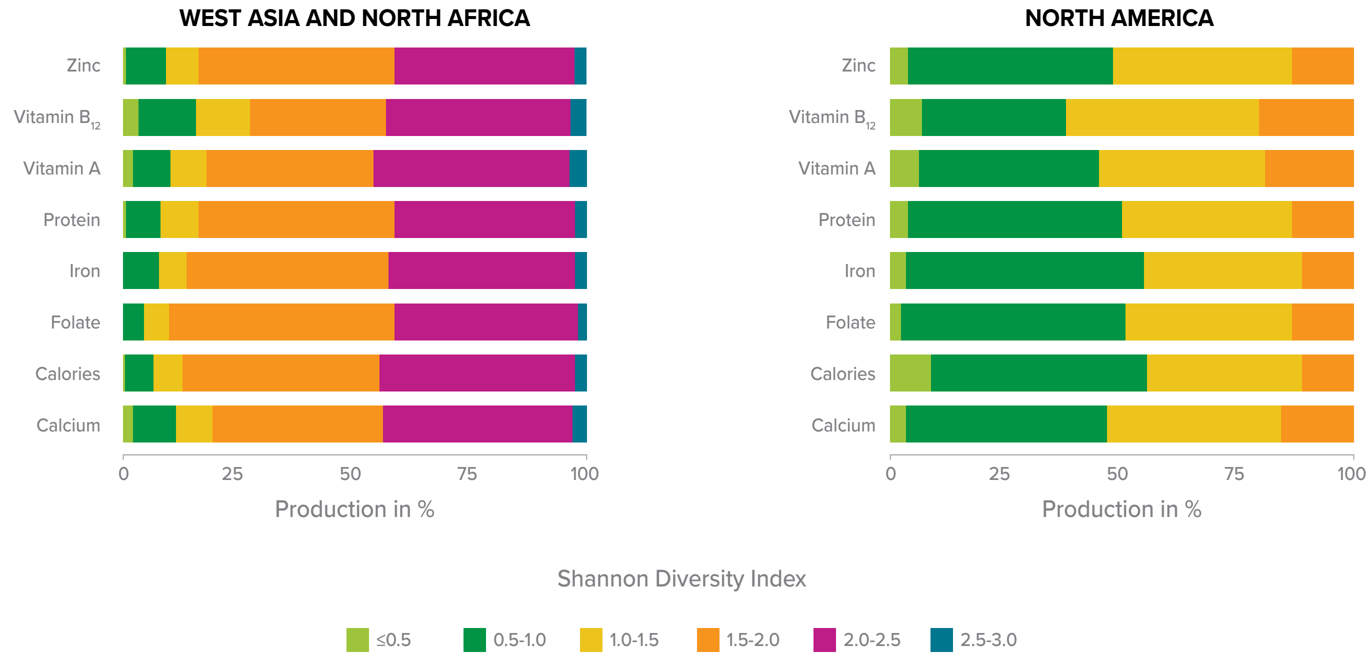
involved in multi-partner food system collaborations. In addition, U.S.-supported Feed the Future Innovation Labs and the Foundation for Food and Agriculture Research (FFAR) should continue to be supported. Last, impact could be leveraged by partnering with other large institutions with long histories of designing and delivering research for development in LMICs, such as the local small- and medium-scale enterprises in the countries of investment, the International Fund for Agricultural Development (IFAD), and CGIAR.

Within this context, the U.S. should consider the following recommendations for how agricultural R&D investments can improve resiliency of small-scale producers in LMICs against global shocks:

1. **Ensure the availability of resources to address climate change adaptation and mitigation.** The impacts of climate change are being felt in the agricultural sector and are expected to intensify in the coming years. More intense and unpredictable extreme weather events are already increasing food insecurity. Research could focus on developing and disseminating new climate-resilient agricultural practices and technologies to help small-scale producers adapt to changing weather patterns and mitigate greenhouse gas emissions while also improving their productivity and incomes. Improved agricultural technologies that should be targeted for investment include drought-resistant crop varieties, better irrigation systems, more precise fertilizer application, and additives to cattle feed to improve feed efficiency and/or reduce enteric methane emissions. Producers also need better and closer to real-time information and climate services on the environmental impacts of given food products and the agronomic conditions and practices that influence crop choices. These technologies can help small-scale producers to increase their yields and improve their resilience to climate change and other environmental stressors. R&D should also not unintentionally overburden women's time and workload with climate-smart practices, as they are already burdened with significant responsibilities in the household and on farms.

2. **Focus on soil health and nutrient management.** While governments are scrambling to reduce their dependence on fertilizer imports coming from Russia and Belarus, it will be challenging to ensure fertilizer is available, affordable, and distributed to the most vulnerable farmers in the near term. One near-term

Figure 7. Small-scale producers generate diverse landscapes and nutrients



Source: Herrero, M et al. 2017. Farming and the geography of nutrient production for human use: a transdisciplinary analysis. The Lancet Planetary Health, 1(1), pp.e33-e42.

solution could be for development donors and investment banks to create a mechanism to provide emergency funds to countries within Sub-Saharan Africa that need assistance, or perhaps a fund specifically to make fertilizer more affordable and accessible that involves contributions from industry and development agencies, including the U.S. government through the GAFSP. However, both mechanisms may not be able to quickly fill the immediate needs of farmers. In the long term, there is an argument for the world to reduce its dependence on fossil fuels and chemical fertilizers. While this will not solve immediate needs, the U.S. should invest in R&D and partner with the private sector to innovate and scale up organic fertilizer, biofertilizers, and fertilizer alternatives, and innovations that boost fertilizer efficiency and nutrient uptake, such as soil amendments, bio-stimulants, microbiomes, and other solutions. These solutions and technologies should be accessible and affordable for small-scale producers. For example, the Global Fertilizer Challenge supported by the U.S. government and other donors has begun to pool funds to address fertilizer shortages. There should be continued support for this initiative by the U.S. and others. There should also be investments to increase the efficiency of chemical fertilizer use and to produce more nutritious, less environmentally intensive crops and animals in environmentally and ecologically sustainable ways. Research should also focus on developing integrated approaches to improving soil health, quality, and nutrient management. This can include research on cover cropping, no-till agriculture, and precision nutrient management and their translation to LMICs.

3. **Strengthen production and supply chains of a diverse range of crops.** Low levels of productivity, high production risks, and insufficient diversification towards producing more nutritious foods are critical drivers of the elevated cost of healthy diets, especially in low-income countries. Small- and medium-scale farms make up 84% of all farms and 33% of the land area globally and are more predominant in Asia and Sub-Saharan Africa. Data suggest that these farms produce 53% to 81% of micronutrients in the food supply essentially because their farms are so diverse (Fig. 7) (Herrero et al., 2017).

Research could focus on developing sustainable and scalable production methods for various crops, including fruits, vegetables, legumes, and nuts, and, where appropriate, biofortification and fortification of crops and food, respectively. These methods include breeding for disease resistance and pest tolerance and exploring new cultivation methods that can improve yields and reduce environmental impacts that support the growth of small-scale farming operations and promote rural development. One critically important emerging program, the Vision for Adapted Crops and Soils (VACS), led by the Office of the Special Envoy for Global Food Security at the U.S. Department of State, in partnership with the African Union and the United Nations Food and Agriculture Organization (FAO), will identify the most nutritious traditional crops across the continent of Africa, as well as "assess the expected challenges posed to those crops by climate change, and seek to boost public and private investments to adapt those crops to anticipated effects of climate change" (U.S. Deptartment of State, 2023). It will be important to ensure VACS becomes mainstreamed within the Feed the Future initiative and leverages existing partnerships with research organizations like the CGIAR to ensure its sustainability.

Other long-term R&D innovations, through private and public sector on-farm investment, should focus on circular systems that minimize food loss or convert waste or by-products into fertilizers and feed, reduce pesticide and herbicide use, and limit the overuse of freshwater resources. Technology and financial incentives may be important to assist farmers in diversifying crops, and research should focus on exploring the potential of emerging technologies such as precision agriculture, gene editing, artificial intelligence, and robotics. This can help improve agriculture's efficiency and sustainability while reducing labor and environmental costs that come with more specialty crops beyond the core staples. These technologies should be disseminated through effective extension programs and public-private partnerships to reach small-scale producers in remote areas.

Small-scale producers often produce food for local consumers shopping at local markets, so R&D should focus on improving food safety and nutrition to improve the health and well-being of them and their communities. This can include developing new methods for detecting and preventing the spread of bacteria, fungi, and/or pathogens that cause foodborne illnesses and promoting the production of diverse and nutritious crops.

4. **Improve access to markets and finance, especially for women producers.** Small-scale producers face significant challenges in getting perishable foods to markets that meet food safety, food quality, and price standards. Such challenges include inadequate access to infrastructure, price information, and power asymmetries, leaving them in poverty traps, particularly women. They also lack the technical and organizational capacity to manage their farms and access finance effectively. Research should focus on identifying and addressing the barriers that small-scale producers and other actors face, including lack of access to credit and inadequate market information systems. This can include developing new market linkages and innovative financing models that include partnerships with multilateral development banks to expand lending to small-scale producers, improve farmer organizations' structural capacity to negotiate with buyers, and build their capacity by providing training on best practices in agriculture and business management and ensuring farmer organizations' technical and managerial ability.

5. **Strengthen supply chain infrastructure.** Small-scale producers often lack access to supply chain infrastructure, such as storage and processing facilities and transportation networks. Inadequate food storage, poor road infrastructure, limited food preservation capacity, and the lack of physical access to food markets, especially for highly perishable foods, lead to significant food losses and inefficiencies along the food supply chain in LMICs. These issues can drive up the cost of nutritious foods in urban and rural areas, a formidable barrier to accessing healthy diets, especially for the poor. R&D should focus on identifying the infrastructure needs of small-scale producers and developing strategies to address these needs, such as building community-based storage facilities and developing low-cost transportation options. Such efforts can help reduce post-harvest losses and improve the quality of their products. Improvements in this area would ensure that the diversity of nutritious food already found in small-scale production systems (including livestock and fish) reach markets at lower prices, focusing on where costs could be reduced while still providing a sufficient price for producers. Investments could include roads, irrigation, and water technologies, technical assistance (rural advisory services/extension), cold storage systems and other post-harvest storage facilities, credit and finance, market and logistics information systems (e.g., price information), and R&D of climate-resilient, nutritious foods. Significant public sector investment in infrastructure provides the platform for private sector investment in market development. These "basic" investments would allow for small-scale farmers, ranchers, and fisherfolk to have

a better shot at filling demand. The private sector can also play an opportunistic role in keeping food supply chains moving, particularly in modernizing supply chains through more digitization and "agriculture 4.0" to further minimize blockages, shortages, and constraints that continue to weaken supply chains.

6. **Foster and build local capacity.** It is crucial for the U.S. to invest in local research capacity building and delivery systems like extension to ensure that solutions reach small-scale producers, particularly women. This capacity building should be at both the human and institutional levels. Giving voice and agency to local producers and the private sector allows for their participation and leadership in R&D funding/prioritization decisions. Without their engagement from the start, adoption of technologies and other R&D tools produced could be futile. It is also critical to ensure that the R&D investments do not cause unintended negative consequences, burdens or harms, particularly for women who already face significant hurdles.

CONCLUSION

The U.S. can play an important role in supporting small-scale producers by ramping up agricultural development assistance through the Feed the Future initiative and focusing on key R&D investments. Without the U.S. and its strong support, the opportunity for food systems and agriculture to become more resilient in the face of shocks could be lost. The U.S. agricultural R&D agenda should increase investment and focus on a range of areas to improve the lives and livelihoods of small-scale agriculture producers and their households living in LMICs by addressing food supply system constraints and vulnerabilities and ensuring food systems are more resilient. One such area of investment is more resources for Feed the Future with broader investments in food systems beyond but inclusive of agriculture R&D. However, it is crucial to ensure that the research is aligned with the needs and priorities of these communities and that the findings are disseminated effectively to those who can benefit from them. Investing in R&D requires working with private sector entities, particularly small-and medium-scale enterprises, and local farmer groups, particularly women, to assess their R&D needs and ability to adapt to their context and situation.

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