GLOBAL FOOD POLICY REPORT 2016

IFPRI

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The International Food Policy Research Institute (IFPRI), established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. The Institute conducts research, communicates results, optimizes partnerships, and builds capacity to ensure sustainable food production, promote healthy food systems, improve markets and trade, transform agriculture, build resilience, and strengthen institutions and governance. Gender is considered in all of the Institute's work. IFPRI collaborates with partners around the world, including development implementers, public institutions, the private sector, and farmers' organizations.

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Preface

The *2016 Global Food Policy Report* is the fifth in an annual series that provides a comprehensive overview of major food policy developments and events. In this report, distinguished researchers, policymakers, and practitioners review what happened in food policy, and why, in 2015 and look forward to 2016. This year's report takes an in-depth look at the latest research on opportunities and challenges the world will face in achieving the new Sustainable Development Goals (SDGs) related to food and nutrition security.

The year 2015 saw notable developments in the global commitment to ending hunger and undernutrition and to sustainability. Following on the success of the Millennium Development Goals in halving global poverty, the SDGs call for eradicating poverty, hunger, and malnutrition by 2030. The 17 SDGs put food security and nutrition front and center in their vision of a sustainable world. Several other international events reinforced this commitment to sustainable foods systems, notably the 21st UN Conference of the Parties (COP21), which made unprecedented commitments to mitigation and adaption to climate change, and a G7 commitment to a zero-carbon economy by the end of the century. Regional agreements also moved forward on food policy, including food safety policies in South and East Asia, initiatives for climate-smart agriculture in Africa, and prioritization of food security by regional organizations in Latin America and the Middle East and North Africa. World food prices remained low, as did energy prices, with benefits for consumers.

Natural and human disasters had major impacts on food security. Continued slow economic growth, particularly in China and Russia, combined with low oil prices reduced food security in Central Asia and the Arab region, and have slowed growth throughout Asia and Latin America. The expanding conflict in Syria, Iraq, and Yemen led to unprecedented numbers of displaced persons and refugees, with global impacts. Continuing conflicts and violence in Nigeria, the Central African Republic, Somalia, and South Sudan, and in Central America, drew less attention but nevertheless slowed progress in reducing hunger and food insecurity. Weather extremes associated with El Niño—predicted to be one of the largest ever—are already linked to a drought in Ethiopia that has left over 8 million in need of food aid, and impacts are expected to be severe in Central America and the Philippines.

In 2016 the world will begin to address the new global commitments on food security, nutrition, and poverty. This is an extraordinary opportunity to build on the synergies between human development and sustainability, and truly end hunger and food insecurity by 2025.

Topics covered in the *2016 Global Food Policy Report* were the result of consultations with top experts in the field. For inclusion in this report, a topic has to represent a new development in food policy or a new way of looking at an important food policy issue; the topic has to be international in scope; and assessments and recommendations must be backed by evidence based on high-quality research results or expert judgment.

I hope this report is met with interest not only by decisionmakers who set the food policy research agenda but also by media, nongovernmental organizations, and broad groups of civil society who all have a big stake in food policies that benefit the world's poorest and most vulnerable people.

I welcome your feedback, comments, and suggestions.

SHENGGEN FAN
Director General

Acknowledgments

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SPERZIEBONEN

FOOD POLICY IN 2015–2016

Reshaping the Global Food System for Sustainable Development

Shenggen Fan

SUMMARY The year 2015 saw a new global commitment to sustainable development that will require a reshaping of the world's food system. The well-being of people and the planet will depend on creation of a food system that is more efficient, inclusive, climate-smart, sustainable, nutrition- and health-driven, and business-friendly.

The year 2015 was a watershed moment for the international development community. The endpoint of the Millennium Development Goals (MDGs) in 2015 represented the culmination of an ambitious agenda designed to improve human well-being worldwide. Adopted in 2000 by the United Nations (UN) member countries, the MDGs were an enormous undertaking that achieved some striking advances: extreme poverty, child mortality, and hunger all fell by around half between 1990 and 2015.[1] We also made important progress in reducing maternal mortality, combating HIV/AIDS and malaria, raising primary school enrollment, and boosting total official development assistance. UN Secretary General Ban Ki-Moon has called the MDGs "the most successful anti-poverty movement in history."[2]

Still, we cannot sit back and declare victory. Progress varies by region, and millions of people still live in conditions of severe deprivation. Poverty and hunger remain serious problems. Conflicts have killed, injured, and displaced millions of people. Population growth and urbanization are pushing up food demand while natural resources are under strain. And climate change, extreme weather, and environmental degradation not only impose hardships now, but threaten to do so even more in the future.

So the global community committed to a new set of objectives in 2015—the Sustainable Development Goals (SDGs)—to chart a path toward meeting current human needs without compromising the ability of future generations to meet their needs. The 17 goals and 169 targets will anchor the global development agenda for the next 15 years. At the core of the SDGs are goals to eliminate extreme poverty, hunger, and malnutrition, and to conserve the environment.

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At the same time, we are moving toward more comprehensive—or systems level—thinking as we look at issues of poverty, hunger, and malnutrition and come to a greater understanding of their complexity. The world's food system includes all of the activities and elements—environment, people, inputs, processes, knowledge, infrastructure, and institutions—involved in getting food from farms to consumers' plates. Just as important, it includes the outputs of these activities, such as socioeconomic and environmental outcomes. Because the food system reaches into so many areas, it has a large part to play in people's prosperity, food security, and nutrition. Not only does the food system generate the calories and nutrients that people require for good health, it also is the basis for the livelihoods of millions of the world's poorest people.

> Creating a world food system that operates for the well-being of people as well as the planet is a major challenge.

Creating a world food system that operates for the well-being of people, as well as the planet on which we all depend, is a major challenge. We need a food system that can help us reach a whole range of SDGs by 2030. What would such a food system look like? How close have we come to achieving it? And how do the events and issues of 2015 fit into the effort to build a sustainable food system?

LOOKING BACK AT 2015

A new chapter opened with the September UN General Assembly meeting, at which the UN member countries adopted the SDGs. The new goals are meant to be truly global and apply not just to developing countries, but to every country. They cover a wider set of policy areas than the MDGs did, and the 169 targets are intended to advance the goals in specific ways. SDGs 1 and 2, for instance, call for ending poverty and hunger, including all forms of malnutrition, by 2030. Although the goals are global, actions will need to be led and implemented by individual countries, with participation not only from national governments, but also from local communities, the private sector, aid donors, researchers, and other partners.

Discussions also took place on how to pay for global development efforts. In July 2015, a global conference in Addis Ababa on financing development led to several new agreements, such as a social compact to provide all people with basic services including education, health, and water and sanitation, as well as a commitment to universal secondary education and equal economic rights for women. The conference also reaffirmed that the developed countries would spend 0.7 percent of their national income on official development assistance—a decades-old goal that only a few countries have met.[3]

In December 2015, the 21st UN Conference of the Parties (COP21) in Paris marked a new approach to coping with climate change. It moves away from the mandated cuts in greenhouses gases (GHGs) typified by the Kyoto agreement and instead allows countries to put forward their own plans for lowering domestic emissions. With a goal of keeping the average global temperature increase below 2 degrees Celsius—and ideally even below 1.5 degrees Celsius—188 countries submitted plans for slowing the pace of GHG emissions. Moreover, every five years countries will submit updated and increasingly ambitious plans.

Also in December, the World Trade Organization's (WTO) ministerial meeting in Nairobi resulted in a package of decisions, including a commitment to eliminate subsidies for farm exports and to seek a permanent solution for treatment of countries' public holdings of food stocks for food security purposes—an unresolved issue that has been an important point of contention.

Along with these global decisions, many developments in 2015 served to underline the interconnectedness of the world's countries and people. Economic and natural forces, as well as people, crossed borders and had wide-ranging impacts across countries.

Overall global economic growth was disappointingly slow in 2015, at 2.4 percent, amid slow growth

in the emerging economies.[4] At the same time, world food prices continued their downward slide, falling for the fourth year in a row. The Food Price Index of the Food and Agriculture Organization of the United Nations (FAO) averaged 19 percent less in 2015 than it did in 2014.[5] Plentiful supplies coupled with modest demand, as well as appreciation of the US dollar, appear to underpin the fall in food prices. World oil prices slid dramatically, reaching their lowest level in 11 years at the end of 2015.[6]

A series of shocks buffeted countries, regions, and food systems across the world in 2015. Flooding in southern Africa, drought in Central America, and a major earthquake in Nepal led to widespread food insecurity. In March, a strong El Niño weather pattern commenced, with severe effects for food security in several regions. It led to one of the worst droughts in decades in Ethiopia, leaving millions of people in need of relief assistance.

The year also saw the numbers of displaced people reach unprecedented crisis proportions. Although conflicts in various countries contributed to the massive movements of people, the civil war in Syria is responsible for the bulk of the displaced. The flow of refugees represents not only hardship and risk for the displaced people themselves, but also daunting challenges for the host communities and for the international humanitarian system.[7]

In Africa, although the continent as a whole did not meet the MDG 1 goal of halving poverty and hunger, 18 countries did achieve the poverty goal.[8] African countries have pursued other goals as well, with mixed results. East Africa surpassed the Comprehensive Africa Agricultural Development Programme (CAADP) target of 6 percent agricultural growth in 2008–2014, reaching a rate of 6.6 percent growth. But total public spending on agriculture as a share of public spending in Africa fell far short of the CAADP target of 10 percent. In early 2016, the World Health Organization declared that Ebola transmission had ended in Guinea, Liberia, and Sierra Leone. This outbreak of the virus killed more than an estimated 11,000 people.[9] Conflict in several countries, including Central African Republic, Nigeria, Somalia, and South Sudan, jeopardized food security there. And as climate change effects began to be felt, several initiatives were launched to promote the spread of climate-smart agricultural policies and practices across Africa.

Developments and conditions in the Middle East and North Africa in 2015 were troubling, even beyond the conflicts in Syria and elsewhere. With the price of oil falling, the revenues of the oil-rich Gulf Cooperation Council countries were expected to fall by 50 percent in 2015, putting a strain on their finances. For oil-importing countries, the benefit of lower oil prices was counteracted by reduced demand for goods and services from the Gulf states. Hunger and malnutrition remain serious problems in many countries in the region, even as obesity rates in some countries soar.

In contrast, South Asia benefited from rapid economic growth in 2015. Poverty and hunger have fallen in the region but remain high. Weather extremes and disasters, including earthquakes, droughts, and heat waves, posed challenges for the region's food security. Yet the countries of South Asia made a number of food policy advances, including new initiatives related to nutrition policy and food safety in Bangladesh, a new sanitation program and an irrigation program in India, and programs to improve farmers' inputs in India and Pakistan.

In East Asia, rice prices—an important indicator of food security—fell slightly in 2015, even though production was modest, probably due to large stockpiles of rice in the region. In 2016, however, as the weather effects of El Niño decrease production, stockpiles could decline and prices could become more volatile; the East Asian countries may find it difficult to ensure an affordable supply of staple grains for the poor and hungry in the region.

> The flow of refugees represents not only hardship and risk for the displaced themselves, but also daunting challenges for the host communities and the humanitarian system.

2015 FOOD POLICY TIMELINE: ISSUES, ACTIONS & EVENTS

JANUARY

Spotlight on Soils. The United Nations declares 2015 the "International Year of Soils" to focus the world's attention on "healthy soils for a healthy life."

FEBRUARY

Growing Numbers of Refugees. Turkey becomes the world's biggest refugee-hosting country, with nearly 1 million refugees from Syria alone. Intensified conflict in Yemen leaves 12 million people food insecure and 1.8 million children malnourished.

MARCH

Ebola Outbreak in West Africa. The epidemic in Guinea, Liberia, and Sierra Leone disrupts markets and trade, and 1.2 million people face crisis levels of food insecurity.

APRIL

Major Earthquake Hits Nepal. A magnitude 7.8 quake leaves an estimated 1.4 million people in need of food assistance and destroys 52,000 metric tons of grain stocks.

MAY

Showcasing Food for the World Expo Milan. A global exposition on "feeding the planet energy for life" opens, showcasing technologies for a sustainable future.

JUNE

Pope Calls for Earth Stewardship. Pope Francis's encyclical highlights the impact of climate change on the poor and stresses our responsibility to care for the Earth.

Ambitious Goals Set by G7. For the first time, the G7 commits to ending extreme poverty and undernutrition by 2030 and sets a zero-carbon economy goal for the end of the century.

GLOBAL TRENDS & ENVIRONMENT

THE SUSTAINABLE DEVELOPMENT GOALS LEAD THE WAY TO 2030

GLOBAL ECONOMIC RECOVERY REMAINS SLOW

GLOBAL AGRICULTURAL PRICES FOR MAJOR COMMODITIES DECLINE FOR FOURTH YEAR IN A ROW

JULY

Agenda Set for Financing Development. In Addis Ababa, Ethiopia, 193 UN member states meet and agree to a new social compact to provide critical public services—health, education, energy, water, and sanitation—for all.

SEPTEMBER

SDGs Adopted. The UN General Assembly formally adopts 17 Sustainable Development Goals with 169 targets covering a broad range of sustainable development issues. SDGs 1 and 2 are "no poverty" and "zero hunger" by 2030.

NOVEMBER

El Niño Brings Ethiopian Drought. Suffering the worst drought in decades, 8.2 million Ethiopians are in need of relief assistance.

AUGUST

Low, Stable Food Prices. Bumper crops lead to notably low and stable international food prices, which hit a six-year low.

DECEMBER

COP21 in Paris. World leaders negotiate an unprecedented agreement on climate change, committing all countries to limit global warming to 2°C and offering poorer countries financial help to cut emissions and cope with the effects of climate change.

Focus on Food Waste. By invitation from 20 agricultural ministers, IFPRI and FAO launch the G20 Technical Platform on the Measurement and Reduction of Food Loss and Waste.

Agricultural Export Subsidies to Be Eliminated. Tenth WTO Ministerial Conference culminates in historic Nairobi package, includes a commitment to abolishing subsidies for farm exports.

CLIMATE CHANGE REMAINS AT THE TOP OF THE GLOBAL POLICY AGENDA

THE STRONGEST EL NIÑO IN 18 YEARS CAUSES DROUGHTS AND FLOODS THAT THREATEN FOOD SECURITY IN AFRICA, CENTRAL AMERICA, AND ASIA

THE REFUGEE CRISIS, AND ITS IMPACT ON LIVELIHOODS AND FOOD SECURITY, DEEPENS AND BECOMES THE FOCUS OF POLICYMAKERS

After a series of food safety scandals, food safety is a pressing issue in China, which passed new regulations in 2015. Other countries in the region have also been working toward bringing local food-safety inspection guidelines up to regional standards.[10]

> Latin American countries achieved several of the MDGs, including the poverty and hunger goals.

Final agreement on the Asian Infrastructure Investment Bank was reached, and this new institution is expected to help East Asia meet its substantial infrastructure needs.

Central Asia remains vulnerable to shocks in the wake of an economic downturn in Russia—due in part to low oil and gas prices and international sanctions, which substantially reduced remittances from migrants. Inflation is high, and economic growth is expected to slow. Still, all Central Asian countries except Tajikistan managed to meet the MDG target of cutting poverty and hunger by half by 2015. And several countries in the region are adopting new policies to promote food security and improved nutrition.

Latin American countries achieved several of the MDGs, including the poverty and hunger goals, thanks in part to strong agricultural and economic growth and expanded social safety nets. Hunger and undernutrition remain problems in some areas, though, such as Central America and the Caribbean, and the whole region suffers from serious rates of overweight, obesity, and related noncommunicable diseases. In January 2015, most countries in the region adopted a regional plan for food security that commits them to eliminating hunger by 2025.

BUILDING A FOOD SYSTEM THAT WORKS FOR PEOPLE AND THE PLANET

As the events of 2015 showed, while our current food system has major strengths, it also suffers from significant weaknesses. On the one hand, it feeds more than 6 billion people—more than many in earlier decades and centuries would have believed possible. On the other hand, it leaves nearly 800 million people hungry. It does not provide all people with a healthy, safe, and nutritious diet; many of those who get sufficient calories are still malnourished. The food system does not generate adequate livelihoods for millions of people employed in the food system. And in a context of scarce natural resources and advancing climate change, it is not environmentally sustainable.

A food system that promotes the well-being of people and the planet should have six characteristics: it should be efficient, inclusive, climate-smart, sustainable, nutrition- and health- driven, and business-friendly.

Efficient

To begin with, we need a food system that produces more food using the fewest resources possible. The UN reports that the world's food producers will need to produce 70 percent more food by 2050 to feed a projected world population of 9.6 billion.[11] Yet the world's land and water resources are already under serious pressure. Technologies, institutions, and policies must all be designed to promote the efficient and productive use of these resources. Value chains, markets, and trade systems need to work more efficiently. By reducing distortions in trade policies, the recent WTO agreement to end export subsidies is a promising step in this direction.

In addition, there is growing awareness that loss and waste of the food we produce constitute a large source of inefficiency in our food system. Estimates of the share of food lost and wasted globally through the various stages of the food value chain fall in the range of 30 percent, and even higher for some products.[12] Food loss is particularly high during agricultural production and processing in developing countries, and food waste is common at the consumer stage in industrialized countries. Moreover, lost or wasted food has high environmental costs—perhaps 30 percent of the world's agricultural land is devoted to producing food that will never be eaten. International organizations, research institutions, national governments, and others have undertaken

initiatives to reduce food loss and waste, but so far these efforts have resulted in few major success stories (see Chapter 3, "Toward a Sustainable Food System: Reducing Food Loss and Waste"). Becoming more efficient will involve improving infrastructure, technology, transportation, and distribution along the supply chain, and educating consumers about food waste. A new G20 Technical Platform on Food Loss and Waste, launched by the International Food Policy Research Institute (IFPRI) and FAO in 2015, will provide knowledge on best practices in these areas.

Inclusive

We need to make sure that opportunities and economic growth reach poor and marginalized people, such as smallholders, women, and youth, who have important roles to play in ending hunger and malnutrition. These groups often face constrained access to assets and markets and are at risk of exclusion from increasingly complex food value chains. Maximizing the potential of commercially viable smallholder farms and empowering women and youth are not only critical for food security and nutrition, but also central to achieving several other SDGs, especially those related to reducing inequality.

An overwhelming majority (84 percent) of the world's 570 million farms operate on less than 2 hectares of land. Small farms are a critical source of income, employment, and food for billions of people in many developing countries,[13] but they are also home to half of the world's hungry.[14]

Smallholders are not always the most efficient producers in agricultural systems. Given that labor on small farms is often supplied by family members, such farms typically benefit from the low cost of supervising workers, which can make them more efficient than larger farms. But this advantage diminishes as agriculture becomes more capital intensive and as large farms benefit from economies of scale with the increased use of tractors and other machines.[15] Policies should help smallholders shift either toward producing more nutritious and profitable foods or toward engaging in off-farm employment.[16]

Empowering women is also a vital step in boosting agricultural output and productivity. Female farmers' yields are estimated to be 20–30 percent lower than men's. This is mainly because women have less access to resources, such as land titles, inputs, and financial services, and they face the additional demands on their time of household work and childcare.[17] Removing these inequalities and closing the gender gap in agricultural yields could increase developing countries' agricultural output by between 2.5 and 4.0 percent and in turn reduce the number of undernourished people by 12–17 percent (100–150 million people).[18]

> Maximizing the potential of smallholders, including women and youth, is critical to food security and nutrition, and to achieving multiple Sustainable Development Goals.

Climate-smart

Climate change is modifying the environment in which agriculture operates by bringing about changes in temperature, precipitation, and weather volatility. It is already having significant negative impacts on crop yields and is expected to decrease yields even more in the coming decades, just as the world requires higher yields to meet future food needs. For example, global cereal yields are projected to fall by 20 percent by 2050.[19] Moreover, commercially viable smallholder farmers, who have such an important role to play in achieving food security and in meeting the SDGs, are particularly vulnerable to the extreme weather events associated with climate change, because they are already operating with limited resources, assets, and capacities (see Chapter 2, "Climate Change and Agriculture: Strengthening the Role of Smallholders").

Of course, the food system itself is a significant contributor to climate change. The FAO estimates that the global food system is responsible for about one-fifth of GHG emissions (see Figure 3 in Chapter 7). A climate-smart food system, therefore, is crucial. Such a system would integrate

2016 GLOBAL FOOD POLICY REPORT SURVEY

Over 1,000 individuals representing more than 80 countries responded to a Global Food Policy Report survey on perceptions about food policy and food security now and for the future, and on priorities among the Sustainable Development Goals.

The respondents, most of whom work in agricultural or economic development, or the health and nutrition field, are pessimistic about the possibility of eliminating hunger and undernutrition by 2025 globally. They are more optimistic, however, about eliminating hunger and undernutrition in their own countries. Among the 17 Sustainable Development Goals, most respondents give priority to ending hunger.

GLOBAL FOOD POLICIES

More than half are dissatisfied with global food policies.

Even more are dissatisfied with food policies in their own country.

Men and women have different views.

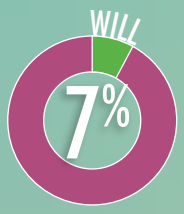
Yes, I'm satisfied with current **global** food policies.

Yes, I'm satisfied with current food policies **in my own country.**

HUNGER & UNDERNUTRITION

People are more optimistic about ending hunger and undernutrition in their own country than globally.

Yes, global hunger CAN be eliminated by 2025.



Yes, global hunger WILL be eliminated by 2025.

Yes, hunger **in my country** CAN be eliminated by 2025.

Yes, hunger **in my country** WILL be eliminated by 2025.

Young people are more pessimistic about ending global hunger.

Yes, global hunger WILL be eliminated by 2025.

Yes, hunger **in my country** WILL be eliminated by 2025.

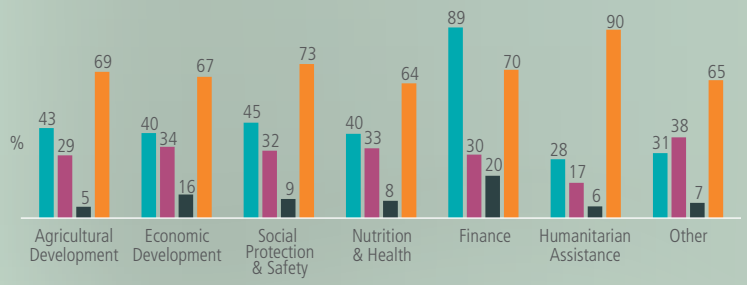
SUSTAINABLE DEVELOPMENT GOALS: PRIORITIES

SDG2, end hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

Yes, ending hunger and undernutrition is a prerequisite to ending extreme poverty.

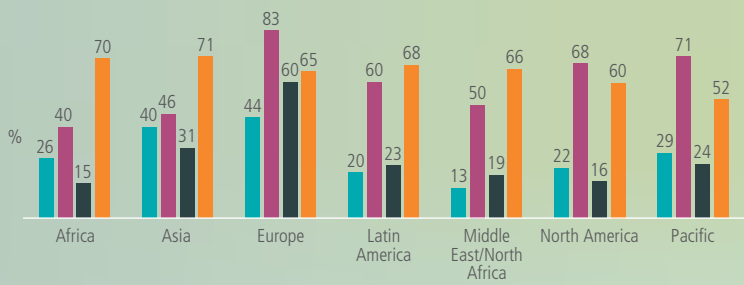
PERSPECTIVES FROM THE FIELD

Respondents working in finance are the most optimistic about eliminating hunger by 2025; those in agricultural development are the least optimistic.



REGIONAL PERSPECTIVES

Europeans are the most optimistic about ending hunger and undernutrition by 2025; Africans are the least optimistic.



Satisfied with global food policies

Think global hunger and undernutrition can be eliminated by 2025

Think global hunger and undernutrition will be eliminated by 2025

Think ending hunger and undernutrition are a prerequisite to ending extreme poverty

Source: The survey was conducted online, from January 25-31. IFPRI invited over 17,000 individuals to participate. Complete survey questions and results are available at www.ifpri.org/gfpr/2016.

agricultural development and responsiveness to climate, while aiming to reduce or remove GHGs and build resilience.

Building a climate-smart food system will proceed faster if we invest in technologies and policies that can meet more than one goal. That is, solutions should be designed not only to increase productivity, but also to improve food security and nutrition and to help farmers mitigate or adapt to climate change. A number of such technologies have already been identified, including zero-till farming; certain crop varieties, such as C4 rice; and agroforestry systems in which farmers grow trees and shrubs on their farmland. Many of these technologies are suitable for smallholder farmers.

Sustainable

A sustainable food system is one that efficiently meets current and emerging demand for food without jeopardizing the availability of scarce natural resources. At present, resource use in agriculture is unsustainable. For example, as much as 85 percent of global water use goes to agricultural irrigation,[20] of which 15–35 percent is thought to be unsustainable.[21] Furthermore, nearly a quarter of all global land has been affected by environmental degradation.[22]

We can avoid sacrificing the environment for food security and nutrition by focusing on sustainable intensification, whereby increased food production goes hand in hand with more efficient use of natural resources and reduced environmental impacts. Although there is debate over exactly what sustainable intensification entails in practical terms,[23] researchers have identified a number of agricultural technologies that can reduce trade-offs among sustainability, food security, and nutrition and even exploit synergies among them, such as nitrogen-use efficiency, heat- and drought-tolerant crop varieties, precision agriculture, and drip irrigation.[24] Sustainable intensification strategies can also help promote soil health and sustainable land management, which are key to producing a sustainable food supply; ensuring ecosystem services, such as habitats for beneficial insects and pollinators; and promoting human health (see Chapter 5, "Land and Soil Management: Promoting Healthy Soils for Healthier Agricultural Systems").

Many ways of using water more efficiently in agriculture already exist. Lining irrigation canals would help reduce water loss, for example, and such technologies as modern drip or sprinkler irrigation systems would improve the application of water to crops. Effective water management through pricing, taxes, subsidies, and quotas can reduce water waste by giving farmers incentives to adopt resource-efficient technologies and penalizing those who engage in unsustainable practices (see Chapter 4, "Water, Nutrition, and Health: Finding Win-Win Strategies for Water Management").

Researchers have identified agricultural technologies that can reduce trade-offs among sustainability, food security, and nutrition, and even exploit synergies among them.

Energy is required throughout the food system to produce crops, livestock, and fish; to process, store, and distribute food products; and to prepare and preserve foods. To be sustainable, the global food system will need to ensure widespread access to modern energy. Although sustainably meeting the world's needs for food and energy will be challenging, there are several potential opportunities for doing so through greater use of renewable forms of energy, such as hydropower and solar power; carefully managed biofuels; and more efficient cookstoves (see Chapter 7, "Green Energy: Fueling the Path to Food Security").

Global diets are also on an unsustainable trajectory. Three current trends are worrisome: increasing numbers of people are consuming more calories than they need for a healthy and active life; rising numbers of people are consuming more protein than they require and shifting their consumption toward animal-based protein; and demand for beef, which is an inefficient and resource-intensive food source, is rising rapidly (see Chapter 8, "Shifting Diets: Toward a Sustainable Food Future"). These trends

impose high costs not only in terms of human health and nutrition, but also in terms of the environment, through land use and GHG emissions. So far, efforts to shift people's diets, primarily through labeling and consumer education, have had limited success. It is time to develop strategies that correspond better with how people actually make dietary decisions.

Nutrition- and health-driven

Our current food system does not provide a nutritious diet to all people. Worldwide, an estimated 2 billion people suffer micronutrient deficiencies, and 795 million people are undernourished. Although undernutrition is slowly declining, 162 million children under age five still suffer from stunted growth, most of them in Africa south of the Sahara and South Asia. Not only is undernutrition the single biggest contributor to child mortality, but it also impairs people's cognitive and physical development, hindering their educational attainment and labor productivity, and ultimately undermining the economic progress of countries.

At the other end of the spectrum, a growing number of people are suffering from overnutrition: currently more than 2 billion people are overweight or obese. Moreover, undernutrition and obesity increasingly coexist in the same households. Many countries are also experiencing increased threats to the safety of food supplies. We need to build a global food system that makes it easier for people to consume safe, nutritious, diverse diets in appropriate amounts, while limiting processed foods of limited nutritional value.

> "Agricultural value chains—from farm to table—need to be designed with both nutrition and sustainability in mind.

Agricultural value chains, which encompass all actors and activities from the farm to the table, need to be designed with both nutrition and sustainability in mind (see Chapter 6, "Nutrition and Sustainability: Harnessing Value Chains to Improve Food Systems"). Various types of value chain interventions are possible: interventions could be designed to result in greater supplies of nutritious foods, greater demand for those foods, or better functioning of value chains through more information or regulation. Such interventions could include, for example, nutrition education for consumers, "cold chains" that can help keep perishable foods fresh, and contract farming arrangements that encourage farmers to grow nutritious crops.

Gender also plays an important role in building a nutrition-driven food system, given women's important roles in agricultural production and as consumers and caregivers. IFPRI's gender-related research shows, for instance, that empowering women in agriculture can help improve their households' dietary diversity and reduce child stunting.[25]

Business-friendly

Global, national, and local food systems must be supported by well-functioning markets and partnerships in food supply chains and by an environment that allows food-system entrepreneurs to promote long-term, market-based solutions. Private sector participation in the global food system, in the form of domestic and foreign investments, can help push forward critical advances in technology, productivity, and other outcomes. In addition to promoting links between private sector parties along the supply chain, the stakeholders in the food system should facilitate partnerships between private sector actors and public bodies, development agencies, and civil society organizations.

It is also important to use market and trade policies to soften the negative effects of market shocks and improve resilience across the supply chain. Governments and civic organizations should provide stability and mitigate the risk of extreme food price volatility through, for example, well-regulated food warehousing and reserve systems.

To function well for the private sector, the enabling environment will require, among other things, adequate transportation, communications, and energy infrastructure; availability of finance; and agricultural research and extension services. It is useful to keep in mind that private sector actors in

the food system are likely to contribute to such goals as nutrition and sustainability if pursuing those goals also expands their potential for profits (see Chapters 3 and 8).

A FOOD SYSTEM WE CAN ALL THRIVE IN

A food system index is needed to help measure progress in these six dimensions and to quantify changes in the many moving parts of the food system. Such an index, along with more research and more experimentation with policies and technologies, will give us a better idea of how to advance, step by step, in making improvements to the global food system.

A food system that is efficient, inclusive, climate-smart, sustainable, nutrition- and health-driven, and business-friendly will promote the well-being of people and the planet, as it helps us achieve many of the SDGs. Such a food system would contribute to, for example, the SDGs related to food security and nutrition, gender equity, water and sanitation, employment, and land use. By operating in a climate-smart way, it would move countries closer to meeting their COP21 commitments. And it could help the world end hunger and undernutrition by 2025, a goal adopted by IFPRI in 2015 and joined by several countries and partners through the Compact2025 initiative.

Changing the global food system in these ways will not be easy. But having a vision of where we want to be is a vital first step. Ultimately, a global food system that supports a healthy, well-nourished population and a healthy planet can be sustained for generations. ■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CLIMATE CHANGE AND AGRICULTURE

Strengthening the Role of Smallholders

Kanayo F. Nwanze and Shenggen Fan

SUMMARY Smallholder farmers have a vital role to play in global food security and nutrition, and in supporting a range of development and climate change goals. Strengthening the resilience and commercial viability of these farmers, particularly women and youth, can increase their capacity to contribute to these global goals.

Smallholder farmers are key contributors to global food security and nutrition. The 500 million smallholder farms in the developing world provide an estimated 80 percent of the food produced in Asia and Africa south of the Sahara.[1] Yet smallholders are a vulnerable and often neglected group, who account for most of the world's poor and hungry. Globally, the poor and hungry live predominantly in rural areas, where agriculture is their main source of livelihood.[2] Smallholders face a mix of interrelated risks and challenges that threaten their livelihoods, food security, and nutrition—among these, climate change looms large. Increasing the resilience and viability of smallholder farming could both reduce rural poverty and food insecurity, and contribute broadly to the Sustainable Development Goals (SDGs).

Evidence is strong that climate change will continue to have negative impacts on agriculture, increasing the vulnerability of smallholder farmers, especially in tropical regions.[3] Climate change exacerbates the production challenges faced by smallholders and increases the likelihood of agricultural and income losses, pests and diseases, and asset depletion.[4] For example, yields of staple crops grown by smallholders, such as maize, rice, and wheat, are expected to decline in the coming years as a result of climate change.[5]

At the United Nations General Assembly in September 2015, world leaders agreed on the SDGs—17 goals with 169 targets—which will anchor the global development agenda for the next 15 years. At the core of the SDG initiative are goals to eliminate extreme poverty, hunger, and malnutrition, and preserve our planet. Smallholders have a unique role to play in this new development agenda and can contribute to several SDGs. Smallholder agriculture, especially if well

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integrated into a diversified rural economy and agrifood value chains, can contribute to more inclusive growth and, critically, to employment generation. Even very poor subsistence farmers can be empowered to manage resources sustainably and can benefit from goals focused on education, peace, and gender equality. Assistance through such measures as safety nets and support through off-farm employment to diversify livelihoods can also help develop rural communities and disrupt cycles of poverty, hunger, and undernutrition. This support can also promote more inclusive patterns of growth and cushion the short-term impact of transitioning into nonfarm activities.

Although smallholder agriculture is often recognized as a vital sector for development, it has rarely enjoyed the policy and institutional support necessary to allow smallholders and rural economies to thrive.[6] A commitment to treat smallholder farms as viable businesses is key to unlocking the sector's potential to contribute to the broader development agenda. Indeed, meeting many of the SDGs will require support to strengthen smallholders' resilience to various shocks, including climate shocks, which put their livelihoods and prosperity at risk. Investing in solutions that offer multiple wins, such as increased productivity or profitability, improved food security and nutrition, and climate change mitigation and adaptation, will foster resilience and facilitate smallholders' integral role in achieving the SDGs.

SMALLHOLDERS' ROLE IN COMBATING CLIMATE CHANGE

Many smallholders earn low incomes and lack access to adequate education, land, credit and financial services, technical assistance, and markets. Such limited resources and capacities leave smallholders extremely vulnerable to the direct impacts of climate change, particularly the higher frequency and intensity of extreme weather events, such as heat waves and severe droughts, extreme rainfall and floods, and tropical cyclones. These same limitations will also make it difficult for smallholders to adapt to the effects of climate change, further constraining their productivity and resilience.[7] For smallholders to build resilience to climate shocks, investments must be made in climate change mitigation and adaptation measures. Multiple-win solutions, such as climate-smart agriculture (CSA), can offer opportunities for smallholders to sustainably and efficiently produce more nutritious crops while contributing to positive climate action. These solutions can reap high returns: studies show that multiple-win solutions have large benefits for smallholders and create spillover effects for the rest of society.[8]

Smallholders are highly vulnerable to climate shocks

Smallholders are not all the same—they are a diverse set of households living in different types of economies.[9] They do, however, share a vulnerability to climate shocks. Smallholder productivity depends on well-functioning ecosystems and ecosystem services. Predictable freshwater delivery is particularly important because smallholders in many developing countries engage in rainfed agriculture. Changes in weather patterns, such as longer dry seasons or extended rains, require farmers to make adjustments to their agricultural activities, which in turn can increase pressure on ecosystems, for example, through overextraction of water or inappropriate use of agrochemicals.[10]

Land degradation also compounds the vulnerability of smallholders. The Food and Agriculture Organization of the United Nations (FAO) estimates that 12 million hectares of land are lost annually to drought and desertification, and also predicts that the fertility of arable land will be negatively affected by climate change.[11] In Africa south of the Sahara, up to 20 percent of arable land may become much less suitable for agriculture by 2080.[12] The world's drylands, which cover about 40 percent of the world's land surface and are inhabited by about 3 billion people, are also extremely vulnerable to climate change.[13] This puts smallholders who tend farms in drylands—more than 200 million of whom are in Africa south of the Sahara—at high risk.[14]

Smallholders have limited capacity to adapt to climate shocks

Large farms with access to capital and resources may be able to adapt to unpredictable changes.

Smallholders, however, the vast majority of whom are poor, lack access to assets and services that could help them cope with the results of unexpected weather or other unforeseen challenges. In India, for example, where smallholders contribute 70 percent of the country's agricultural production, more than half of the country's agriculture is rainfed and is thus heavily dependent on a predictable monsoon season.[15] When the monsoon arrived late in 2011, small farmers with fewer assets, higher risk aversion, and less access to irrigation and weather information were less able to respond effectively to the delay than farmers with greater assets.[16]

Smallholders also face policy-related constraints, such as distortionary price regulation and poor extension services.[17] These barriers make it difficult for smallholders to build the resilience needed to prepare for, cope with, and recover from shocks, and to improve their welfare.[18]

Leverage climate-smart agriculture to achieve broader development goals

Strategies to promote climate change mitigation and adaptation should be an integral component of efforts to strengthen the contribution of smallholders to global food security, nutrition, and climate action. Developing and implementing strategies that address these multiple goals requires a holistic assessment of synergies, trade-offs, and opportunities, as well as coordination of support to smallholders by policymakers, researchers, and practitioners. CSA offers a triple-win strategy—simultaneously improving smallholder productivity for nutritious crops and helping smallholders both adapt to climate change and mitigate agriculture's contribution to climate change.[19] For example, development of climate-ready crops, such as C4 rice, has been found to double water use efficiency, increase yields by almost 50 percent, and increase nitrogen use efficiency by 30 percent.[20] Climate-smart approaches to agriculture can have high payoffs. Research suggests that adaptation and mitigation initiatives can have valuable economic, environmental, and social spillover effects for smallholders and their communities.[21] In Niger, for example, smallholders are promoting regrowth of trees and shrubs on agricultural land using the farmer-managed natural regeneration technique. This low-cost, simple agroforestry approach protects crops from heat, provides families with firewood, allows farmers to keep livestock, enhances biodiversity, and combats desertification. As one of the poorest countries in the world, Niger is also extremely vulnerable to climate change, particularly drought and desertification. Farmer-managed natural regeneration has been adopted on about 5 million hectares across the country since the 1980s, constituting around 50 percent of total farmland. In many cases, it has halted and reversed desertification.[22] By improving crop yields, diversifying livelihoods, and on average, doubling farmers' income, such investments can generate high economic, social, and environmental payoffs for smallholder agriculture. These agroforestry initiatives have spread across Africa south of the Sahara, including to Ghana and Zambia.[23]

Zero-tillage agricultural systems are another approach that can offer multiple benefits. One study found that smallholder farms in the Indo-Gangetic Plains of India that adopted zero-tillage systems became almost carbon neutral in the span of three years (from 2009 to 2012), as emissions from farming activities were counterbalanced by carbon sequestration. The same study showed that farmers' incomes increased by almost US$100 per hectare per year with zero-tillage systems, mainly because of lower input and production costs.[24]

The potential of CSA initiatives to support economic development, poverty reduction, and food security is attracting global-level attention. The Global Alliance for Climate-Smart Agriculture, for example, was launched in 2014 following the UN Climate Summit in New York. With members from government, civil society, farmer associations, and research organizations, the Global Alliance focuses on scaling up CSA to improve food security and nutrition worldwide. The initiative provides tools and methodologies for assessing stakeholder needs in terms of adopting CSA, and supports regional and country-level action suited to local environments.

The largest global financing source dedicated to supporting the adaptation of poor smallholder farmers to climate change is the Adaptation for Smallholder Agriculture Programme. Launched in 2012 by the International Fund for Agricultural Development (IFAD), the program gives smallholders access

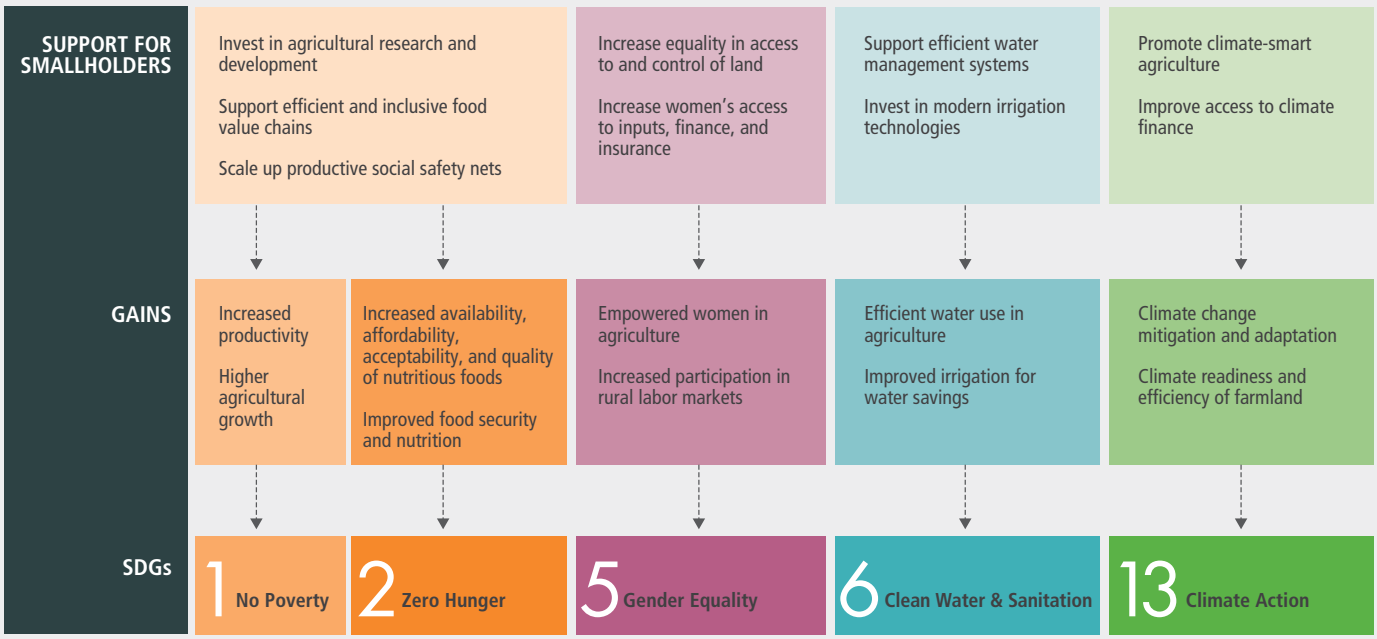
to climate finance that promotes adaptation initiatives by sharing knowledge on CSA, land management, postharvest practices and technologies, and women's empowerment. Eight million smallholder farmers are expected to benefit from this financing by 2020.[25]

SMALLHOLDERS' ROLE IN ACHIEVING THE SDGs

Smallholders will be critical to achieving many SDGs and targets on time, despite the many challenges they face.[26] Figure 1 provides examples of ways in which support to smallholders can help overcome these challenges and strengthen their role in achieving particular SDGs. A more comprehensive summary of the challenges that smallholders face, potential gains from supporting smallholders, and key interventions or investments is provided at the end of this chapter (Table 1).

Although smallholder agriculture contributes to climate change, it is also a key part of the solution to climate change and the attainment of SDGs. Smallholders have the potential to significantly reduce greenhouse gas (GHG) emissions, maintain ecosystem services, and preserve biodiversity; they also often produce higher output per unit of land than large farms, reducing pressure for agricultural land expansion.[27] Because of their size, smallholders can take advantage of labor-intensive CSA techniques that also enhance productivity and support biodiversity. Successful smallholders can also contribute to the attainment of the SDGs related to poverty alleviation, education, gender equality, water use, energy use, economic growth and employment, sustainable consumption and production, and ecosystem management. Ensuring the achievement of the SDGs, therefore, will depend on strengthening smallholder resilience to various shocks, including climate shocks, and investing in successful small farms.

FIGURE 1 Support to smallholders can contribute to multiple SDGs—key examples



Source: Authors' compilation, adapted from Farming First, "The Story of Agriculture and the Sustainable Development Goals" (2015), http://www.farmingfirst.org/sdg-toolkit#home.

Make implementation of the SDGs inclusive of smallholders

In working to achieve the SDGs, countries must adopt context-specific policies that are inclusive of all smallholders, including women and youth. While all smallholders are vulnerable, women and men have different adaptive capacities, in large part because of unequal access to land and technologies, which often leaves women less able than men to cope with shocks. For instance, men are more likely to own farming assets and have access to technologies that could support adaptation to climate change.

A preliminary study in Mali suggests that access to irrigation allowed men to increase their value of production almost enough to offset the negative impact of climatic shocks. Women, however, were less able to adapt because they had only limited access to irrigation and other farm technologies that could be used to increase productivity.[28] Another study undertaken in Kenya suggests that when women had equal access to information on climate-smart adaptation practices, they were as likely as men to adopt such practices.[29] Empowering women in agriculture not only will improve climate adaptation practices, but also can contribute to other societal gains, such as improved household nutrition. According to an FAO multicountry study, women who have equal access to resources can increase yields by close to 30 percent, improve agricultural outputs, and reduce the number of undernourished people by up to 17 percent.[30]

SDG implementation must also be inclusive of youth in agriculture. As the world becomes progressively more urban, sustainable cities will depend on greater amounts of food, clean water, and environmental services that only vibrant rural economies can provide.[31] However, young people are increasingly abandoning agriculture and rural areas in search of employment in cities or abroad.[32] Rural youth in impoverished regions do not see employment in agriculture as a viable career. In Africa, for example, there is great potential to increase opportunities on-farm and in value chains, yet these opportunties are unrecognized by or inaccessible to most young people.[33] There is a pressing need to create opportunities for young people to earn a decent living in the agricultural and nonfarm rural sectors in order to promote thriving rural economies.

Treat smallholder agriculture as a viable business to achieve multiple SDGs

Treating smallholder agriculture as a business when it has potential to become commercially viable will help to leverage its contribution to multiple SDGs. For example, supporting a shift from traditional subsistence farming to high-value, climate-smart, and nutrition-driven agriculture for smallholders can greatly contribute to the attainment of several SDGs. Making this shift will require sustained policy and institutional support, and sufficient investments in key areas, including financial facilities and risk management tools, knowledge and technical skills, market access, and social safety nets for smallholders.

Give smallholders access to financial and risk management tools

To sustain and grow their operations, smallholders require access to financial capital and facilities, including climate finance, and to risk management tools, including insurance. Bundling financial and nonfinancial services, such as credit or savings together with insurance, can provide a comprehensive solution for smallholders.[34] Such solutions are especially crucial in the event of unexpected climatic shocks. In Bolivia, IFAD's Adapation for Smallholder Agriculture Programme provides finance to smallholders that will help communities adapt to climate change and receive climate-risk management training, among other projects. This initiative is expected to improve the resilience of at least 49,000 smallholder farmers.[35] Similar investments are being made across Africa south of the Sahara. The lessons learned from these initiatives will provide insight regarding the effectiveness and sustainability of climate finance interventions under various designs and circumstances.

Accessible risk management tools, such as index-based insurance, can help smallholders manage the insecurity inherent in farming livelihoods. Weather index–based insurance provides farmers with a payout during poor and irregular weather, increasing their resilience by protecting them from the worst effects of weather-related shocks.[36] In

the past, the high costs associated with measuring losses made agricultural insurance unaffordable for smallholders. Weather index–based insurance, however, does not require costly measurements, making it cost-effective for smallholders. In Ethiopia and Senegal, for example, farmers who were previously considered uninsurable (because of poverty and lack of education, among other reasons) participated in the R4 Rural Resilience Initiative, which provided access to improved climate-risk management tools, such as natural resource rehabilitation. The insurance component of the initiative covered almost one-third of Ethiopian farmers from 2009 to 2012.[37] In India, more than 30 million smallholders have adopted weather-indexed insurance in recent years, enabling some farmers to shift toward more profitable farm production systems that may incur higher risk.[38] The global Platform for Agricultural Risk Management, managed by IFAD, assesses agricultural risk and facilitates integration of risk management strategies into public policies, agricultural investment programs, and private sector practices. Through this platform, IFAD is strengthening its understanding of agricultural risk and developing better tools to assist smallholders.[39]

Provide smallholders the knowledge and technical skills needed to build climate resilience

Strengthening the capacity of smallholders to mitigate and adapt to climate change–induced shocks by adjusting farming strategies—particularly by adopting CSA—will be critical to their success. For example, providing farmers with knowledge and training on how to adjust sowing dates and introduce drought- or flood-resilient crops can facilitate adaptation. Initiatives of this type are being supplemented by investments in improved climate information services, a core activity in Adaptation for Smallholder Agriculture–supported programs across Africa and Asia.

Ensure smallholders have access to high-value markets

Linking smallholders to high-value markets can help to increase the profitability of smallholder enterprises and connect rural and urban areas. Strengthening rural-urban linkages allows for better integration of rural farmers with urban centers and provides expanded market-based agricultural opportunities.[40] Some farmers, however, face hard constraints—such as marginal lands and long distances to markets—that are likely to impede efforts to increase profits or to participate in high-value markets. Improved road networks can increase access for smallholders, and off-farm employment opportunities should also be promoted for these farmers.[41]

An example of a successful rural-urban link is India's dairy grid, popularly known as Operation Flood. Small dairy farmers were linked to urban consumers in a chain of production, procurement, processing, and marketing. The dairy grid involved 13 million participants, including almost 4 million women, in the value chain as of 2008, giving them access to urban markets. Consumers also benefited, gaining access to more and better-quality milk.[42]

The Strategic Partnership Program supported by IFAD and the International Food Policy Research Institute (IFPRI) aims to provide smallholders with better access to markets for high-value commodities and to opportunities related to climate change mitigation.[43] From 2008 to 2011, the program implemented four activities in Morocco related to market access and climate change mitigation, and identified new market opportunities for high-value CSA products and services, such as carbon sequestration.[44]

Provide smallholders social protection

Social protection programs, including social safety nets, provide a critical short-term cushion for coping with livelihood shocks, such as extreme weather, and facilitate investment in long-term productivity-enhancing or exit opportunities.[45] A preliminary study in Honduras suggests that social protection programs can boost community and smallholder resilience and adaptive capacity while reducing poverty and improving food security. Specifically, social protection measures that focused on enhancing social and human capital are thought to have reduced smallholder and community vulnerability to drought.[46] Cross-sectoral social protection programs, such as Ethiopia's Productive Safety Net Programme, which is paired with a food security and household asset–building program, are

examples of important forms of social protection. These measures can help support improvements in productivity with multiple benefits for smallholders and other vulnerable groups.[47] To generate further benefits, social protection programs should also integrate gender considerations and be designed to suit country contexts.

SUPPORTING THE CONTRIBUTION OF SMALLHOLDERS

Smallholders are essential to achieving global food security, nutrition, and positive climate action. Fostering smallholders' resilience is key. In addition, a new outlook on global food security and nutrition that views smallholder agriculture as a business can further promote the role of smallholders in achieving gains in climate change adaptation and mitigation, food security and nutrition, and poverty reduction. With the right tools and strategies, successful smallholders can contribute significantly toward a host of development goals. The SDGs, therefore, must be inclusive of smallholders, especially smallholder women and rural youth—groups extremely vulnerable to shocks but also critical to ensuring global food security and nutrition for all. Additionally, strengthening rural-urban linkages can boost smallholder productivity and profitability, and promote better access to nutritious food for urban consumers.

At the global level, international climate negotiations must recognize the vital role of smallholders. Given the strong link between agriculture and climate change, support for smallholders needs to be a cornerstone of global agreements related to climate change. At the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in December 2015, a global agreement was signed to combat climate change and unleash actions and investments toward a low-carbon, resilient, and sustainable future. Agriculture, however, was only indirectly recognized in the final agreement as a key component to combat climate change. Against that backdrop, it is critical to ensure that agriculture is integrated in ongoing and follow-up efforts to COP21 and that smallholders are recognized for their potential contribution to climate action.

Finally, global agreements, including COP21 and the SDGs, must translate to local action. The SDGs call for country-level implementation to end poverty, protect the planet, and ensure prosperity for all. Similarly at COP21, 195 countries agreed to submit updated climate plans every five years and define roadmaps for implementation. Such plans must go beyond governments and afford other sectors, including smallholders, the opportunity and means to contribute to their country's economy and overall well-being, and to truly promote inclusive growth. ■

TABLE 1 How smallholders can contribute to the SDGs

Issues/challenges faced by smallholders	Gains from supporting smallholders	Key interventions/ investments needed	Sustianable Development Goals
Smallholders account for most of world's poor	‣ Increased productivity improves smallholders' income and helps them contribute to greater agricultural growth ‣ Agricultural growth is at least twice as effective in reducing poverty as other sectors—however, resource costs must be considered	‣ Investing in agricultural research and development (R&D) and extension ‣ Scaling-up productive social safety nets ‣ Promoting land rights and efficient land markets ‣ Supporting efficient and inclusive food value chains ‣ Supporting nutrition-sensitive agricultural production	1 No poverty
Smallholders account for most of world's hungry and many are malnourished	‣ Increases ability of smallholders to produce and purchase more nutritious foods by lowering food prices for poor consumers, and by raising demand for rural labor ‣ Improves food security and nutrition for smallholders		2 Zero hunger
Many smallholders lack access to high-quality education and technical know-how	‣ Smallholder-friendly agricultural extension services help farmers to access skills, inputs, and technologies ‣ Well-designed extension services can offer high returns on investment	‣ Creating extension services that provide knowledge and skills for use of new technologies ‣ Strengthening capacity to improve human, organizational, and institutional capacities and knowledge systems for providing in-country solutions	4 Quality education
Smallholder women have less access to resources than men	‣ Empowering women in agriculture will contribute to reduction of global hunger ‣ Increased participation in flexible, efficient, and fair rural labor markets ‣ Women mediate pathways from agriculture to nutrition	‣ Increase equality in access to and control of land ‣ Improving women's access to inputs and credit ‣ Expanding women's access to education ‣ Supporting gender-driven agricultural policies for improved nutrition	5 Gender equality
Smallholders face declining water resources	‣ Better water-use efficiency in agriculture can help to meet future food and nutrition requirements ‣ Adoption of modern irrigation technologies can lead to better irrigation efficiences and water savings	‣ Eliminating inefficient subsidies that promote overuse of water ‣ Establishg efficient water management systems ‣ Investing in efficient irrigation technologies	6 Clean water and sanitation
Smallholders lack access to energy	‣ Improved access to energy can improve living standards and reduce hunger ‣ Greater energy efficiency is needed, as demand is expected to increase, especially in the developing world	‣ Improving energy efficiency in production, processing, and retail sectors ‣ Eliminating inefficient subsidies to nonfood crops for biofuels ‣ Promoting rural renewable energy use	7 Affordable and clean energy

Issues/challenges faced by smallholders	Gains from supporting smallholders	Key interventions/ investments needed	Sustianable Development Goals
Smallholders are not always seen as entrepreneurs who contribute to the local and global economies	▸ Spurs economic growth—income multipliers are linked to agricultural growth ▸ Attracts youth to profitable business opportunities and leverages "youth dividend"	▸ Supporting smallholders with profit potential to move up to more commercial activities through various means, such as improved access to land, markets, infrastructure, and trade ▸ Tailoring agriculture employment interventions to specific needs of young people	8 Decent work and economic growth
Smallholders lack access to high-value markets that could improve profitability	▸ Rural–urban linkages can help to address both rural and urban hunger and poverty	▸ Connecting smallholders in rural and peri-urban areas to high-value urban markets ▸ Promoting pro-smallholder value chains through increased access to information and communication technologies	11 Sustainable cities and communities
Smallholders lack infrastructure to process and store postharvest yields, leading to food loss	▸ Food loss reduction measures can improve food availability and access, and reduce hunger and malnutrition ▸ Increases resource-use efficiency	▸ Investing in infrastructure and transportation ▸ Promoting research and training on food loss prevention in the packing and processing industries	12 Responsible consumption and production
Smallholders are vulnerable to climate change threats, such as land degradation and drought	Climate-smart agriculture leads to multiple wins: ▸ Increased productivity and profitability ▸ Climate change mitigation and adaptation ▸ Climate readiness and efficiency of farmland	▸ Promoting climate-smart agriculture technologies and practices ▸ Improving access to climate-related risk management ▸ Expanding agricultural R&D to produce more nutritious foods with fewer resources and reduced GHG emissions	13 Climate action
Smallholders respond to changing conditions by increasing pressure on ecosystems, such as overextraction of water and use of agrochemicals	▸ Sustainable intensification can help to meet rising food demand, reduce negative environmental effects, and preserve ecosystems		15 Life on land

Source: Authors' compilation.

Note: Adapted from Farming First, *The Story of Agriculture and the Sustainable Development Goals (2015),* http://www.farmingfirst.org/sdg-toolkit#home.

Reducing Food Loss and Waste

Monica Schuster and Maximo Torero

SUMMARY Reducing food loss and waste can contribute to food security and sustainability. Measuring food loss and waste, identifying where in the food system it occurs, and developing effective policies along the value chain are essential first steps toward addressing the problem.

On the way from field to fork, substantial food loss and waste is common, posing a challenge to both food security and sustainability. Growing demand for food, stemming from both population growth and dietary changes associated with increasing wealth, is creating pressure on the world's available land and scarce natural resources and contributing to greenhouse gas emissions. Food loss and waste compound this pressure. The overall productivity of our food system is reduced by food loss and waste, which can result in lower incomes for food producers and higher costs for food consumers. Much of the burden falls on the poor.

Food loss and food waste have recently caught the attention of both researchers and policymakers, and sparked interest in initiatives to understand and reduce their impacts. As policymakers look to achieve the Sustainable Development Goals (SDGs) and the climate change commitments of 2015, reducing food loss and waste may provide an efficient means to improve food security and sustainability.

Food loss and waste occur at different places along the food value chain: in production, postproduction procedures, processing, distribution, and consumption.[1] Figure 1 shows the stages of the value chain at which food loss may occur, as well as the types of loss likely at each stage. These vary with different commodities and geographical locations. However, loss and waste are commonly the result of underlying inefficient, unjust, and unsustainable food systems.[2]

By reducing food loss and waste, we can improve food availability and food access—increasing the productivity of the food system without increasing agricultural inputs, the use of scarce natural resources, or the application of

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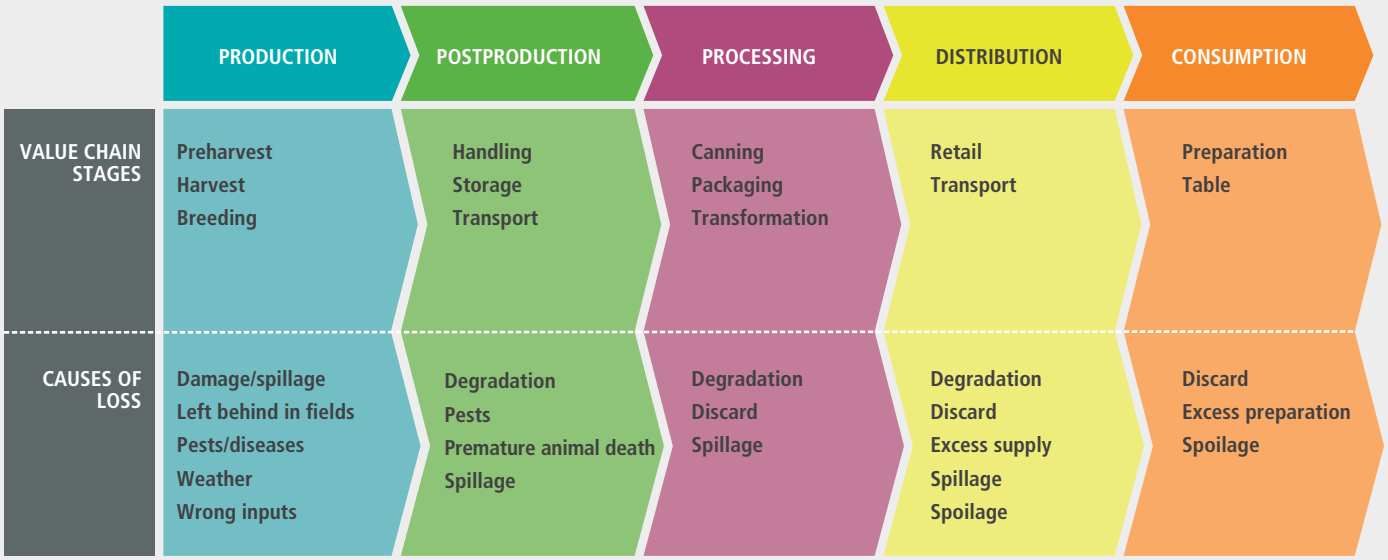
FIGURE 1 Food losses along the value chain



Source: Authors.

improved production technologies. However, success stories of reducing food waste and food loss are rare, and measurements of food loss and food waste remain highly inconsistent.[3]

DEFINITIONS OF FOOD LOSS AND WASTE

Food loss and waste have been defined in many ways, and disagreement remains over proper terminology.[4] Although the terms "postharvest loss," "food loss," "food waste," and "food loss and waste" are frequently used interchangeably, they do not refer consistently to the same aspects of the problem.[5] Also, none of these classifications includes preharvest losses, such as crops lost to pests and diseases before harvest, crops left in the field, crops lost as a result of poor harvesting techniques or sharp price drops, or food that was not produced because of a lack of proper agricultural inputs and technology. To incorporate loss and waste along all stages of the value chain, from preharvest to table waste, we propose a more expansive definition using a new term: "potential food loss and waste" (PFLW), which includes these important preharvest losses and unrealized potential production (Figure 2).

DIFFERING METHODOLOGIES

Differences in definitions of food loss and food waste can affect the methodologies used to measure and interpret loss.[6] Two estimation methodologies have been used to study food loss and waste. The macro approach, which uses aggregated data from national or local authorities and large companies, provides a low-cost way to measure overall food loss and waste along an entire value chain. The drawbacks to this approach include its lack of representative and good-quality data, particularly for low- and middle-income countries and for specific stages of the value chain, including primary production, processing, and retail.[7]

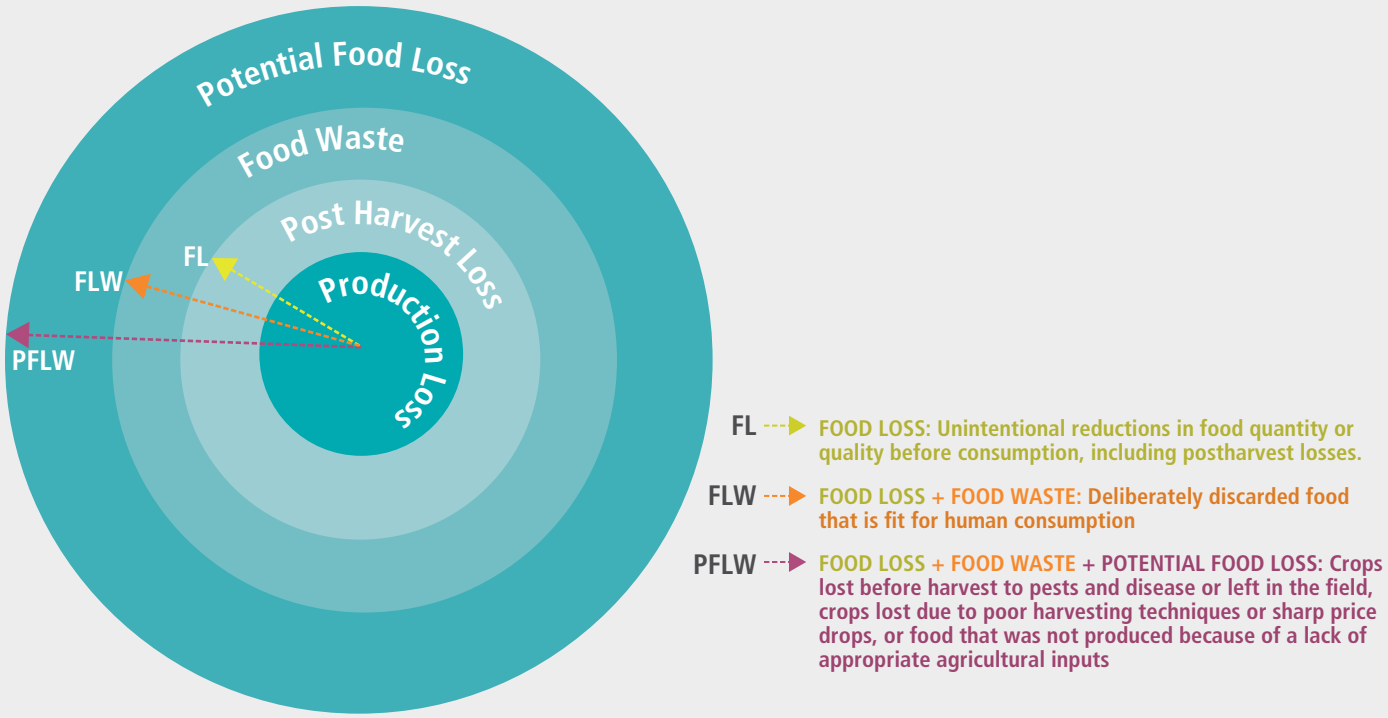
The micro approach uses data on specific actors at different value chain stages. These data are highly specific to region and context, and thus more useful for disentangling the origins of food loss and waste along the value chain and providing insights

into potential prevention strategies. However, the micro approach is costly and time consuming to implement, and hampered by the inherent difficulty of collecting sufficient responses to represent an entire value chain or region. In addition, results from micro-level studies are often difficult to compare because the studies are adapted to specific objectives and stages of the value chain, and use different data collection and estimation methodologies. Neither the macro not the micro approach calculates PFLW—clearly presenting an area where measurement of food loss and waste needs improvement.

WHAT IS NEEDED?

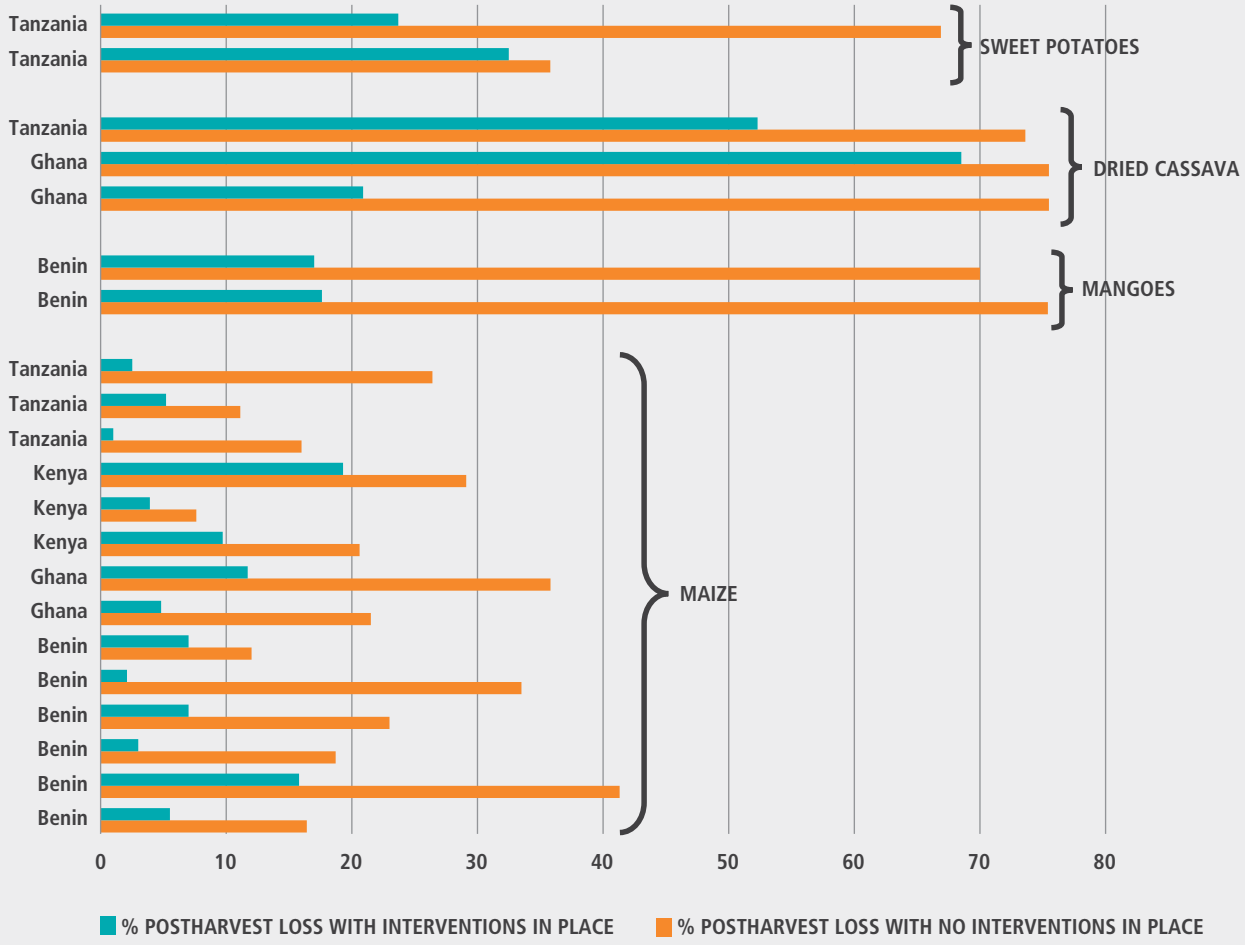
Our lack of clear knowledge about the real magnitude of food loss and waste is a major barrier to addressing the problem.[8] Estimates of global magnitudes vary widely. An overview of recent studies on global food loss and waste magnitudes shows a range from 27 percent to 32 percent of all food produced in the world. Moreover, there are significant differences across studies at the commodity level.[9] According to the Food and Agriculture Organization of the United Nations (FAO), cereal losses are estimated at 19–32 percent, root and tuber losses at 33–60 percent, and fruit and vegetable losses at 37–55 percent.[10] A review of 213 papers on Africa south of the Sahara identified large differences in estimates attributable not only to the choice of methodology, but also to such factors as agroecological conditions, technology, and socioeconomic contexts affecting both production and postproduction (Figure 3).[11] Standardized estimation methods are clearly necessary. But these alone will not

FIGURE 2 Food loss and waste terminology



Source: Authors.

FIGURE 3 Range of postharvest loss estimates by commodity from various studies in Africa



Source: Authors' interpretation based on H. Affognon, C. Mutungia, P. Sangingac, and C. Borgemeistera, "Unpacking Postharvest Losses in Sub-Saharan Africa: A Meta-Analysis," *World Development* 66 (2014): 49–68.

Notes: Each pair of bars represents a separate study of postharvest food loss and waste for a particular commodity.

be sufficient to identify the underlying causes and potential solutions to food loss and waste, and especially to PFLW, or to monitor specific progress on reduction targets.

As discussed above, a standard definition and terminology for food loss and waste is crucial. To be most useful, the definition should adopt a value chain approach and include preharvest losses. Rooted in this definition, goals for reducing food loss and waste must include both quantitative and qualitative criteria, measurable in economic, caloric, or quality-adjusted weight terms.

In addition, assessments must identify loss and waste occurring at particular value chain stages, not just the overall loss. PFLW measurement must also take into account that food loss and waste often originate at different stages along the value chain in different geographical locations.[12]

Estimation methods used for low- and middle-income countries should differ from those used in high-income countries because of data availability.

The methodology for developing countries should measure food reductions at different stages of the value chain and should be applicable across crops and regions. Representative surveys of farmers, middlemen, wholesale buyers, and processors will allow for the characterization of inputs, harvesting, storage, handling, and processing practices for each of these agents, as well as for the estimation of product quantities, quality, and prices along the value chain. As a basis for estimating PFLW, the methodology should use the highest *potential* production level (the "production possibility frontier") for a particular commodity and a specific region, expressed in either quantities or equivalent prices. Using potential, rather than actual, production guarantees the inclusion of losses relative to potential yield, preharvest losses, and harvest losses in the food loss calculation. By expressing the loss in terms of quantity or price, the methodology differentiates between losses in physical quantities and reductions in quality and value.

In developed countries, detailed data on food loss and waste in the processing, distribution, wholesale, and retail stages are often tracked by companies but not made available to researchers and policymakers. Transparency should be encouraged in order to systematize data collection and to increase access to reliable food loss and waste information. The methodology must capture both quantitative and qualitative food loss, as well as discretionary food waste in the processing, large distribution, and retail sectors. Food service waste and household waste are more challenging to capture—data will need to be collected on representative samples using a variety of methods (such as waste composition analysis, questionnaires, interviews, or waste diaries).[13]

WHAT HAS BEEN DONE SO FAR?

The issue of food loss and waste is high on the political agenda in industrialized countries, and food waste is likely to become an increasing problem in developing countries as standards of living improve. In 2015, the G20 agriculture ministers noted "with great concern the significant extent of food loss and waste throughout food value chains," describing it as "a global problem of enormous economic, environmental and societal significance."[21] Several initiatives to reduce food loss and waste have been undertaken by international organizations and research institutes, national and local governments, civil society actors, and retailers.

International organizations and research institutes

The Global Initiative on Food Loss and Waste Reduction (also known as SAVE FOOD), launched jointly by the FAO and the private sector trade-fair organizer Messe Düsseldorf in 2011, is probably the largest worldwide initiative to fight food loss and waste. The initiative is built on four pillars: research and assessment; support for evidence-based policies; awareness raising (such as "Think.Eat.Save"); and coordination of global initiatives, including collaboration with donors, national governments, the private sector, and other international organizations such as the Organisation for Economic Co-operation and Development (OECD) and the European Commission. The OECD's Food Chain Analysis Network dedicated its fourth annual meeting in 2013 to the issue of reducing food waste, and the European Commission currently co-funds two initiatives: one aimed at reducing food waste in Europe (FUSIONS) and one aimed at estimating food loss in Africa south of the Sahara (APHLIS). The Natural Resources Institute and the Global Strategy to Improve Agricultural and Rural Statistics implement cost-effective methods to quantify

> The methodology used to measure food loss and waste must capture both quantiative and qualitiatve food loss along the value chain, as well as discretionary food waste in processing, distribution, and retail sectors.

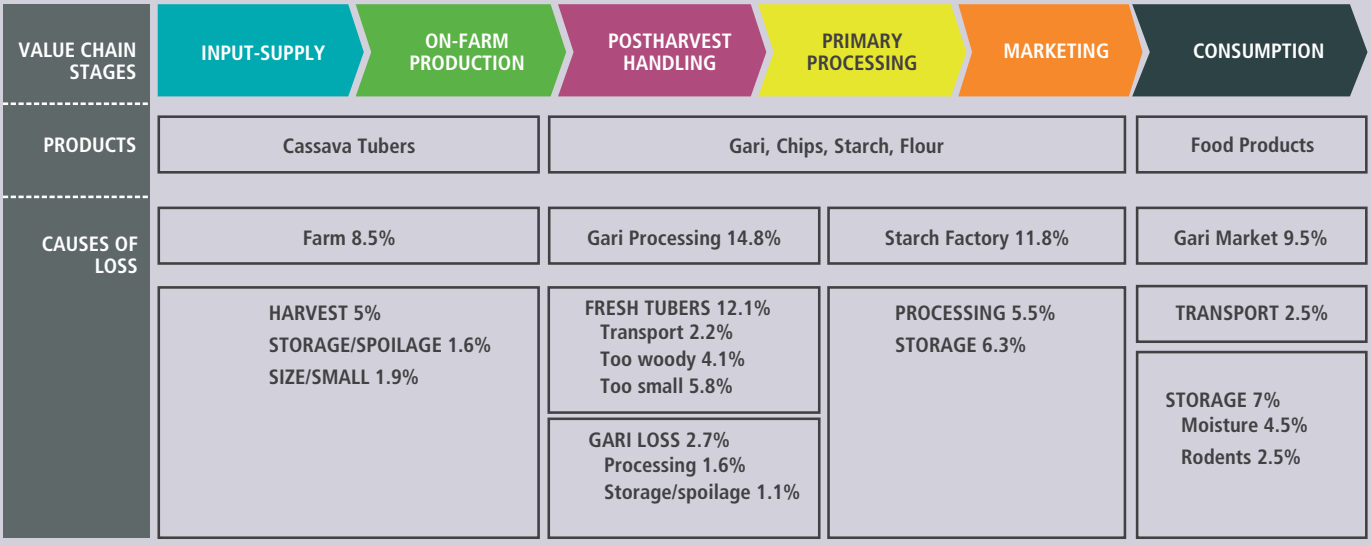
BOX 1 Case studies of food loss—Kenya and Nigeria

Food loss and waste occur at different points along the value chain, depending on the particular food crop and the particular context. A study in Kenya that looked at potatoes—an important food crop primarily cultivated by smallholders—found a variety of production factors causing loss and waste along the value chain, including poor land preparation and soil management, and ineffective pest and disease control.[14] Losses also occur throughout the postharvest stages. Using a methodology to measure postharvest losses, the authors found that up to 95 percent of recorded damage and loss in the Kenyan potato value chain occurs at the production level, where diseases, the use of inappropriate harvesting tools, and an insufficiently trained workforce play a major role.

Another study, looking at the major production constraints in potato-producing areas of Kenya, has identified bacterial wilt as the most common disease.[15] Its prevalence is partly attributable to use of seeds from informal sources (because of the high cost of certified seeds) and to inadequate rotation of crops.[16] Both of these factors tend to accelerate the spread of seed-borne diseases which, compounded by the lack of effective control methods, make bacterial wilt a major constraint for small-scale potato farmers. Potential solutions include suitable crop rotation (growing potatoes once every four seasons) and removal of volunteer potatoes (tubers left in the soil following a commercial potato harvest, which create a serious weed problem).[17]

A study of the cassava value chain in Nigeria used survey information collected from farmers, marketers, and processors to estimate losses.[18] Local farmers and agroprocessing companies produce cassava; farmers, middlemen (mostly women), and agroprocessing companies perform postharvest handling and processing activities to turn the cassava into *gari* for human consumption and starch for use by the food and beverage industry; and finally, middlemen and agroprocessing companies market and trade the cassava. In contrast to Kenya's potato value chain, in the Nigerian cassava value chain major losses occur postharvest, during *gari* and starch processing, rather than during production (Figure 4). This is consistent with a wider study that looked at losses of cassava in Ghana, Nigeria, and Vietnam, and found that a shortage of peeling capacity led to processing delays that caused losses.[19] A shift to mechanical peeling would help to tackle this problem. Although efforts to date have made limited progress, it is estimated that improvements in processing could lower losses by about 44 percent.[20]

FIGURE 4 Losses in the Nigerian cassava value chain



Source: FAO, *Post-harvest Losses along Value and Supply Chains in the Pacific Island Countries,* Brief (Rome: 2015). Reproduced with permission; data are derived from GIZ, *Food Losses in Cassava and Maize Value Chains in Nigeria—Analysis and Recommendation for Reduction Strategies* (Bonn: 2013).

loss and waste, and identify reduction opportunities. Finally, the World Resources Institute, in conjunction with the FAO, the United Nations Environment Programme, the Consumer Goods Forum, the World Business Council for Sustainable Development, FUSIONS, and the Water and Resources Action Program, coordinates the multistakeholder Food Loss and Waste Protocol initiative to develop a global, harmonized accounting and reporting standard. This protocol, which is still under review, is focused on how to measure food loss and waste but does not include preharvest loss.[22]

National and local governments

To address food loss and waste, governments primarily engage in national and local awareness campaigns. These are often implemented in schools but can also be disseminated through online resources and radio podcasts. The governments of Belgium, France, Ireland, the Netherlands, and the United Kingdom have been particularly active in awareness campaigns.

Civil society

Consumer and retailer attitudes are important determinants of the amount of food wasted by supermarkets and households. Several civil society initiatives in high-income countries target food loss and waste by providing incentives and ideas for alternative use or by raising consumer consciousness. Approaches taken by these programs include recovering and redistributing food that would have been wasted (by harvesting crops that are left in the field and redistributing them to needy people—for example, Gleaning Networks and food banks); increasing consumer awareness (through lobbying, training, or communal cooking events—for example, Love Food Hate Waste, Feeding the 5000, and Green Cook); promoting bottom-up innovations to reduce food waste (for example, the Food Surplus Entrepreneurs Network); and encouraging the reuse of food waste (for example, The Pig Idea).

Retailers

Relatively few initiatives have been established at the retail level, but some supermarkets have adopted strategies to address food loss and waste. One such strategy is selling food that has passed its "best before" date at discounted rates. Some supermarkets also engage in food redistribution with local associations or participate in awareness campaigns.

THE WAY FORWARD

The SDGs emphasize both increasing food security and reducing stress on natural resources. Reducing food loss and waste can make a critical contribution to these broad goals. SDG 12 focuses specifically on sustainable consumption and production patterns; SDG target 12.3 calls for halving global food waste at the retail and consumer levels, and reducing food losses along the value chain by 2030. In addition to these targets, the Committee of World Food Security has called on all public, private, and civil society actors to promote a common understanding of food loss and waste and to create an enabling environment for its "food use-not-waste" agenda, especially for monitoring, measurement, and reporting targets.[23] And in May 2015, the G20 agriculture ministers highlighted the global challenge of preventing and reducing food loss and waste, and encouraged all G20 members to strengthen their collective efforts.

> We need to set concrete targets at regional and country levels to reduce food loss and waste. For developed countries, the focus should be on waste; for developing countries, the focus in the short term should be on food loss, but also consider best practices for reducing waste in the longer term.

In this context of international commitment, identifying the magnitudes, causes, and costs of food loss and waste across the value chain,including PFLW, is critical for setting priorities for action.

Identifying appropriate places for intervention will require an integrated value chain approach and the coordination of a wide diversity of actors, including multidisciplinary researchers, policymakers, and private sector and civil society actors. Addressing loss and waste will require a common understanding of the concept[24] as well as a collaborative effort to collect better micro-data across different commodities and contexts. To achieve target 12.3, we need to set concrete targets at both regional and country levels, and specifically address the relevant differences between developing and developed countries. For developed countries, the focus should be on waste; for developing countries, the focus in the short term should be on food loss, but it should also give attention to how to leapfrog to best practices for reducing waste.

“ Smallholders, in particular, who produce only small surpluses, often face substantial market failures that contribute to food loss and waste. Public sector investment can address some of these market shortcomings, such as the need for appropriate storage facilities.

Both the public and the private sectors have roles to play in reducing food loss and waste. Governments should focus on ensuring that public-sector investments facilitate reductions in food loss and waste. Such investments include a broad gamut of areas related to food systems and can have multiple benefits: information on best practices, food safety, education, roads, regulations and standards, and addressing market failures.

Smallholders, in particular, who produce only small surpluses, often face substantial market failures that contribute to food loss and waste. Public-sector investment can address some of these shortcomings, such as the need for appropriate storage facilities, efficient transport systems, policies that improve access to credit, support for market incentives for improved food safety (as in the case of aflatoxins), and access to crop varieties resistant to weather shocks.[25] For example, food quality and safety standards not only facilitate export of produce grown in Africa to international destinations, but also help ensure that smallholder farmers and their families fully benefit from high-quality, nutritious food grown locally.

The private sector also has a role to play, particularly when reducing food loss and waste can generate profits. For example, choosing appropriate crop varieties, dealing with preharvest pests, and making processing and retail decisions may be best addressed by the private sector.

Analyzing the factors affecting food loss and waste at the micro-, meso-, and macro-levels can help in identifying effective reduction interventions.[26] Looking at the micro-level causes of food loss and waste, studies point to credit constraints as one of the main bottlenecks to technology adoption to reduce food loss and waste.[27] Others point to the importance of education;[28] to contractual practices;[29] and to the growing need to improve infrastructure, particularly in rural areas.[30]

Micro-level causes can be linked to broader meso- and macro-level causes that overarch different stages of the value chain. For example, strict food safety concerns and regulations can lead to safe food being rejected for import or removed from markets.[31] Other systemic causes relate to inappropriate technologies, changing consumer demands, and low capacities to adopt innovations or respond to changing consumption patterns. Thus, context-specific cost-benefit analyses have to be systematically carried out to identify the most sustainable and efficient interventions for reducing loss and waste.

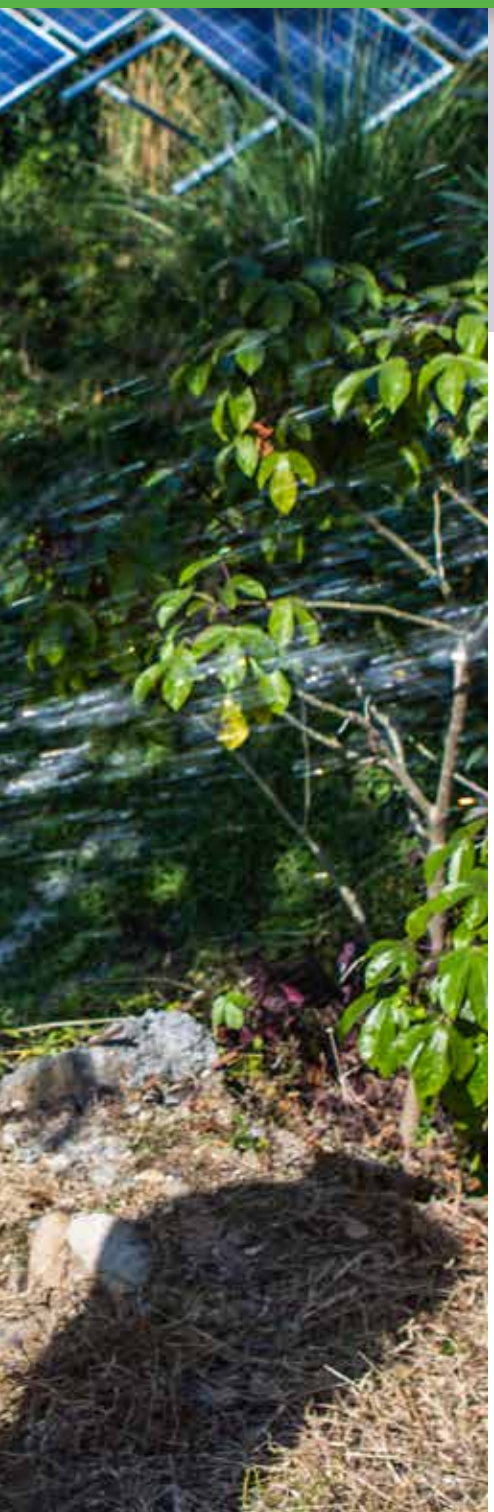
Finally, policymakers and value chain actors need to translate insights into action. International organizations have the power to bring this important topic to the table and create platforms for information exchange—such as the technical platform on measurement and reduction of food loss and waste launched by the International Food Policy Research Institute and FAO as a result of the

G20 summit in Turkey in December 2015.[32] States also have a key role to play in creating a successful enabling environment, and all public and private value chain actors need to transform theory about food loss and waste into concrete interventions in order to generate the multiple benefits of increased food availability and reduced environmental pressures. ■

WATER, NUTRITION, AND HEALTH

Finding Win-Win Strategies for Water Management

Claudia Ringler and Simone Passarelli



SUMMARY Sound development and management of freshwater resources can unlock potential to improve food security, nutrition, and health. Maximizing these benefits jointly, however, requires that water management be adapted to highly variable contexts, embedded in sound environmental policies, and cognizant of all economic costs and benefits.

Demands on water—one of life's most basic necessities—are increasing rapidly. In 2010, more than half of the world's population was living in countries experiencing medium to high levels of water stress (defined as those that withdraw more than 20 percent of their annual internally available water resources). Without a change in the way this critical resource is used and managed, by 2050, 68 percent of the world's population will be living with medium to high levels of water stress. More than one-third of humanity—36 percent—was already living under conditions of severe water shortage in 2010 (defined as withdrawing more than 40 percent of water resources annually); this share is expected to grow to 52 percent by 2050.[1] Low-income countries are more likely to suffer from severe water shortages and, importantly, from more frequent water shortages. Without substantial attention to water management in the development agenda, agriculture, energy, environmental integrity, health, nutrition, and poverty reduction are all likely to be at risk as a result of the high interdependence between water and other sectors.

While the Millennium Development Goals focused on water supply and sanitation, the much larger role of water for human development—through food, nutrition, safe supply and sanitation, and environmental sustainability—is recognized in the newly adopted Sustainable Development Goals (SDGs). SDG 6 sets comprehensive targets for water, encompassing the management of water, wastewater, and water-related ecosystems. Water also features in most other SDGs either directly, as in the goals for oceans and ecosystems, or indirectly, as in the goal for food security and nutrition. Understanding the synergies among the multiple uses of water will be central to meeting the SDG targets.

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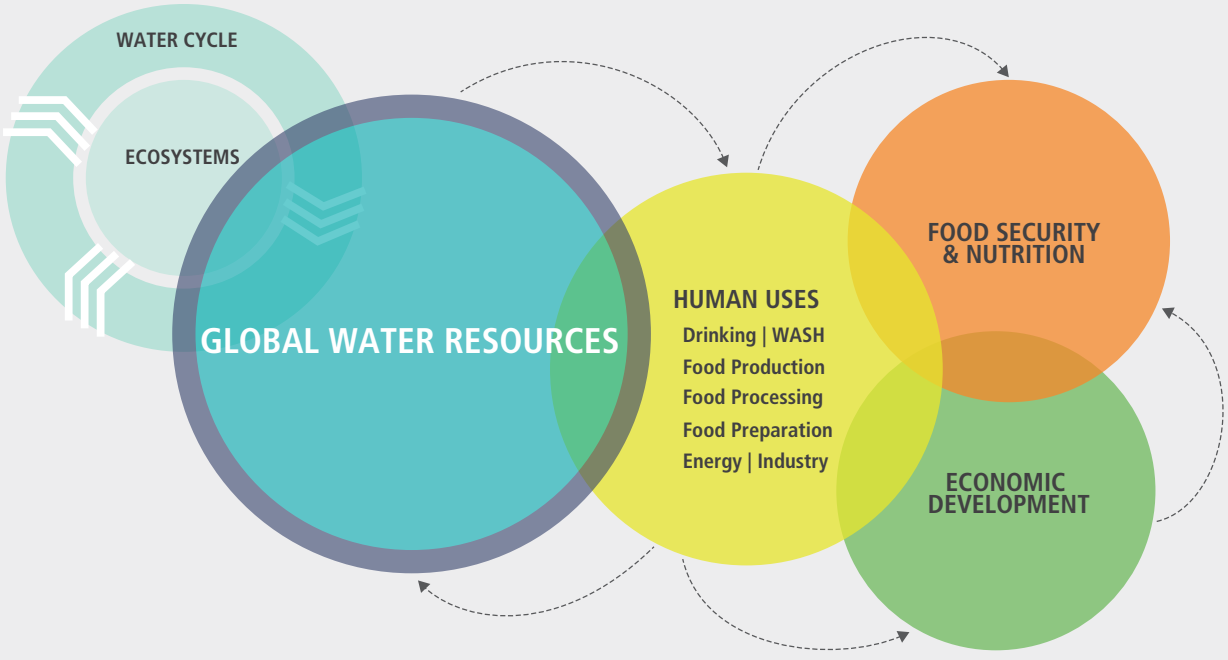
This chapter explores the potential synergies and interactions among various water uses and users that can help achieve a sustainable balance of water uses for food, nutrition, and health.

THE MULTIPLE DEMANDS ON WATER

Water is an irreplaceable resource for food security, nutrition, and health. Water of sufficient quantity and quality is an essential input to food production, animal rearing, and fisheries, as well as production of fibers and plants for medicinal purposes. About 85 percent of all freshwater resources consumed by humans are used for irrigated agricultural production.[2] Processing and preparation of food products also require water and pollute water resources. Drinking water itself contains important nutrients, and safe drinking water and sanitation are fundamental to the nutrition, health, and dignity of all.[3] Water is similarly important for the generation of energy, not only hydropower, but also thermoelectric, nuclear, coal, and bioenergy, and to a lesser extent other renewables.[4] Water is also used for most industrial processes. Finally, water is essential to the functioning of most ecosystems on which humanity depends.[5] Thus, balancing water across food security, nutrition, and health must be considered within a wider context ranging from ecosystem protection to economic development (Figure 1).

Despite the overwhelming importance of water for all living beings, water resources are seldom priced to reflect their true scarcity, and their impacts remain an afterthought in many national food and energy security strategies.[6] This is perplexing because the options to substitute other resources in place of water are very limited (compared with energy, for example, which can be obtained from a variety of sources), and globally available freshwater resources are essentially fixed.

FIGURE 1 The multiple demands on water



Source: Adapted from High Level Panel of Experts, *Water for Food Security and Nutrition: A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security* (Rome: 2015).

Note: WASH = water, sanitation, and hygiene.

As a result, the absolute and relative population, industrial production, and grain output at risk of water scarcity is rapidly increasing.[7] Water pollution and degradation are accelerating, particularly in Africa and Asia, with potentially adverse impacts on human health.[8] Groundwater depletion is reaching critical levels in large food-producing areas, particularly in parts of China, India, Pakistan, and the United States.[9] Safe groundwater resources have been close to fully depleted in several Persian Gulf countries that, as a result, rely on energy-intensive desalination for water access. Globally, the water demands from agriculture, municipalities, and industry are all expected to continuously increase, highlighting the need to improve both the efficiency and sustainability of water management strategies.[10] Finally, water resource "stability" is also increasingly under threat from climate variability and climate change. Many of the world's poorest countries are also those most subject to intra- and interannual variability of water resources.[11]

Even in areas of seeming water abundance, water can be out of reach for marginal groups as a result of poor access rights or underinvestment in supply systems that would make water widely available and affordable for all. Women are often excluded from water access, which they need for both domestic and agricultural purposes, through restrictions on land tenure and water rights.[12] And women bear the greatest burden of increasing water scarcity, because they are often responsible for water collection and can spend several hours a day on this task.[13] Consequently, poor and marginalized populations may have the most to gain from improvements in water access.

THE ROLE OF WATER FOR FOOD, NUTRITION, AND HEALTH

Water affects nutrition and health through several direct pathways, and supports agriculture and other livelihood functions through indirect pathways.

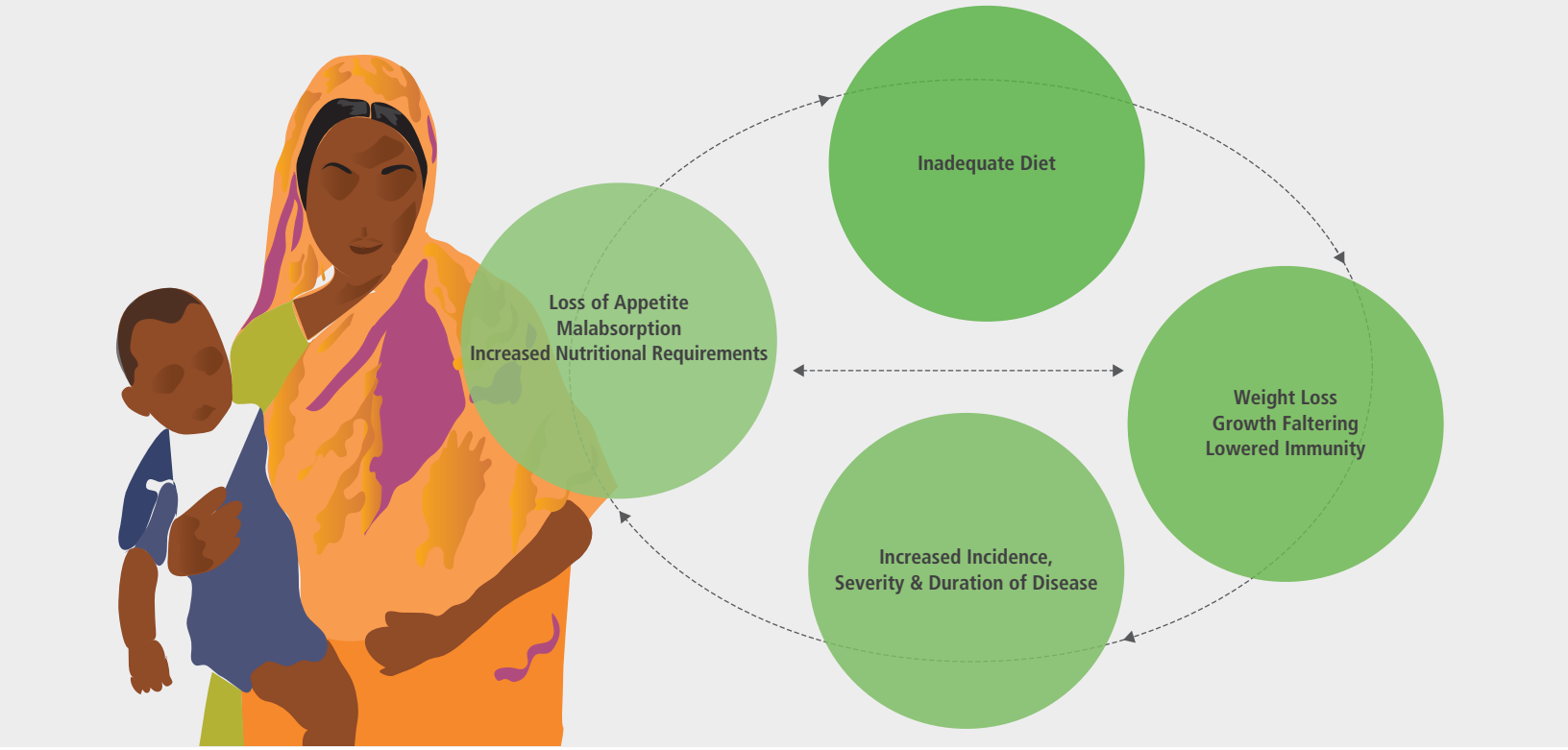
Direct linkages: Water, nutrition, and health

As the vector for many of the diseases that adversely affect nutritional status, water is one of the main pathways through which health and nutrition interact. Malnutrition and health status are closely linked by biological processes in the body. Inadequate diversity and quantity of nutrients can lead to a suppressed immune system, making an individual more susceptible to contracting a disease and hampering recovery. Diseases can also cause symptoms that reduce nutritional status, for example, malabsorption of nutrients as a result of diarrhea, reductions in appetite or activity, and heightened nutrient requirements for fighting disease (Figure 2). Thus, the cycle of undernutrition and poor health status can be self-perpetuating unless interrupted.

The critical role of water, sanitation, and hygiene (WASH) in ensuring adequate nutrition and health has long been recognized.[14] Water directly affects nutrition and health status primarily through diarrheal disease, nematode infections, and environmental enteric dysfunction (EED), an acquired disorder of the small intestine.[15] Recent literature highlights how unsanitary environmental conditions may delineate a strong pathway to undernutrition through EED. The ingestion of fecal bacteria, a consequence of poor sanitation and hygiene, has been hypothesized as the cause of EED, which includes symptoms like reduced absorption in the gut and chronic systemic immune activation. Recent studies have suggested that these changes lead to growth retardation in children, exhibited in the form of child stunting.[16] Although the long-term effects are still under investigation, evidence suggests that the integration of EED prevention into nutrition programming could provide a major advance in efforts to eliminate global stunting. Thus, improvements in WASH conditions—including access to clean water and toilets, improved handwashing practices, and reductions in exposure to fecal matter—could potentially improve child nutritional status.[17]

Diarrheal disease is the second leading cause of death in children under five, killing approximately 760,000 children each year. Repeated incidence of diarrhea in the first two years of life appears to significantly increase a child's risk of stunting.[18] Other water-related diseases—including schistosomiasis, malaria, and nematode infections—also have important impacts on nutritional status. These

FIGURE 2 The infection–undernutrition cycle



Source: Adapted from UNICEF, *Harmonized Training Package: Resource Material for Training on Nutrition in Emergencies* (New York: 2007).

diseases can all be mitigated with improved water management strategies.

Indirect linkages: Water for agriculture and livelihood activities

Water, nutrition, and health also interact through indirect pathways. Time spent collecting water far from the home, the purchase of expensive and sometimes unsafe water from vendors, and the contamination of groundwater with heavy metals are indirect water-to-nutrition pathways that can prevent families from providing safe environments and adequate childcare.[19] In addition, since water is essential for multiple important activities—such as bathing, washing, handicraft making, cultural practices, and transportation—it can be central to quality of life, livelihoods, and income generation and thus to food security and nutrition.[20] And, water's indispensable role for crop, livestock, and fish production serves as an important indirect pathway for promoting nutrition and health. Without reliable water access, food and nutrition security can be severely compromised.

Expanding and ensuring access to water for irrigation show promise for improving nutrition and health status. A recent study identifies five impact pathways linking irrigation to nutrition outcomes for Africa south of the Sahara.[21]

Irrigation as a source of greater diversity in available foods. Irrigation can substantially improve agricultural productivity and crop diversity, and can often introduce a second growing season.[22] Since the dry season is often the "hunger" season, creating conditions for food production during the time of greatest resource scarcity can help prevent seasonal hunger.[23] Irrigation can also boost production of more water-intensive but nutritious crops, such as fruits

and vegetables, and thus enhance dietary diversity. And research shows that on balance, irrigation lowers food prices, creating a net benefit for consumers since the majority of farmers are net food buyers.[24]

Irrigation as a source of income from market sales and employment generation, particularly in the lean season. Farmers engaged in irrigation can generally achieve higher crop yields, grow a greater variety of food under unfavorable climate conditions, and typically sell part of their product in markets. While essential for the dry season, access to irrigation technologies can improve water control and production levels even in the rainy season. With climate change and increasing rainfall variability, reliable water access for agriculture could provide an important source of resilience.

Irrigation as a source of improved water supply, sanitation, and hygiene through multiple-use water systems. The causal links between poor WASH environments and chronic undernutrition are still under investigation, although associative relationships have been found.[25] Improving access to clean water sources for both agricultural and domestic uses can improve the sanitation environment within and around a household, potentially lowering the incidence and prevalence of diarrheal disease. Reductions in exposure have the potential to improve affected households' morbidity while also creating positive effects in terms of the disease burden in the surrounding community.[26] Some evidence suggests that reductions in the number of episodes of diarrhea in children under two years of age can also reduce the probability of stunting. Thus fewer exposures to contaminants could bring benefits for child health and nutrition.[27]

Irrigation as an entry point for women's empowerment through increased asset ownership, control over resources, and time. Given the substantial time burden women face in collecting water and caring for sick children, improvements in the proximity and cleanliness of water sources could support women's empowerment. Depending on how time savings are used, it could also increase time available for childcare, income-generating activities, or rest and leisure, which contribute to overall well-being. Depending on the targeting and implementation of irrigation development, proper engagement with women could also lead to their involvement in and control over income generation. Some studies have found that when women have greater control over income, they are more likely to invest in education, food, and health purchases than men.[28]

Irrigation as a potential source of health risks, reducing nutrition and health status. Despite the benefits proposed above, poorly managed irrigation can lead to losses in productivity, nutrition, health, and women's empowerment. Increasing the availability of water around the household could hypothetically introduce a vector for malaria, dengue, schistosomiasis, cholera, dysentery, and other diseases, if preventive measures are not taken. The association between mosquito-transmitted diseases and irrigation depends on a multitude of factors, including the type of water source (surface or groundwater, moving or stagnant), water management and application practices, the presence of livestock, socioeconomic status, local resistance, and vector control programs. Research on the question of whether irrigation increases malaria prevalence has had mixed results; while some studies suggest that dam construction is associated with higher malaria transmission, others find this to be the case only where there is low resistance and no control mechanisms are in place.[29]

There are also some concerns about whether irrigation can increase exposure to pollution, especially pesticides; some research has found greater occurrence of headaches and blurred vision in irrigation workers.[30] However, all of these risk factors already occur in standard agricultural practices and can be mitigated with proper management, such as the careful handling of pesticides, malaria control mechanisms, and improvements in sanitation and hygiene practices.

BALANCING RISKS AND BENEFITS

Balancing risks and benefits requires strengthening the positive pathways among water, food, nutrition, and health, as well as implementing and monitoring well-designed risk mitigation measures. A balanced approach is illustrated, for example, by the World Health Organization's recommendation

for malaria-ridden countries, which calls for intermittent rather than daily iron supplementation for young children. Since iron increases susceptibility to malaria, supplementation can potentially lead to a net negative effect for morbidity and mortality.[31] Likewise, increasing irrigation access can introduce new vectors for disease transmission, for example through freshwater snails that cause schistosomiasis. Thus, irrigation interventions must be sensitive to both health and nutrition. Risk mitigation requires standard health education and promotion of complementary water management practices, such as avoiding standing water during mosquito- or snail-breeding seasons.

Benefits and costs of irrigation for food security, health, and nutrition will depend on highly variable local contexts, including water sources, scarcity, and distribution, as well as the scale of irrigation systems. Tradeoffs for sustainability will also have to be assessed within the local context. For example, large-scale irrigation technologies might require large pumping systems that increase energy use to the detriment of the environment; however, these same systems might also lower global food prices and reduce deforestation by raising yields, to the benefit of food and nutrition security.[32] Small-scale irrigation is possible with manual pumps, but these can be labor intensive, with adverse effects on food security, women's empowerment, nutrition, and health. Large-scale dams may bring immense benefits in terms of irrigation for agriculture or hydropower but can introduce adverse environmental consequences, such as sedimentation, eutrophication (that is, nutrient runoff that causes excessive plant and algae blooms), salinization, and disruption of fisheries and ecosystems, with a myriad of associated nutrition and health consequences. Thus, when considering irrigation development, a comprehensive set of benefits must be weighed against all costs, including those to the environment.

The water source also shapes the benefits and risks associated with irrigation systems. In water-scarce areas, wastewater is often repurposed for irrigation, a practice that can introduce pathogens to water consumers and agricultural workers. However, substantial progress has been made toward properly treating, applying, and testing water under these circumstances to avoid harmful effects.[33] Microirrigation technologies—such as drip and subsurface irrigation—have been identified as effective methods for increasing water use efficiency, reducing exposure to potential contaminants for workers and consumers, and mitigating salinization.[34]

WHAT NEEDS TO BE DONE

Evidence is still limited regarding the pathways by which water affects nutrition and health, especially indirect pathways such as crop and livestock production, women's empowerment, and environmental conditions. Despite the fact that many transmissible diseases in developing countries are attributable to poor water quality and management—and agriculture represents the main consumer of water—practitioners rarely coordinate WASH, nutrition, and agricultural interventions. Poor integration is perpetuated by "silos" within agencies, administration, and objectives that hamper cross-sectoral research. In addition, researchers face challenges in testing complex and interdisciplinary interventions, which require large sample sizes in each of several treatment arms.

At the same time, sustainable solutions to undernutrition will need to incorporate attention to both water and agriculture. The 2013 *Lancet* series on maternal and child nutrition estimated that a 90 percent increase in coverage of evidence-based, *nutrition-specific* interventions could reduce stunting in the highest-burden countries by only about 20 percent. More integrated approaches are therefore necessary to generate impact.[35] The prevention of stunting and disease are highly sustainable outcomes in and of themselves, since their impacts last a lifetime and have additional positive consequences for generations. By ensuring proper water management and access, chronic undernutrition and diseases can potentially be prevented, while also improving diets, livelihoods, and sustainable and equitable water usage.

Improved water access and management, however, must not be viewed as a panacea for sustainable food, nutrition, and health outcomes. To ensure that policies are able to contribute to multiple objectives, a number of other factors must be taken into account.

First, balancing multiple objectives for water will be challenging in a world facing shifts in rainfall patterns, temperatures, drought, flooding, other extreme weather events, and growing industrial and private demand. Expanding irrigation without proper water management strategies could lead to greater water scarcity and even conflicts over usage rights. Potential strategies to mitigate these challenges include

- institutional reforms to improve the efficiency of water distribution by the public sector, farmer organizations, and the private sector;
- internalization of water use externalities through water markets;
- introduction of economic incentives for water management, such as water prices, taxes, subsidies, quotas, and ownership or use rights;
- investments in traditional infrastructure (such as dams) and nontraditional technologies (such as green infrastructure) to improve the sustainability of resource exploitation; and
- improvements in the conveyance, distribution, and application efficiency of irrigation systems.[36]

Improving the WASH environment in and around the household cannot be fully achieved through reliable water access alone. Behavior changes in areas such as handwashing, use of latrines, disposal of child feces, and open defecation may be required at the community level to generate positive impacts for nutrition. Furthermore, livestock management to reduce children's exposure to animal feces and prevent contamination of water sources must be addressed. Ensuring that water is adequate for consumption through testing or point-of-use treatment is required in multiple-use water systems. To enhance program impact, policymakers need to consider complementary interventions, such as behavior change communication that spans agriculture, nutrition, and WASH.

Access to services, notably credit and markets, that contribute to the success of irrigation projects must also be considered. Adoption of small-scale irrigation systems, used by a single household or a small group of households, often hinges on access to credit. But financial services in developing countries often are weak, do not reach rural households, are not gender sensitive, suffer from high interest rates, and lack sufficient capacity to provide credit for all. Increased access to microfinance for both men and women could help farmers in the adoption of irrigation and other complementary inputs to improve farmers' livelihoods. Moreover, irrigation interventions to promote the production of fruits and vegetables, which often have short shelf lives, should be accompanied by plans to connect producers to reliable markets, so that incomes are maximized and food loss and waste is reduced.

Finally, agriculture projects that aim to improve nutritional status should not be conducted at the expense of evidence-based, nutrition-specific interventions. When used complementarily, both nutrition-sensitive water interventions and nutrition-specific interventions could compound benefits to individuals. For example, interventions to ensure adequate and diverse complementary feeding practices for children six months to two years old could be integrated with the promotion of crop diversity in irrigated agriculture through a source that also provides safe drinking water. Adopting both a nutrition- and water-sensitive approach to program development can maximize benefits for individuals.

The benefits of coordinating water, nutrition, and health interventions promise to be substantial. To properly evaluate the returns to linking interventions in these sectors, research must rigorously examine nutrition and health indicators through the lenses of both agriculture and water. This will require coordination across disciplines by researchers, policymakers, and project implementers. At the policy stage, coordinated efforts by practitioners in the water, nutrition, agriculture, health, and environment sectors can ensure that long-term sustainability is achieved through a necessary balance between human and environmental objectives. ■

LAND AND SOIL MANAGEMENT

Promoting Healthy Soils for Healthier Agricultural Systems

Jawoo Koo, Ephraim Nkonya, Carlo Azzarri, Cindy Cox, Timothy Johnson, Adam Komarek, Ho-Young Kwon, Alex De Pinto, Cleo Roberts, and Wei Zhang

SUMMARY Soil and land management are essential for a sustainable food supply and ecosystems. Healthy soils can support sustainable agricultural production, mitigation of the impacts of climate change, and other ecosystem services. Interventions that show promise for improving soil health include investment in sustainable intensification technologies, climate-smart agriculture, and ecosystem-level management.

Sustainable management of soils and land provides a global public good, supporting agricultural productivity, climate change mitigation and resilience, and a range of ecosystem services. The irreplaceable functions of soils have only recently been widely recognized, and 2015—proclaimed the "International Year of Soils" by the United Nations (UN)—could mark an important turning point for addressing soil and land degradation. The Sustainable Development Goals (SDGs) put the focus of development on agriculture, climate change, and protecting biodiversity and the environment—all of which are closely related to soil health. SDG 15 specifically calls for halting and reversing land degradation. And a global initiative called "4 per 1,000" launched at the 21st Conference of the Parties (COP21) in Paris calls for addressing both climate change and food security by sequestering 0.4 percent of atmospheric carbon in the world's soils annually.

Evidence of the potentially tragic consequences of neglecting soil and land resources is abundant. The Dust Bowl years on the Great Plains of the United States in the 1930s were the result of rapid erosion caused by decades of continuous monocropping of shallow-rooted annual crops. In northwestern China, similar unsustainable practices led to widespread dust and sandstorms from the 1970s to 1990s. Globally, we are losing 75 billion tons of soil every year to unsustainable practices, with impacts that not only harm poor farmers but also extend far beyond the agriculture sector.[1] Climate change impacts, including

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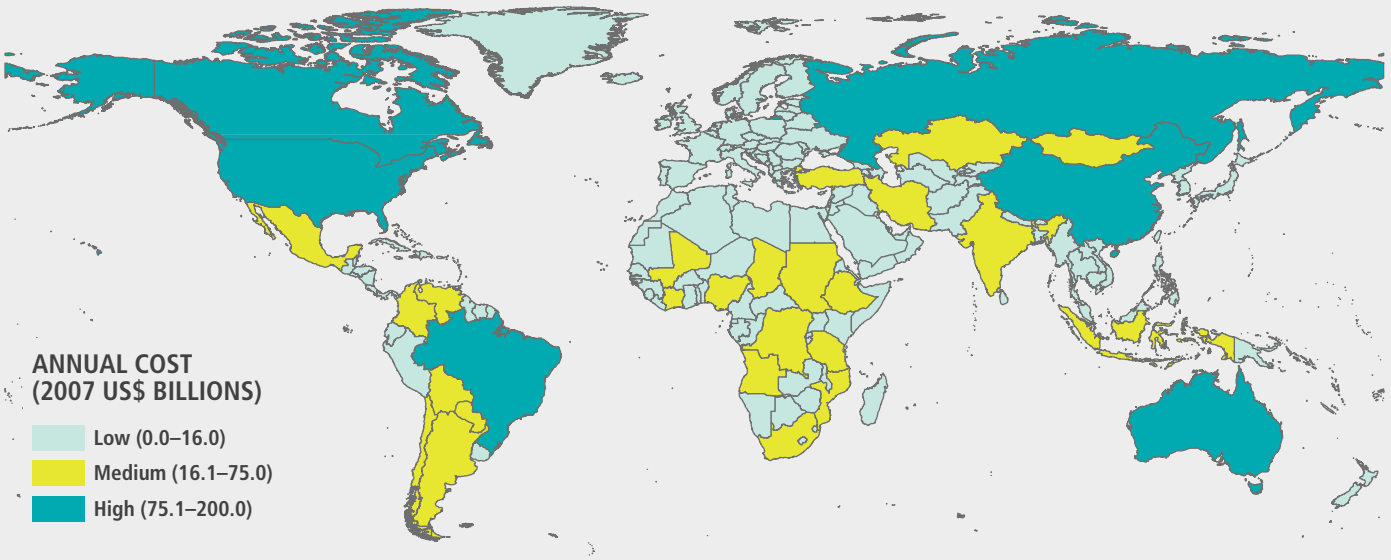
FIGURE 1 Global annual cost of land degradation, 2001–2009



Source: E. Nkonya, W. Anderson, E. Kato, J. Koo, A. Mirzabaev, J. von Braun, and S. Meyer, "Global Cost of Land Degradation," in *Global Assessment of the Economics of Land Degradation,* edited by E. Nkonya, A. Mirzabaev, and J. von Braun (Dordrecht, Netherlands: Springer, 2016).

temperature increases and rainfall variability, will add to the existing stress on soils and agricultural production.

Fortunately, practices and policies are being tested that show promise for averting irreversible damage to the world's soil resources. Innovations in management, soil conservation programs, and Green Revolution practices have not only improved agricultural efficiency and productivity but have also decreased erosion. Below we review the challenges of soil and land management, lessons learned, and policy options that could help achieve the sustainability goals at a global scale.

CHALLENGES

While the impact of soil and land degradation on farm production has long been recognized, understanding of the off-farm and even global impacts of soil and land management is recent. Sustainable development will require healthy soils, not only for increased agricultural production as a growing global population requires more food, but also to ensure sustainability of critical ecosystem services. Given the fundamental importance of healthy soils, how do we coordinate, promote, and monitor multisectoral efforts? And how do we mobilize resources to ensure long-term soil health?

Valuing land degradation

Robust economic evaluation of the costs and benefits of increasing sustainable management is required to mobilize large-scale investments and strengthen policy commitments. Although a growing literature has examined the global-scale costs and benefits of sustainable land management, there is little consensus. One innovative study estimated the annual cost of global land degradation at about US$300 billion (about 0.4 percent of global gross domestic product in 2007), and provided new insights into the cost of land degradation (Figure 1).[2] First, more than half of the total cost is attributable to degradation of ecosystem services—primarily loss of carbon sequestration, biodiversity, genetic information, and various cultural services—that largely affects beneficiaries other than local land users. Clearly land degradation

is not just a problem for farmers—it is everyone's problem. Second, the rewards of action outweigh the costs. Potential returns from investment to prevent land degradation are projected to be double the cost of inaction in the first six years alone, and up to five times larger over 30 years. Third, loss of carbon sequestration accounts for a large share of the cost of unsustainable management practices, including about 75 percent of the US$57 billion annual cost of land degradation occurring on farms that grow maize, rice, and wheat globally.

Valuing soil carbon

Carbon markets have been established to create financial incentives for reduction of greenhouse gas (GHG) emissions (especially CO_2), including carbon losses from soils, through trading of emissions allowances (carbon credits) among emitters. Agricultural emissions comprise 14 percent of global GHG emissions. Creation of carbon markets was expected to create a win-win opportunity for farmers—incentives for land management would increase soil fertility while plants would absorb CO_2 from the atmosphere, mitigating climate change. However, although the global carbon market reached a value of more than US$100 billion in 2009, agriculture has been largely excluded. Obstacles to participation include high levels of uncertainty about agriculture's mitigation potential because of measurement difficulties; concerns about permanence because sequestered soil carbon is lost rapidly when mitigation practices are abandoned; large transaction costs including those of monitoring, reporting, and verifying changes in soil carbon and emissions; and in the case of smallholders, the need to work together to generate a market-viable quantity of emission reductions.[3] Despite growing scientific evidence of the benefits of soil carbon sequestration and economic analyses demonstrating the power of carbon markets to foster more sustainable land management, market valuation of carbon in agriculture has not fulfilled its potential.

Monitoring agricultural sustainability

Measuring the status of land and soils, especially over large areas, is difficult, but recent technological advances in estimating soil organic carbon and moisture using unmanned aerial vehicles and satellites offer potential for more effective monitoring. New monitoring frameworks attempt to devise a simple model of inherently complex agricultural systems to support actionable measures. The Africa RISING project, for example, is developing a Sustainable Intensification Index using a set of indicators across space and time: economic (income, poverty); human (education, health, nutrition); environmental (soil carbon input, erosion, water-use efficiency, on- and off-farm vegetation); social (farmer groups, social capital, gender equity); and productivity (yield, total factor productivity).[4] The framework will be used as a monitoring tool for diverse farming systems across Africa. Another approach, developed by HarvestChoice, uses a satellite-based estimation of aboveground biomass to quantify the spatio-temporal trends in biomass appropriated by agriculture.[5] Preliminary findings from detailed mapping across Africa south of the Sahara suggest that the method can identify hot spots of accelerating biomass harvest from crops, indicating areas of active agricultural intensification.

WHAT IS AT STAKE?

By placing goals related to soil and land management on the agenda, the UN commitment recognizes the critical role of soil and land for realizing its new goals. Beyond the direct contribution of soil health to agricultural sustainability, what is at stake?

Sustainable food supply

Management of land and soil fertility, particularly soil carbon, is essential for reliable agricultural production and resilience to external shocks, including climate change. Soil organic matter, of which about 60 percent is carbon, is critical to soils in terms of fertility, ecological processes, plant productivity, and ultimately human survival. Soil carbon plays a central role in (1) maintaining soil structure, notably increasing water-holding capacity and soil permeability, aeration, and drainage; (2) providing energy and substrate for microbial activity; (3) promoting a reservoir of available organic nitrogen, phosphorus, and other essential plant nutrients; and (4) creating a cohesive physical structure that protects against

water and wind erosion. Carbon storage in soils is also critical for climate change mitigation. Potential increases in soil organic carbon from improved agricultural practices could offset the equivalent of 5 to 15 percent of global fossil fuel emissions.[6]

Over the past 25 years, a quarter of Earth's land has suffered degradation due to loss of organic matter.[7] Fertilizer, in the form of either inorganic or organic amendments, is essential to maintain soil productivity. Under continuous intensive cultivation, soils lose mineralized organic nitrogen, and consequently available phosphorus becomes largely inaccessible to plant uptake. And in some soils, a further chain reaction may reduce the soil's ability to hold on to essential nutrients. Left without replenishment of nutrients and organic material, soils can become unresponsive to fertilizer applications. In extreme cases, degradation can be irreversible. The resulting loss of agricultural productivity is likely to perpetuate poverty traps.[8] The organic material's contribution to soil fertility, therefore, cannot be understated and may determine the agricultural potential of soils.[9]

Ecosystem services

Complex landscapes enhance local diversity in agricultural systems and provide supporting and regulating ecosystem services critical for agriculture.[10] Among other important contributions, landscape diversity provides more food sources and habitats for beneficial insects than simple or monoculture landscapes, and is correlated with greater diversity and abundance of populations of natural enemies of plant pests as well as lower incidence of plant disease.[11] Further research on how landscape structure and heterogeneity influence interactions among host, pathogen, and environment may lead to practical measures to reduce the impact of plant disease.[12]

Landscape diversity also provides habitats for pollinators, which provide another ecosystem service critical for agricultural production. Evidence suggests that conserving habitats for wild pollinators within agricultural landscapes improves both the level and stability of pollination, leading to increased yields and income for farmers.[13] These environmental services depend on on-farm management and the structure, composition, and functioning of the surrounding landscape.[14]

Human health

Better understanding of the soil health–human health nexus is critical to developing sustainable strategies of soil fertility management to improve human health.[15] Recent studies have investigated various aspects of the nexus, including food security, human contact with various chemicals in soils, and human contact with soil pathogens.[16] Researchers at the International Food Policy Research Institute (IFPRI) along with partner organizations have focused on the relationship of soil health to food security, particularly food availability and quality. To increase food availability, studies have focused on developing sustainable soil management practices to raise agricultural productivity while reducing adverse impacts on environmental and human health. The Economics of Land Degradation Initiative and related work have highlighted the importance of sustainable soil fertility management by determining the high cost of inaction in the face of land degradation.[17] To enhance food quality, the transfer of nutrients from soils to plants to people has been examined. Led by IFPRI, the Research for Ethiopia's Agriculture Policy (REAP) program introduced fertilizer blends to Ethiopian farmers for replenishing nutrient-depleted soils. Similarly, the HarvestZinc project led by HarvestPlus, a biofortification initiative, has offered a means to alleviate nutritional deficiencies by linking zinc levels in soils, plant uptake, and human nutrition.[18]

PROPOSED ACTIONS

Despite the challenges of managing soil and land for agricultural sustainability, interdisciplinary research and public interest surrounding the sustainable development agenda are generating unprecedented amounts of site-specific data, decision-support tools, and consensus around a sustainable food security roadmap. To provide guidance in global food policy development and implementation, we propose the following actions based on this growing knowledge.

Implement sustainable intensification technologies

Agricultural intensification—producing more food from existing farmland—is the prevailing paradigm

for meeting global food needs as the world's population heads toward 9.6 billion by 2050. Carefully designed, site-specific sustainable intensification (SI) technologies offer a means of increasing the food supply while reducing environmental impacts and GHG emissions. Based on decades of research, a number of initiatives are proving the feasibility of SI at various scales. The Africa RISING initiative, for example, aims to identify successful SI practices in six African countries.[19] Working closely with smallholder farmers in diverse locations and farming systems, Africa RISING uses location-specific research to ensure technologies are appropriate to local culture and agroecology. But changes in agricultural systems often entail trade-offs, which need to be taken into account by policymakers. Preliminary results from a modeling exercise using Malawi as a case study suggest that farm productivity, profitability, and soil carbon can increase if farmers use a mixture of organic and inorganic sources of nitrogen—the simulation showed a 24 percent increase in profits over a 20-year period, relative to a maize monoculture system using only inorganic fertilizer. However, while profits increase, the combination of organic and inorganic sources of nitrogen also increases the leaching of nitrogen from soils. Addressing the relative importance of trade-offs in different contexts can help in formulating effective policies for sustainable agriculture.

Scaling up adoption of SI technologies among farmers is, however, a daunting task requiring a nuanced understanding of farmers' livelihoods, careful planning for iterative implementation, and systematic monitoring to understand environmental linkages and their effects. Because SI technologies take a "whole-farm" approach, they are more complex than other interventions for sustainability. For example, SI requires farmers to adopt a package of practices, which may need to be applied in a particular order and at specific times. The benefits, however, can be substantial. For example, evidence from the "doubled-up" legume technology tested by Africa RISING in Malawi shows that by growing an additional legume in order to supplement household nutrition and income, farmers successfully doubled both farm output and soil fertility benefits, because legume crops increase soil fertility. Similarly, in Tanzania, technologies including crop diversification through intercropping, soil fertility management, postharvest management, and integration of high-value vegetable crops have boosted farmers' earnings by 70 percent. These cases provide a knowledge base for policies to scale up adoption of SI technologies.

Invest in perennials

Simplified agroecosystems featuring annual crops have largely replaced ecosystems dominated by heterogeneous perennial vegetation. Despite the advantages they offer for sustainable soil and land management, perennials account for a smaller share globally of farming systems, investment dollars, and plant-sourced calories than annual crops.[20] Perennials develop long-lived, deep roots for better access to nutrients and water, enabling more resilience to harsh environmental conditions while producing more biomass both above and below ground. They are superior to annuals in terms of reducing soil erosion, transferring organic inputs to soil microorganisms, and increasing the amount of carbon stored in the soil—key for improving soil health. These organic inputs and microorganisms improve soil fertility and structure as well as increasing water infiltration and storage, all of which increase water availability to crops. By supplying soil with carbon, perennials improve the ability of food crops to utilize mineral fertilizers and potentially help farmers adapt to climate change. A variety of available perennial crops suitable for livestock forage, fruit production, agroforestry, and nitrogen fixation can be integrated into mixed-use farming systems through rotation, intercropping, and monoculture. However, there are virtually no varieties of perennial grain available on the market yet, with the exception of the pigeon pea—a semiperennial cultivated in East Africa. This lack of perennial availability limits the potential contribution these crops can make to increasing food security. Further investment is needed to scale up the development and integration of perennial crops into mixed farming systems.

Promote climate-smart soil and land management

To address future challenges to food security and achieve the SDGs, climate-smart agriculture must

BOX 1 Decision-support tools for soil and land management

As countries experience economic growth and choose among available development pathways, they are in a favorable position to adopt natural resource use technologies and production practices that favor healthy soils and ecosystems. In order for decision-makers to develop long-term policies that address sustainability, they must have tools for evaluating trade-offs, opportunities, and repercussions of available options. IFPRI researchers have developed a modeling approach that combines and reconciles the limited resolution of macro-level global economic models with detailed models of biophysical processes at high spatial resolution. This suite of models provides clear insights into the economic, productivity, and carbon-storage implications of alternative policies.

A recent application of this approach in Colombia, a country fully invested in pursuing low-emissions development strategies, reveals the importance of considering the full scope of interactions among various land uses. Results indicate that investments in increasing the efficiency and productivity of the livestock sector and reducing land allocated to pasture are preferable to policies that target deforestation alone or target a reduction of emissions in crop production. Investments in livestock productivity and land carrying capacity would reduce deforestation and provide sufficient gains in carbon stock to offset greater emissions from increased crop production while generating higher revenues.

Source: Authors.

be made operational. Climate-smart agriculture is an umbrella term that includes many approaches built on geographically specific solutions, such as no-till farming, fertilizer deep-placement technology, and integrated soil fertility management. The concept embraces three pillars: (1) sustainable increases in productivity, (2) enhanced resilience and adaptation of farming systems, and (3) mitigation of GHG emissions.[21] One of the greatest challenges facing development practitioners is to design climate-smart soil and land management strategies that satisfy all three pillars of climate-smart agriculture.[22] IFPRI researchers have developed a modeling framework in which crop modeling analyses—incorporating remote sensing data, national statistics databases, and various climate scenarios—are used to simulate a stress test for agricultural systems and to identify best responses to climate and market risks (Box 1). Using this framework, a portfolio of options to increase productivity and climate change resilience can be identified, along with the GHG emissions expected with each option, so that best investments can be selected. In addition, ongoing IFPRI research is focusing on the global effects of widespread adoption of climate-smart agriculture practices on production of major crops, GHG emissions, and key food security metrics.

Manage ecosystem services at the landscape level

A landscape perspective is necessary to understand how land use affects ecosystem services.[23] The scale at which ecosystem services are rendered determines the relevant management units for supporting sustainable agriculture.[24] For example, ensuring reliable ecosystem services from insect populations (including crop pollination and pest regulation) requires coordinated land-use management among local farmers, as well as judicious use of chemical insecticides to limit harm to beneficial insects. To achieve this level of coordination across farm boundaries, research and policy attention needs to move beyond the traditional field and farm scale to the agricultural landscape.[25] A greater level of collaboration and public investment in research and extension are necessary. Future management and planning efforts should move toward a landscape perspective.

Recognize soil, land, and ecosystem services as public goods

Many ecosystem services behave as public goods.[26] For example, forests on private land sequester carbon, creating a public good in that no one can be excluded from the benefit of carbon sequestration.[27] In many cases, both the costs and the benefits of soil,

land, and ecosystem management by farmers largely accrue to people "off-farm." A recent study finds that 54 percent of the cost of long-term loss of ecosystem services resulting from land degradation is borne by people off-farm. For some biomes, off-farm costs are much higher—for example, an estimated 76 percent of the cost of world deforestation is off-farm.[28] On the positive side, this means that farmers who plant trees or adopt other sustainable land management practices create both on- and off-farm benefits. Policies and strategies for achieving SDG 15—zero net land degradation by 2030—should reflect the public goods created by on-farm practices. The trade-off (or opportunity cost) of restoring degraded lands accounted for about 94 percent of the total cost of taking action against land degradation, largely due to losses farmers incur to restore a high-value biome and foregone benefits from the low-value biome associated with land degradation.[29]

Payment for ecosystem services (PES) programs can address these high costs by helping land users internalize some or all of the off-farm benefits generated by sustainable land management practices. A number of successful programs in countries ranked both low and high on the UN's Human Development Index have demonstrated that PES can be successfully implemented if key preconditions are in place—regardless of the human development level. The key preconditions are strong local and national institutions that ensure land tenure and a market-based program for payments. For example, the Plan Vivo projects in Africa have implemented a number of successful PES programs rooted in community-based forest management practices. Mozambique's Sofala Community Carbon program pays farmers for on-farm carbon sequestration, adding to the benefits of on-farm ecosystem services, including sustainable timber and nontimber forest product harvesting.

Costa Rica offers a success story of restoration of deforested lands. The country's political constitution and its 1996 Forestry Act provide a framework for rewarding land users who provide off-farm ecosystem services through certified forest conservation. The payments are financed through fossil fuel taxes, water fees, and donor contributions. Land users engaged in forest conservation enjoy direct payments, tax breaks, and payments for carbon credits from local and international buyers. The country has invested significantly in environmental awareness, leading to changes in perceptions about ecosystem services. All of this has led to successful restoration of deforested lands and other sustainable natural resource management practices.

GROWING EVIDENCE

Unsustainable land management practices are driving the annual loss of 75 billion tons of soil from global cropland, with impacts that go far beyond agriculture.[30] As soil is increasingly recognized as a limited and irreplaceable natural resource, this can change. Through global initiatives to address soil and land degradation issues, momentum is gathering to put agriculture on a more sustainable track. Research is generating data and powerful analytical tools to create a roadmap of actions for achieving the SDGs. Major challenges remain, including development of effective governance and financing strategies for sustainability.[31] But the evidence needed for practical application of better approaches is growing. Climate-smart agriculture technologies and management practices that promote sustainable intensification, supported by landscape-level approaches and economic valuation of ecosystem services, provide reason to be optimistic about sustainable management of soil and land, and ultimately food security for future generations. ■

NUTRITION AND SUSTAINABILITY

Harnessing Value Chains to Improve Food Systems

Summer Allen, Alan de Brauw, and Aulo Gelli

SUMMARY Meeting global goals for nutrition and sustainability will require joint solutions tailored to diverse situations. Value chain analysis provides a promising framework for understanding effective interventions to achieve better outcomes for both health and environment.

Improving nutrition and fostering environmental sustainability are critical development challenges that the world has pledged to take on via the recently adopted Sustainable Development Goals (SDGs). Of the 17 SDGs, 11 address improved access to nutritious food and 13 require improved stewardship of the world's natural resources. Overall, the SDGs, launched by the United Nations to guide the post-2015 development agenda, acknowledge that these two goals are intertwined; in fact, SDG 2 (zero hunger) specifically calls for achieving food security and improving nutrition while promoting sustainable agriculture.

Existing food systems combined with rising incomes and changing food demand are putting increasing stress on the world's natural resources.[1] At the same time, a significant share of the world's poor suffer micronutrient deficiencies even as the proportion of people who are overweight or obese is growing in almost every country.[2] This situation points to the need for new initiatives to increase consumption of nutritious foods among populations currently unable to afford a healthy diet, while reducing demand for unhealthy, low-nutrient foods and foods developed through unsustainable supply chains. There is no one-size-fits-all solution—initiatives must account for heterogeneity in economic, environmental, and social contexts that affect diets and sustainability.

VALUE CHAINS, NUTRITION, AND SUSTAINABILITY

Agricultural value chains encompass all actors and activities involved in food production, so understanding how they bring food from farm to table can help policymakers identify feasible solutions to the challenge of simultaneously

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FIGURE 1 A milk value chain

Source: Adapted from A. Gelli, C. Hawkes, J. Donovan, J. Harris, S. Allen, A. de Brauw, S. Henson, N. Johnson, J. Garrett, and D. Ryckembusch, *Value Chains and Nutrition: A Framework to Support the Identification, Design, and Evaluation of Interventions,* IFPRI Discussion Paper 1413 (Washington, DC: International Food Policy Research Institute, 2015).

improving nutrition and the environment. In addition to providing a framework for characterizing several dimensions of a food system—including agricultural production, the diversity of food supply, and food affordability—value chain analysis can also reveal points of entry for catalyzing improvements in both nutritional outcomes and environmental impacts. Figure 1 provides a simple illustration of the stages and actors in a milk value chain.

Although value chain analysis was developed to highlight the flow of economic value, it can also demonstrate the flow of nutritional value, how it is enhanced or diminished, and how sustainability is affected at each step along the value chain.[3] Nutritional value refers to the micronutrient content of food that is consumed. Undernutrition, the primary focus in this chapter, is a lack of adequate micronutrients in the diet and is most critical for women of childbearing age and children under age five. Overweight and obesity, the result of a diet with too many calories, can occur in conjunction with a lack of adequate nutrients, especially among children.[4] While 161 million children under five years old suffer stunting (that is, they are too short for their age) as a result of chronic undernutrition, an estimated 43 million children under five were overweight in 2011.[5] In broad terms, improved nutrition is not just a result of increased nutrient content in individual foods but, more critically, of improvements in overall diet quality.

Sustainability requires that short-term actions not jeopardize the long-term productive capacity of a system. Therefore, a sustainable food value chain is one that is profitable over the longer term while not permanently depleting natural resources.[6] Sustainable diets are diets that can adapt to a changing climate, fluctuations in the availability of land and water resources, and overall social and economic development—all of which are context specific. Because sustainability is a broad concept, the discussion here is primarily limited to the economic and environmental characteristics of food systems. The context and incentives shaping food value chains can play a central role in improving both sustainability and nutrition.

USING VALUE CHAINS TO ACHIEVE MULTIPLE GOALS

A complex range of factors can shape nutritional and environmental outcomes in food systems, including agricultural production, supply and demand for nutritious foods, and price transmission through the chain. Choices related to food production and consumption reflect market conditions, habits, cultural preferences, environmental factors, government policies, religious beliefs, income levels, and risk tolerance. All of these factors can be explored and better understood through value chains.

Looking first to nutrition, agricultural production—the base of a food value chain—is one of many factors that affect the availability and consumption of adequate nutrients. Low-income households typically subsist on monotonous, staple-based diets. This lack of dietary diversity is strongly associated with inadequate intake and risks of micronutrient deficiencies.[7] Increasing diversity in agricultural production can improve diversity in diets, but the relationship is not necessarily straightforward. Analyzing value chains can help clarify why that's so—in part because dietary choices also depend on markets.[8] Food is stored, distributed, processed, marketed, prepared, and consumed in a range of ways that affect the access, acceptability, and nutritional quality of foods for the consumer. Prices also play a key role in the accessibility of nutritious food. For example, many households in developing countries are both consumers and producers of food, meaning that food price increases can have diverse impacts on production and consumption decisions. While some interventions could create economic, environmental, and nutritional benefits, a detailed analysis of any potential intervention is needed to determine whether it presents win-win options or entails trade-offs among the desired outcomes.

One example of an intervention with multiple goals is efficiency improvement in temperature-controlled supply chains—known as "cold chains." Cold chains can improve economic returns to vegetable- and animal-sourced food production by maintaining the nutritional content longer and reducing both losses to spoilage and risks of contamination. However, the economic benefits may be limited if consumers do not value the additional nutrient density (that is, the proportion of nutrients in a food relative to calories) or improved food safety. Because nutritional content and food safety are invisible, consumers may not be willing to pay more for these qualities without some form of third-party endorsement, whether public or private, such as information campaigns or consumer reporting.[9] Nevertheless, in theory, diets would be expected to improve with investments in cold chains as a result of a drop in prices for nutrient-dense foods. The environmental effects, on the other hand, may be mixed. Reduction in food loss and waste would increase the sustainability of the food system by reducing resource use throughout the chain. However, overall resource use might increase because of the nature of the food system: cold chains require energy, vegetable production typically uses pesticides, and animal-sourced foods are resource intensive.

Value chain interventions to increase sustainability can target actors able to implement location-specific sustainable management practices in agriculture, namely smallholder farmers, farmer organizations, and local businesses. Understanding the context-specific constraints and opportunities at the level of farmers and farmer organizations can support the design of more efficient policies that enable sustainability and long-term growth. Smallholders, for example, can play an important role in improving sustainability and nutrition, but also present a challenge in terms of scaling up interventions. Smallholders have a comparative advantage in crops that require high labor inputs, such as dairy products, tree crops, and vegetables. But to achieve economic success, crop processing, transport, and marketing often need to be aggregated to reduce transaction costs, and proper storage is required to avoid spoilage. To support production of nutritious crops, contractual relationships between smallholders or smallholder groups and buyers, such as food processors, can promote investments, reduce risk, and stabilize prices and production. Linking such contractual relationships to sustainable management targets and labeling can increase economic and environmental sustainability. Strong public programs can help ensure both economic and environmental sustainability where the private sector might not.[10]

Attention to gender—that is, considering gender roles in agricultural tasks such as sowing, weeding, harvesting, and marketing, as well as the roles played by men and women in choosing what foods to grow, eat, and prepare—can play a significant role in making interventions for nutritious and sustainable value chains successful. Including women in the management of natural resources can lead to more economically and environmentally sustainable outcomes.[11] As women become more empowered in agriculture, nutrition outcomes improve among children. However, there are also potential negative consequences. For example, women who

are more engaged in commercial agriculture or nonfarm income-generating activities may have less time to care for their children.[12] Additionally, although supermarket supply chains for vegetables have grown, their positive effects on nutrition have been muted because revenues from vegetable sales, which were previously controlled by women, are now controlled by men, who typically spend less on nutrition and dietary quality.[13]

A VALUE CHAIN TYPOLOGY FOR INTERVENTIONS

Value chain interventions can be divided into four categories based on the profile of supply and demand for nutritious foods that characterize particular contexts (Figure 2).[14] The typology identifies where interventions can achieve the greatest nutritional impacts for particular situations; it is also useful for analyzing sustainability investments.

Interventions to increase food supply

Ample demand for specific nutritious foods may exist in places where supply is limited (Figure 2, top left quadrant). Poor production practices, a lack of infrastructure that results in high transaction costs, or a lack of trust among actors in the value chain can all contribute to inadequate supply. In this case, interventions should aim to enhance supply by improving production practices, organizing production and postharvest activities to increase efficiency, and facilitating expansion of market opportunities. An ongoing project in eastern India, run by the social enterprise eKutir, is working with microentrepreneurs to provide retail outlets and distribution channels to support both increased production of vegetables and increased access to a varied diet for poor households. By addressing constraints in the market distribution of vegetables, the project aims to reduce loss of perishable products and make the value chain more sustainable.

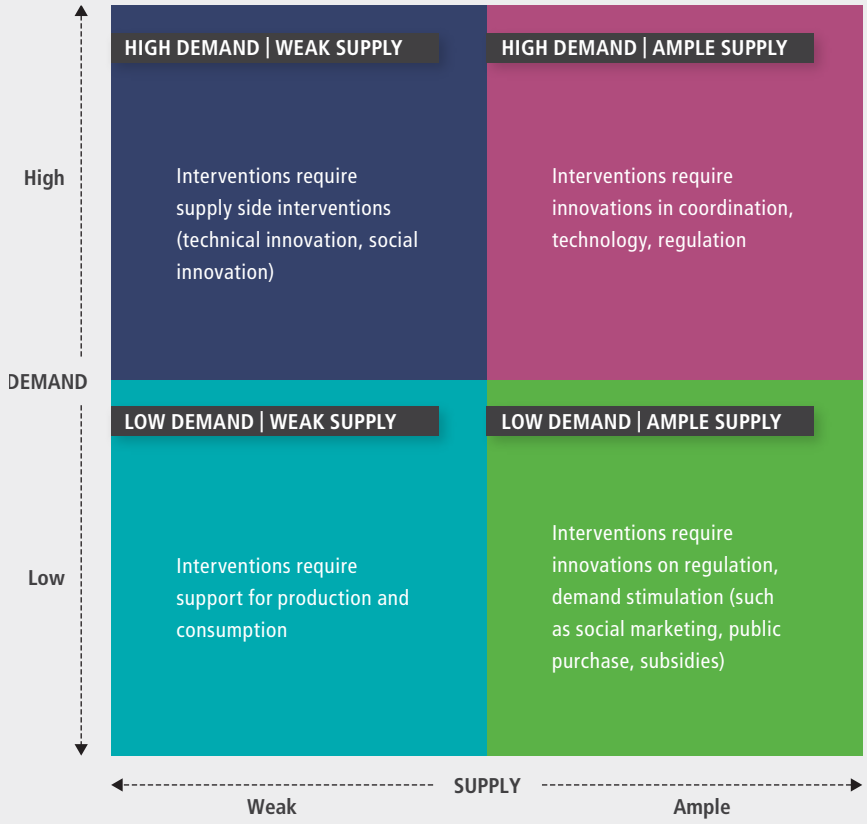
When both supply and demand for diverse foods are weak, intensive investments will be required on both the production and consumption sides (Figure 2, bottom left quadrant). Introducing new types of nutritious foods can address this situation—interventions must both develop a stable source of supply and promote demand for the new food. The introduction of biofortified crops, such as orange sweet potato in the HarvestPlus Reaching End Users project, fits this description. Orange sweet potato was bred for high vitamin A levels to address a common micronutrient deficiency. The project integrated production, demand creation, and market improvements to stimulate production and consumption of the new crop. An impact evaluation of the project reported increased vitamin A intake among children in both Mozambique and Uganda. Fostering demand presented little difficulty because consumers enjoyed the taste of orange sweet potatoes; on the supply side, making planting material available to farmers was crucial to success.[15]

Interventions to change food demand

In some cases, nutritious foods are widely produced but are not consumed by the target populations, as a result of habits or relative costs (Figure 2, bottom right quadrant). Interventions should focus on changing consumption, health, and nutrition practices to address both undernutrition and overnutrition (obesity and overweight). Food transfers or public procurement programs, such as school meals, can directly create demand for nutritious food. Mass media or behavior change communication (BCC) can indirectly increase demand. In India, a partnership between PRADAN, a nongovernmental organization, and iKure, a social enterprise, is promoting vegetable and pulse consumption using a mix of seed provision and communication schemes. Pulses provide an important source of iron, and they offer a protein source that is relatively sustainable in environmental terms, with low carbon emissions and soil-degradation rates.

Malnutrition is often a product of unbalanced diets, including overconsumption of processed foods such as refined grains, sugars, and unhealthy fats, alongside underconsumption of fruits, vegetables, and whole grains. And so interventions should aim to reduce both supply and demand for highly processed foods. In institutional settings, such as schools and hospitals, setting nutrient- and food-based standards can improve diets. For private consumers, BCCs teaching targeted nutrition messages can decrease demand for low-nutrient foods.

FIGURE 2 Typology of value chain intervention contexts, based on the supply and demand of nutritious foods



Source: A. Gelli, C. Hawkes, J. Donovan, J. Harris, S. Allen, A. de Brauw, S. Henson, N. Johnson, J. Garrett, and D. Ryckembusch, *Value Chains and Nutrition: A Framework to Support the Identification, Design, and Evaluation of Interventions,* IFPRI Discussion Paper 1413 (Washington, DC: International Food Policy Research Institute, 2015).

Other means of addressing overnutrition include fiscal measures; in Mexico, for example, taxes imposed on soft drinks resulted in increased prices and decreased demand for soft drinks relative to water.[16]

BCCs can have a broad impact on health by combining the promotion of nutritional foods with education about healthy behaviors and care and feeding practices for infants and young children. For example, in the PRADAN/iKure project, health camps offer women information on dietary diversity, hygiene practices, and anemia, as well as time allocation and household decisionmaking roles. BCCs have proved effective in a homestead gardening program in Burkina Faso that was designed to reduce undernutrition.[17] However, there is no evidence yet that BCCs can reduce overnutrition or the pressure overconsumption may put on natural resources.

Interventions to enhance value chain organization and performance

Where both demand and supply exist for nutritious food, interventions should focus on optimizing the nutrient flow along the value chain (Figure 2, top right quadrant). Optimizing the value chain implies maximizing efficiency and minimizing waste in the existing chain while maintaining or enhancing the nutritional content of foods. For example, in Vietnam, distrust between milk producers and milk-collection agencies led to poor quality and low producer prices in the milk industry, because smallholder producers

generally did not expect fair payments from collection depots. As a result of an intervention offering third-party testing to smallholders, threat of regulation increased both milk quality and producer prices and reduced the amount of wasted milk.[18]

Providing quality assurance and improving regulatory frameworks are other fruitful supply-side interventions. Regulation of the private sector, when properly enforced, can benefit consumers' health.[19] Both nutritional fortification and regulations for food safety, for example, are often mandated by public policy and can be implemented on a large scale.

Other targeted interventions can enhance information flows along the chain. Better access to information can improve supply by increasing efficiency or boost demand by increasing consumers' knowledge of and willingness to pay for nutritious and safe foods. Success is more likely when these interventions are supported by government regulations but implemented with private sector participation. A school meal program in Chile, for example, improved tendering regulations for public procurement of foods in 1999, which reduced transaction costs and sparked private sector involvement. Meal quality, meal-service infrastructure, and labor conditions among food handlers all improved, and the promotion of a sustainable, local supply chain reduced the program's environmental footprint.[20]

DESIGNING BETTER VALUE CHAIN INTERVENTIONS

Research and practice are just beginning to explore the nexus of nutrition and sustainability. Achieving the SDGs will require that we move quickly to find interventions that will both improve nutrition and ensure sustainability. A number of challenges must be addressed, including filling knowledge gaps, managing trade-offs among goals, and engaging the private sector in support of improved diets and sustainability.

Filling knowledge gaps

As a first step, gaps in our knowledge about nutrition and sustainability interventions must be identified and addressed. Broadly speaking, there is still much to learn about how to improve agricultural productivity alongside diet quality and environmental sustainability.

On the production side, key questions concern the feasibility of targeting interventions toward the poorest smallholders and least formal enterprises along the value chain. For example, how can contracts between smallholders and crop buyers be profitable while promoting better nutrition and sustainability? How can credible, effective, and affordable means of certification for nutritional value and food safety be provided without excluding smallholders and the informal sector?

On the consumption side, research is needed on ways to stimulate the consumption of nutritious foods. How can the most vulnerable be assured access to more nutritious food? How can overconsumption, which has deleterious effects on both health and natural resources, be addressed? Current understanding of how diets respond to changes in prices, incomes, or opportunity costs is limited, especially for less developed countries. Data on dietary intakes provide a good starting point for planning and adopting a nutrition-sensitive value chain approach, but such data are expensive to collect and context specific to a small area. In addition, not enough is known about how consumers' attitudes and food practices evolve in response to better information about nutrition and healthy diets.

Designing feasible, cost-effective scaled-up strategies to promote improved nutrition and reduced environmental impacts will require further research and empirical evidence. For example, a pilot study in Kenya provided microfinance, irrigation, and agricultural training to encourage vegetable production in the dry season, in an effort to both improve the availability of nutritious foods and increase smallholders' resilience to environmental shocks.[21] The pilot showed that strong partnerships are essential for scaling up microfinance.

Managing trade-offs

Goals for nutrition, sustainability, and economic development will not always be complementary; to meet multiple goals, interventions will need to manage trade-offs and constraints. Support for diversifying and increasing the output of nutritious foods must take account of the limits of land and water

inputs, as well as any potential risks from climate change. Economic incentives may lead smallholders to produce crops that are profitable in the short term, without considering nutritional value or long-term sustainability.[22] To overcome this constraint, interventions could prioritize development of reliable marketing channels for nutritious, sustainable smallholder products. Seasonality may be an important constraint as well. Many smallholders are net buyers for part of the year, so they are affected by both consumer and producer prices—meaning that any interventions that affect prices can have both positive and negative effects for this population.

Win-win outcomes for smallholders and consumers may be possible but are far from certain, and the trade-offs require careful, context-specific analysis. For example, targeting consumers to improve nutrition outcomes may not be cost-efficient or compatible with sourcing from smallholders in a sustainable way, at least in the short term. However, clearly identifying the costs and effects of interventions may justify commitment of additional resources for pro-smallholder engagement or provide insights on longer-term solutions, such as partnerships with smallholders to increase sustainability.

Time allocation trade-offs must also be taken into account. Processing food, for example, may provide new, more nutritional products that are easier to prepare, which would potentially save time for women and, if the nutritional products also require less cooking, also reduce fuel use. Such products could still have environmental costs, however, if, for example, the required processing is water intensive. Careful examination of these trade-offs is a priority for future research.

Engaging the private sector

Value chain interventions for improved nutrition and sustainability must engage a range of stakeholders, including the private sector. Private actors in food value chains range from vertically integrated multinational corporations to individuals who transport, store, aggregate, or sell food. While the private sector can be engaged to support goals of improved nutrition or sustainability, such interventions are most likely to be successful if profit incentives are aligned with the desired goals. Policymakers should engage with the private sector to find ways to align public and private objectives related to nutrition and sustainability.

Several efforts are currently underway that involve the private sector in interventions designed to provide economic benefits and increase access to sustainable and nutritious diets. For example, in 2014, the PepsiCo Foundation announced a five-year, US$5 million grant to the Inter-American Development Bank to launch the Sustained Program to Improve Nutrition (SPOON). This program is designed to prevent undernutrition and reduce the risk of obesity among infants in poor areas of Colombia, Guatemala, and Mexico. It focuses on improving infant-feeding practices and promoting the use of a nutritional supplement. A behavior change strategy will encourage healthy feeding habits.[23]

A VALUABLE FRAMEWORK

With the SDGs set for 2030, comprehensive strategies are needed to identify win-win scenarios to reach economic and nutritional goals while ensuring the long-term sustainability of the world's food systems. Value chains provide a unique framework to support strategic evaluation of the opportunities for and constraints to improving diets, and to identify the trade-offs and complementarities among the goals of higher incomes, better nutrition, and improved sustainability.

Diverse interventions are underway using value chains to address specific dietary goals. The knowledge generated by these interventions should lead to more sustainable and lasting solutions for improved nutrition. But further research is required to address the twin challenges of sustainability and better nutrition. How do diets respond to interventions at various points in the value chain, from producer to consumer, and across a variety of contexts and countries? What are the constraints along the value chain to improved nutrition and sustainability? Where must trade-offs be made among major goals? And where are the opportunities for rapid improvements? Value chain analysis can help answer these questions and provide a valuable framework to improve both nutrition outcomes and the sustainability of global diets. ■

GREEN ENERGY

Fueling the Path to Food Security

Channing Arndt, Siwa Msangi, and James Thurlow

SUMMARY Energy is vital to the global food system and food security, but countries will need to explore greener energy paths to address climate change. Opportunities for achieving both green energy and food security goals include solar and hydropower in Africa, biofuels in poor countries, and energy-saving cookstoves.

Two major events in 2015 have placed green energy and food security at the forefront of the global development agenda. In September, governments from across the world adopted the 17 Sustainable Development Goals (SDGs), which, among other things, aim to reduce hunger and food insecurity (SDG 2), and to ensure access to sustainable, reliable modern energy for all (SDG 7). In December, at the 21st Conference of the Parties (COP21), governments negotiated a global agreement to tackle climate change. Countries pledged to progressively reduce their future contributions to global greenhouse gas (GHG) emissions.

Achieving universal food security and energy access while switching to greener energy sources will be a tremendous challenge. The United Nations estimates that there are still 795 million undernourished people in the world.[1] The International Energy Agency (IEA) estimates that one-fifth of the world's population lacks access to electricity, and that two-fifths still burn traditional biomass, such as wood, for heating and cooking.[2] Beyond these challenges, even if all countries meet their commitments under the new climate agreement, food systems may still be threatened by rising global temperatures.[3] Exploiting synergies between the development and climate goals will be crucial to success.

To better understand these synergies, this chapter reviews energy's role in the global food system and outlines the scale of effort needed to chart a greener energy path for developing countries. Major potential synergies between global energy and food security goals are identified, including promising opportunities

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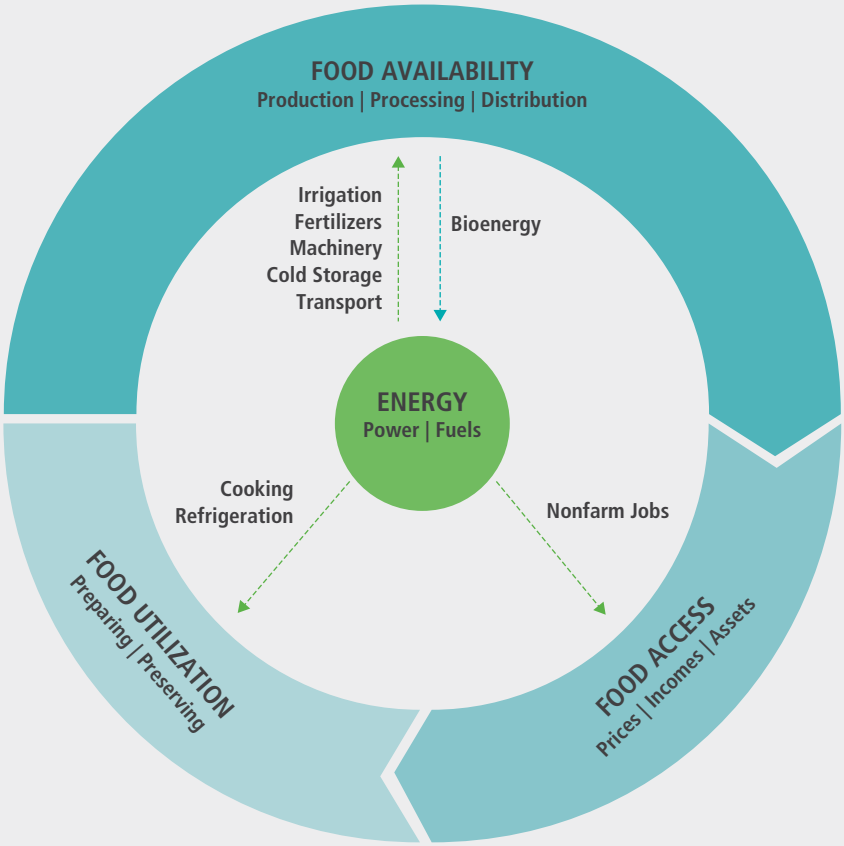
FIGURE 1 Energy's links to food security



Source: Authors.

in South Asia and Africa south of the Sahara, where two-thirds of the world's undernourished people live and where access to modern energy is extremely limited. Taking advantage of such opportunities will require both long-term investments and more immediate policy action.

LINKING GREEN ENERGY AND FOOD SECURITY GOALS

Energy and food security are closely interlinked (Figure 1). Energy is used throughout the food system—in production of crops, livestock, and fish; in processing, storage, and distribution of food products; and in preparation and preservation of food within households. Some uses are readily apparent—petroleum is used to run tractors, boats, and trucks; electricity powers irrigation schemes and cold storage facilities. Other energy uses are embodied within agricultural inputs, such as natural gas used to produce chemical fertilizers and pesticides. The Food and Agriculture Organization of the United Nations (FAO) estimates that in total, the global food system consumes about one-third of the world's available energy, with only about 25 percent of this energy consumption devoted to food production; the remainder is used downstream in processing, storage, transport, and preparation.[4] Agriculture is also a supplier of energy, for example, when households burn wood and other biomass for cooking

or when farmland is used to grow crops for biofuel production.

Achieving global food security requires more energy and greater efficiency

Global demand for food will rise as the world's population grows and becomes more affluent. To prevent an increase in food prices and food insecurity from accompanying this growth, global food production will have to increase by about 70 percent by 2050, according to projections from the International Food Policy Research Institute (IFPRI) and FAO. A 70 percent increase will require substantial investments in technologies and infrastructure to raise farm productivity.[5] Asia's Green Revolution provides an indication of what is needed to achieve these productivity gains. Much of Asia's success in raising crop yields resulted from adoption of modern seed varieties. However, it also involved greater use of chemical fertilizers, irrigation, and machinery, all of which use more energy than traditional farming—as a result, the Green Revolution greatly increased the energy intensity of Asia's food system (that is, the amount of energy used per hectare or per unit of food). Demand for energy will continue to rise as Asia develops into a high-income region.

Today, food systems in high-income countries use five times more energy per person than food systems in low- and middle-income countries.[6] A simple extrapolation from the global food system's current energy use suggests that feeding a population of 9.6 billion people in 2050 will require a 20 percent increase over the world's current energy supply. This projection assumes "business as usual," so it may overstate future energy demand growth. Under the new climate agreement, fossil fuel use may be constrained by policy, which may lead to greater reliance on more expensive alternatives. But even if the climate agreement fails, the IEA predicts a long-term upward trend in fossil fuel prices.[7] Global food systems will therefore face incentives to become more energy efficient.

Improving energy efficiency in the food system can also help stabilize food security. Food stability means that households have adequate access to food *on a continuous basis*. An increase in global energy prices, for example, was one of the main drivers behind the sharp rise in food prices in 2008, which reduced households' access to affordable food and worsened food insecurity in the years that followed.[8] Conversely, the decline in energy prices in 2015 has lowered food prices, which should benefit net food consumers—generally urban residents and poorer farmers.[9] However, while lower food prices may benefit the poor today, fluctuations in global food prices may reduce incentives for productivity-enhancing investments along the food chain. Improving the energy efficiency of food systems is therefore an essential step toward ensuring long-term food security.

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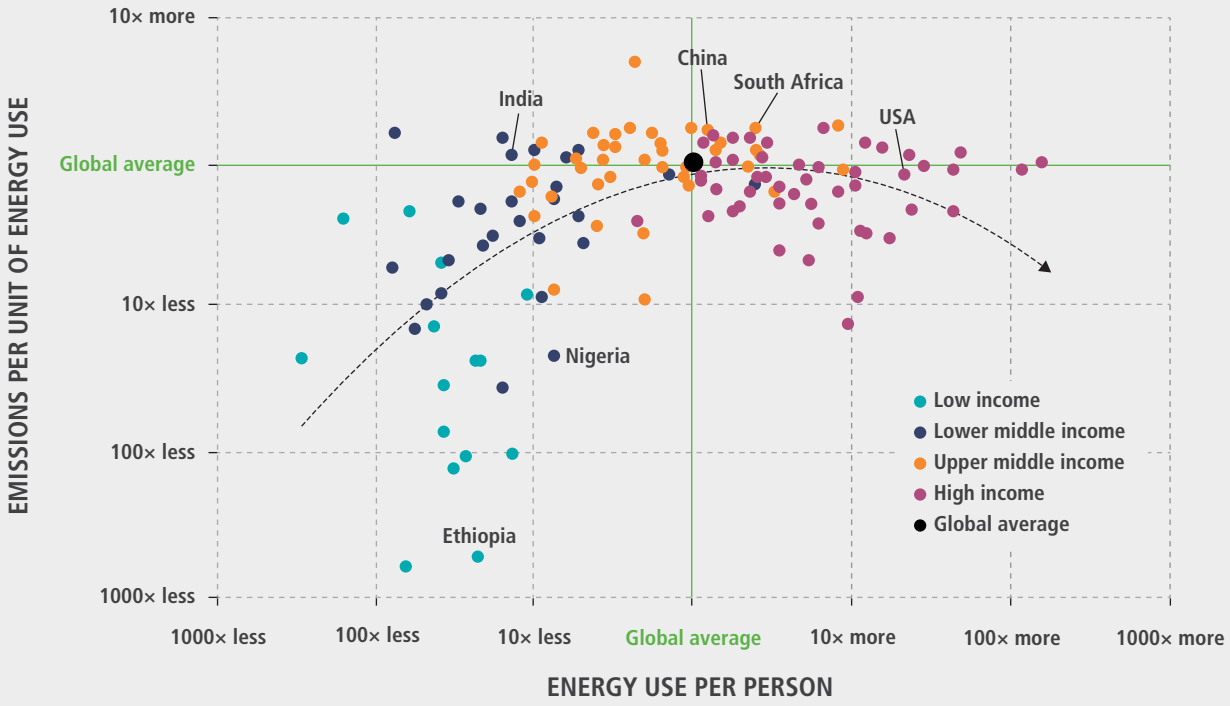
Reducing emissions despite rising energy demand is a daunting task

The global food system is not the main source of rising energy demand. The Organisation for Economic Co-operation and Development (OECD) predicts that the global economy will be 4 times larger in 2050 than it is today, implying far more rapid expansion outside of the food system.[10] Economic growth has long been synonymous with rising energy demand. People living in low-income countries consume 5 times less energy than the average person in the world, and 10 times less than the average person living in high-income countries (Figure 2). As poor countries develop, they will account for a disproportionate share of the increase in global energy demand. Therefore, while improving energy efficiency is essential—both in the food system and elsewhere—greater efficiency is unlikely to prevent energy demand from rising in the future.

FIGURE 2 Energy use rises with development, and emissions intensity eventually falls



Source: Authors' calculations using the World Bank's World Development Indicators data for 2011 (accessed in October 2015).

Note: Both the *x*-axis and *y*-axis show the natural log of the ratio of each country's energy or emissions to the global average. The figure is based on the 132 countries where data are available. Trend line is a fitted polynomial.

High-income countries not only use more energy per person than low-income countries, but they also generate three times more GHG emissions per unit of energy, which is referred to as the "emissions intensity" of energy use (Figure 2). The emissions intensity of energy use tends to rise as poor countries move toward upper-middle-income status; it then falls as countries develop further. This decline in emissions intensity is not rapid enough to offset the increased emissions from rising energy demand—average emissions per person in high-income countries is still twice that in upper-middle-income countries. If poor countries today were to replicate the energy trajectory of developed countries, the accumulation of GHGs in the atmosphere would reach levels associated with severe climate change by the latter half of the 21st century.[11]

Reducing emissions is important for global food security

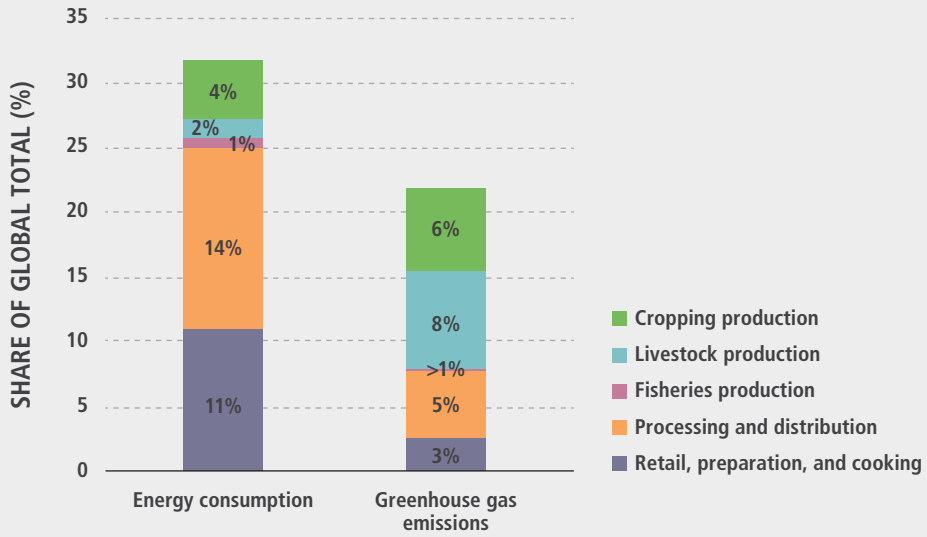
Time will shape the impacts of climate change on the global food system. Plausible projections suggest that by 2050 climate change will cause agricultural productivity growth to slow, particularly in poor countries where food insecurity is already a major concern.[12] IFPRI estimates that damage to agricultural production from climate change will mean a slower rate of reduction in malnourishment—leaving 10 percent more malnourished children in developing countries by 2050 (in comparison with a scenario without climate change).[13] Research also indicates that the entire food system may be vulnerable. Recent country studies from Africa suggest that the indirect effects of climate change—notably, damage to rural road

networks—may have a greater impact on welfare than direct harm to agricultural production.[14] In general, from now until 2050, climate change is expected to slow but not reverse current progress toward achieving global food security.

If GHG emissions grow unchecked beyond 2050, however, temperature increases and other associated impacts are expected to be well outside of historical experience, with deeply uncertain and potentially profoundly negative implications for both the environment and human welfare. Poor people in poor countries would likely be among the first to suffer. Demand for energy to maintain necessary refrigeration, climate-control of food storage, and handling facilities (such as the "cold chain" in the dairy or meat sector or low-humidity cereal storage) will increase with rising temperatures. Failure to meet these rising energy needs would have serious implications for food safety, human health, and the viability of those sectors. Avoiding severe climate change is highly desirable and may require mitigation policies that are more ambitious than those offered by the new climate agreement.

Of course the food system is not only on the receiving end of climate change. It is also a major emitter of GHGs and will need to play its part in reducing future emissions. The FAO estimates that the global food system still generates one-fifth of the world's GHG emissions (Figure 3). Two-thirds of these emissions come from the production of crops, livestock, and fish. However, only about half of these *on-farm* emissions are from energy use—the rest are methane from rice paddies and ruminant livestock. Adopting green energy sources can therefore reduce only part of the food systems' emissions. However, there are opportunities to reduce *off-farm* emissions. Consistent with the high share of energy use downstream from the farm discussed above, the FAO estimates that more than half of food system emissions in high-income countries are attributable to the energy used during food processing, distribution, and preparation. In contrast, only a quarter of food system emissions in lower-income countries are off-farm. With greener energy sources, emissions from food systems in poor countries can be substantially contained even as these systems are transformed and modernized.

FIGURE 3 The food system's contribution to total global energy consumption and greenhouse gas emissions



Source: Adapted from FAO (Food and Agriculture Organization of the United Nations), *"Energy Smart" Food for People and Climate* (Rome: 2011).

Modest progress has been made toward greener energy

Can poor countries chart a greener path to meeting their future energy needs while also improving food security? Based on global progress, it would appear that they can. Renewable energy technologies accounted for almost half of the world's newly installed electricity generation capacity over the last two years.[15] In addition, various countries, including India and Indonesia, have used lower oil prices as an opportunity to reduce fuel subsidies. For these and other reasons, including an economic slowdown in China, the relationship between global economic growth and emissions growth has weakened for the first time in at least four decades.

Most of the recent expansion in renewable energy has occurred in Europe and East Asia. Not surprisingly, the lowest-income and most food-insecure regions of South Asia and Africa south of the Sahara have not been leading the global transition to green energy sources. The degree and timing of engagement in an energy transition presents difficult choices for policymakers in poor countries. Clearly, poor countries do not wish to compromise their development prospects, especially their food security. However, a stabilized climate requires very low or even negative net emissions globally, which implies eventual global participation in any effective mitigation regime. Fortunately, low-income countries are often well endowed with sun, wind, and hydropower resources, opening the possibility for substantial synergies between green energy and food security. There are other green energy opportunities, such as nuclear power, but their potential contribution to reducing global food insecurity is less certain. Below, we identify three major opportunities for exploiting greener energy sources while also significantly addressing global food insecurity.

> The degree and timing of engagement in energy transition presents difficult choices for policymakers in poor countries. Fortunately, low-income countries are often well endowed with sun, wind, and hydropower resources.

PROMISING OPPORTUNITIES

Solar power and hydropower in Africa

Undernourishment is most prevalent in Africa, and unlike in the rest of the world, the number of undernourished Africans has risen since 1990.[16] Africa is also the region where access to modern energy is most lacking. More than 600 million Africans live without access to electricity, and even those with access must contend with high energy prices and an unreliable supply.[17] To complicate matters further, Africa's population is expected to double to 2.5 billion people by 2050, and its economy will be, by conservative estimates, four times larger than today's.[18] The task of feeding and fueling Africa's population and contributing to its economic growth would be enormous even in the absence of climate change. As it is, Africa must accomplish this task while both coping with the global warming already built into the climate system and aiming for a transition to green energy sources.

That transition may come soon, because renewable energy options are plentiful in Africa and could provide the power needed to transform its food system. Hydropower is already the main source of electricity in the region, but there is huge potential for expansion. The IEA estimates that if fully exploited, hydropower could supply three times more electricity than is currently available in Africa, and at a lower cost than any other technology.[19] Importantly, most of the unexploited potential lies in Central and East Africa, where undernourishment is highest and energy access is lowest.

Of course, hydropower is not without its own challenges. It is vulnerable to seasonal and long-term climate change and raises concerns about environmental damage. While some dams could provide water for irrigated agriculture, they may also flood farms and displace communities. And while hydropower is a viable option for bulk electricity supply, it

will need to compete against Africa's massive fossil fuel reserves, which are expected to last for centuries at current extraction rates. Nevertheless, if these challenges are managed, hydropower in Africa is perhaps the single largest opportunity to promote both green energy and global food security.

Even with hydropower, connecting everyone to national electricity grids will be difficult. One-quarter of all Africans—mostly those in remote and food-insecure rural areas—will still be off-grid by 2040, largely because the relatively low population density in Africa makes infrastructure development a challenge in terms of connecting people to roads, water, or electricity.[20] Africa's renewable energy resources provide a possible solution, however. Although solar power is not yet a cost-competitive option for bulk electricity supply, recent research suggests that mini-grid solar (photovoltaic) power may already be the lowest-cost technology option for as many as 55 million people in rural Africa.[21] This number, estimated more than five years ago, has likely grown as solar technologies have improved and costs have declined by a factor of two or more.[22]

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Biofuels production in poor countries

Greening transport systems is a high priority, not least because food distribution via those transport systems becomes a larger component of the food chain as countries develop. Biofuels offer one means of reducing transport's fossil fuel use. In fact, the IEA considers biofuels (and to a lesser extent, electric vehicles) the main means of reducing transport emissions, at least through 2040.[23] Despite dropping prices for fossil fuels, global demand for biofuels is expected to continue to increase, driven by mandates in major economies including the European Union (EU) and the United States. Biofuels will almost inevitably be an integral part of the global response to climate change.

Biofuels are often treated with suspicion by people concerned about global food security. As mentioned, rising demand for biofuels in developed countries was likely a contributing factor to the sharp rise in world food prices in 2008. Climate scientists are also concerned that clearing land to make way for biofuel crops could contribute to GHG emissions. The overlap between biofuel production, emissions reductions, and food security may therefore be a negative one. This concern has prompted numerous responses. The EU imposes strict "sustainability criteria" on imported biofuels to ensure a net reduction in emissions. In the United States, the state of California has adopted a low-carbon fuel standard as an incentive for reducing the carbon intensity of the overall fuel pool, which has been proposed as a replacement for or supplement to the national Renewable Fuel Standard. The current national standard favors corn-based ethanol, with few incentives to reduce emissions outside the transport sector.[24]

Despite these concerns, biofuels may offer an opportunity to improve food security. Most research focuses on how biofuel policies and production in developed countries (and Brazil) affect food imports and prices in developing countries.[25] Yet, for many poorer countries in Africa and elsewhere, biofuels may be better viewed as a potential export or as a means for reducing fossil fuel imports. A growing body of research suggests that producing conventional biofuels in low-income countries could raise rural incomes beyond what is required to offset rising food prices.[26] Studies in Ethiopia also found that farmers' participation in biofuel programs encouraged greater use of fertilizers and improved farming technologies, leading to higher food-crop productivity and better food security during the year.[27] One precondition for success, however, was farmers' access to high-quality, productive biofuel crops. Efforts to promote Jatropha as a biofuel crop in many parts of Africa, for example, have failed due to the use of low-yielding varieties and inadequate extension services.[28]

In summary, experience indicates that when poorly structured, biofuel policies in developing countries lead to negative outcomes for both the environment and food security. However, with properly structured and applied policies, biofuels have potential to contribute simultaneously to goals related to the environment, energy accessibility, and food security. More research is needed to determine when and where biofuels can be a positive force in low-income countries.

Improved cookstoves and better sourcing of biomass

Burning biomass for cooking accounts for almost half of the energy used by food systems in developing countries.[29] Not only is this form of cooking inefficient and unhealthy, but it is also a major source of GHG emissions. Using more energy-efficient cookstoves would lower emissions, either by reducing the amount of biomass burned or, better yet, by substituting cleaner fuels such as natural gas for biomass. Tackling climate change will require major expansion of the use of efficient cookstoves. One of the IEA's more ambitious climate change mitigation scenarios includes 1.6 billion people gaining access to their first clean cookstove.[30] Such cookstoves can lower emissions, improve health outcomes, and reduce the time households spend collecting firewood, thus possibly raising households' agricultural productivity and incomes.

> “Using more energy-efficient cookstoves would lower emissions, improve health, and possibly raise incomes.

Equally important is access to better-quality biomass. Scavenging for receding fuelwood sources is not a sustainable pattern of energy use, and charcoal use cannot simply be wished away. Although a number of countries are trying to outlaw charcoal production, urban households will continue to use charcoal even if connected to electricity grids, due to unreliable service. Pushing for higher-productivity, agroforestry-based methods of producing biomass quickly and making the conversion of biomass more efficient will avoid GHG emissions (and lost carbon sequestration) from deforestation. It will also reduce the long distances that women and children must travel to find energy for their households.[31]

The link between improved cookstoves and food security is somewhat indirect, and more research is needed to confirm the time benefits and income gains from using these stoves. Research is also needed to identify those cookstove technologies that are both economically viable and most effective at improving health outcomes. However, the sheer magnitude of the problem and its possible solution could make this one of the largest synergies between green energy and global food security.

NOW IS THE TIME TO ACT

Achieving universal food security and access to modern energy is an enormous challenge, further complicated by climate change and the need to transition to greener energy sources. In the coming decades, more energy will be needed to support food system transformation in developing countries, particularly within the world's poorest regions. Unfortunately, these are also the regions where energy supply is most lacking and energy distribution systems are ill-equipped to reach many of those in need, namely the rural poor. Exploiting synergies between the SDGs and the global climate agreement will be essential if both goals are to be achieved within their established time frames.

There are three areas where we see potential. First, Africa is home to most of the world's undernourished people and to an immense renewable energy resource base; there is huge potential to harness low-cost hydropower and reach more remote rural populations using solar power. Second, rising global demand for biofuels provides an opportunity for low-income countries to reduce their dependence on fossil fuels while also raising rural incomes. More research is needed on how to minimize emissions from land-use change and prevent adverse effects on food production and prices. Finally, the developing

world burns a lot of biomass for cooking, which results in one of the largest sources of global GHG emissions. If new cookstoves lead to even modest improvements in fuel efficiency, this improvement would go a long way toward reducing poor countries' food system emissions.

To take advantage of these opportunities, governments in developing countries need financial support and technology transfers, largely from developed countries. The COP21 climate agreement promises to provide at least some of these resources, but major infrastructure investments take time. Countries must also search for more immediate policy actions to promote energy efficiency and reduce emissions in their food systems. Many of these actions are well known, such as reducing fossil fuel subsidies and reducing food loss and waste. Now is the time to act on the many potential synergies between global efforts to promote green energy and food security. ■


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SHIFTING DIETS

Toward a Sustainable Food Future

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SUMMARY A global convergence toward Western-style diets that are high in calories, protein, and animal-based foods poses challenges for food security and sustainability. To quantify the benefits of shifting these consumers to more sustainable diets, several possible diet shifts are modeled. A framework is proposed to tackle the crucial question of how to shift people's diets through the retail and food services sector.

Demand for food is growing as a result of population growth and changing diets. As nations urbanize and citizens become wealthier, people generally increase their calorie intake and the share of resource-intensive foods—such as meats and dairy—in their diets.[2] Rapidly transforming food value chains are also contributing to diet changes, as multinational agribusinesses, food manufacturers, retailers, and food service companies increasingly influence what is grown and consumed worldwide.[3] Juxtaposed to these trends are roughly 800 million people who remain undernourished and 2 billion people suffering from micronutrient deficiencies.[4]

The world needs to close a 70 percent "food gap"—that is, the expected gap between the crop calories available in 2006 and expected calorie demand in 2050.[5] At the same time, the world needs to reduce agriculture's impact on land, water, and other resources as well as its contribution to climate change.[6] Relying solely on increased production to close this gap would exert pressure to clear additional natural ecosystems, making it hard to achieve the United Nations Sustainable Development Goals (SDGs), including long-term food security. For example, to increase food production by 70 percent while avoiding further expansion of agricultural land, crop yields would need to increase 33 percent faster between

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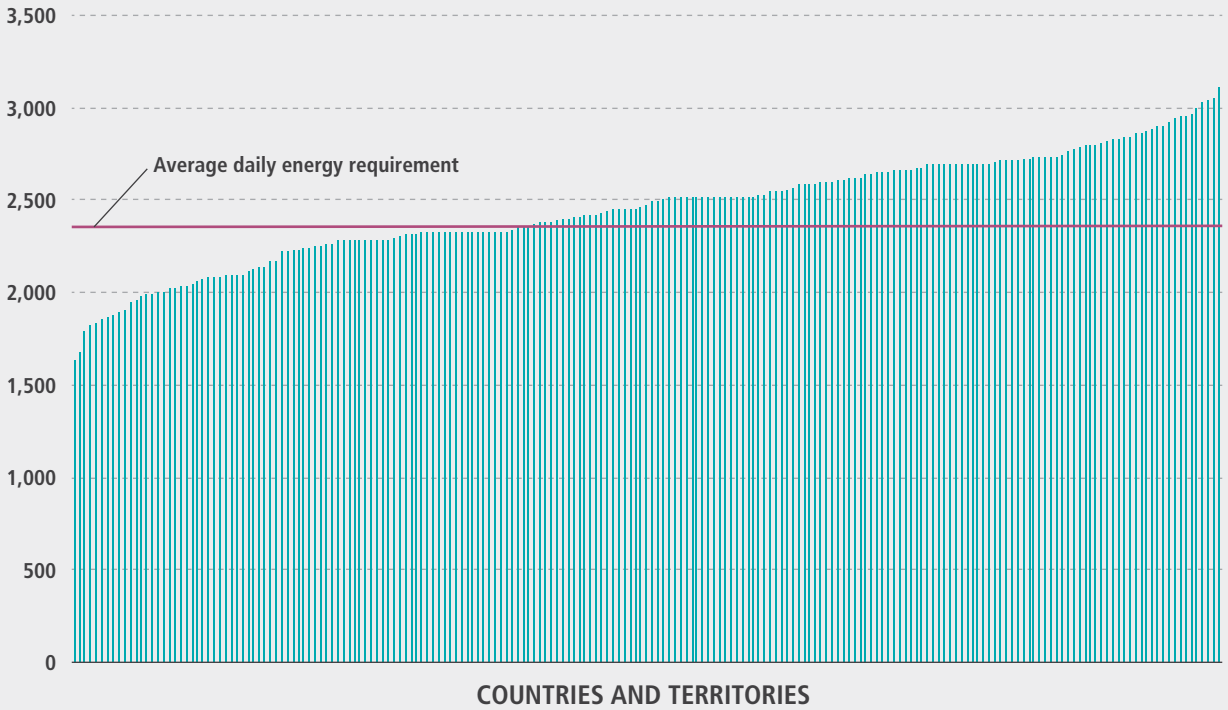
2006 and 2050 than they did in the previous four decades—a period that encompassed accelerated yield growth prompted by the Green Revolution.[7] In short, relying on yield increases alone will likely be insufficient. We must also explore shifts in food demand, including shifting diets, reducing food waste, and avoiding competition from bioenergy.

This chapter examines how shifting diets—the type, combination, and quantity of foods consumed—can help close the food gap sustainably. While the focus here is on calories and protein, diet shifts must also be implemented with an eye toward providing the full range of nutrients essential to a healthy diet.

THREE GLOBAL DIET TRENDS

Three current global diet trends increase the challenge of sustainably closing the food gap: (1) overconsumption of calories, (2) overconsumption of protein and a shift toward animal-based sources, and (3) growing demand for beef, in particular. The analysis below uses national-level food supply data from the Food and Agriculture Organization of the United Nations (FAO). It is important to note that the data mask differences in diets consumed by different population groups within countries—particularly between rural and urban areas and between high- and low-incomes—that must be taken into account in any effort to shift diets.[8]

FIGURE 1 Average daily per capita calorie consumption relative to average daily energy requirement (countries and territories, kcal/capita/day, 2009)



Source: GlobAgri model with source data from FAO, FAOSTAT (Rome: 2015), and FAO, *Global Food Losses and Food Waste—Extent, Causes, and Prevention,* (Rome: 2011).

Note: Each bar on the *x*-axis represents one of 205 countries and territories. Average daily energy requirement of 2,353 kcal/capita/day is given in FAO (2015). Individuals' energy requirements vary depending on age, sex, height, weight, pregnancy/lactation, and level of physical activity.

Overconsumption of calories

People overconsume calories when their calorie intake exceeds what they need for an active and healthy life. Overconsumption increases the size of the food gap and drives unnecessary agricultural impacts. It also contributes to overweight and obesity,[9] negatively affecting health and productivity.

Over the past five decades there has been a global trend toward greater per capita availability of calories. In 2009, average per capita calorie consumption in more than 60 percent of the world's countries and territories exceeded average daily energy requirements (Figure 1). Countries exceeding this calorie threshold, however, can still have large numbers of people below the threshold, especially populous countries in the process of urbanizing, such as China.[10] Globally, there are now two and a half times more overweight people than undernourished people. More than one in three adults is overweight and one in ten is obese.[11] The related economic and healthcare costs are formidable. Obesity's global economic cost alone was estimated to be around US$2 trillion in 2012, on par with armed conflict or smoking.[12]

While there are signs that per capita calorie availability may be peaking in developed countries, it is rising in developing countries, particularly in emerging economies, such as Brazil and China.[13] Once considered a problem of high-income countries, obesity and overweight are now rising in low- and middle-income countries too, especially in urban areas—although obesity is also on the rise in rural areas and among poor populations.[14]

Overconsumption of protein and a shift toward animal-based sources

People overconsume protein when their dietary protein intake exceeds the body's protein requirements for maintenance and growth. This increases the size of the food gap, agricultural resource use, and environmental impacts.

Global average per capita protein availability has been growing for decades.[15] In 2009, in all but 19 countries and territories, average per capita protein consumption was greater than estimated average daily requirements (Figure 2) (although, as noted above, countries will likely also have a significant percentage of their population below the protein consumption threshold).[16] In addition, the share of animal-based protein relative to plant-based protein is growing. Between 1961 and 2009, global average per capita availability of animal-based protein grew by 59 percent while that of plant-based protein grew by only 14 percent.[17]

> Overconsumption increases the size of the food gap, drives unnecessary agricultural impacts, and contributes to overweight and obesity. Once just a problem of high-income countires, overweight and obesity are on the rise in low- and middle-income countries.

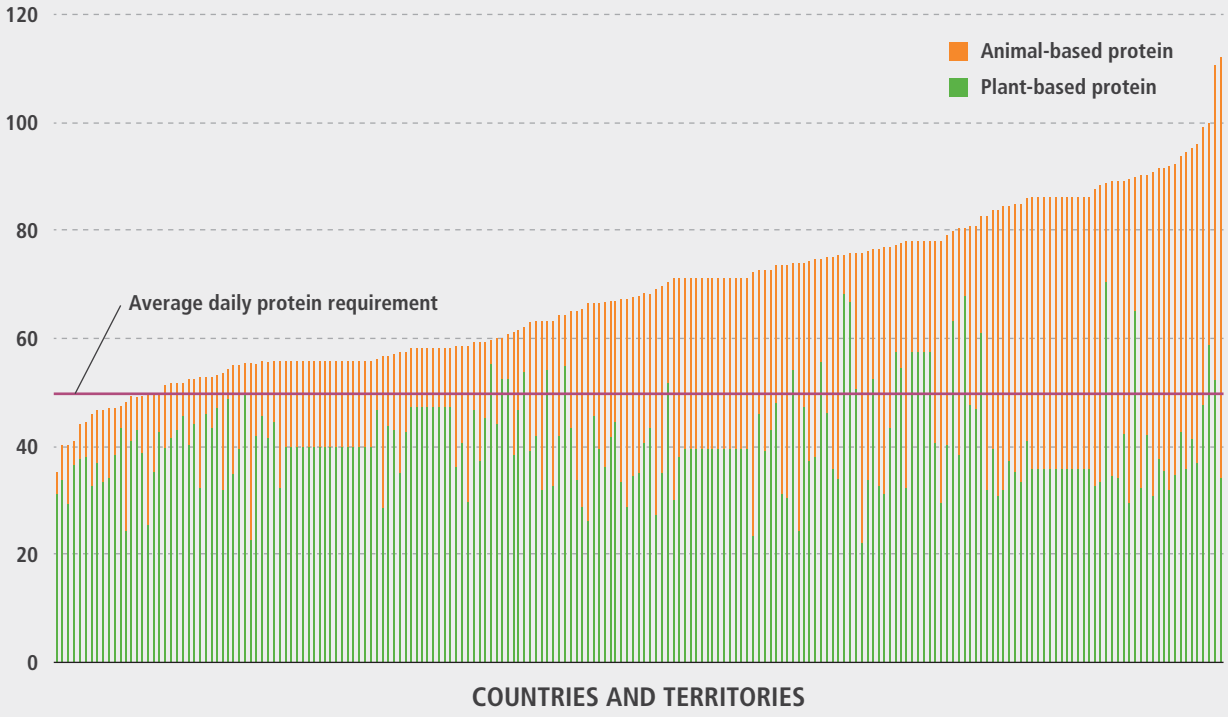
Animal-based protein production is typically more resource intensive and has greater environmental impacts than plant-based protein production (Figure 3). While the impacts shown in Figure 3 are global means—masking variations across locations, production systems, and farm management practices—they enable general comparisons across food types.

Looking ahead, total consumption of animal-based foods is projected to rise by nearly 80 percent between 2006 and 2050.[18] Although animal-based food consumption may be peaking in some developed countries, it is projected to rise in developing countries, especially in emerging economies and also urban areas.[19]

Rising beef consumption

Per capita beef consumption has been rising in emerging economies and showing signs of peaking in some developed countries. In Brazil, per capita beef availability has increased steadily over recent decades and is now more than three times the world average, having surpassed that of the United States

FIGURE 2 Average daily per capita protein consumption relative to average daily protein requirment (countries and territories, grams protein/capita/day, 2009)



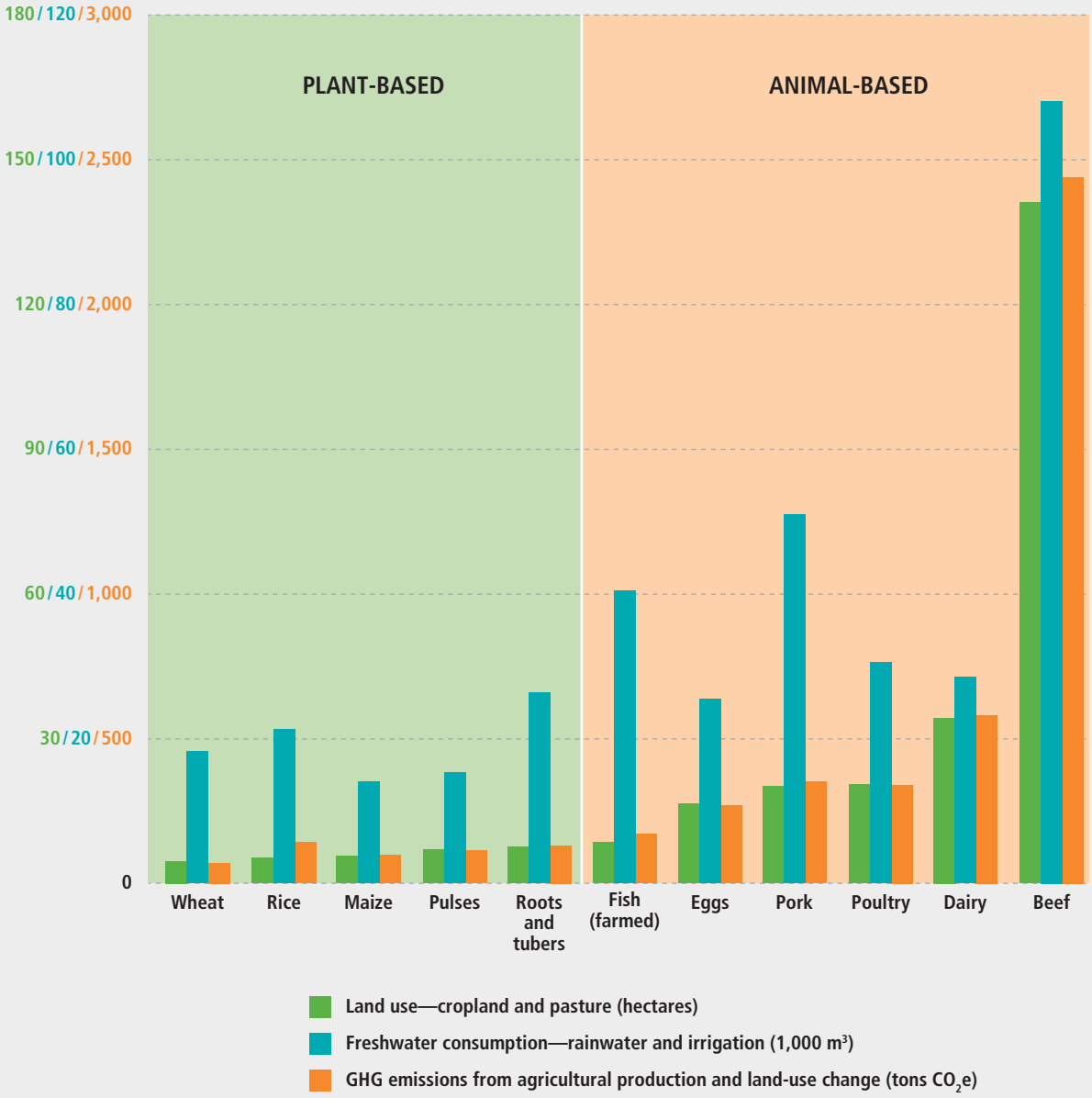
Source: GlobAgri model with source data from FAO, FAOSTAT (2015) and FAO, *Global Food Losses and Food Waste—Extent, Causes, and Prevention,* (Rome: 2011).

Note: Each bar on the *x*-axis represents one of 205 countries and territories. Average daily protein requirement of 50 grams/day is based on an average adult body weight of 62 kilograms (S. C. Walpole, D. Prieto-Merino, P. Edwards, J. Cleland, G. Stevens, and I. Roberts, "The Weight of Nations: an Estimation of Adult Human Biomass," *BMC Public Health* 12 [2012]) and recommended protein intake of 0.8 g/kg body weight/day (G. L. Paul, "Dietary Protein Requirements of Physically Active Individuals," *Sports Medicine* 8, 3 [1989]). Individuals' energy requirements vary depending on age, sex, height, weight, pregnancy/lactation, and level of physical activity.

in 2008. In China, per capita beef availability is still only half of the world average, but is growing. In India, growing demand for dairy products is spurring an expansion in the cattle population.[20] In the European Union, per capita beef availability declined by 29 percent between 1991 and 2011, and is expected to remain relatively stagnant to 2050. Global demand for beef is projected to increase by 95 percent between 2006 and 2050, with much of this growth occurring in countries where current per capita consumption is low, such as China and India.[21]

Beef has one of the lowest "feed-to-food" conversion efficiencies of commonly consumed foods. Only 1 percent of gross cattle feed energy and 4 percent of ingested protein are converted to human-edible calories and protein.[22] As a result, beef uses more land and freshwater, and generates more greenhouse gas (GHG) emissions per unit of protein than other commonly consumed food (Figure 3). One-quarter of the earth's land mass, excluding Antarctica, is used as pasture, and beef accounts for one-third of the global water footprint of farm animal production.[23] Ruminants (of which beef is the most commonly produced) are responsible for nearly half of GHG emissions from agricultural production.[24] Recognizing the potential environmental implications of demand growth, several international organizations and researchers have stated that reducing

FIGURE 3 Impact of production of animal- and plant-based foods, global (per ton of protein consumed, 2009)



Source: Authors' calculations. Land use and GHG emissions: GlobAgri model with source data from FAO, FAOSTAT (Rome: 2015), and FAO, *Global Food Losses and Food Waste—Extent, Causes, and Prevention* (Rome: 2011); freshwater consumption: M. M. Mekonnen and A. Y. Hoekstra, "A Global Assessment of the Water Footprint of Farm Animal Products," *Ecosystems* 15 (2012); and farmed freshwater fish consumption: R. Waite, M. Beveridge, R. Brummett, S. Castine, N. Chaiyawannakarn, S. Kaushik, R. Mungkung, S. Nawapakpilai, and M. Phillips, *Improving Productivity and Environmental Performance of Aquaculture* (Washington, DC: World Resources Institute, 2014).

Note: Data presented are global means. Indicators for animal-based foods include resources used to produce feed, including pastureland. Tons of harvested products were converted to quantities of calories and protein using the global average edible calorie and protein contents of food types as reported in FAO (2015). "Fish" refers to all aquatic animal products. Protein amounts refer to human consumption. Based on the approach taken by the European Union for estimating emissions from land-use change for biofuels, land-use change impacts are amortized over a period of 20 years and then shown as annual impacts. Land and GHG emissions estimates for beef production are based on dedicated beef production, not beef that is a coproduct of dairy. Dairy figures are lower in GlobAgri than some other models because GlobAgri assumes that beef produced by dairy systems displaces beef produced by dedicated beef production systems. Tons refers to metric tons.

the consumption of GHG-intensive food, particularly beef, is an important element in limiting global warming to 1.5 to 2 degrees Celsius above preindustrial levels.[25]

THREE PROPOSED DIET SHIFTS

Three potential diet shifts that could contribute to a sustainable food future were analyzed using the GlobAgri biophysical model, using a 2009 baseline, to estimate the impacts on agricultural land use and GHG emissions. These shifts target countries and populations that currently consume high amounts of calories, protein, or beef—or are projected to by 2050. They do not target undernourished people, nor do they seek to eliminate animal-based food consumption, recognizing that livestock production is an important source of livelihood and income. The economic effects of the various diet scenarios were not estimated; these would need to be carefully monitored and managed.

1. **Reduce overconsumption of calories.**

- **Eliminate obesity and halve overweight.** This scenario assumes that an obese person on average consumes 500 more calories per day than a person eating the average energy requirements, and that each overweight person on average consumes 250 more calories per day than the average energy requirements of people with sedentary lifestyles.[26] Calorie consumption is reduced proportionately across all foods eaten in each region to eliminate obesity and cut the number of overweight people in half.
- **Halve obesity and halve overweight.** With the same assumptions as the previous scenario, the numbers of obese and overweight people are both reduced by half.

2. **Reduce overconsumption of protein by reducing consumption of animal-based foods.**

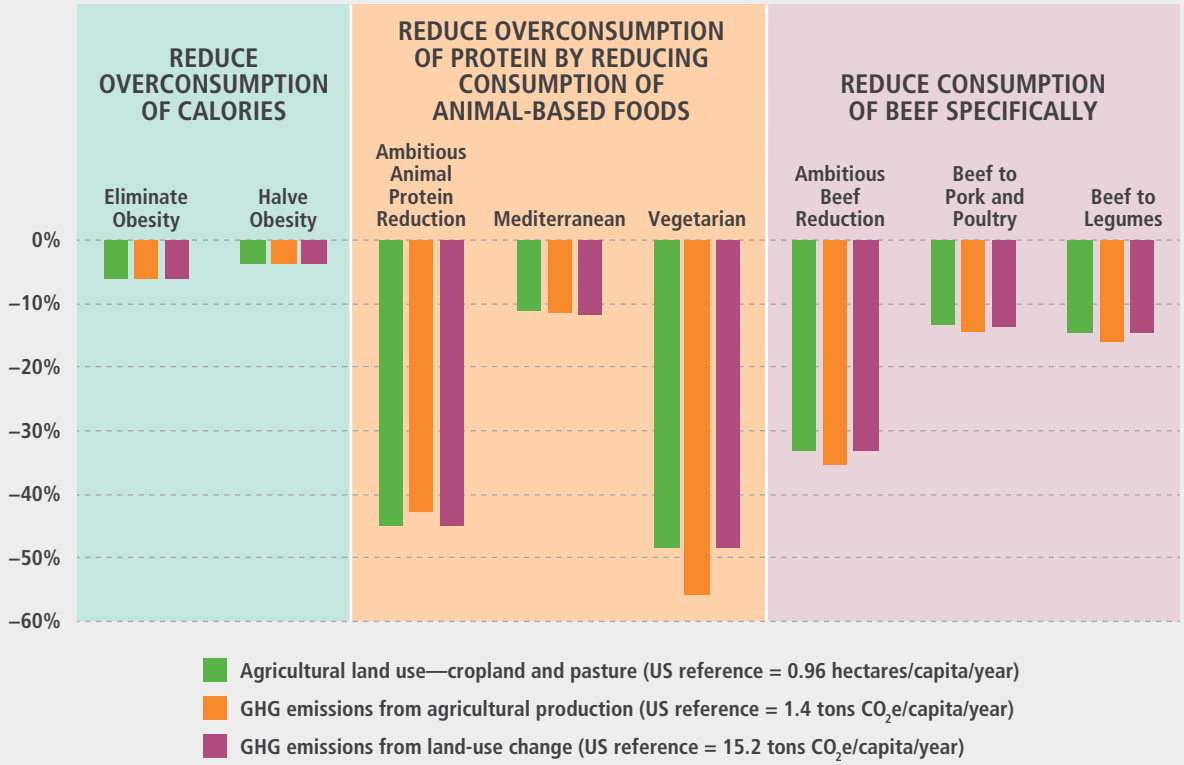
- **Ambitious animal protein reduction.** In regions that consumed more than 60 grams of protein per capita per day, diets were modified to reduce protein consumption to 60 grams per capita per day by reducing animal-based protein consumption proportionately across all sources of meat and milk. Globally, animal-based protein consumption was reduced by 17 percent.
- **Traditional Mediterranean diet.** In regions that consumed more than 40 grams of animal-based protein per capita per day, diets were shifted to the actual average diet of Spain and Greece in 1980, without lowering calorie intake.[27]
- **Vegetarian diet.** In regions that consumed more than 40 grams of animal-based protein per capita per day, diets were shifted to the actual vegetarian diet as observed in the United Kingdom between 1993 and 1999, without lowering calorie intake.[28]

3. **Reduce beef consumption specifically.**

- **Ambitious beef reduction.** In regions where daily per capita beef consumption was above the world average and calories consumed were above 2,500, beef consumption was reduced to the world average. Globally, beef consumption was reduced by 30 percent.
- **Shift from beef to pork and poultry.** In regions where daily per capita beef consumption was above the world average, beef consumption was reduced by one-third and replaced by pork and poultry, proportionate to the amounts consumed in each region, without lowering calorie intake.
- **Shift from beef to legumes.** In the same regions as the above scenario, beef consumption was reduced by one-third and replaced with increases in equal sizes of pulses and soy, without lowering calorie intake.

Figure 4 shows the effects of the three diet shifts on per capita agricultural land use and GHG emissions in one high-consuming country: the United States.[29] Adding one average American to the world population in 2009 would have resulted in nearly 1 additional hectare needed to produce food, an additional 1.4 tons of carbon dioxide equivalent (CO_2e) emitted from agricultural production, and 15.2 additional tons of CO_2e from converting that extra hectare of land to food production. Reductions in animal-based food consumption led to deep reductions in land use and GHG emissions associated with the average American diet, with reductions ranging from

FIGURE 4 Predicted per person land and GHG savings from applying the shifts to the average US diet (% change relative to 2009 reference year)



Source: GlobAgri model.

Note: Data are for the United States and Canada relative to 2009 reference year. Land use includes both cropland and pasture used to grow food and animal feed. Land-use change emissions are amortized over a period of 20 years and then shown as annual impacts. Calculations assume global average efficiencies (calories produced per hectare or per ton CO_2e) for all food types. GHG = greenhouse gas. Tons refers to metric tons.

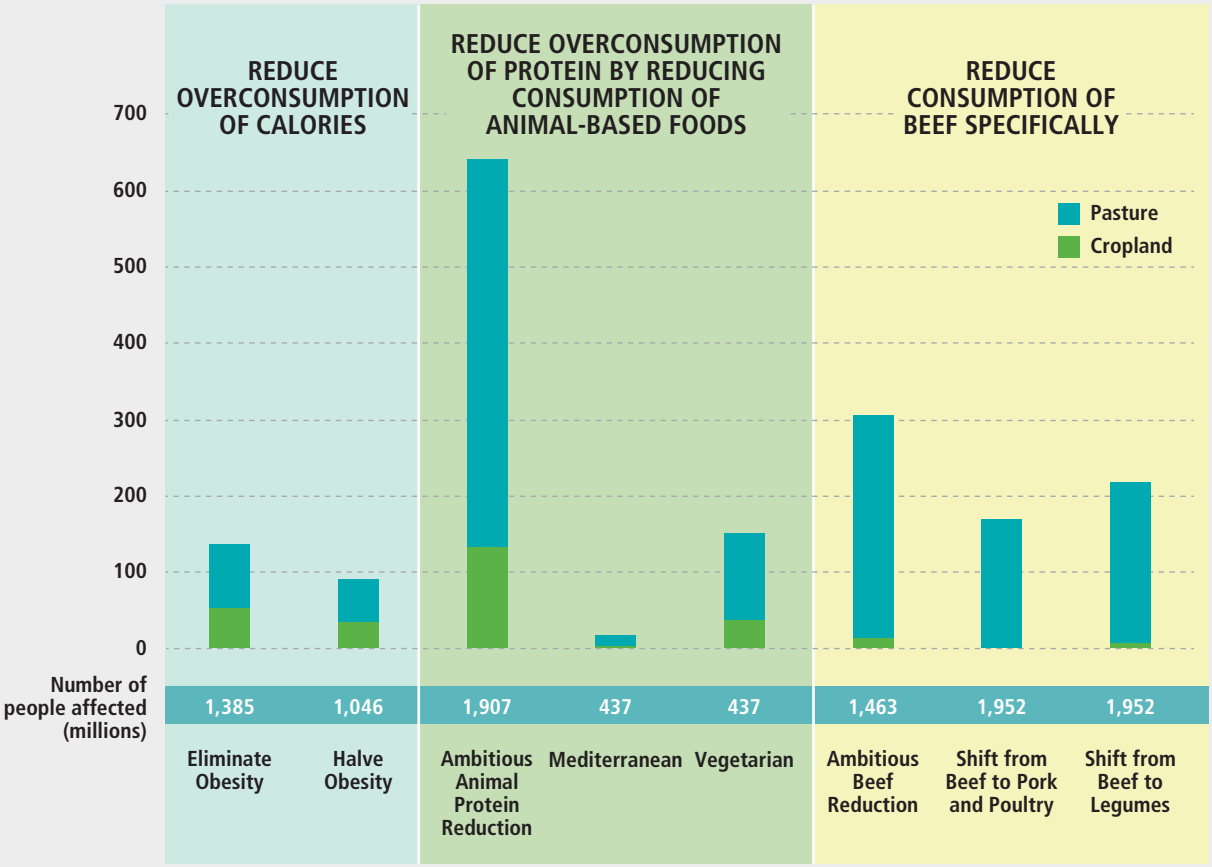
- 11–12 percent (*Traditional Mediterranean Diet* scenario);
- 13–16 percent (*Shift from Beef to Pork and Poultry* and *Shift from Beef to Legumes* scenarios);
- 33–35 percent (*Ambitious Beef Reduction* scenario); and
- 43–56 percent (*Ambitious Animal Protein Reduction* and *Vegetarian Diet* scenarios).

As a point of comparison, the land use and GHG emissions associated with the average American diet in 2009 were roughly twice those associated with the world average diet—suggesting that the *Ambitious Animal Protein Reduction* or *Vegetarian Diet* scenarios would bring the environmental impacts of the average American diet in line with the world average.

Figure 5 shows the global effects of the three diet shifts on agricultural land use. The shifts were applied to between 440 million and 2 billion people (between 6 percent and 29 percent of the world population), depending on the specific scenario and level of ambition. Because a wholesale shift by an entire region to a vegetarian diet or Mediterranean diet is very ambitious, we applied these scenarios to only half of the populations in the regions affected by those two scenarios (North America and Europe).

Assessing the amount of land "freed up" at the global level by reducing overconsumption by the

FIGURE 5 Predicted savings in agricultural land use from applying the shifts globally (millions of hectares saved relative to 2009 reference year)



Source: GlobAgri model.

Note: The *Shift from Beef to Pork and Poultry* scenario includes a 196 million hectare (Mha) decrease in pasture, but a 26 Mha increase in cropland, for an overall 170 Mha "savings."

world's wealthier countries makes it clear that these diet shifts could make a significant contribution to a sustainable food future. The *Traditional Mediterranean Diet* scenario spared around 20 million hectares of land, the two obesity reduction scenarios spared between 90 million and 140 million hectares of land, and the *Vegetarian Diet* scenario and three beef reduction scenarios spared between 150 million and 300 million hectares.

Moreover, under the *Ambitious Animal Protein Reduction* scenario—which affected the diets of nearly 2 billion people—500 million hectares of wetter (nonarid) grazing land were spared, along with 130 million hectares of cropland. This is a total quantity of land greater than the roughly 500 million hectares of agricultural expansion between 1961 and 2006.[30] It could potentially free up enough land to meet future food needs—including the growing demand for beef and dairy by those who currently consume little—without net agricultural expansion. Because the effects of food production on water use and GHG emissions roughly track the land effects across different food types (Figure 3), these scenarios can also be expected to generate significant

freshwater savings and emissions reductions at the global level.

In summary, our analysis yields the following insights about the three diet shifts:

- **Reduce overconsumption of calories.** While reducing overweight and obesity is important for human health, it contributes less to reducing agricultural resource use and environmental impacts than the two shifts that reduce consumption of animal-based foods.
- **Reduce overconsumption of protein by reducing consumption of animal-based foods.** This diet shift resulted in the largest benefits, including deep cuts in per capita land use and GHG emissions among high-consuming populations and dramatic reductions in agricultural land use—and associated GHG emissions—when applied at the global level.
- **Reduce beef consumption specifically.** The effects of this shift were larger than the obesity reduction scenarios, but smaller than the most ambitious scenario that reduced animal-based food consumption more broadly. Nevertheless, this shift is worth pursuing because of its relative ease of implementation and because it has historical precedent. In the United States and Europe, per capita beef availability has already fallen substantially from historical highs while availability of pork and chicken has increased.[31] As shown in Figure 5, when applied globally this shift could result in savings of up to 300 million hectares of wetter (nonarid) pasture land—close to the entire area of pasture expansion since 1961.[32]

The diet shifts would help close the gap between crop calories available in 2006 and expected demand in 2050. Based on the FAO's assumption that 25 percent of all crops (measured by calories) will be dedicated to animal feed by 2050,[33] we calculate that applying the *Ambitious Animal Protein Reduction* scenario to projected consumption patterns in 2050 could reduce the food gap from about 70 percent to 50 percent—thereby significantly reducing the challenge of sustainably feeding nearly 10 billion people by midcentury.[34] But with global trends overwhelmingly pointing to further increases in consumption and overconsumption, how can the tide be turned?

WHAT CAN BE DONE TO SHIFT DIETS?

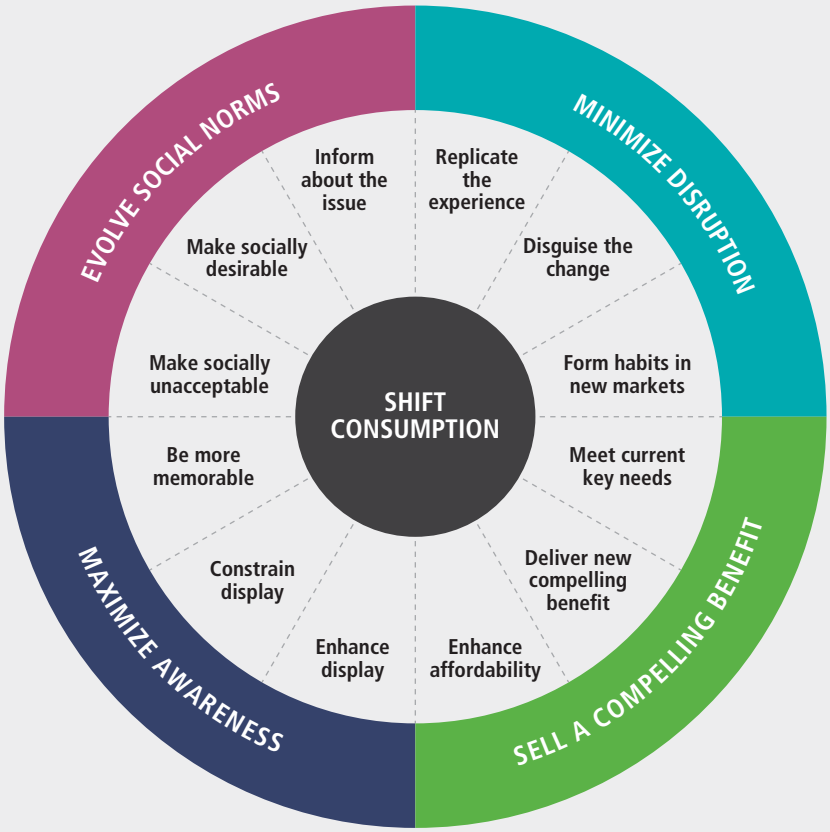
Efforts to encourage more sustainable eating have largely focused on consumer education and package labeling. These have had limited success influencing consumers, whose purchases are typically based on habit and subconscious mental processing rather than on rational, informed decisions.[35] In addition, attributes like price, taste, and quality tend to be more important than sustainability in purchasing decisions.[36]

Shifting diets requires strategies that work in step with how consumers make decisions and influence the factors that drive their food purchases. Given the growing influence of global food companies on consumer choices, it is important to engage companies in efforts to shift diets.[37] In 2000, supermarkets accounted for 70 to 80 percent of food retail sales in France and the United States.[38] Supermarkets are playing a growing role in developing countries today, increasing their share of food retail sales in East Asia, Latin America, urban China, South Africa, and Central Europe from an estimated 5–20 percent in 1980 to 50–60 percent in 2000.[39] At the same time, consumers are increasingly dining out. In the United States, expenditures on "food away from home" as a share of total food expenditures grew from 25 percent in 1954 to 50 percent in 2013.[40] In China, out-of-home food consumption grew more than 100-fold between 1978 and 2008.[41]

> Given the growing influence of global food companies on consumer choices, it is important to engage these companies in shifting consumers toward sustainable diets.

To help shift consumption, we developed the Shift Wheel framework (Figure 6), which is informed by consumption shifts successfully orchestrated in the fast-moving consumer goods sector. It comprises four complementary strategies:

FIGURE 6 The Shift Wheel framework for shifting consumption



Source: J. Ranganathan, D. Vennard, R. Waite, T. Searchinger, P. Dumas, and B. Lipinski, *Shifting Diets,* Installment 11 of *Creating a Sustainable Food Future* (Washington, DC: World Resources Institute, 2016).

- **Minimize disruption.** Changing food consumption behavior typically involves changing habits—a difficult task. This strategy seeks to minimize the disruption of the shift to consumers' existing habits by minimizing changes to a product's taste, look, texture, smell, packaging, and location within a store. For example, companies have created animal product substitutes from plant- or fungus-based proteins, replicating the familiar taste and texture of chicken, eggs, ground beef, and fish as closely as possible. Others have blended in new ingredients within current formats to help disguise the shift toward plant-based ingredients. Another approach is to replicate packaging formats and product placement; in the case of soy milk, a number of brands have launched packaging that looks similar to fresh milk, and have placed the product in retailers' chillers alongside fresh milk.
- **Sell a compelling benefit.** This strategy involves marketing a product attribute known to shape consumers' food purchases. It requires identifying and delivering product attributes that can stimulate a behavior change, such as health, affordability, taste, or product quality. For example, Birds Eye repositioned its pollock fish fingers as healthier "Omega 3 Fish Fingers" and, in doing so, helped shift a large proportion of sales away from codfish fingers to more sustainable pollock.[42] Similarly, a few countries have introduced

BOX 1 Could food taxes drive diet shifts?

Taxes intended to correct negative externalities (such as environmental pollution) associated with inefficient markets—known as Pigouvian taxes—impose a tax equal to the social cost of the externality. Although favored by some economists, these taxes can be politically difficult to implement because of opposition from the public and affected industries.[50]

Several jurisdictions—including Barbados, Chile, Denmark, Finland, France, Hungary, Mexico, and local governments in the United States—have established taxes on foods high in fat, salt, and sugar, citing health reasons.[51] However, the "fat tax" in Denmark was abolished after one year, in part because consumers were able to purchase the same products without a tax in nearby Germany.[52]

Food taxes could change purchasing choices. Reviews of the efforts either to tax unhealthy foods or to subsidize healthier foods, such as fruits and vegetables, indicate significant effects on consumption.[53] Although experience with food taxes is limited, evidence from modeling studies suggests potential for substantial reductions in specific targeted "undesirable" foods, such as sugary soft drinks. Models also suggest that taxes on undesirable foods work best when complemented by removal of taxes or provision of subsidies on "desirable" substitutes. Estimates of elasticities of consumption for various meats also suggest that a tax on beef, for example, could shift consumption to other meats.[54]

Studies on food taxes also highlight potential caveats. First, taxes imposed at the agricultural production level—such as a beef tax—may not work if production shifts to other countries.[55] Likewise, retail-level taxes may not be effective if consumers can shop abroad, as the Danish "fat tax" experience suggests. Finally, taxes may have to be high to substantially reduce consumption. One survey suggested that a 10 percent tax on meat would be needed to achieve just a 10 percent reduction in consumption.[56] Such high taxes could have unfair distributional consequences unless carefully managed.

taxes on unhealthy foods to make healthier foods comparatively more affordable (Box 1).

- **Maximize awareness.** The more consumers see or think of a product, the greater the likelihood they will consider purchasing it.[43] This strategy involves increasing the visibility of a product by enhancing its availability and display through memorable advertising. For example, a school cafeteria in Minnesota found that students waiting to pay for their lunch faced an array of grain-based snacks, chips, granola bars, and desserts near the cash register, leading to impulse purchases. Rather than simply removing these products, which would have reduced total sales, the cafeteria replaced them with fruits. As a result, fruit sales increased, snack food sales decreased, and total revenue did not significantly decrease.[44] In other cases, distribution and display of the less sustainable food is limited, curtailing consumption.

  Creating memorable advertising campaigns can increase the probability of a particular food's being purchased.[45] Coca-Cola, for example, is associated with the color red, its distinctive bottle shape, its logo script, and its ability to refresh on a hot day.[46] In the United States, agricultural commodity marketing programs have introduced memorable advertising campaigns, such as "Got Milk?" and "Beef: It's What's for Dinner." Memorable marketing programs for plant-based foods could help shift consumption. On the flip side, some countries are experimenting with limiting marketing of undesirable foods. Chile passed a law in 2012 that aims to limit children's exposure (through marketing and sales) to unhealthy foods.[47]

- **Evolve social norms.** What people eat is highly influenced by cultural and social norms. This strategy involves adapting or changing the underlying social and cultural norms by informing and educating consumers. For example, to reduce the consumption of shark fin in China—which nearly led to the extinction of several shark species—the conservation organization WildAid ran a series of public service announcements in

2006 on the devastating effects of shark fishing. The campaign featured high-profile celebrities, including basketball star Yao Ming, Olympic athletes, business executives, famous actors, and screenwriters, publicly declaring their opposition to shark fin soup and challenging its social acceptability. Building on the campaign, several prominent businessmen petitioned the National People's Congress to ban shark fin at government banquets. In response, China's State Council banned shark fin at official receptions in 2012. The Chinese Ministry of Commerce reported a 70 percent decline in shark fin sales during the 2012–2013 Spring Festival.[48]

Given the significant benefits of shifting diets, how might the Shift Wheel be applied to achieve this end? The first step would be to analyze the landscape of animal- and plant-based food consumption in a given geography or market: who the consumers are; what they are eating; and where, when, why, and how this consumption is occurring. This analysis would identify the most promising intervention points, which could be a specific occasion (for example, evening family meals); product format (for example, meatballs); social perception (for example, that plant-based protein is inferior to meat); demographic groups (for example, millennials); or specific outlets (for example, school or workplace cafeterias). The next step would involve designing approaches to achieve the chosen shift by drawing on relevant strategies from the Shift Wheel. The final steps would involve testing the selected approaches and scaling up successes.

> "Reducing overconsumption of food, especially resource-intensive food, could contribute significantly to a sustainable food future. A shift in diets could help close the food gap and reduce agriculture's pressure on land, water, and climate.

RECOMMENDATIONS

In a world on course to demand 70 percent more calories, nearly 80 percent more animal-based foods, and 95 percent more beef by 2050,[49] reducing overconsumption of food—especially resource-intensive foods—could contribute significantly to a sustainable food future. The three diet shifts proposed in this chapter can help close the food gap and reduce agriculture's pressure on land, water, and climate. The crucial question is how to make these shifts happen. To this end, we offer four recommendations for governments, research institutes, nongovernmental organizations, and food companies.

1. **Set targets, test the Shift Wheel, learn from the results, and scale up successes.** Governments and food companies should set quantifiable targets and test the use of the Shift Wheel to increase the share of plant-based protein in diets and reduce beef consumption specifically. Shifting to more sustainable food consumption choices can both reduce consumer costs and help businesses deliver on their sustainability commitments, including those around water, climate change, and deforestation.
2. **Ensure government policies are aligned with promoting sustainable diet choices.** Governments should ensure coherence among agriculture, health, nutrition, water, biodiversity, and climate change policies in relation to promoting sustainable diets. Agriculture production subsidies should be an important focus given their size and influence on what types of food farmers produce. Since subsidy reform is likely to be politically difficult, taxation and other regulations related to product labeling, marketing, or both should also be explored.
3. **Increase funding for efforts targeted at shifting diets.** Governments and the philanthropic community should create funding mechanisms to support the development, testing, and rollout of evidence-based strategies to shift diets.

4. **Create a new initiative focused on testing and scaling up strategies to shift diets.** A new initiative should be established to test the Shift Wheel in specific contexts and catalyze new approaches to shifting diets, conduct pilot tests, build an evidence base, measure behavior change and its impacts on people and the environment, and share and scale up successes. Its goal should be to increase the share of plant-based protein in diets and reduce beef consumption specifically. ■

Regional Developments

In addition to global events and food policy changes, 2015 also saw important developments with potentially wide repercussions in individual countries and regions. This chapter offers perspectives on major food policy developments across the major regions: Africa, the Middle East and North Africa, Central Asia, South Asia, East Asia, and Latin America and the Caribbean. The individual regional sections cover many critical topics:

- Facing climate risks and growing populations with regional cooperation and accountability in Africa
- Growing refugee populations, food insecurity, and conflict in the Middle East and North Africa
- Vulnerability to external shocks and falling remittances that increase Central Asia's food insecurity
- New policies for food safety, nutrition, and financial and social inclusion in South Asia
- Expected impacts of the Trans-Pacific Partnership in East Asia
- Latin America and the Caribbean's contribution to global food security and global environmental public goods

Africa

Ousmane Badiane, Tsitsi Makombe, and Julia Collins

The recently adopted global sustainable Development Goals (SDGs) present Africa with a new opportunity to achieve critical food security and nutrition milestones. Despite positive development trends, Africa is expected to fully achieve only three Millennium Development Goals (MDGs) by the end of 2015. The major goal of cutting poverty and hunger by half (MDG 1) is among those the continent is not expected to achieve on schedule. Renewed support for Africa's agricultural development and transformation, however, can be seen in the SDGs along with the 2014 Malabo Declaration goals under the Comprehensive Africa Agriculture Development Programme (CAADP). In the Malabo Declaration, African leaders recommitted to the goals and principles of CAADP and made further commitments in the areas of agricultural financing, poverty and hunger reduction, trade, resilience, and mutual accountability.[1] Important next steps include (1) aligning the two sets of goals and integrating them into national development programs, in particular national agricultural investment plans; (2) catalyzing multistakeholder partnerships; (3) strengthening capacities; and (4) mobilizing funds needed to deliver results.

POSITIVE GROWTH AND DEVELOPMENT TRENDS

Africa has enjoyed positive trends in economic and agricultural growth as well as poverty and hunger reduction in recent years. However, in the aftermath of the 2007–2008 global financial and commodity crises, the rate of improvement has slowed for most indicators. Gross domestic product (GDP) per capita continued to increase, but grew at only 1.3 percent annually from 2008 to 2014, a significant drop from 3.5 percent in the 2003–2008 period (Figure 1).[2] Overall GDP growth is expected to decline from 5.0 percent in 2014 to 3.8 percent in 2015, and to rise slightly to 4.3 percent in 2016.[3] Agricultural value-added grew at 2.6 percent annually in 2008–2014, also down from its 2003–2008 rate of 3.8 percent. Although Africa as a whole did not meet the CAADP agricultural growth target of 6 percent in 2008–2014, eastern Africa actually exceeded that goal, with a growth rate of 6.6 percent.

In contrast, progress in reducing poverty accelerated. The share of the population living on less than US$1.25 per day (purchasing power parity) decreased from 42.9 percent in 2003 to 36.9 percent in 2014, with a faster decline during the second half of the decade. About 18 African countries are on track to meet the MDG poverty target by the end of 2015 or have already surpassed it.[4] The poverty gap—a measure of the intensity of poverty based on the mean shortfall from the poverty line—also declined more rapidly in 2008–2014, at an annual rate of –2.6 percent, than in 2003–2008, when the rate was –1.5 percent (Figure 2). Hunger also continued to decrease moderately, with the prevalence of undernourishment declining from 22.1 percent in 2003 to 17.0 percent in 2014. The share of stunted children declined from 40.2 percent in 2003 to 35.9 percent in 2014. Thirty-five African countries have met at least one of the five World Health Assembly nutrition targets; Kenya is on track to meet all five targets.[5]

Public agricultural expenditures continued to rise, but the rate of increase slowed compared with earlier years. Expenditures grew by 2.3 percent annually during 2008–2014, down from a more impressive 6.6 percent increase in 2003–2008. The share of agricultural expenditures in total public

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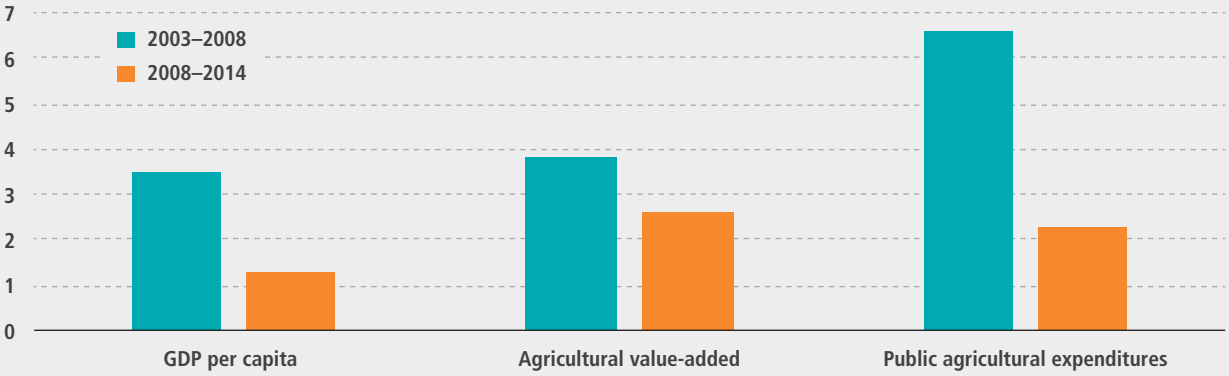
FIGURE 1 Average annual growth (%) in Africa



Source: O. Badiane and T. Makombe, "Core CAADP M&E Indicators," in *Beyond a Middle Income Africa: Transforming African Economies for Sustained Growth with Rising Employment and Incomes,* 2014 Annual Trends and Outlook Report, edited by O. Badiane and T. Makombe (Washington, DC: International Food Policy Research Institute, 2015).

expenditures dropped from an average of 3.5 percent in 2003–2008 to 3.0 percent in 2008–2014, falling short of the CAADP target: a 10 percent agricultural expenditure share.

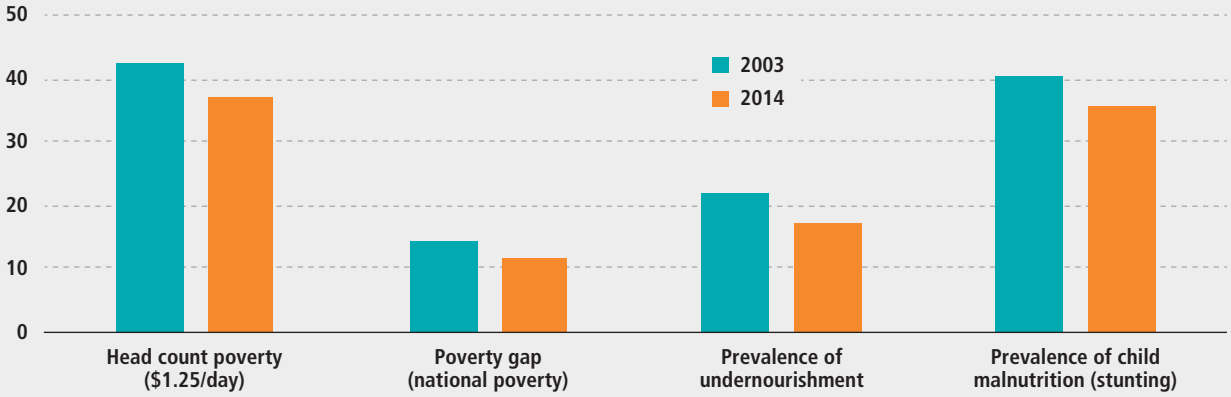
Economic growth and food security in western Africa continued to be affected by the Ebola epidemic that began in December 2013 and resulted in thousands of deaths. By early 2015, the number of new cases had fallen significantly, but the most severely affected countries—Guinea, Liberia, and Sierra Leone—continued to face repercussions of the disease throughout the year. The World Food Programme found "coping strategies" generally associated with food insecurity—such as skipping meals or consuming wild foods—in common use in Ebola-affected areas in early 2015.[6] Dependence on these strategies decreased later in the year as food security improved.[7] The effects of Ebola are projected to lower overall economic growth for 2015 in all three countries, and other negative impacts related to weakening of the healthcare systems may be felt for years.[8]

ADVANCING MUTUAL ACCOUNTABILITY

With the 2014 Malabo Declaration, African heads of state and government pledged mutual accountability for an extensive set of development commitments. In order to monitor and report on progress, African leaders committed to conducting continental biennial agricultural reviews. In 2015, CAADP stakeholders began gearing up for the first review, to be held in 2018. To operationalize the commitment, the African Union Commission and the New Partnership for Africa's Development Planning and Coordinating Agency (NPCA) developed a CAADP Implementation Strategy and Roadmap and a Programme of Work, which were launched at the 11th CAADP Partnership Platform meeting in March 2015. And to provide stakeholders with a standard set of parameters for benchmarking progress, the African Union Commission and NPCA, with the support of technical partners such as the Regional Strategic Analysis and Knowledge Support System (ReSAKSS), produced a revised CAADP Results Framework for 2015–2025.[9] The framework outlines 40 indicators for tracking and reporting on progress.

Following the CAADP Partnership Platform meeting, several technical meetings took place to further define the "what," "why," and "how" of the first biennial review. For example, permanent secretaries of agriculture from 32 African countries met

FIGURE 2 Poverty and hunger, average annual level (%) in Africa



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to discuss their role in the reviews and mainstreaming of Malabo commitments in national agricultural investment plans. At an NPCA-organized meeting in August and at the ReSAKSS conference in September, delegates agreed that a continent-level report will be prepared based on the 2016 country or regional reports, which will help to define baselines for assessing progress.

Agriculture joint sector reviews are expected to inform the country and regional reports and the biennial reviews. The International Food Policy Research Institute (IFPRI) and ReSAKSS worked with various partners to establish a technically robust, comprehensive, and inclusive review process. Joint sector review assessments were conducted in 11 countries to help strengthen institutional and technical capacities for review, and produced action plans to improve countries' review processes. In addition, IFPRI and ReSAKSS provided technical support to the Economic Community of West African States (ECOWAS) to implement the first regional joint sector review. A regional assessment, modeled after the country assessments, is currently underway. Reports on progress in implementing government, donor, and private sector commitments from the New Alliance for Food Security and Nutrition will provide another key input for the biennial reviews. In 2015, ReSAKSS collected data and helped to draft the 2015 New Alliance country- and continent-level reports.

EXPANDING CLIMATE-SMART AGRICULTURE

Climate-smart agricultural practices, using many strategies derived from traditional practices, are beginning to spread across Africa. However, adoption rates are presently low and impact will be limited in the absence of greater efforts to increase adoption and impact.[10] Several 2015 initiatives promoted the uptake of climate-smart agriculture at the country, region, and continent levels. The multistakeholder Africa Climate-Smart Agriculture Alliance facilitated several multisectoral country dialogues and supported the development of national climate-smart agriculture programs and their integration into agricultural investment plans. For example, during workshops in Malawi and Zambia, delegates established national steering committees and developed plans for scaling up climate-smart agriculture.

To better coordinate climate-smart agriculture efforts across the continent, NPCA launched the Pan-Africa Alliance and Platform on Climate Change during the first pan-Africa forum on climate-smart agriculture in May 2015. The platform aims to advance the African Union goal of at least 25 million farming households practicing climate-smart agriculture by 2025. It will promote the development of a coherent climate-smart agriculture agenda for Africa, provide a forum for stakeholders to deliberate on best practices and partnerships, and review country progress against continentwide goals. The 2nd Africa Ecosystem Based Adaptation for Food Security Conference, another continentwide forum held in 2015, culminated in a resolution to establish an African Ecosystem Based Adaptation for Food Security Assembly to promote this approach in Africa.

In West Africa, ECOWAS held a high-level forum for climate-smart agriculture stakeholders in June 2015 to reflect on opportunities, challenges, and strategies for developing climate-smart agriculture. At the forum, ECOWAS launched an intervention framework on climate-smart agriculture and created the West Africa Alliance for the Convergence and Coordination of Climate-Smart Agriculture Initiatives to operationalize the framework. Also, country-level climate-smart agriculture programs, designed to integrate national agricultural investment plans with climate-change strategies, were developed in eastern and southern Africa.

KEY CHALLENGES AND OPPORTUNITIES

Despite falling poverty rates, large numbers of Africans are still trapped in poverty, and many are undernourished. The central challenge facing African policymakers is sustaining and accelerating inclusive economic growth to lift people out of poverty more rapidly.

African fatalities related to civil unrest are expected to be lower in 2015 than 2014, which saw the largest number of fatalities since 1999.[11] Nevertheless, conflict threatened food security and development in several African countries in 2015, including Nigeria, Central African Republic, Somalia, and South Sudan. Among countries with available data, the lowest-ranked in IFPRI's 2015 Global Hunger Index were Chad and Central African Republic, where recent conflicts and ongoing violence have hampered progress in reducing hunger and child mortality.[12] Other countries experiencing conflict, including Democratic Republic of the Congo, Somalia, and South Sudan, were not ranked due to lack of data, but suffer from extremely high rates of hunger as well.

Creating employment for the 11 million young Africans projected to enter the labor force each year for the next decade is another serious challenge. The burgeoning labor force presents great opportunities for growth, if the new workers can be absorbed into productive employment; but currently many young workers are unemployed or working in low-productivity jobs. Putting these young people to work will require productivity increases in agriculture and the informal sector, where most will work, as well as in formal wage employment.[13]

The informal sector, which produces inexpensive goods and services for local consumption, has played an important role in Africa's growth recovery. The large number of small, informal firms could generate widespread employment opportunities, provided countries can devise and implement policies to support product sophistication and enterprise growth.[14] Such policies could include widening access to professional and vocational training, and improving transport and energy infrastructure. Rapid urbanization, a growing middle class, and increasing incomes are leading to more diversified diets and an expanding role for purchased and processed foods; these widespread changes offer new opportunities for employment in food preparation, processing, and marketing.[15]

Agricultural research and development (R&D) is one of the keys to increasing growth in agricultural productivity. Yet only a handful of African countries account for most of the substantial increase in agricultural R&D spending and human resource capacity since 2000.[16] Several countries remain plagued by high researcher turnover, inadequate funding, and high levels of funding volatility.[17] Countries need to share lessons and best practices for increasing and retaining human capacity, mobilizing funding for R&D from both private and public sectors, and creating an enabling policy environment to foster

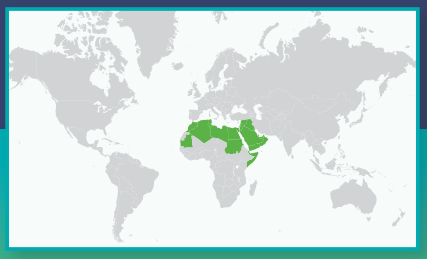
private sector funding and participation in agricultural R&D.

THE WAY FORWARD

In 2016, the focus of African policymakers will be on mainstreaming the SDGs, the Malabo commitments, and other development programs including climate-smart agriculture; ensuring adequate systemic capacities for evidence-based policy planning, implementation, review, and dialogue; and mobilizing resources to deliver on commitments. Country and regional reports to feed into the first continental CAADP biennial review are slated to be prepared in 2016. Meeting the Malabo commitments and addressing the challenges described above will require action on many fronts, including continued improvement in governance and institutions, increased investment in agricultural R&D and market access, and industrial policy strategies to raise productivity in the informal sector. Investing in education and targeted skills training are necessary to help young workers find productive opportunities.[18] Infrastructure investments will be key to reducing constraints on productivity growth in agriculture, agribusiness, and other informal and formal sectors. Moreover, raising agricultural productivity growth will require reform of input subsidy programs to reduce the crowding out of commercial fertilizer distributors, as well as improvements in soil fertility to allow farmers to make more efficient use of fertilizer.[19] ■

Middle East and North Africa

Nadim Khouri and Clemens Breisinger



The regional conflicts of the Middle East and North Africa became global in 2015, as evidenced by the massive increase in people fleeing violence and its consequences: threats against their lives, deprivation, and hunger. The Syrian conflict alone has caused the death of 250,000 people, the internal displacement of 7.6 million people, and the migration of more than 4 million people.[1] While the flow of refugees from Syria and other conflict-ridden countries to Europe garnered major media attention, neighboring countries—including Jordan, Lebanon, and Turkey—have been challenged by a much bigger inflow.[2] While Arab countries collectively hosted about 7 million refugees in 2014—roughly 40 percent of the global refugee population—more than 6 million of the world's refugees originate from the Arab region (Figure 1).[3]

In addition to armed conflict and the refugee crisis, external factors also buffeted the region in 2015. China's economic downturn diminished oil demand, further decreasing the price of the region's main export. The oil revenues of the Arab Gulf Cooperation Council countries (GCC) are expected to fall by more than 50 percent in 2015 compared with 2014, forcing governments of oil-rich Arab countries to make significant budget cuts or increase debt levels. Oil-importing countries, including Egypt, Jordan, and Lebanon, are beginning to suffer from the resulting decrease in demand for goods and services from the GCC, which is counteracting some of the positive impact of lower fuel import bills.[4]

Across the Arab region, there is a renewed consensus on the urgency of addressing the conflicts, the refugee crisis, and economic challenges posed by the international environment, which are impeding development. Consensus-building around regional priorities for the newly launched Sustainable Development Goals (SDGs), along with some key food policy changes in the region, may afford a new opportunity to address food security, nutrition, and poverty needs, and contribute to regional stability.[5]

CONTINUING CONFLICT UNDERMINES ADVANCES

The Arab revolutions that began in late 2010 halted, and in some cases reversed, the region's progress in achieving the Millennium Development Goals (MDGs). Just when peace was needed for the final push to achieve the MDGs by the 2015 deadline, conflicts intensified in Iraq, Libya, Syria, and Yemen, and their effects spilled over into Egypt, Jordan, Lebanon, and Tunisia. The Gaza Strip has not yet recovered from the destruction of its infrastructure in July 2014, and tension has persisted in Bahrain and other countries in the region.

Even accounting for notable setbacks in recent years, however, the Arab region had previously been on track to reach most of the MDGs by 2015.[6] Notable regionwide progress included improvements in education, sanitation, child mortality rates, and maternal health. But these advances hide great disparities among subregions and countries. The least developed countries (LDCs) in the region (in particular Comoros, Djibouti, Mauritania, Somalia, Sudan, and Yemen) were not expected to achieve most of the MDGs on schedule. For the region as a whole, progress has been weakest toward the goal of cutting the levels of poverty, hunger, and malnutrition by half (MDG 1). Recent setbacks have been serious. Current estimates suggest that poverty has risen above the 1990s level, with more than 7.4 percent of the

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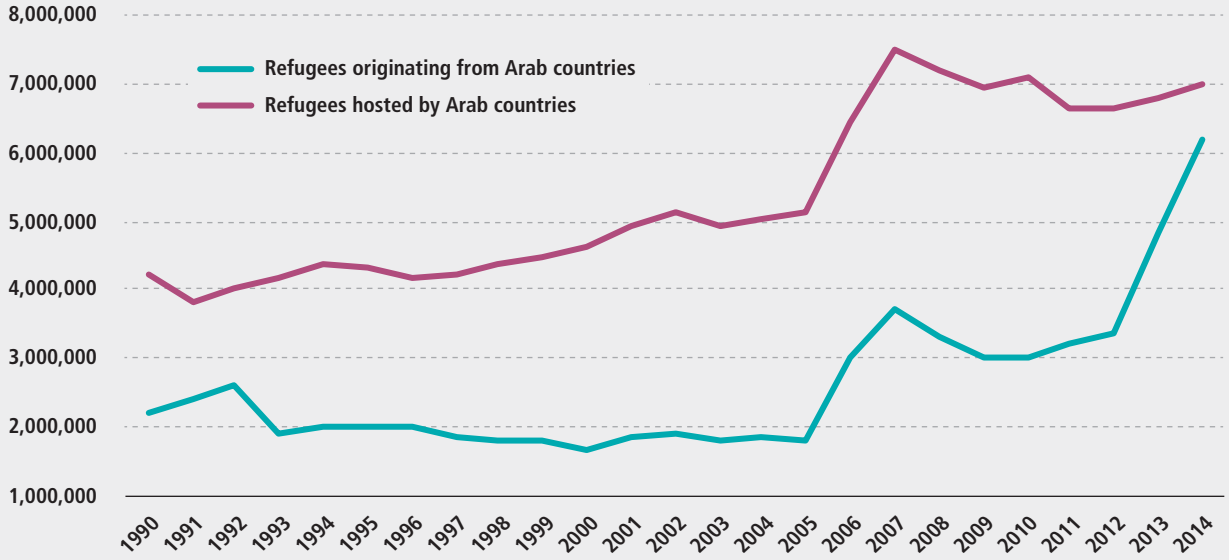
FIGURE 1 Refugees hosted by and originating from the Arab region



Source: Authors' calculations based on World Development Indicators 2015 (World Bank 2015). WDIs use data from the United Nations High Commissioner for Refugees (UNHCR), *Statistical Yearbook*, and data files, complemented by statistics on Palestinian refugees under the mandate of the UN Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) as published on its website. Data from UNHCR are available online at www.unhcr.org/statistics/populationdatabase.

Note: The Arab region is composed of the 22 member states of the Arab League.

population living in extreme poverty as of 2012 and poverty levels expected to rise further by the end of 2015.[7] And with an estimated 50 million people still undernourished, "the region is far behind on meeting the target of halving undernourishment."[8] The picture is worse in Arab LDCs, where extreme poverty rates are estimated at more than 21.6 percent, undernourishment affects more than 29 percent of the total population, and more than 35 percent of children under five are underweight, as of 2012.

PRIORITIZING FOOD AND NUTRITION SECURITY

The Arab region participated in the global dialogue that developed the 17 Sustainable Development Goals (SDGs) adopted by the UN General Assembly in October 2015. Emerging regional consensus has established food security as the priority goal,[9] based on the final version of SDG 2 (which promotes the integration of sustainable agriculture with food security and the necessity of ensuring support to women), and has specifically highlighted the importance of nutrition.[10] The goal of eliminating extreme poverty (at the US$1.25 per day level) also has regional acceptance. Notably, the consensus recommendations recognized the importance of peace and improved governance to development.[11]

Prioritizing food security is consistent with the latest estimates and research-based evidence on the development needs of the Arab region.[12] National-level food insecurity remains "serious" or "alarming" in most Arab countries, reflecting pervasive vulnerability (Figure 2). The Arab region will remain dependent on food imports, despite a persistent discussion in the region on the desirability of "food self-sufficiency at any cost." While most Arab countries spend less than 20 percent of their foreign exchange earnings on food imports (Figure 2), any discussion of self-sufficiency needs to explore the

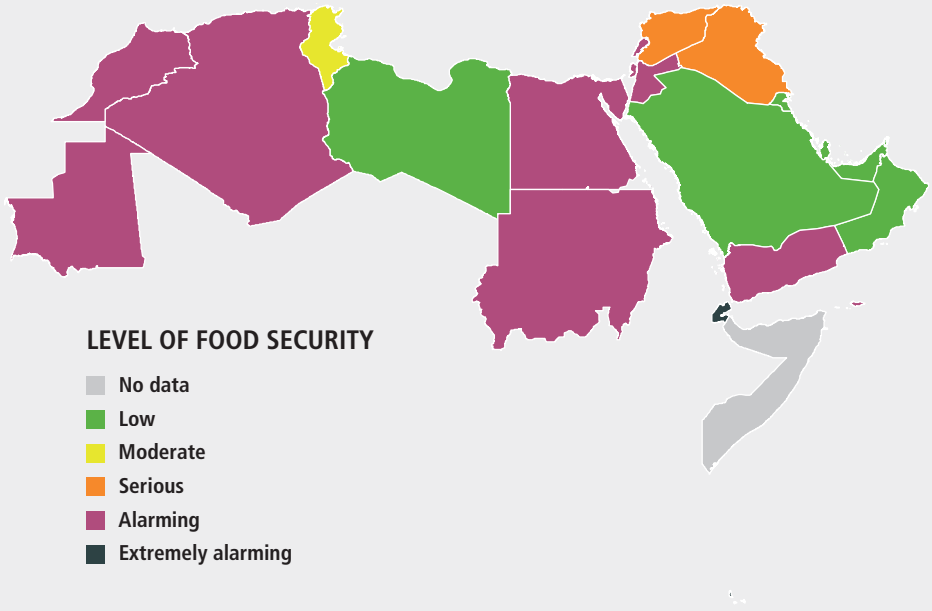
feasibility and true cost of this idea, which is likely to be high. A more realistic and beneficial strategy for reducing food insecurity may be to further improve trade and trade infrastructure, including storage. In several countries, domestic agriculture, including rainfed agriculture, has potential to increase its contribution to regional food security. However, given regional water scarcity, any efforts to increase agricultural production or productivity will need to address sustainability issues for food production systems, as laid out in the SDGs.

Conflict management will be central to improving household-level food and nutrition security, including eliminating hunger, which is often concentrated in areas undergoing conflict. Nutrition interventions should focus on child stunting, obesity, and the combination of both—the so-called "double burden" of malnutrition. Stunting levels in many Arab countries are significantly higher than per capita income levels would suggest, with more than 20 percent of children too short for their age in 10 Arab countries.[13] Several countries, including Djibouti, Egypt, Kuwait, Somalia, and Syria, experienced a decrease—rather than the desired increase—in the annual rate of reduction in child stunting in recent years. At the same time, obesity rates in the region are among the highest in the world. An estimated 45 percent of adults are severely overweight, with serious health consequences, including for children of obese mothers.[14]

MAJOR FOOD POLICY DEVELOPMENTS IN 2015

The primary regional organization, the Arab League, does not have the capacity to engage with the

FIGURE 2 National-level food security, Arab region



Source: Arab Spatial, National Food Security, http://bit.ly/1ST6ECv. Food import data: Food and Agriculture Organization of the United Nations, Statistics Division database, http://faostat.fao.org, accessed on November 11, 2015; Total export and remittance data: World Bank, World Development Indicators (WDI) Databank, http://data.worldbank.org/data-catalog/world-development-indicators, accessed on November 2, 2015.

Note: A country's macro-level food security is defined as food imports divided by total exports plus net remittance inflows (food imports / [total exports + net remittance inflows]). All indicator values are generally computed as three-year averages over the period 2010–2012. For more information, see C. Breisinger, O. Ecker, P. Al-Riffai, and B. Yu, *Beyond the Arab Awakening: Policies and Investments for Poverty Reduction and Food Security,* IFPRI Food Policy Report 25 (Washington, DC: International Food Policy Research Institute, 2015).

security and political problems of the region. Instead, the Arab League has focused on increasing trade integration within the region, which may offer a feasible first step toward resolving the region's seemingly intractable political issues. A long-standing plan to create a regionwide Arab Customs Union (ACU) in 2015 has now been put on hold, and a more limited subregional customs union composed of the GCC countries was established. Several other regional cooperative efforts were initiated in 2015. The Arab League launched the Climate Nexus Initiative in Cairo in November, which will support development of greater regional policy coherence across the SDGs for climate change, disaster risk reduction, food and water security, and social vulnerability.[15] The World Bank and the Arab Monetary Fund launched an initiative that, among its key objectives, aims to secure financing for small and medium enterprises as well as other links in the food-and-agriculture value chain.[16] And in a promising sign for future coordination of water distribution from the Nile, Egypt, Ethiopia, and Sudan signed an agreement of principles on Ethiopia's Grand Renaissance dam project in March 2015.

At the country level, policymaking activity has often increased in Arab countries in times of crisis, such as the 2008 and 2011 global food crises and the Arab Awakening. But such policy changes are often neither fiscally sustainable nor well targeted to the poor.[17] In 2015, with large territories and populations affected by extreme violence, countries are finding it even more difficult to focus on long-term sustainable development solutions. Even for the countries that have avoided getting pulled into the violence, the ongoing conflicts distract from critical development priorities, including participatory and representative government, the rule of law, and equitable development.

> Consensus is emerging on the need to aggressively innovate in pursuit of peace through development, and there is growing agreement on the need to prioritize and sustain food security assistance.

Egypt is among the few exceptions. The Egyptian government continued its effort to reform subsidies, including cutting environmentally and socially detrimental fuel subsidies, which created overall economic and distributional gains. Reforms were also made to the food subsidy system, including (1) boosting the dietary value of the basket of subsidized food through the addition of a greater variety of eligible foods; (2) transfer of most users to smart cards, which allow for electronic replenishment of food assistance funds, thus increasing efficiency and reducing the risk of corruption or misuse of food assistance funds; and (3) initiating a new food waste reduction project.[18]

OUTLOOK FOR 2016

The outlook for the Arab region for 2016 is not much improved, particularly if conflict persists. However, there is hope that the mounting evidence of the costs of inaction will sway decisionmakers to support policy reforms to improve governance, fight corruption, and increase the competitiveness of Arab economies.[19] The following three areas are high priorities for policy intervention to improve food and nutrition security in Arab countries.

- **Peace-building through development activities at local and national levels.** Consensus is emerging on the need to aggressively innovate in pursuit of peace through development. Although overall and permanent peace may remain elusive, there is growing agreement on the need to prioritize and sustain food security assistance. Innovation is needed to go beyond the current emergency relief measures. In October 2015, the Committee on World Food Security agreed to a set of nine principles and implementation strategies, known as the Framework for Food Security and Nutrition in Protracted Crises, which is designed to guide governments and assistance agencies in stepping up their development engagement, including in conflict zones.[20]

- **Education and subsidy reforms to improve nutrition.** Outside of conflict areas, following the model of the emerging success in Egypt, governments should focus on ending harmful subsidies and strengthening safety nets in order to improve nutrition for the truly poor and food insecure, including addressing the double burden of malnutrition.
- **Research and improved data gathering and analysis.** Ultimately, there is hope that more inclusive and participatory societies will emerge from the present regional chaos. Sound data and information for decisionmaking on rural development and food security (such as the Arab Spatial Food and Nutrition Security Analyzer[21]) as well as demonstrable solutions suitable for scaling up are needed. Development of these tools while the turmoil is still ongoing may even hasten peace. The turmoil started in peri-urban and rural areas; perhaps if rural development is addressed, that is also where it will end. ■

Central Asia

Kamiljon Akramov and Allen Park

Economic developments in 2015 confirmed prevailing wisdom about Central Asia's vulnerability to external shocks, as countries in the region contended with declining global commodity prices and spillover effects from the economic downturn in Russia. The Russian downturn directly affected national economies not only through reduced remittances, an important source of income for many Central Asian households, but also through its contribution to the volatility of the region's currencies. These developments combined to weaken macroeconomic stability, economic growth, and household welfare in Central Asia. In addition, a larger-than-expected slowdown in China, which has become an increasingly important trading and investment partner in the region, placed further constraints on Central Asia's economies.

The current economic slowdown disrupted a period of rapid economic growth, which had generated significant improvement in household welfare and living standards in the region.[1] With the exception of Tajikistan, all Central Asian countries achieved two key Millennium Development Goals—cutting both extreme poverty rates and the proportion of undernourished people by half—ahead of the 2015 deadline.[2] Commodity prices, which reached historic highs during this period of growth, benefited not only the resource-rich countries of the region (Kazakhstan and Turkmenistan) but also the resource-poor countries (Kyrgyzstan and Tajikistan), whose migrants were able to find employment in Russia and send remittances home. Uzbekistan benefited from both high commodity export revenues and significant inflows of remittances.

The impact of the current negative trends on regional household food security will become clearer as more household-level data become available. Despite some progress, household-level data on food and nutrition indicators in the region remain limited. The recently published findings from the 2014 Kyrgyzstan Multiple Indicator Cluster Survey—which provides nationally representative data on a wide range of health, nutrition, and education indicators focused on women and children—demonstrate positive trends in child nutritional outcomes, suggesting that stunting rates for children under five declined from about 18 percent in 2012 to 13 percent in 2014.[3] Similar surveys are being conducted in Kazakhstan and Turkmenistan.[4]

MAJOR DEVELOPMENTS

Recent developments reflect Central Asia's exposure to global commodity price fluctuations and economic change in Russia, the region's most important trading partner. Export revenues in the region have collapsed due to declining commodity prices. For example, Kazakhstan's export revenues in the first three quarters of 2015 dropped by 33 percent compared with the same time frame in 2014.[5] Similar trends are observed in other Central Asian countries. Moreover, low oil and gas prices and international sanctions deepened Russia's recession in 2015, with a severe impact on Russian labor demand and real wages.[6] While it is difficult to disaggregate the effects specifically attributable to Western sanctions from the effects of the slump in the Russian economy as a whole, it is clear that demand for Central Asian migrant labor has suffered. The combination of declining labor migration, a weaker ruble, and falling real wages led to a significant reduction of remittance flows from Russia to the Central Asian countries (Figure 1).

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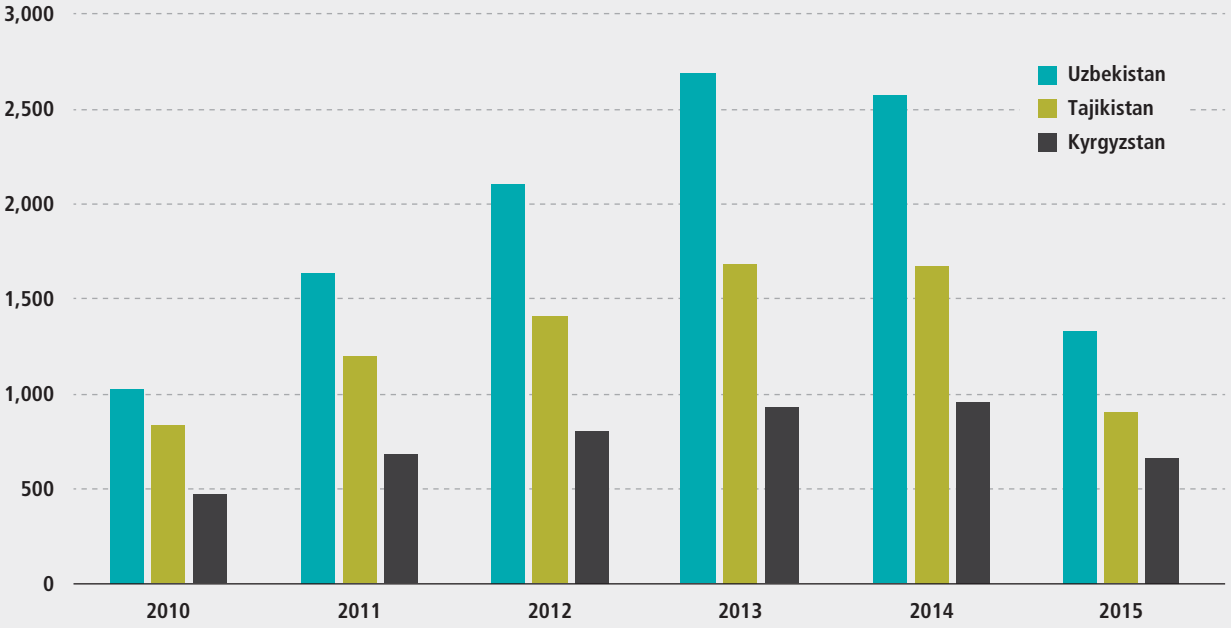
FIGURE 1 Total remittances from Russia, 2010–2015 (first half), in US$ millions



Source: Central Bank of Russia.

Russian authorities appear to have responded to deteriorating labor conditions by tightening regulations on labor migration. New laws taking effect in 2015 increased registration requirements and sharply raised legal fees for citizens of the Commonwealth of Independent States countries, which have a visa-free regime with Russia. Migrant laborers are now required to carry international passports, purchase health insurance, and pass medical and language tests in order to obtain a work permit.[7] According to the Federal Migration Service of the Russian Federation, the number of officially registered labor migrants from Tajikistan and Uzbekistan in Russia declined by 16.1 percent and 17.3 percent, respectively.[8] In the first half of 2015, the total value of remittances to these countries declined by almost half compared with the same period in the previous year. Citizens from Eurasian Economic Union (EEU) countries are exempted from the new requirements. The number of officially registered migrants from new EEU member Kyrgyzstan, the other major labor-sending Central Asian country, saw only a 6 percent decline over the same period. In fact, labor migration from Kyrgyzstan rebounded after the country became a full member of the EEU in August 2015.

The Russian downturn has directly affected Central Asian households. Results from a February 2015 household survey in southern Tajikistan conducted for the US Agency for International Development indicated that 38 percent of household members working abroad had returned home in the preceding six months.[9] Of these, 98 percent had returned from Russia. Although seasonal factors account for some of the influx, about half of returning migrants cited reasons other than seasonal leave, financial achievement, or family and health issues for returning to Tajikistan. This suggests that these migrant workers returned due to a lack of work, legal status, or both, which can be tied to related developments in Russia.[10]

Declining export revenues and remittance inflows exerted pressure on national currencies throughout Central Asia (Figure 2). Government responses were varied: Turkmenistan devalued its

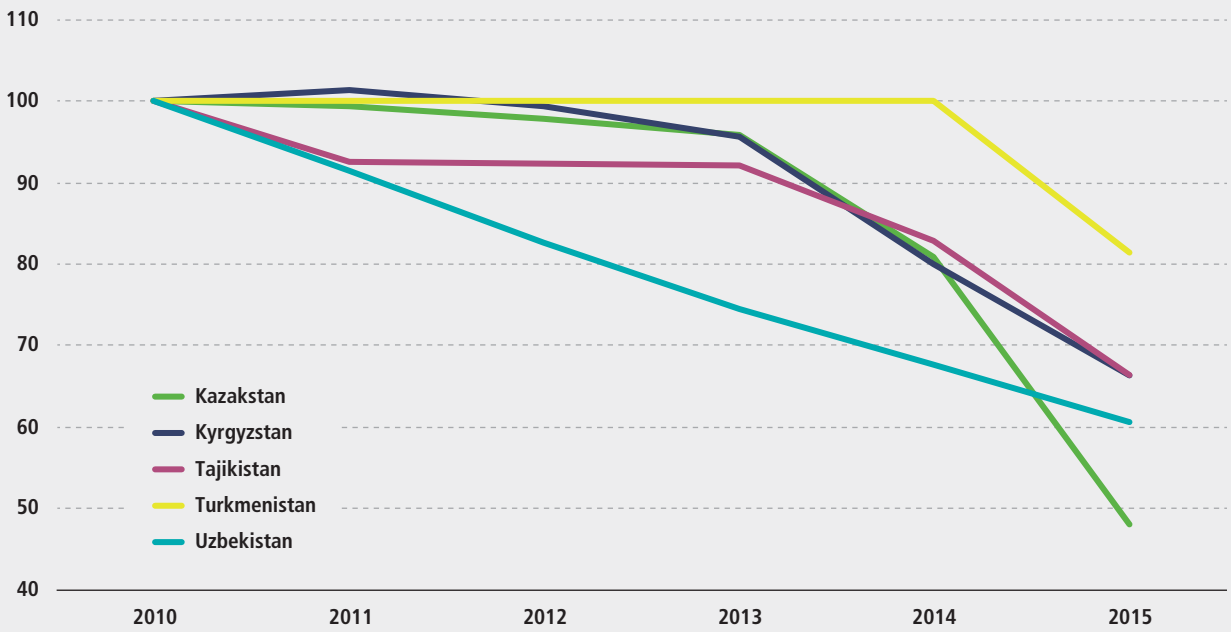
currency for the first time since 2008 and Kazakhstan changed its exchange rate policy from a manged floating to a freely floating regime, while Uzbekistan maintained tight control over the official exchange rate even as the parallel-market premium fluctuated wildly.

Combined with strong exchange rate pass-through, the trend of weakening currencies has created strong inflationary pressures on consumer prices throughout the region. These pressures are especially significant in countries that depend heavily on food imports, including Kyrgyzstan and Tajikistan. Inflation is expected to reach double digits in these two countries and may lead to erosion of household income, increased poverty, and lower diet quality, especially among households in lower income groups.[11] Overall economic growth is expected to slow substantially in all countries of the region.[12]

The expansion of the EEU may have important implications for agriculture and food security in Central Asia. In August 2015, Kyrgyzstan joined Armenia, Belarus, Kazakhstan, and Russia as the fifth member of the regional economic union. The agreement allows Kyrgyzstan to phase in the adoption of tariffs, as well as technical, sanitary, and phytosanitary regulations related to food products.[13] This may have a positive effect on Kyrgyzstan's major food exports to other EEU countries: fruits, vegetables, and dairy products. The EEU adopted some important policies related to food security and the creation of a common market for agricultural and food products in 2015, including draft unified phytosanitary requirements and changes in import tariffs for numerous agricultural and food products.[14] In addition to EEU expansion, the World Trade Organization (WTO) formally introduced Kazakhstan as a member in July 2015 after nearly two decades of negotiations. Among the major obstacles during negotiations for Kazakhstan's WTO accession were concerns over agriculture, including government support for the sector, market access, and sanitary and phytosanitary measures.

Food and nutrition policy is garnering renewed attention from governments in the region. In

FIGURE 2 Exchange rates in Central Asia, end-of-year US$ per national currency, 2010 = 100



Source: Authors' depiction using data from respective central banks; data for 2015 as of November 10, 2015.

October, Kyrgyzstan adopted a national food security and nutrition program in order to meet the UN Sustainable Development Goals of eliminating hunger and malnutrition by 2030.[15] The program aims to ensure supply of and access to food through agricultural development, social protection programs, and better access to information. Other priorities of this initiative include increasing dietary diversity and ensuring food safety. The program will be financed by the national and local governments and supported by international organizations. In April 2015, the government of Uzbekistan adopted a resolution designed to improve health and nutrition and prevent diseases related to malnutrition. The resolution outlined national goals, including five-year targets for consumption of fruits and vegetables, domestic production of healthy foods, and reduction in alcohol and tobacco use. The government has pledged only 3.7 billion Uzbek som (about US$1.4 million at the official exchange rate) to the 22 nutrition-specific projects under this initiative.[16]

Central Asian countries are also continuing to cooperate with international organizations on projects related to agricultural development, food security, and poverty. In 2015, the World Bank launched a pilot initiative to improve standards in the Kyrgyz dairy sector, with the ultimate goal of making local products viable in export markets. In addition, the Food and Agriculture Organization of the United Nations finalized an agreement with Kyrgyzstan targeting four broad areas for cooperation: sustainable production, agricultural productivity, climate change resilience, and rural poverty. In April, Tajikistan released the first in a series of poverty studies that use new methodological approaches based on international best practices. These were developed with support from the World Bank and the government of the United Kingdom.

LOOKING FORWARD

In 2016, Central Asian countries will remain vulnerable to further decline in and volatility of commodity prices, as well as deepening of the Russian recession and China's economic slowdown.[17] These adverse factors may have direct impacts not only on migrant remittances, domestic economic growth, and employment opportunities in Central Asian countries, but also on poverty and household-level food and nutrition security. Countries in the region need to develop a consistent set of economic policies to mitigate possible macroeconomic and structural imbalances. The ongoing global El Niño phenomenon creates additional uncertainty for the region's economies. Although strong El Niño episodes have been associated with increased snow accumulation and irrigation flows in Central Asia in the past, the region still faces long-term challenges related to climate change and is vulnerable to extreme weather conditions. [18]

Evidence suggests that social protection policies can reduce poverty and undernourishment, and mitigate the temporary negative effects of external shocks. Many studies also show that properly targeted social protection measures allow households to increase and diversify their food consumption. Such measures may stimulate investment in agricultural production and other economic activities, and enhance nutrition, health, and education, with positive implications for employment and productivity.[19] However, social protection programs in most Central Asian countries are very limited. For example, in Kyrgyzstan and Tajikistan less than 10 percent of the population is covered by social assistance, compared with 26 percent for middle- and low-income countries globally and 32 percent for transitioning countries in Eastern Europe and Central Asia. Moreover, the assistance is poorly targeted—only a fraction reaches poor households. In Kyrgyzstan, just one-third of total transfers are received by the poorest quintile of the population. In Tajikistan, only 8 percent of total social transfers are received by the poorest quintile.[20] To remedy these shortcomings, the countries of Central Asia should not only enhance their social protection policies but also ensure that such transfers are properly targeted to poor households. ■

South Asia

P. K. Joshi, Akhter Ahmed, Stephen Davies, and Anjani Kumar

South Asia is the fastest growing region in the world, with regional economic growth projected to reach 7.0 percent in 2015 and 7.6 percent in 2016.[1] However, poverty and undernourishment persist (Figures 1 and 2). Rapid economic growth is a result of declining oil prices, increasing investment, and continuing strong consumption in most of the region.[2] All the countries of South Asia achieved the Millennium Development Goal of reducing poverty by half well ahead of the 2015 deadline, and have shown growing improvement in human development and nutrition indicators. The Global Hunger Index (GHI) for South Asia declined from 47.7 in 1990 to 29.4 in 2015, moving from "alarming" to "serious."[3] Although progress with respect to the GHI slowed between 2000 and 2005, it regained momentum between 2005 and 2015 as a result of various food and nutrition security programs. Nevertheless, South Asia is still home to more than 35 percent of the world's poor (more than 300 million people).

The region faced numerous challenges in its efforts to reduce food and nutrition insecurity in 2015, including a catastrophic earthquake in Nepal, social unrest in Bangladesh, serious drought in rainfed areas and unseasonable rainfall and hailstorms in irrigated parts of India, and severe heat waves and an unseasonable storm (dubbed a mini-cyclone) in Pakistan. These calamities killed several thousand people and substantially reduced agricultural production. On a positive note, food price inflation across South Asia was controlled, arguably at least in part because of falling global prices for major commodities. As a result of favorable weather conditions, Bangladesh enjoyed a bumper rice harvest, which led to a drop in rice prices. Elections in Nepal and Sri Lanka brought in new governments, and Nepal adopted its long-awaited new constitution, moving to a federal system of governance.

At the regional level, integration through the South Asia Association for Regional Cooperation (SAARC) moved forward. The association's 18th Summit was held in Kathmandu, Nepal, in late 2014, with the primary goal of promoting greater integration to foster peace and prosperity in South Asia. Regional heads of state identified key areas for mutual cooperation.

POLICIES FOR IMPROVING NUTRITION OUTCOMES AND FOOD SAFETY

Bangladesh has been actively addressing food safety and nutrition issues. This year saw the introduction of the National Nutrition Policy, designed to improve nutrition among the poor, especially mothers, children, adolescent girls, and underprivileged sectors of society, and to promote national development through healthier diets and improved living standards. Bangladesh is the first South Asian country to introduce mandatory fortification of refined edible oil with vitamin A. The government also launched a pilot project jointly with the International Food Policy Research Institute (IFPRI) in 2015 on agriculture, nutrition, and gender linkages, to identify actions and investments that can leverage agricultural development for improved nutrition and to make recommendations on invigorating pathways to women's empowerment.[4] The government plans to use the research-based evidence produced by the project to

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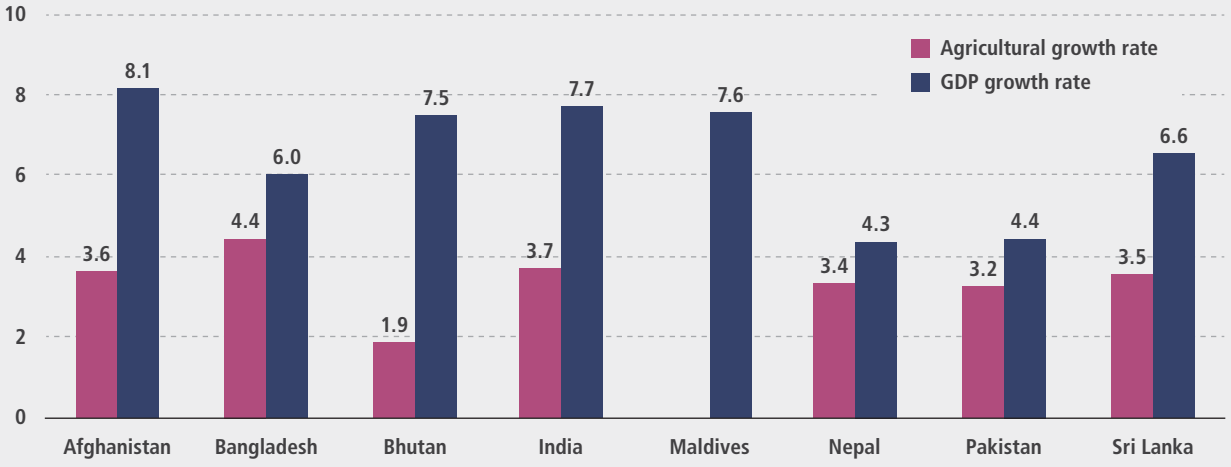
FIGURE 1 South Asia, annual growth rate (%) in GDP and agricultural GDP, 2003–2014



Source: World Bank, data.worldbank.org, accessed December 17, 2015.

design, implement, and scale up the most effective interventions at the national level.

Bangladesh also established a Food Safety Authority in 2015 to enforce regulations and procedures for safety standards, in compliance with the Bangladesh Food Safety Act. The Ministry of Food is implementing a project called Institutionalization of Food Safety in Bangladesh for Safer Food, with technical support from the Food and Agriculture Organization of the United Nations.[5]

India launched a new sanitation program—Clean India Mission—in 4,041 towns, to clean the streets, roads, and infrastructure, in order to address unhygienic conditions that are linked to disease and constrain improvements in nutrition and health outcomes.

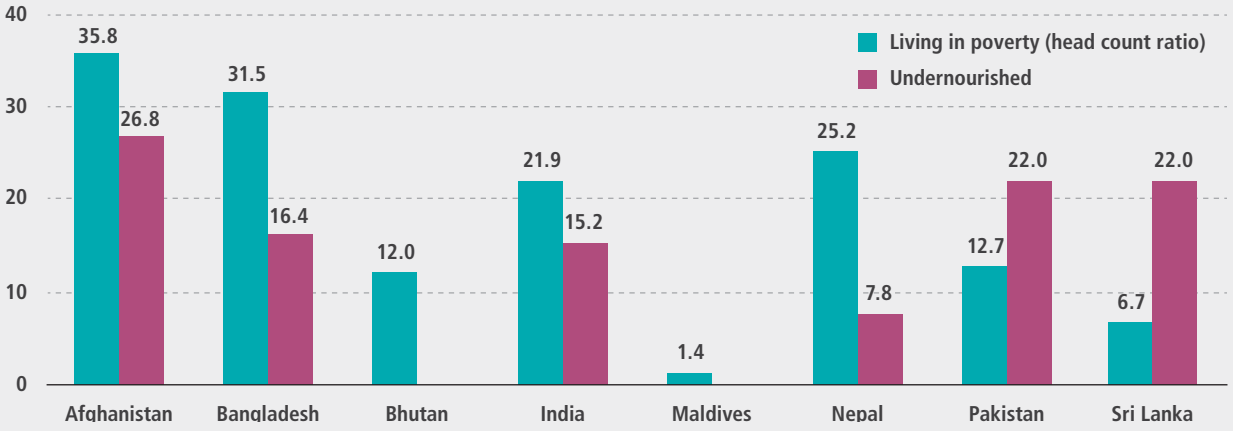
In addition, Sri Lanka is developing a food and nutrition security policy, and Nepal is formulating a new National Food Safety Policy that is expected to be operational by 2016.

POLICIES FOR INCREASED AGRICULTURAL PRODUCTION

Several programs and policies were introduced in the region to boost agricultural productivity through improved input delivery systems. For example, the region saw several important efforts to expand the availability of improved cultivars and quality seed to farmers. Pakistan's Seed Act of 1976 was amended to promote the private sector's role in seed multiplication and distribution, and to strengthen seed quality control systems.[6] Nepal moved forward with efforts to put its National Seed Vision 2013–2025 into effect with the introduction of frameworks to improve varietal registration and seed distribution systems. In a unique regional development, Bangladesh, India, and Nepal began to cooperate on harmonization of rice varietal evaluations in order to accelerate the release and commercialization of new cultivars across all three countries.[7] Throughout the region, policy reforms have been accompanied by important stakeholder discussions regarding effective levels of seed system regulation, appropriate roles for the public and private sectors in seed markets, protection of breeders' and farmers' rights, and biodiversity conservation.

Bangladesh and India developed and released biofortified cultivars of rice and pearl millet. While Bangladesh released zinc-fortified rice varieties for large-scale cultivation, India opted for iron-fortified pearl millet varieties and hybrids. Widespread

FIGURE 2 South Asian population in poverty and undernourished (%)



Source: World Bank, data.worldbank.org, accessed December 17, 2015. Data for Afghanistan is from 2011; Bangladesh 2010; Bhutan 2012; India 2011; Maldives 2009; Nepal 2010; Pakistan 2010; and Sri Lanka 2009.

consumption of these new varieties is expected to significantly improve micronutrient uptake, with positive effects on health and well-being. In Pakistan, the amendment of the Seed Act provides for registration of genetically modified varieties (GMOs), signaling the country's approval of GMO cultivation following proper scientific testing.

In 2009, Afghanistan developed a comprehensive National Agriculture Development Framework focused on increasing agricultural production, enhancing economic regeneration, managing natural resources, and reforming governance structures. However, limited institutional capacities and financial resources are hampering implementation.[8] Afghanistan will need to develop better governance structures and institutional arrangements, and muster considerable financial support, to improve incomes and livelihoods in the agricultural sector.

India launched a flagship irrigation program with a planned outlay of Rs. 500 billion (about US$7.67 billion) over the next five years, with the primary objectives of expanding cultivable area under assured irrigation, improving on-farm water use efficiency, and promoting adoption of water-saving methods for more "crop-per-drop."[9] The scheme targets 50 million hectares and is expected to improve agricultural productivity, reduce risk, and enhance drought resilience.

POLICIES FOR FINANCIAL AND SOCIAL INCLUSION

Pakistan announced a relief package of Rs. 341 billion (approximately US$3.24 billion) for small farmers, including direct cash supports and loans to revive the sector, which has suffered from unfavorable weather conditions and declining incomes.[10] The direct benefits of the package comprise, in roughly equal thirds, cash payments to small farmers; reductions of input prices, primarily for fertilizer; and subsidies and guarantees on agricultural loans plus support for imports and marketing. The cash supports and access to credit are expected to benefit small farmers. However, there are several major concerns: The package will increase Pakistan's fiscal deficit by an estimated 0.4 percent of gross domestic product.[11] Furthermore, previous general credit schemes reached relatively few farmers in Pakistan—only 14 percent in 2013—and were terminated because funds failed to reach targeted beneficiaries.[12]

India launched two new social security schemes providing access to insurance: (1) the Prime Minister's Insurance Scheme for accident and disability coverage of up to Rs. 200,000 (approximately US$3,065) for an annual premium of Rs. 12 (approximately 18 US cents), and (2) the Prime Minister's Life Insurance Scheme for term life coverage, also of Rs. 200,000, for an annual premium of Rs. 330 (approximately US$5.51).[13]

In mid-2014, the Indian government launched a financial inclusion program, known as the Prime Minister's Plan for People's Wealth, to provide universal access to bank accounts. In a record period of 14 months, 187 million bank accounts[14] were opened with combined deposits of about US$3.8 billion.[15] The initiative is considered a prerequisite for direct cash transfers for food and fuel to targeted beneficiaries, and is expected to reduce public expenditure; however, these transfers have not been implemented as yet.

LOOKING FORWARD

The future looks bright for the region, given favorable oil prices, falling global food prices, increasing public investment, and an improving business environment. However, the countries in the region would benefit from reforms to increase transparency in governance, consolidate various programs, and attract private sector investment in infrastructure. Market and climate risks will continue to present a challenge—solutions may require a new blend of technologies, policies, and institutions. In 2016, the South Asian countries will need to begin addressing the new Sustainable Development Goals and could benefit from learning lessons on best practices within the region and elsewhere to assist them in achieving the goals by 2030. ■

East Asia

Kevin Chen, Peter Timmer, and Longwen Chiang

With close to 30 percent of the world's population and 9 percent of the world's land, East Asia, including China, accounts for 25 percent of the world's hungry and 40 percent of its malnourished.[1] Because of its size, the region must be a priority for achieving the new Sustainable Development Goals. While East Asian countries, including Vietnam and China, made significant efforts to modernize their agricultural sectors in 2015, less progress has been made in tackling the broader goals of sustainability and gender equality in agriculture.[2] In the policy realm, the focus on rice self-sufficiency and food safety remains largely unchanged.[3] Countries such as Indonesia and the Philippines, which seemed likely to pull back from costly self-sufficiency goals, have instead committed to even more ambitious targets. The El Niño season of 2015–2016 was the strongest ever recorded. The impact on rice production in Southeast Asia was severe (although official Indonesian rice production statistics do not yet reflect this impact). Both Indonesia and the Philippines turned to imports to keep food stocks at adequate levels; rice prices rose substantially in both countries. In this potentially volatile context, stable prices of basic commodities, particularly rice, will be of paramount importance in ensuring that the gains made in poverty reduction are not lost.

In China, food safety has been a central concern for the government since the 2008 melamine incident, when adulterated milk led to the hospitalization of an estimated 54,000 babies. While it is too early to say that this incident will not be repeated, substantial policies have been passed to address food safety issues. On April 24, the National People's Congress approved an amendment to the national Food Safety Law establishing a traceability and point-of-origin system for all products entering the supply chain, as well as more comprehensive regulations and reporting requirements for additives and other chemicals.[4] Such changes have been taking place all across Asia. Laos, Myanmar, and Vietnam recently entered the Association of Southeast Asian Nations (ASEAN) Sustainable Agrifood Systems—a series of high-level food safety talks that aim to bring local food safety inspection guidelines up to regional standards.[5] Although policies have been moving in the right direction, the biggest challenge remains the lack of political will and resources necessary to impose current technological standards on a traditional food system. Infrastructure is lacking to properly monitor and support existing systems. Mustering the substantial resources needed to monitor small-scale operations will be difficult, given the amount of food processed and marketed through the traditional marketing system.

Surprisingly, rice prices have not experienced high volatility leading into El Niño. According to the recent rice price tracker from the Food and Agriculture Organization of the United Nations, average prices have actually decreased slightly. Despite a decline in global inventories, the price decrease is expected to continue in 2016 as a result of low demand from regular rice importers. There are two major reasons for this: (1) there has been an increase in the stockpile of rice to meet the goals of self-sufficiency among the largest rice importers (and large stockpiles in Thailand), and (2) the full impact of El Niño is not expected until mid-2016. In particular, countries such as the Philippines and Thailand that have been affected by low precipitation have some of the largest rice reserves in East Asia.[6]

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Together with sizable production gains in China and Indonesia, these stocks have stabilized rice prices.[7] However, current forecasts predict a 2015 rice harvest of 672.3 million tons, which is lower than the already unremarkable 2014 output.[8] A small harvest combined with a likely rapid drawdown this year mean world rice inventories are expected to hit a new low in 2016, with current forecasts of about 164 million tons. Given this situation, policies supporting open trade of agricultural products should be strengthened to ensure that rice remains affordable. Vulnerable populations are especially sensitive to volatile food prices, and sudden price changes can push those who have escaped from poverty back below the poverty line.

MAJOR POLICY DEVELOPMENTS

With the passage of the revamped Food Safety Law and a new set of priorities highlighted by the Number One Central Document, China is signaling a transition from a focus on quantity to a focus on quality in its food supply.[9] However, the most significant policies are likely to be initiatives to promote regional development, such as the Asian Infrastructure Investment Bank and the One Belt, One Road infrastructure initiative. Internally, the major policy focus as described by the Central Document is a mix of land reform, sustainable agricultural production, and fiscally sustainable agricultural support policies. Land reforms will free up an additional 428 million hectares of farmland to contract farmers to achieve economies of scale and increase income. Focus has shifted from an emphasis on grain production to a more diverse agricultural structure entailing greater production of industrial crops, forage crops, livestock, and fish, while still maintaining self-reliance for grain. It should be noted that striving for self-sufficiency in grain at all costs is a difficult policy to sustain fiscally in the context of an uncompetitive and inefficient domestic grain sector.

Another 2015 highlight in China was the change in agricultural price support policy. The previous price support policy set the minimum purchase price of domestic grain well above international prices, effectively providing a subsidy. The 2015 Central Document calls for a decoupling of prices from the subsidy—meaning the government will now purchase grain at the market price and provide direct subsidies to producers and consumers. In the second half of 2015, the Chinese government cut the reserve price of corn and other grain, and minimum purchase prices were not increased above 2014 levels.

The Philippines, expected to suffer from the impacts of El Niño, has boosted research and funding to develop drought- and flood-resistant agriculture. While self-sufficiency has always been a stated policy, the agriculture secretary has promoted additional efforts to reach the goal by 2016. Overall, the government's goals remain the same: create a developed country for the next generation, lower dependence on imports of rice, stabilize income for farmers, and promote social protection and food security. To achieve these goals, the government earmarked 86.1 billion Philippine pesos (US$1.9 billion) for its Agricultural Development Program in 2015, which will be used to boost rice production and improve irrigation in the top rice-producing provinces, such as northern Luzon. In addition, a comprehensive program of the Department of Agriculture is being implemented to address climate change and to disseminate innovations such as rice-based agrifood systems.

Recent cabinet shake-ups in Indonesia have raised questions about the traditional role of the Bureau of Logistics (BULOG) in regulating food prices. The vice president announced in September that the bureau would import 1.5 million metric tons in November/December to address shortages associated with the El Niño drought. However, his proposal was overruled by the president at the urging of the agriculture minister, and uncertainties remain. Indonesia must find a way to balance its desire for self-sufficiency in basic food crops; the demands of the growing palm oil industry, which is Indonesia's main cash crop (and a source of air pollution in the region because land is cleared by burning); and a rapidly diversifying diet among urban consumers. Possible negative impacts on the poor should be borne in mind—high rice prices caused by restriction of imports increase both urban and rural poverty among net rice buyers.

As one of the countries most likely to benefit from inclusion in the Trans-Pacific Partnership,

Vietnam has taken major steps to ensure it is prepared by joining a series of food security initiatives and continuing to privatize state-owned agricultural enterprises. Already closely watched by multinational investors, Vietnam is likely to receive a surge of foreign direct investments ahead of the trade agreement.[10] Such investments will complement the technological transfers implemented by the Ministry of Agriculture and Rural Development to modernize its infrastructure and introduce high-tech farming. In addition, there has been public discussion of much-needed policy reforms for land distribution and ending inefficient agriculture subsidies that pose barriers to foreign investment.

Thailand is still struggling to handle the results of a rice-buying scheme that has led to huge stockpiles of overpriced rice.[11] This worrisome policy is expected to continue, albeit with some reforms, as political elites attempt to curry favor with rice farmers. Some promising programs, such as technical support to increase productivity by introducing high-quality rice and promoting efficient water use and GMOs, are important steps toward meeting domestic demand and maintaining exportable supply.

The pressing challenge for Myanmar is dealing with the aftermath of Cyclone Komen and making necessary structural improvements to minimize the damage of similar incidents in the future. Already US$50 million has been earmarked to provide assistance. However, the decrease in agricultural production linked to the cyclone has led to a significant increase in the need for food aid in some districts. The government's current goals include restructuring skewed land distribution, improving the links that connect financial services to farmers, and increasing funding for agricultural research.[12] Development of a National Action Plan for Food and Nutrition Security is underway to provide a strategy for strengthening the agricultural food and energy sector, including nutritious food production. It is not yet clear what priorities the newly elected populist government will set for the sector.

2016 AND BEYOND

In 2016, pressure from changing diets and global warming will continue to increase in East Asia's agriculture sector. With the rise of average incomes and the emergence of a middle class, the demand for diverse foods—already reflected in the rapid emergence of supermarkets—will increase. In China, per capita annual meat consumption, now at 59 kilograms, is already double the world average; a recent report expects it to reach 74 kilograms, which is in line with that of Taiwan and Hong Kong.[13] To produce so much meat will require an amount of feed corn nearly equal to all of the current output of Brazil and Argentina. This trend is replicated across other East Asian countries, with regional per capita meat consumption expected to almost double over the next 20 years.[14] Such rapid growth is expected to put a tremendous strain on agricultural supply chains as countries adapt to the growing role of livestock. While the current demand for feed grains is largely met by imports, how growing demand will be met going forward is an important question. One possible source of solutions lies in government support for innovations in agricultural technology. From high-tech drones for monitoring soil conditions to China's e-commerce platforms specializing in fresh produce, such investments could help maximize yields in a sustainable way for countries facing limited land and other resource challenges.

Aside from structural changes, the agriculture sector of East Asia will face two major changes: the Trans-Pacific Partnership and the Asian Infrastructure Investment Bank. As yet, neither initiative has released details on its policies, but the scale and potential impact of both warrant a closer look. The trade pact aims to increase economic ties among partner nations and provide substantial benefits to exporters of various commodities through tariff reductions. Vietnam and Japan are expected to be among the biggest winners in Asia as a result of tariff cuts for their clothing and auto industries, respectively. In terms of agriculture, short-term benefits are likely to emerge for all trading nations, particularly large exporters such as Australia and the United States. However, the Trans-Pacific Partnership may also create political turmoil when protected commodities (for example, rice in Japan) face increasing pressure from foreign imports. In the long term, self-sufficiency policies can be expected to become

increasingly untenable as countries are forced to restructure their agriculture programs in the face of cheaper imports.

The Asian Infrastructure Investment Bank aims to complement and cooperate with the existing multilateral development banks to jointly address Asia's daunting infrastructure needs.[15] While some see the establishment of the bank as a political move to further China's interests in the region, others perceive it as a welcome development for Asia.[16] Given that Asia is projected to need US$8.22 trillion in infrastructure investments by the end of this century across critical sectors including agriculture and transportation, the bank is likely to play a key role in future development efforts.[17]

Overall, there is reason to be optimistic about East Asia's prospects for 2016. Despite the immediate threat from El Niño and the longer-term threat of climate change, countries have achieved tangible results in addressing these issues. As the new policies in the agrifood sector are implemented in 2016, their effectiveness can be judged. ■

Latin America and the Caribbean

Eugenio Díaz-Bonilla and Maximo Torero

For Latin America and the Caribbean (LAC), the news on food security has been mixed in 2015. On the positive side, the region has met international goals for significant reductions in undernutrition. However, global developments are driving down commodity prices to the detriment of exporting countries and contributing to an economic slowdown in countries throughout the region.

POVERTY AND FOOD AND NUTRITION SECURITY

The LAC countries achieved several of the Millennium Development Goals (MDGs) set for 2015. The region succeeded in cutting by half both the percentage of underweight children under five and undernourishment in the total population between 1990 and 2015 (Figure 1). The region has also successfully reduced the percentage of people with incomes below US$1.25 in purchasing power parity (PPP) per day by half. Latin America (without the Caribbean) has also reached the goal set by the 1996 World Food Summit of cutting the total number of undernourished people in half (Figure 1).

Several factors appear to have supported the achievement of those targets, including the relatively strong performance of the agricultural sector in recent decades (which improved food availability);[1] the decline in poverty resulting from high economic growth rates; and the expansion of safety nets for the poor and vulnerable, which also helped to reduce LAC's high levels of inequality. Compared with other regions, LAC shows the highest coverage by social safety nets (such as conditional cash transfers) of the poorest 20 percent of the population (Figure 2). Other factors that have arguably contributed to the region's achievements include advances in education and the status of women; improvements in water, sanitation, and health infrastructure; and the spread of democracy in the region since the 1980s and 1990s.

Although the region shows significant improvements as a whole, food security conditions are still worrisome in some countries, particularly in Central America and the Caribbean (CAC). Also, taking a broader perspective on malnutrition among the world's developing regions, LAC suffers some of the worst indicators related to overnutrition and related diseases,[2] problems that coexist with undernutrition in some countries.[3]

To address these issues, the presidents and heads of state of most of the LAC countries approved the regional Plan for Food Security, Nutrition and Hunger Eradication at the January 2015 Summit of the Community of Latin American and Caribbean States (CELAC). The plan consists of four pillars—food production, food safety, support to vulnerable groups, and attention to natural disasters—that are each supported by policy recommendations and regional coordination. The plan commits the region to achieving "zero hunger" by 2025, five years ahead of the schedule set by the newly approved UN Sustainable Development Goals (SDGs).

PRODUCTION AND SUSTAINABILITY

At the global level, LAC continues to be a significant producer of agricultural and food products, with about 13 percent of the world's agricultural production in 2013 (measured in PPP).[4] LAC is also the world's main net exporter of agricultural and food products, making the region a major bulwark to two

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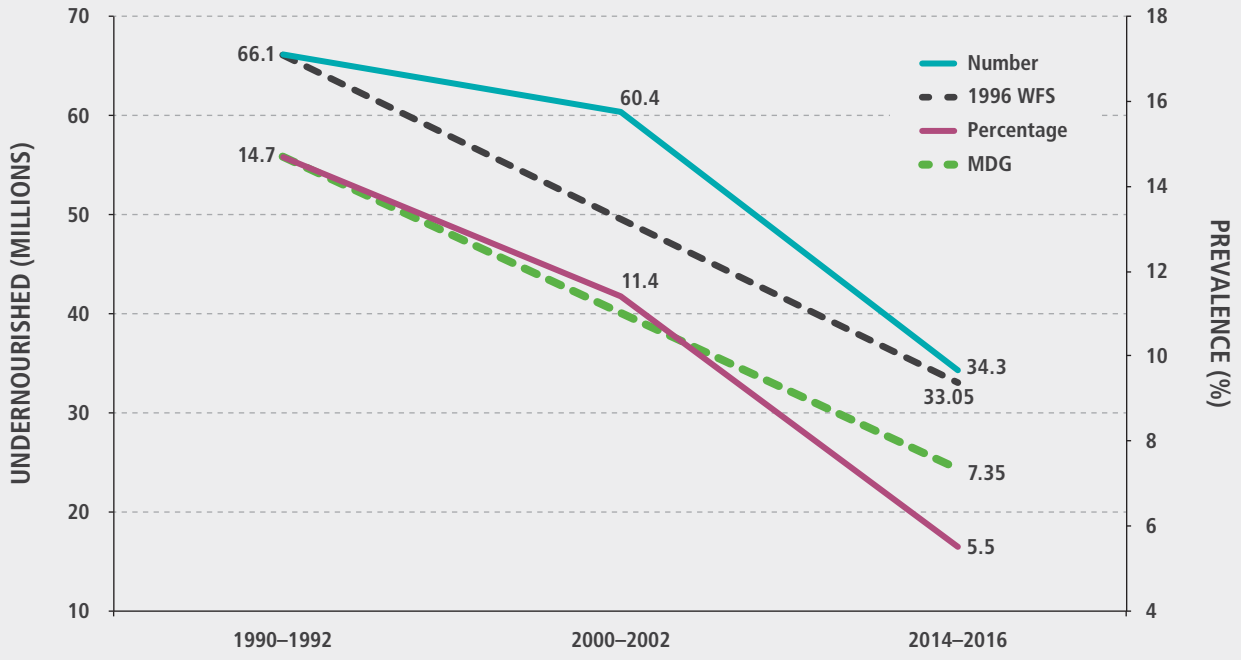
FIGURE 1 Number of undernourished and prevalence of undernourishment in Latin America and the Caribbean



Source: Adapted from FAO (Food and Agriculture Organization of the United Nations), IFAD (International Fund for Agricultural Development), and WFP (World Food Programme), *The State of Food Insecurity in the World 2015: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress* (Rome: FAO, 2015).

Note: WFS = World Food Summit; MDG = Millennium Development Goal.

aspects of global food security: food availability and stability.[5]

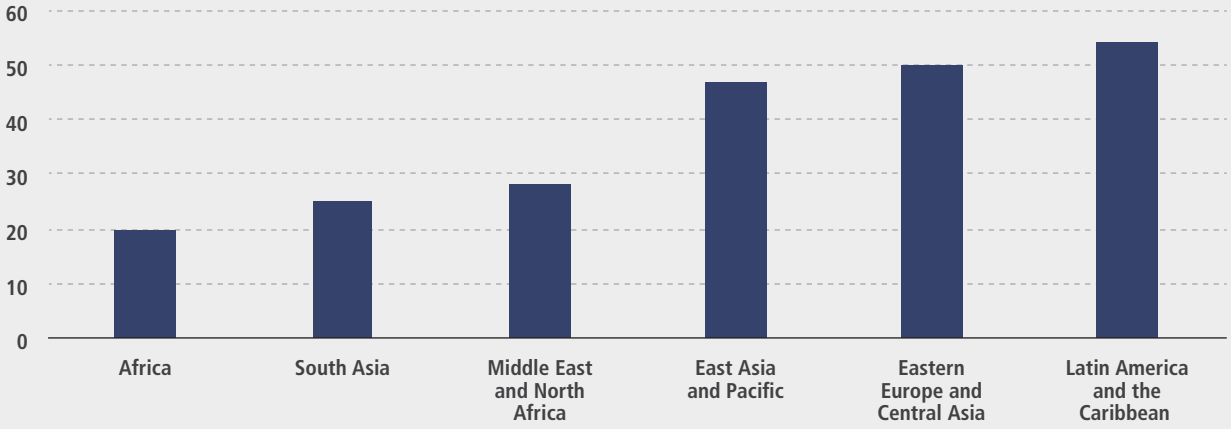
While increases in agricultural production and exports in recent decades are due in part to improvements in productivity, they were also made possible by an expansion in agricultural land that is closely linked to deforestation.[6] The loss of forest cover should be monitored to ensure long-term sustainability. According to satellite data collected by Terra-i, the rate of deforestation in LAC declined in 2013–2014 to about 1.7 million hectares per year, compared with the 2008–2011 period, when about 3.1 million hectares were deforested per year.[7] Nevertheless, this constitutes a significant loss of forest cover, and the rate of deforestation appears to have increased in the first half of 2015.

Rapid land-use change is putting pressure on LAC's role as a major provider of global environmental public goods, including biodiversity, oxygen, and carbon sinks. Temperature and precipitation changes, heat extremes, and the melting of glaciers associated with climate change will all have adverse effects on agricultural productivity, hydrological regimes, and biodiversity. In Brazil, for example, without additional adaptation, crop yields could decrease by 30–70 percent for soybeans and up to 50 percent for wheat at warming of 2°C.[8]

Shorter-term developments that need consideration are the continuing multiyear drought in Central America and the formation of what may be the strongest El Niño since the 1997–1998 episode, although it is not yet clear whether this episode will have as great an impact.[9]

Over the long term, sustaining LAC's dual role as a key contributor to global food security and global environmental public goods will require substantial

FIGURE 2 Social safety net coverage for the poorest quintile by region (%)



Source: World Bank, *The State of Social Safety Nets 2014* (Washington, DC: 2014).

investment in agricultural research and development, infrastructure, and governance of natural resources.[10] Failure to make these investments would have far-reaching implications for the world.

MACROECONOMIC DEVELOPMENTS

Economic growth has slowed in many LAC countries as a result of the current world economic deterioration and the decline in the prices of the region's commodity exports. After enjoying growth of more than 3 percent in per capita gross domestic product (GDP) during the years since 2000, LAC per capita growth slowed to less than 1 percent in 2014, and projections by international organizations indicate zero or negative per capita growth in 2015 and 2016.[11] The average, however, hides significant differences within the region. Some countries, including Bolivia, the Dominican Republic, Panama, and Peru, are expected to experience per capita growth of 4 percent or more in 2016.

A combination of slow global growth, technological change in energy, and other macroeconomic factors has led to a fall in commodity prices, particularly energy prices.[12] According to commodity price data from the World Bank, crude oil prices as of September 2015 had declined by about two-thirds from their peak in 2008–2011, while agricultural commodities, including soybeans, wheat, corn, and rice, had declined by 40–50 percent. For oil importers in CAC, lower energy prices are beneficial, but for countries that are net exporters of energy, agricultural products, or both, the drop in commodity prices is slowing growth.

The expected increase in interest rates in the United States (which will strengthen the dollar and lower commodity prices), the slowdown in China (which will also put downward pressure on commodity prices, particularly metals), and uncertainties in growth and financial prospects elsewhere in the world have increased the probability of a global economic recession in 2016 and 2017. In addition to the impacts on LAC's growth and commodity prices already mentioned, a new recession will entail a decline in capital flows, an increase in the cost of the external debt, and for some countries in CAC, a decline in remittances. For the CAC countries, the net effect of lower oil prices (positive) and lower capital flows and remittances (negative) remains to be seen. The poor macroeconomic climate has already reduced infrastructure investments across the region even though, to support future growth, LAC should increase these investments from roughly 3 percent to 6 percent of GDP, according to World Bank estimates.[13]

OTHER DEVELOPMENTS

On July 20, 2015, the United States and Cuba announced the restoration of diplomatic relations, which were broken off in 1961. The elimination of this problem in the relations within the Americas may open the door to further advances in regional economic integration. However, it is still too early to evaluate the potential impacts of these developments on production and trade of sugar and other agricultural products.

Negotiation of the Trans-Pacific Partnership Agreement was also completed in 2015. The trade agreement, which includes three LAC countries—Chile, Mexico, and Peru—could affect production and trade patterns significantly in LAC and the world. As of this writing, ratification by the legislatures of the partnership countries is still pending.[14]

2016 PROSPECTS

The year 2016 is likely to be a difficult one for the LAC region. The deepening slowdown of the global economy may contribute to declining employment and increasing poverty in LAC. Uncertainties about the impact of the current El Niño and the persistence of negative weather conditions in Central America and elsewhere in South America add to the challenging circumstances. To face the potentially difficult time ahead, countries in the region need to devise a coherent set of macroeconomic and sectoral policies. In the medium and longer term, they need to increase investments in education, infrastructure, research and development, and governance of natural resources if the region is to maintain its dual role of supporting global food security and providing environmental public goods. Both are necessary to maintain sustainable and inclusive growth. Following on the region's success in meeting international targets to reduce undernutrition and the promising launch of CELAC's food security plan, LAC countries must move to strengthen food and nutrition policies, including safety nets, to achieve the regionwide objective of zero hunger by 2025. ■

FOOD POLICY INDICATORS: TRACKING CHANGE

DECISIONMAKERS AND POLICY ANALYSTS NEED SOLID EVIDENCE AND TIMELY INFORMATION to develop and implement effective food policies. The International Food Policy Research Institute (IFPRI) develops and shares global public goods—including datasets, indicators, and indexes—as part of its mission to provide research-based policy solutions that sustainably reduce poverty and end hunger and malnutrition. This information can be used to gauge the impact of policy changes and the progress made on specific aspects of development.

This section provides updates on data generated by IFPRI research in 2015, including indicators on investments in agricultural research, public spending in agriculture, food policy research capacity, and agricultural total factor productivity, as well as a hunger index at the country level. All indicators are available online and present an interactive display of the data.

Agricultural Science and Technology Indicators (ASTI)

Policymakers increasingly recognize that greater investment in agricultural research is an essential element in raising agricultural productivity. Data on the size and scope of research capacity and investments, as well as on the changing institutional structure and functioning of agricultural research agencies, enhance our understanding of how agricultural research promotes agricultural growth. Indicators derived from such information allow the performance, inputs, and outcomes of agricultural research systems to be measured, monitored, and benchmarked.

The International Food Policy Research Institute's Agricultural Science and Technology Indicators (ASTI) initiative is the main source of statistics and other information on agricultural research in low- and middle-income countries. Working with a large network of country-level collaborators, ASTI conducts primary surveys to collect data from government agencies, higher education institutions, nonprofits, and private for-profit companies involved in agricultural research and development (R&D) in nearly 80 developing countries worldwide. ASTI publishes quantitative and qualitative information and identifies trends in funding sources, spending levels and allocations, and human resource capacities, at both country and regional levels.

Table 1 presents only a fraction of the available ASTI indicators. The ASTI website (www.asti.cgiar.org) offers additional indicators—including national-level time-series data on researcher capacity by qualification level, age bracket, and commodity—as well as a detailed breakdown of agricultural R&D investment by funding source and cost category. The interactive country pages on the ASTI website allow users to access country-level time-series data, make cross-country comparisons, create graphs, and download country datasets. The country pages also feature recent ASTI factsheets, other country-level publications, and detailed institutional information on agencies involved in agricultural R&D. Moreover, the interactive benchmarking tool on the ASTI website is a convenient map-based instrument allowing users to make cross-country comparisons and rankings based on a wide set of financial and human resource indicators. The detailed ASTI datasets are available in an easy-to-use data download tool. Finally, detailed spending and human-capacity data for CGIAR centers are also available.

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TABLE 1 Agricultural science and technology indicators

Low and middle income countries by region	Latest year available	Agricultural research spending		Agricultural research spending as a share of AgGDP (%)	Agricultural researchers (FTEs)	Agricultural researchers (FTEs) per 100,000 people economically engaged in agriculture	Female share of total agricultural researchers (%)
		2011 PPP dollars (million)	2011 US dollars (million)				
Africa south of the Sahara							
Benin	2011	32.4	14.7	0.61	155.7	8.9	12
Botswana	2011	18.4	10.2	2.63	123.8	39.3	29
Burkina Faso	2011	29.9	13.5	0.76	218.0	3.2	11
Burundi	2011	12.8	4.3	0.50	132.3	3.1	15
Cape Verde	2011	3.6	2.2	1.51	21.0	67.7	38
Central African Republic	2011	3.4	1.9	0.16	134.0	10.7	19
Chad	2011	17.0	9.0	0.15	123.3	3.9	7
Congo, Democratic Republic of	2011	19.5	11.1	0.20	412.4	3.0	9
Congo, Republic of	2011	7.5	4.6	0.94	104.0	19.4	18
Côte d'Ivoire	2011	59.1	28.6	0.42	130.6	4.8	na
Eritrea	2011	2.9	1.1	0.30	116.8	6.7	7
Ethiopia	2011	87.2	25.4	0.20	1876.6	5.5	9
Gabon	2011	0.9	0.6	0.09	42.6	22.3	25
Gambia	2011	5.2	1.7	0.86	65.9	10.8	14
Ghana	2011	139.0	64.3	0.69	607.0	9.8	20
Guinea	2011	5.6	2.1	0.21	265.0	6.2	4
Guinea-Bissau	2011	0.2	0.1	0.02	9.0	1.9	na
Kenya	2011	259.9	100.4	0.91	1147.2	8.4	25
Lesotho	2011	2.5	1.4	0.96	41.1	12.2	46
Liberia	2011	6.7	3.5	0.51	45.1	4.9	20
Madagascar	2011	12.5	4.2	0.16	193.1	2.5	27
Malawi	2011	32.6	15.9	0.99	162.3	3.2	14
Mali	2011	51.1	22.7	0.61	307.0	10.8	22
Mauritania	2011	11.4	4.7	0.47	61.8	7.7	14
Mauritius	2011	31.2	17.3	4.86	150.7	342.5	39
Mozambique	2011	22.8	12.6	0.35	313.6	3.4	31
Namibia	2011	60.4	38.8	3.79	89.4	34.9	38
Nigeria	2011	550.1	265.9	0.29	2687.6	21.6	na
Rwanda	2011	32.2	14.0	0.67	180.4	3.9	24
Senegal	2011	32.2	16.1	0.82	112.2	2.7	14
Sierra Leone	2011	9.3	3.3	0.21	81.7	6.2	14
South Africa	2011	294.5	193.6	2.05	746.3	63.4	na
Sudan	2012	57.3	26.3	0.14	932.8	15.6	40
Swaziland	2011	6.2	3.3	1.43	27.1	19.6	28
Tanzania	2011	97.7	32.5	0.33	814.8	4.7	25

Notes: na = not available; a = data for 2006. Table only includes countries where ASTI has conducted survey rounds since 2002. Agricultural research includes government, higher education, and nonprofit agencies but excludes the private for-profit sector. Purchasing power parities (PPPs) measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. PPPs are relatively stable over time, whereas exchange rates fluctuate considerably. Measuring researchers in full-time equivalents (FTEs) takes into account the proportion of time researchers spend on research activities. For example, four university professors who spend 25 percent of their time on research would individually represent 0.25 FTEs and collectively be counted as 1 FTE.

Table 1 continued

Low and middle income countries by region	Latest year available	Agricultural research spending		Agricultural research spending as a share of AgGDP (%)	Agricultural researchers (FTEs)	Agricultural researchers (FTEs) per 100,000 people economically engaged in agriculture	Female share of total agricultural researchers (%)
		2011 PPP dollars (million)	2011 US dollars (million)				
Togo	2011	10.7	4.9	0.42	114.7	8.4	8
Uganda	2011	122.4	40.4	0.88	353.9	3.1	21
Zambia	2011	19.5	9.5	0.42	233.1	7.0	na
Zimbabwe	2011	20.3	10.2	0.84	176.7	5.3	33
Asia-Pacific							
Bangladesh	2012	250.6	78.2	0.37	2121.0	6.6	12
Cambodia	2010	22.4	7.4	0.18	284.4	5.6	22
China	2008	5,475.7	2,970.7	0.50	43,200.0	8.6	na
India	2009	3,375.4	1,092.8	0.40	11,216.5	4.2	na
Indonesia	2009	770.4	316.8	0.28	na	na	na
Laos	2010	24.2	7.5	0.42	227.2	9.3	na
Malaysia	2010	592.3	282.5	0.99	1609.4	102.8	49
Nepal	2012	53.4	17.8	0.28	403.4	3.6	13
Pakistan	2012	333.0	93.9	0.18	3,678.3	14.5	12
Sri Lanka	2009	61.8	21.6	0.34	618.8	15.5	47
Vietnam	2010	136.0	44.5	0.18	3744.2	12.5	na
Latin America and Caribbean							
Argentina	2008	490.7	318.2	1.07	3,930.5	278.2	41[a]
Barbados	2012	1.3	1.3	2.01	9.9	247.5	0
Belize	2012	2.3	1.3	0.66	12.6	39.4	23
Bolivia	na	na	na	na	na	na	na
Brazil	2008	1,748.6	1,537.7	1.36	4,633.2	39.9	34[a]
Chile	2008	130.3	93.8	1.24	674.6	69.6	30[a]
Colombia	2008	182.5	114.7	0.56	956.6	26.9	32[a]
Costa Rica	2012	37.1	25.5	1.06	241.5	75.9	34
Dominica	2012	0.2	0.1	0.18	3.0	50.0	33
Dominican Republic	2012	20.4	10.4	0.30	199.6	45.1	24
Ecuador	na	na	na	na	na	na	na
El Salvador	2006	6.6	0.4	0.15	76.9	12.4	15
Grenada	2012	0.4	0.3	0.71	1.8	20.0	na
Guatemala	2012	15.6	7.3	0.14	141.8	6.6	20
Honduras	2012	7.5	3.9	0.17	87.6	13.2	14
Jamaica	2012	11.8	7.4	0.89	62.1	29.6	47
Mexico	2008	655.2	404.7	1.12	4,066.8	50.2	22[a]
Nicaragua	2012	17.5	7.0	0.38	131.5	38.1	30
Panama	2012	15.5	8.5	0.74	133.0	51.9	18
Paraguay	2006	13.3	7.1	0.20	128.3	16.3	32
Peru	na	na	na	na	na	na	na
St. Kitts and Nevis	2012	0.8	0.5	5.13	4.5	90.0	82
St. Lucia	2012	0.3	0.2	0.63	2.2	12.2	9

Low and middle income countries by region	Latest year available	Agricultural research spending		Agricultural research spending as a share of AgGDP (%)	Agricultural researchers (FTEs)	Agricultural researchers (FTEs) per 100,000 people economically engaged in agriculture	Female share of total agricultural researchers (%)
		2011 PPP dollars (million)	2011 US dollars (million)				
St. Vincent and the Grenadines	2012	0.7	0.5	1.07	2.5	22.7	na
Trinidad and Tobago	2012	18.0	11.0	7.82	83.0	180.4	43
Uruguay	2006	80.5	63.7	1.70	400.4	210.8	43
Venezuela	na	na	na	na	na	na	na
Central and West Asia and North Africa							
Algeria	2012	91.6	38.3	0.21	593.4	17.6	51
Egypt	2012	528.4	144.7	0.44	8419.7	133.3	36
Jordan	2012	36.2	15.0	1.84	272.3	228.8	18
Lebanon	2012	38.2	21.3	0.95	209.2	747.1	48
Morocco	2012	147.3	442.3	0.49	556.3	19.0	23
Oman	2012	110.0	2.6	6.51	243.6	63.6	31
Tunisia	2012	63.0	97.1	0.64	541.6	66.1	33
Turkey	2012	537.3	376.7	0.51	3009.4	38.5	32
Yemen	2012	38.7	13.7	0.56	526.7	23.8	7

Statistics of Public Expenditure for Economic Development (SPEED)

The Statistics of Public Expenditure for Economic Development (SPEED) database is a resource of the International Food Policy Research Institute (IFPRI) that contains information on agricultural and other sectoral public expenditures in 112 developing countries and 34 developed countries from 1980 to 2013 (Table 2).

Policymakers, researchers, and other stakeholders can use this robust database to examine both historical trends and the allocation of government resources across sectors. It also allows for comparisons with other countries within a region or at a similar level of development. Because the SPEED database covers many countries for a long time period, it allows analysts of government spending to examine national policy priorities, as reflected in the allocation of public expenditures, and track development goals and the cost-effectiveness of public spending both within and across countries.

IFPRI researchers have compiled data from multiple sources, including the International Monetary Fund, the World Bank, the United Nations, Eurostat, and national governments, and conducted extensive data checks and adjustments to ensure consistent spending measurements over time that are free of exchange-rate fluctuations and currency denomination changes. Differences from the data reported in the *2014–2015 Global Food Policy Report* may arise from revisions of the public expenditure data as well as other variables such as population, deflators, exchange rates, and total and agricultural gross domestic product (GDP). As was the case for the 2014–2015 report, the United Nations Statistical database was used to obtain a more complete time-series of both the GDP deflator and the purchasing power parity (PPP) converter.

Global per capita agricultural expenditure rose at a rate of 0.33 percent per year between 1980 and 2013. Public spending per capita in agriculture declined at the global level between 1980 and 2000, and much of the observed growth took place in the last 13 years (2000–2013).

However, developing and developed countries have exhibited different trends. For developed countries, despite their large volume of investments, agriculture represents only a marginal portion of the economy. Per capita agricultural expenditure declined continuously from 1980 to 2013, but is still relatively high, averaging over US$100 per person in the 2000s. The ratio of agricultural expenditure to agricultural GDP also remained high, at above 20 percent. In developing countries, on the other hand, although agriculture accounts for a larger share of total expenditures, per capita spending was considerably lower, at about half the level of developed countries. In addition, the level of per capita public expenditure in agriculture by developing countries dropped consistently until the early 1990s, but showed an impressive recovery afterward, particularly since 2000.

Download data: http://dx.doi.org/10.7910/DVN/INZ3QK
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TABLE 2 Agricultural public expenditure for economic development, by country

Region/ country	Agricultural expenditure (billions 2005 constant US dollars)			Agricultural expenditure (billions 2005 PPP dollars)			Per capita agricultural expenditure (2005 constant US dollars)			Per capita agricultural expenditure (2005 PPP dollars)			Ratio of agricultural expenditure to agricultural GDP (%)			Share of agriculture in total expenditure (%)		
	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013
East Asia and Pacific																		
China	7.16	8.63	113.94	20.52	24.75	326.65	7.27	6.98	82.24	20.85	20.00	235.76	10.93	4.74	23.44	12.20	8.43	9.52
Fiji[b]	0.03	0.03	0.01	0.06	0.05	0.02	50.31	33.93	10.54	93.75	63.24	19.65	8.17	6.78	2.93	7.24	4.01	1.08
Indonesia	1.78	2.76		8.11	12.56		12.23	14.20		55.72	64.70		9.68	8.11		10.27	9.43	
Malaysia[a]	0.75	0.94	4.12	2.15	2.69	11.86	53.99	45.13	140.96	155.30	129.81	405.44	10.20	8.34	20.66	8.75	5.10	8.40
Mongolia[a]		0.01	0.04		0.03	0.16		3.00	12.53		13.61	56.80		1.20	5.19		2.12	1.76
Myanmar[c]	0.11	0.07	0.09	0.42	0.27	0.34	3.12	1.53	1.69	12.07	5.91	6.53	8.02	2.66	1.18	23.57	14.90	6.26
Papua New Guinea	0.06	0.05		0.13	0.09		19.99	9.83		39.45	19.41		7.97	3.26		8.46	3.97	
Philippines	0.38	0.77	1.50	1.37	2.75	5.34	8.10	11.09	15.22	28.89	39.55	54.27	3.34	5.93	8.13	6.06	6.90	6.00
Singapore	0.02	0.03	0.08	0.04	0.05	0.14	8.35	8.04	14.31	15.38	14.80	26.35	5.63	25.51	131.08	0.44	0.24	0.26
Thailand	0.77	2.47	3.52	2.77	8.94	12.73	16.17	41.95	52.59	58.41	151.53	189.96	7.56	19.49	14.08	9.67	11.30	6.89
Tonga	0.00	0.00	0.00	0.01	0.00	0.00	32.64	5.38	13.64	56.27	9.28	23.51	6.13	1.23	3.04	9.97	0.80	1.15
Vanuatu	0.00	0.00		0.00	0.00		9.75	14.84		11.93	18.16		2.59	2.71		2.96	3.13	
Vietnam[c]		0.46	0.96		2.06	4.26		6.10	10.77		27.09	47.85		6.15	6.49		8.20	3.94
South Asia																		
Afghanistan			0.15			0.60			4.90			19.78			4.40			1.81
Bangladesh	0.19	0.24	1.39	0.71	0.88	5.14	2.34	1.99	8.89	8.63	7.33	32.81	2.74	2.53	8.21	13.02	4.93	11.08
Bhutan	0.01	0.03	0.07	0.04	0.10	0.22	26.62	60.14	90.37	86.48	195.40	293.62	19.53	23.98	26.63	31.86	19.69	13.61
India	1.77	3.49	14.34	7.07	13.95	57.25	2.53	3.66	11.45	10.11	14.60	45.72	2.62	3.13	5.87	7.18	5.26	5.97
Maldives[b]	0.00	0.02	0.00	0.00	0.04	0.01	11.62	72.47	14.74	23.72	147.96	30.09	6.99	46.24	7.17	8.84	12.07	0.74
Nepal	0.06	0.08	0.20	0.27	0.38	0.92	4.08	3.97	7.07	19.04	18.48	32.94	3.93	3.96	5.29	16.39	9.64	9.57
Pakistan	0.10	0.06	0.60	0.50	0.32	3.02	1.23	0.49	3.29	6.20	2.49	16.57	0.98	0.31	1.59	2.13	0.46	1.92
Sri Lanka	0.18	0.24	0.32	0.75	0.99	1.32	11.86	12.99	14.82	49.74	54.46	62.14	9.44	8.69	7.10	5.77	5.28	4.01
Europe and Central Asia																		
Albania		0.06	0.06		0.13	0.13		16.72	17.84		38.26	40.83		2.15	2.71		3.95	1.80
Azerbaijan		0.09	0.26		0.39	1.18		11.08	27.56		50.39	125.33		6.68	16.29		8.01	2.37
Belarus		0.31	0.57		0.95	1.77		30.11	61.03		93.11	188.72		12.56	15.55		5.96	2.79
Bulgaria		0.02	0.32		0.04	0.84		2.02	44.42		5.31	116.71		0.56	17.08		0.25	2.37
Georgia			0.06			0.18			14.63			41.94			8.33			2.27
Kazakhstan			0.64			2.38			39.13			144.48			15.80			3.42
Kyrgyzstan		0.02			0.07			3.32			14.74			2.41			3.54	
Latvia		0.13	0.12		0.24	0.23		51.46	59.45		96.23	111.18		21.42	15.50		2.83	1.35
Lithuania		0.28	0.29		0.53	0.55		77.73	96.89		145.05	180.80		19.87	26.08		8.65	2.61
Moldova		0.01	0.06		0.04	0.20		2.74	16.20		9.71	57.44		1.69	11.80		1.38	3.59
Romania	2.45	1.77	1.09	5.02	3.62	2.24	109.44	77.04	50.35	224.08	157.73	103.10	24.64	12.79	16.32	7.42	6.77	2.56
Russian Federation		0.22	5.84		0.48	12.97		1.45	40.90		3.23	90.83		0.58	17.62		0.15	1.40
Serbia[a]			0.32			0.80			33.26			83.53			13.03			2.30
Ukraine			0.52			1.83			11.41			40.47			5.88			1.11
Middle East and North Africa																		
Algeria[b]		0.51	1.81		1.81	6.40		17.46	47.84		61.87	169.49		7.70	18.63		2.42	3.68
Bahrain[b]	0.01	0.01	0.02	0.02	0.03	0.04	30.59	21.98	13.51	66.13	47.52	29.21	18.58	17.04	28.36	0.63	0.54	0.31
Egypt	0.62	0.83		3.64	4.86		13.79	13.52		81.03	79.46		12.78	8.43		5.14	4.39	

Note: PPP (purchasing power parity) dollars measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. Because of the dramatic differences in countries' agriculture spending, entries have different numbers of decimal places.

a = last year of data available is 2012; b = last year of data available is 2011; c = last year of data available is 2010; d = last year of data available is 2009; e=last year of data available is 2008.

Table 2 continued

Region/ country	Agricultural expenditure (billions 2005 constant US dollars)			Agricultural expenditure (billions 2005 PPP dollars)			Per capita agricultural expenditure (2005 constant US dollars)			Per capita agricultural expenditure (2005 PPP dollars)			Ratio of agricultural expenditure to agricultural GDP (%)			Share of agriculture in total expenditure (%)		
	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013
Iran[d]	0.95	1.11	0.77	4.08	4.76	3.32	24.41	18.32	10.51	104.85	78.67	45.15	8.78	4.80	3.13	3.36	4.22	1.41
Jordan	0.02	0.11	0.04	0.07	0.39	0.14	8.39	25.44	5.29	29.89	90.61	18.86	8.08	37.73	6.98	0.98	4.46	0.70
Kuwait[a]	0.01	0.15	0.13	0.03	0.38	0.34	9.69	95.99	40.95	24.45	242.30	103.36	13.33	70.59	49.10	0.10	0.59	0.41
Lebanon[a]		0.02	0.02		0.05	0.04		7.95	4.69		16.26	9.60		1.13	1.41		0.40	0.24
Morocco	0.48	0.48		1.19	1.18		24.46	17.86		60.02	43.82		9.96	8.14		6.80	4.21	
Occupied Palestinian Territory[a]			0.02			0.04			3.82			10.45			4.80			0.73
Oman	0.05	0.13	0.12	0.15	0.38	0.34	45.42	61.83	32.73	129.77	176.66	93.50	24.24	20.17	22.53	1.85	1.56	0.57
Syria																		
Tunisiad	0.28	0.47	0.43	0.67	1.15	1.04	30.97	32.96	20.30	75.36	80.21	49.39	12.00	9.02	5.37	5.04	10.24	4.71
Turkey[a]	0.48	0.48	0.64	1.16	1.16	1.53	76.45	53.85	58.73	183.26	129.07	140.77	34.71	25.19	18.28	15.63	8.17	4.16
United Arab Emirates	0.46	0.54	7.69	0.75	0.87	12.43	10.51	9.22	102.59	17.01	14.92	165.94	1.52	1.52	15.83	2.08	1.03	3.11
Yemen[a]	0.05	0.05	0.05	0.12	0.11	0.10	54.07	21.54	5.26	114.20	45.48	11.11	14.01	2.78	2.97	0.83	0.67	0.09
Latin America and Caribbean																		
Argentina[d]	0.17	0.14	0.90	0.35	0.30	1.86	5.99	4.13	22.47	12.38	8.55	46.47	2.16	1.84	5.58	0.65	0.58	1.65
Bahamas[c]	0.01	0.02	0.01	0.01	0.01	0.01	44.49	54.29	40.22	42.71	52.11	38.61	11.45	7.47	9.35	1.45	1.67	0.97
Barbados	0.03	0.03		0.02	0.03		102.17	108.39		97.09	103.01		12.77	28.29		3.20	2.80	
Belize	0.01	0.01		0.02	0.01		68.56	37.12		122.30	66.21		12.96	6.96			4.61	
Bolivia	0.03	0.00		0.11	0.01		5.07	0.43		20.27	1.72		2.61	0.32		3.33	0.35	
Brazil		7.23	6.65		16.10	14.81		44.63	33.18		99.46	73.93		20.60	11.94		5.70	2.29
Chile	0.18	0.17	0.61	0.30	0.28	1.03	16.04	11.47	34.87	26.91	19.25	58.49	9.16	4.26	10.59	1.77	1.18	1.66
Colombia	0.13	0.23	0.00	0.31	0.57	0.00	4.75	6.37	0.02	11.58	15.53	0.04	1.40	2.21	0.01	2.00	1.77	2.10
Costa Rica	0.05	0.09	0.46	0.11	0.19	0.94	21.98	26.12	93.82	45.06	53.55	192.35	5.24	5.65	30.31	3.38	3.15	5.38
Dominican Republic	0.24	0.19		0.48	0.37		41.37	23.40		81.67	46.19		13.96	10.13		16.71	7.83	
Ecuador[c]			0.19			0.48			12.89			31.87			4.05			1.59
El Salvador	0.01	0.03	0.05	0.02	0.07	0.10	2.06	5.26	7.45	4.51	11.51	16.29	0.36	1.73	2.47	5.80	1.69	0.98
Grenada		0.01			0.02			109.41			171.72			31.37			9.65	
Guatemala	0.15	0.05	1.19	0.41	0.14	3.21	21.88	5.25	77.17	58.86	14.12	207.54	6.95	1.82	29.36	7.88	2.72	23.00
Jamaica[a]		0.07	0.08		0.11	0.14		27.79	30.42		46.42	50.81		7.89	13.20		2.13	2.17
Mexico[c]	6.60	2.78	4.80	10.09	4.25	7.34	93.79	29.10	40.70	143.41	44.50	62.24	24.42	10.65	15.17	14.56	4.08	2.32
Panama	0.09	0.04	0.10	0.20	0.08	0.21	45.89	12.82	25.58	99.33	27.75	55.37	17.62	5.04	9.81	5.29	1.64	1.36
Paraguay	0.02			0.06			5.28			19.11			1.56			3.47		
Peru			0.33			0.82			10.74			26.83			3.76			1.93
Saint Vincent and the Grenadines	0.00	0.00		0.00	0.01		17.47	29.81		28.64	48.86		9.38	8.74		3.81	3.46	
Trinidad and Tobago[a]	0.14	0.09	0.15	0.25	0.17	0.27	127.51	75.69	111.42	234.64	139.28	205.04	68.72	66.01	181.53	5.10	4.49	2.18
Uruguay	0.03	0.04		0.07	0.09		11.58	13.05		25.08	28.25		2.25	3.63		2.08	1.04	
Venezuela[d]			1.55			3.81			54.31			133.21			15.47			2.06
Africa south of the Sahara																		
Angola		0.08	0.38		0.19	0.94		6.36	17.93		15.52	43.71		7.11	5.74		1.74	1.30
Benin		0.04	0.01		0.11	0.02		6.90	0.87		18.27	2.30		4.44	0.46		7.26	0.67
Botswana[a]	0.06	0.14	0.19	0.12	0.27	0.37	63.40	88.21	96.73	122.04	169.79	186.19	29.17	46.66	53.89	9.71	5.96	3.69
Burkina Faso	0.14	0.28	0.01	0.40	0.77	0.04	21.16	27.45	0.79	58.48	75.87	2.19	19.10	30.21	0.50	31.37	45.68	0.54
Burundi		0.02	0.02		0.07	0.07		2.80	1.68		12.00	7.21		3.80	2.08		5.10	2.79
Cameroon	0.03	0.05		0.06	0.13		3.01	3.88		7.10	9.15		1.19	2.21		2.22	4.16	
Cape Verde[a]		0.00	0.03		0.00	0.05		4.22	51.28		8.53	103.63		1.84	19.93			4.93

Region/ country	Agricultural expenditure (billions 2005 constant US dollars)			Agricultural expenditure (billions 2005 PPP dollars)			Per capita agricultural expenditure (2005 constant US dollars)			Per capita agricultural expenditure (2005 PPP dollars)			Ratio of agricultural expenditure to agricultural GDP (%)			Share of agriculture in total expenditure (%)		
	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013
Central African Republic[a]	0.02	0.02	0.00	0.04	0.04	0.01	8.64	5.81	1.08	15.93	10.71	1.99	4.70	3.46	0.57		9.94	1.69
Congo, Dem. Rep.		0.00			0.00			0.03			0.06			0.03			0.18	
Congo, Republic of		0.00			0.01			1.82			4.71			1.07			0.34	
Côte d'Ivoire	0.12	0.12	0.24	0.32	0.32	0.62	15.01	8.67	11.90	38.47	22.21	30.50	3.76	3.46	4.08	2.60	3.56	5.04
Equatorial Guinea[d]		0.01	0.05		0.02	0.14		13.25	79.84		35.09	211.40		2.31	20.48			0.80
Ethiopia[b]	0.06	0.12	0.23	0.25	0.48	0.93	1.76	2.09	2.56	7.12	8.45	10.37	1.97	3.10	2.41	7.02	9.72	3.90
Gambia	0.01			0.02			10.74			33.96			9.25			17.13		
Ghana[d]	0.06	0.02	0.10	0.26	0.08	0.44	5.41	1.02	4.11	24.23	4.59	18.39	1.76	0.51	1.45	12.21	0.73	1.86
Guinea-Bissau		0.00	0.00		0.00	0.00		0.08	0.62		0.23	1.66		0.03	0.34		1.19	0.89
Kenya	0.14	0.21	0.30	0.46	0.68	0.98	8.70	7.73	6.87	28.06	24.91	22.14	5.35	5.09	4.29	8.28	7.00	4.11
Lesotho[a]	0.02	0.07	0.04	0.04	0.15	0.09	12.64	37.25	18.25	28.82	84.96	41.62	12.29	54.22	25.88	8.02	12.41	3.15e
Liberia[a]	0.02	0.00	0.01	0.06	0.01	0.02	12.33	2.09	1.73	31.20	5.29	4.38	10.62	3.28	0.99	5.02	2.76	1.97
Madagascar[b]		0.04	0.01		0.18	0.04		2.94	0.42		13.36	1.89		3.48	0.59		6.10	1.59
Malawi[b]	0.04	0.04	0.16	0.13	0.12	0.49	6.75	3.92	10.59	20.25	11.76	31.75	4.40	5.79	12.19	10.15	8.85	15.79
Mali	0.02	0.14	0.16	0.06	0.41	0.49	3.19	15.27	10.77	9.48	45.43	32.04	1.85	11.75	5.93	7.05	17.28	9.71
Mauritius	0.03	0.05	0.06	0.07	0.12	0.14	34.55	47.47	51.42	76.79	105.49	114.27	17.02	14.87	24.60	6.87	5.86	2.67
Mozambique			0.29			0.60			11.28			23.35			9.45			6.85
Namibia[b]		0.09	0.24		0.16	0.44		54.26	109.92		98.99	200.52		16.00	35.99		6.04	6.92
Niger	0.06	0.05	0.14	0.15	0.14	0.39	9.49	5.59	8.10	25.82	15.22	22.04	5.46	6.35	7.41	14.17	13.17	8.71
Nigeria	0.54	0.17	0.39	2.48	0.80	1.81	7.29	1.61	2.26	33.61	7.41	10.40	3.42	1.00	0.67	2.92	3.60	1.85
Rwanda[a]			0.08			0.27			7.27			23.50			5.63			7.09
Senegal	0.04	0.05	0.21	0.09	0.12	0.50	6.98	5.89	14.54	16.97	14.31	35.33	6.31	5.34	12.11	4.04	5.23	6.48
Seychelles		0.01	0.01		0.01	0.01		80.50	81.93		118.04	120.15		17.50	26.44		1.99	1.78
Sierra Leone		0.00			0.01			0.74			2.41			0.42			1.57	
South Africa		0.25	0.53		0.46	0.98		6.13	10.14		11.19	18.49		4.04	7.84		0.51	1.08
Sudan	0.25	0.00		0.94	0.01		13.06	0.12		49.28	0.46		6.71	0.06		27.33	3.59	
Swaziland[a]	0.03	0.02	0.04	0.07	0.06	0.10	45.40	25.59	32.85	107.77	60.74	77.99	16.48	12.06	24.10	12.98	5.68	4.23
Tanzania[d]	0.12	0.11	0.42	0.35	0.32	1.27	6.18	3.51	9.54	18.85	10.71	29.11	10.97	3.81	8.68	10.90	8.55	6.70
Togo	0.04	0.02	0.06	0.12	0.06	0.16	16.22	5.23	8.55	45.87	14.78	24.18	10.50	3.66	4.85	6.99	6.13	7.00
Uganda	0.01	0.01	0.13	0.02	0.02	0.38	0.60	0.41	3.42	1.75	1.20	10.03	0.79	0.50	3.54	6.71	1.87	4.64
Zambia[b]	0.36	0.03	0.16	1.21	0.11	0.53	0.06	0.00	0.01	207.79	12.76	38.61	73.83	4.19	7.76	22.81	2.80	7.27
Zimbabwe	0.21	0.26		0.14	0.17		29.17	21.92		19.75	14.84		13.48	10.27		7.03	4.18	
High-income European countries																		
Austria	3.83	3.08	1.35	3.48	2.80	1.22	507.47	385.94	158.86	460.36	350.11	144.11	49.95	57.73	28.55	2.51	2.32	0.76
Belgium	0.88	0.53	0.28	0.79	0.47	0.25	89.39	51.73	24.90	79.90	46.24	22.26	16.80	13.17	8.58	0.88	0.33	0.12
Croatia[b]		0.17	0.68		0.26	1.03		36.56	156.37		55.55	237.60		9.13	35.36		2.50	3.99
Cyprus	0.12	0.18	0.15	0.14	0.20	0.16	181.90	215.64	127.73	198.17	234.92	139.15	27.41	32.97	36.96	15.06	4.61	1.82
Czech Republic		2.73	0.65		4.58	1.09		264.48	60.97		442.60	102.03		69.37	20.68		5.27	1.00
Denmark	0.86	0.43	0.60	0.60	0.30	0.42	168.37	82.96	106.66	117.54	57.91	74.46	13.87	7.06	20.27	0.91	0.35	0.40
Estonia		0.04	0.11		0.07	0.18		31.09	87.33		49.81	139.92		11.94	20.66		1.47	1.78
Finland	6.16	6.60	1.90	5.07	5.43	1.56	1288.18	1292.83	349.83	1059.99	1063.81	287.86	68.92	124.07	36.60	10.74	7.75	1.54
France		8.49	8.91		7.39	7.76		146.38	138.63		127.48	120.73		18.93	24.53		0.89	0.67
Germany	2.96	14.97	6.29	2.74	13.88	5.83	37.38	180.01	76.02	34.67	166.98	70.52	8.70	61.74	29.26	0.49	1.09	0.45
Greece	2.91	2.39	0.29	3.27	2.69	0.33	301.41	223.68	26.40	339.44	251.90	29.73	17.86	17.93	4.49	5.30	3.11	0.25
Hungary		1.53	0.53		2.38	0.83		148.27	53.41		230.12	82.89		27.36	12.23		3.51	0.95
Iceland	0.33	0.26	0.18	0.21	0.16	0.11	1458.78	957.11	541.97	927.31	608.41	344.52	40.34	24.83	14.80	12.44	7.22	2.18

Table 2 continued

Region/ country	Agricultural expenditure (billions 2005 constant US dollars)			Agricultural expenditure (billions 2005 PPP dollars)			Per capita agricultural expenditure (2005 constant US dollars)			Per capita agricultural expenditure (2005 PPP dollars)			Ratio of agricultural expenditure to agricultural GDP (%)			Share of agriculture in total expenditure (%)		
	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013	1980	1995	2013
Ireland		1.11	1.10		0.88	0.88		306.06	238.01		243.61	189.45		17.47	37.12		2.71	1.23
Italy	8.27	7.38	5.45	7.67	6.85	5.05	147.01	129.60	89.28	136.41	120.25	82.84	12.69	15.96	16.87	1.10	0.89	0.61
Luxembourg	0.11	0.14	0.16	0.09	0.12	0.13	306.20	340.47	295.03	258.39	287.31	248.96	52.45	63.66	120.82	2.16	1.44	0.84
Malta	0.01	0.01	0.04	0.02	0.01	0.06	34.74	24.46	91.09	49.30	34.71	129.28	14.24	8.71	40.34	3.77	0.53	1.21
Netherlands	2.34	1.69	1.28	2.10	1.51	1.15	166.30	109.39	76.16	149.22	98.16	68.33	19.63	11.34	12.81	1.05	0.60	0.38
Norway	5.14	3.47	1.99	3.72	2.51	1.44	1259.81	795.91	395.20	912.32	576.37	286.19	94.88	57.79	43.99	7.16	2.99	1.34
Poland		2.08	1.85		3.60	3.20		54.02	48.40		93.51	83.78		14.83	12.93		2.68	1.04
Portugal		1.38	0.74		1.62	0.86		136.86	69.34		160.82	81.48		19.00	19.20		2.14	0.76
Slovakia			0.30			0.54			54.93			99.92			16.38			1.12
Slovenia		0.39	0.27		0.51	0.35		193.61	129.90		254.56	170.79		42.76	30.82		3.61	1.17
Spain	5.88	5.14	4.48	6.18	5.40	4.70	156.81	130.41	95.37	164.85	137.10	100.26	15.51	15.72	16.56	3.36	1.43	0.86
Sweden	3.63	1.91	0.74	2.89	1.52	0.59	436.79	216.03	77.38	348.05	172.14	61.66	39.07	27.37	13.14	2.87	1.06	0.32
Switzerland	7.40	10.10	3.96	5.29	7.21	2.83	1174.54	1438.80	489.72	839.19	1028.01	349.90	99.58	192.54	118.43	4.87	9.24	2.50
United Kingdom	6.21	1.57	3.63	5.37	1.36	3.14	110.29	27.03	57.53	95.35	23.37	49.73	31.27	6.69	26.44	1.19	0.22	0.31
Other high-income countries																		
Australia	1.34	1.77	1.47	1.26	1.67	1.39	90.98	97.74	63.11	85.81	92.19	59.53	6.99	9.77	7.02	1.78	1.24	0.59
Canada[d]	2.25	3.41	2.37	2.24	3.40	2.36	91.68	116.30	70.11	91.54	116.12	70.00	9.99	14.69	13.36	2.20	1.93	1.31
Israel	0.63	0.61		0.76	0.73		168.02	113.97		202.86	137.60		24.79	33.54		1.97	1.49	
Japan	15.06	10.55	6.81	12.81	8.98	5.80	129.90	84.76	53.60	110.51	72.11	45.60	20.85	16.55	12.26	3.49	1.69	0.70
New Zealand[a]	1.14	0.27	0.78	1.06	0.25	0.72	363.64	73.39	174.06	336.46	67.90	161.05	19.88	5.14	10.63	5.42	1.06	1.23
Republic of Korea[a]	1.34	8.03	13.86	1.74	10.42	17.99	35.70	179.82	282.77	46.34	233.43	367.07	6.58	27.36	54.06	5.59	10.02	3.53
United States of America	18.17	11.80	25.61	18.17	11.80	25.61	78.93	44.02	80.03	78.93	44.02	80.03	12.59	8.43	16.18	1.48	0.64	0.86

Global Hunger Index (GHI)

Comprehensive measurement and tracking of hunger globally and by country and region provides evidence of progress and setbacks over time and allows for assessment of the drivers of these changes. The Global Hunger Index (GHI) is designed to raise awareness and understanding of regional and country differences in the struggle against hunger and to trigger action to reduce hunger around the world.

Each year since 2006, the International Food Policy Research Institute (IFPRI) has calculated the GHI for individual countries and regions in the developing world, as well as for the developing world as a whole. GHI scores reflect the multidimensional nature of hunger by combining multiple indicators into one index number, which falls within the range 0–100.

Prior to 2015, the calculation of the GHI included three standardized component indicators. In 2015, the GHI formula was revised to include an additional indicator.

1. Percentage of the population that is undernourished
2. Percentage of children under five who suffer from wasting (low weight-for-height)
3. Percentage of children under five who suffer from stunting (low height-for-age)
4. Percentage of children who die before the age of five (child mortality)

According to the 2015 GHI, the score for the developing world has improved since 2000, falling by 27 percent. Despite progress made, the level of hunger in the world is still classified as "serious." From the 2000 GHI to the 2015 GHI, 17 countries made remarkable progress, reducing their GHI scores by 50 percent or more. Sixty-eight countries made considerable progress with scores that dropped by between 25.0 percent and 49.9 percent, and 28 countries decreased their GHI scores by less than 25 percent. Despite this progress, 52 countries still suffer from "serious" or "alarming" levels of hunger.

Since 2000, Angola, Ethiopia, and Rwanda have seen the biggest reductions in hunger, with GHI scores down by between 25 and 28 points in each country. Despite these improvements, the hunger levels in these countries are still "serious." Eight countries—Afghanistan, Central African Republic, Chad, Haiti, Madagascar, Sierra Leone, Timor-Leste, and Zambia—still suffer from levels of hunger that are "alarming" (see specific country scores for the 2015 GHI in Table 3). Due to insufficient data, 2015 GHI scores could not be calculated for some countries, including Burundi, Comoros, Democratic Republic of Congo, Eritrea, Somalia, South Sudan, and Sudan.

Download data: http://dx.doi.org/10.7910/DVN/JL16EW

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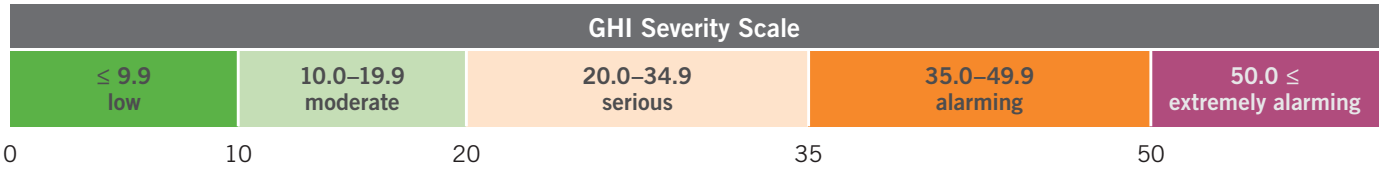

TABLE 3 Global Hunger Index scores (various years), ranked by 2015 country scores

Rank	Country	1990	1995	2000	2005	2015
1	Kuwait	24.3	16.0	<5	<5	5.0
2	Saudi Arabia	15.8	14.3	10.4	11.8	5.1
2	Turkey	14.5	13.4	10.5	7.6	5.1
4	Slovak Republic	–	8.2	8.0	7.4	5.2
5	Romania	9.1	9.6	8.6	6.1	5.3
6	Tunisia	11.5	14.2	8.9	6.7	5.6
7	Uruguay	12.2	9.4	7.6	8.1	5.7
8	Jordan	12.8	10.5	9.8	6.5	5.8
9	Macedonia, FYR	–	11.2	7.9	8.6	5.9
10	Lebanon	12.1	9.4	9.0	10.4	6.4
11	Russian Federation	–	11.7	10.4	7.2	6.6
12	Iran	18.5	16.5	13.7	9.5	6.8
13	Venezuela	16.3	15.3	15.2	13.1	7.0
14	Serbia	–	–	–	–	7.1
15	Mexico	16.8	16.9	10.8	8.9	7.3
16	Kazakhstan	–	15.4	10.7	12.3	8.0
17	Jamaica	12.5	10.7	8.8	8.2	8.1
18	Trinidad and Tobago	13.7	14.7	12.3	11.4	8.3
19	Bulgaria	8.1	10.2	9.4	9.2	8.5
19	Georgia	–	31.8	15.2	10.2	8.5
21	China	25.1	23.2	15.9	13.2	8.6
22	Algeria	17.1	18.0	14.8	12.2	8.7
22	Fiji	12.5	11.2	10.1	9.3	8.7
24	Colombia	16.7	13.0	11.4	10.7	8.8
25	Moldova	–	16.0	15.3	15.7	9.1
25	Peru	30.7	25.0	20.9	18.8	9.1
27	Kyrgyzstan	–	24.1	20.2	14.3	9.4
28	Morocco	18.7	18.8	15.7	17.7	9.5
29	Panama	21.5	18.4	20.1	18.1	9.6
30	Azerbaijan	–	28.3	27.2	16.7	10.0
31	Malaysia	20.4	17.4	15.5	14.6	10.3
32	Suriname	18.5	16.5	16.5	13.1	10.4
33	Paraguay	17.2	15.8	13.5	12.0	10.5
34	Dominican Republic	26.3	20.3	19.4	18.1	10.8
35	El Salvador	22.4	18.6	16.8	13.1	11.1
36	Armenia	–	21.8	17.4	14.1	11.2
37	Thailand	28.4	22.3	17.6	13.6	11.9
38	South Africa	18.7	16.5	18.6	21.0	12.4
39	Gabon	23.2	20.8	18.5	16.2	12.5
40	Mauritius	18.2	17.0	16.1	15.2	12.9
40	Turkmenistan	–	24.5	22.2	17.5	12.9
42	Albania	21.4	19.1	21.1	17.1	13.2
43	Uzbekistan	–	23.7	21.9	18.5	13.3
44	Honduras	26.5	24.7	20.4	17.8	13.4
45	Egypt	20.5	18.9	15.1	13.1	13.5
46	Nicaragua	38.3	32.2	25.6	17.8	13.6
47	Ecuador	23.8	19.7	20.2	19.0	14.0
48	Guyana	25.4	22.7	19.0	17.3	14.4
49	Mongolia	32.0	39.3	33.1	27.0	14.7
49	Vietnam	44.6	38.8	30.3	24.6	14.7
51	Ghana	45.7	36.8	29.9	23.3	15.5
52	Bolivia	38.9	35.1	30.5	27.2	16.9
53	Philippines	30.7	28.9	26.2	22.1	20.1
54	Guatemala	28.8	27.8	28.0	23.9	21.1
55	Gambia	36.4	35.4	27.9	26.3	21.5
56	Benin	46.1	42.6	38.2	33.3	21.8
57	Indonesia	34.8	32.5	25.3	26.5	22.1
58	Iraq	17.4	24.3	24.9	23.6	22.2
58	Nepal	44.5	40.3	36.9	31.6	22.2
60	Cambodia	46.9	45.2	45.0	29.8	22.6
60	Mauritania	40.0	36.6	33.5	29.6	22.6
62	Togo	42.5	44.1	38.6	36.4	23.0
63	Botswana	31.3	34.3	33.2	31.2	23.1
64	Senegal	36.8	36.9	37.9	28.5	23.2
65	Lesotho	25.8	28.5	32.7	30.2	23.5
65	Myanmar	56.3	53.3	45.1	37.4	23.5
67	Kenya	34.8	40.0	37.9	36.6	24.0
68	Cameroon	39.8	43.7	40.4	34.0	24.2
69	Sri Lanka	31.3	29.7	27.0	25.9	25.5
70	Swaziland	22.8	25.8	30.4	27.4	26.0
71	Côte d'Ivoire	33.8	32.1	31.4	32.7	26.3
72	Congo, Rep.	38.9	41.1	38.1	33.5	26.6
73	Bangladesh	52.2	50.3	38.5	31.0	27.3
73	Malawi	58.9	55.9	45.3	39.1	27.3
75	Uganda	39.8	40.9	39.3	32.2	27.6
76	Laos	52.9	51.1	48.7	36.9	28.5
77	Tanzania	42.2	45.2	42.5	36.4	28.7
78	Guinea	47.8	45.8	44.4	38.0	28.8
78	North Korea	30.1	35.9	40.4	32.4	28.8
80	India	48.1	42.3	38.2	38.5	29.0

– = Data are not available or not presented. Some countries, such as the post-Soviet states prior to 1991, did not exist in their present borders in the given year or reference period.

Note: Ranked according to 2015 GHI scores. Countries with a 2015 GHI score of less than 5 are not included in the ranking, but are shown in Table 4. Differences between their scores are minimal. Countries that have identical 2015 scores are given the same ranking (for example, Bulgaria and Georgia both ranked nineteenth). The following countries could not be included because of lack of data: Bahrain, Bhutan, Burundi, Comoros, Democratic Repepublic of Congo, Eritrea, Libya, Oman, Papua New Guinea, Qatar, Somalia, South Sudan, Sudan, and Syria.

Table 3 continued

Rank	Country	1990	1995	2000	2005	2015
81	Mali	51.9	51.3	43.9	38.3	29.6
82	Guinea-Bissau	46.1	42.1	44.2	41.8	30.3
82	Rwanda	53.9	66.3	58.5	44.5	30.3
82	Tajikistan	–	40.3	40.4	36.5	30.3
85	Liberia	54.4	55.2	46.8	41.5	30.8
85	Zimbabwe	33.3	38.1	40.8	39.2	30.8
87	Burkina Faso	53.0	46.1	48.4	49.6	31.8
87	Namibia	35.8	37.0	32.5	28.8	31.8
89	Mozambique	64.5	63.2	49.2	42.4	32.5
90	Angola	67.3	66.8	58.3	45.3	32.6
91	Nigeria	47.7	47.1	41.0	35.2	32.8
92	Djibouti	56.1	56.1	48.5	46.1	33.2
93	Ethiopia	71.7	67.3	58.6	48.5	33.9
93	Pakistan	43.6	40.9	37.9	38.3	33.9
95	Yemen	44.4	44.4	42.9	42.1	34.2
96	Niger	64.7	62.7	53.0	42.8	34.5
97	Afghanistan	47.4	55.9	52.5	44.9	35.4
98	Madagascar	44.8	45.1	44.1	44.4	36.3
99	Haiti	52.1	52.1	42.8	45.4	37.3
100	Sierra Leone	58.8	56.0	53.5	52.4	38.9
101	Timor-Leste	–	–	–	42.7	40.7
102	Zambia	47.0	49.0	50.9	46.7	41.1
103	Chad	65.0	60.6	52.0	53.1	46.4
104	Central African Republic	51.9	51.0	51.4	51.0	46.9

TABLE 4 **Countries with 2015 Global Hunger Index scores of less than 5**

Country	1990	1995	2000	2005	2015
Argentina	7.7	7.2	5.3	5.0	<5
Belarus	–	<5	<5	<5	<5
Bosnia and Herzegovina	–	10.8	9.6	6.8	<5
Brazil	18.2	15.0	12.0	6.7	<5
Chile	6.8	<5	<5	<5	<5
Costa Rica	7.5	7.0	6.1	5.7	<5
Croatia	–	8.6	6.1	<5	<5
Cuba	8.0	13.5	6.1	<5	<5
Estonia	–	10.0	6.8	5.6	<5
Latvia	–	7.7	8.3	5.4	<5
Lithuania	–	9.4	6.7	5.1	<5
Montenegro	–	–	–	–	<5
Ukraine	–	7.1	13.4	<5	<5

Food Policy Research Capacity Indicators (FPRCI)

To achieve agricultural development and food security goals, countries need to strengthen their capacity to conduct food policy research. Strong local policy research institutions play a key role in shaping an evidence-based policymaking process. Measuring national capacity for food policy research can help to guide investments for building this capacity.

To do so we must first understand the elements of the country's current capacity in order to identify needs and gaps. IFPRI's starting point has been the following definition of "food policy research capacity": *any socioeconomic or policy-related research in the areas of food, agriculture, or natural resources*. From there we have sought to reform the various dimensions of capacity into measurable indicators.

IFPRI created a dataset with a number of measures for food policy research capacity in 2010 and has continued to expand and refine it. The data presented in Table 5 are currently collected for 32 countries. Further, IFPRI has developed indicators to measure the quantity and quality of policy research capacity in each country. These indicators follow a consistent methodology to enable relative comparison of values across time and countries. The dataset has been updated with numbers for 2014.

The first indicator is a head count of professionals employed at local organizations whose work involves food policy research or analysis. To introduce some uniformity, IFPRI also presents a modified quantification of the head count: full-time equivalent analysts/researchers with PhD equivalent. To obtain an indicator of per capita food policy research capacity, this research capacity is then divided by the country's rural population. This helps to illustrate the impact of local food policy research in a particular country.

The dataset also estimates the quality of a country's food policy research capacity by tallying the number of relevant publications in international, peer-reviewed journals over a five-year period using searches in two journal databases: EconLit and Web of Science. IFPRI views this as a reflection of the local enabling environment for food policy research. This indicator allows for comparison across countries as it ensures that an internationally accepted standard of quality has been met.

This dataset will continue to be updated and expanded to include additional countries, in order to better facilitate cross-country comparisons, especially between countries with similar agro-ecological environments or those anticipating similar food security-related challenges as a result of climate change. It will also facilitate an understanding of the minimal food policy research capacity threshold for a country and what the returns to scale are. Additionally, it is hoped that such data will aid in informing national policymakers of the importance of investing in local food policy research capacity. Lastly, the data provide donors with a framework for prioritizing investments to strengthen food policy research capacity across countries as well as within countries.

Download data: http://hdl.handle.net/1902.1/20526
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TABLE 5 Food policy research capacity indicators, 2014

Country	Analysts/researchers (head count) in 2014	Full-time equivalent analysts/researchers with PhD in 2014	International publications produced 2010–2014	Full-time equivalent analysts/researchers with PhD per million rural population in 2014	Publications per full-time equivalent researcher with PhD 2010–2014
Afghanistan	43	2.975	1	0.131	0.336
Bangladesh	66	22.9	42	0.217	1.834
Benin	38	4.3	23	0.732	5.349
Burundi	39	5.125	2	0.570	0.390
China*	2,000	1,332.53	1,326	2.096	0.995
Colombia	85	6.45	33	0.553	5.116
Ethiopia	141	30.4	20	0.397	0.658
Ghana	153	23.3	52	1.903	2.232
Guatemala	45	11.9	3	1.559	0.252
Honduras	33	6.125	5	1.628	0.816
Indonesia	146	42.375	14	0.355	0.330
Kenya	155	31.6	59	0.947	1.867
Laos	9	1.75	5	0.407	2.857
Liberia	34	3.075	1	1.402	0.325
Madagascar	187	11.525	12	0.760	1.041
Malawi	68	18.175	20	1.321	1.100
Mali	60	10.05	0	1.066	0.000
Mozambique	37	3.325	11	0.188	3.308
Nepal	27	3.65	2	0.160	0.548
Niger	29	8.825	3	0.605	0.340
Nigeria	349	77.4	28	0.827	0.362
Peru	54	7.15	17	1.068	2.378
Rwanda	64	5.5	4	0.639	0.727
Senegal	71	9.3	11	1.156	1.183
South Africa	198	50.325	222	2.623	4.411
Swaziland	32	2.85	1	2.900	0.351
Tanzania	91	20.75	17	0.604	0.819
Togo	81	6.825	6	1.641	0.879
Uganda	34	10.925	15	0.344	1.373
Vietnam	175	32.525	4	0.536	0.123
Zambia	29	5.3	11	0.608	2.075
Zimbabwe	42	8.875	10	0.931	1.127

*The number of international publications for China is for 2009-2013.

Agricultural Total Factor Productivity (TFP)

Total factor productivity (TFP) is the ratio of total agricultural output (crop and livestock products) to total production inputs (land, labor, capital, and materials). This measure of the efficiency of agricultural systems in terms of output per unit of total input allows for comparisons across time and across countries and regions. An increase in TFP implies greater efficiency, meaning that more output is being produced from a constant amount of resources used in the production process. Partial factor productivity (PFP) measures, such as labor and land productivity, are often used to measure agricultural production performance because they are easy to estimate. These measures of productivity normally show higher rates of growth than TFP because growth in land and labor productivity can result not only from increases in TFP but also from a more intensive use of inputs (such as fertilizer or machinery).

Table 6 presents estimates of TFP and PFP measures for developing countries for three sub-periods between 1991 and 2013 (1991–2000, 2001–2007, and 2008–2013) using the most recent data on outputs and inputs from the Food and Agricultural Organization of the United Nations (FAO).

Results for the period 2001–2013 reflect the strong performance of developing regions during the 2000s, with peak performance occurring between 2001 and 2007. TFP growth in Africa south of the Sahara and in the Middle East and North Africa remained strong between 2008 and 2013 compared to the early 2000s, while growth in Latin America appears to be slowing to the levels observed in the 1990s. In contrast with results from earlier data (reported in the *2014–2015 Global Food Policy Report*), the updated TFP estimates for Asia show slower TFP growth between 2008 and 2013, mostly explained by slower growth in China. The data show a significant increase in the use of feed in China while output continued to grow at an average of 3 percent as in previous years.

As in previous versions of the TFP estimates, the output values are the FAO-constructed gross agricultural outputs, each of which is a composite of 190 crop and livestock commodities aggregated using a constant set of global average prices from 2004–2006. Inputs are agricultural land, measured in hectares, of cropland and permanent pasture; labor, measured by the number of economically active persons in agriculture; and fertilizer, measured by tons of fertilizer nutrients used.[1] The dataset uses FAO's new series of capital stock that aggregates quantity of physical assets at 2005 constant prices. Capital used in crop production from this series (land developments and equipment, plantation crops, and machinery and equipment) is now included as an input, replacing the narrower category of machinery used for previous estimates. Similarly, livestock capital (animal stock, livestock structures, and milking machines) is now used instead of animal stock. Animal feed is also included as an input, measured as the amount of edible commodities (from FAOSTAT food balance sheets) fed to livestock during the reference period. Quantities of the different types of feed are transformed into metric tons of maize equivalents using information regarding energy content for each commodity. This dataset of outputs and inputs was checked and cleaned using different statistical techniques.

Land and labor productivity measures for the individual countries were calculated by dividing total output by total agricultural area and the number of economically active persons in agriculture, respectively. Land and labor productivity measures for the regions (such as Africa south of the Sahara) reflect a weighted average of individual country productivity measures using average output (1991–2013) of each country as weights. TFP is calculated using a growth accounting approach. This approach defines TFP as the ratio of an output index and an input index. As input prices are not available, econometric estimations of the parameters of a global agricultural production function are used as weights to calculate the index of aggregate inputs. Newly available and improved econometric methods were used to estimate the global production function.[2] The weighted average of individual country output and TFP growth rates of individual countries was used to calculate regional averages, using output as weights.

Download data: http://hdl.handle.net/1902.1/20518
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TABLE 6 Average annual growth of agricultural output and total factor productivity (TFP) and levels of land and labor productivity, various years

Region/country	Land productivity				Labor productivity				Output growth (%)			TFP growth (%)		
	1990	2000	2007	2013	1990	2000	2007	2013	1991–2000	2001–2007	2008–2013	1991–2000	2001–2007	2008–2013
Africa south of the Sahara	180	243	334	439	1133	1418	1761	2225	3.5	4.5	4.3	1.5	2.2	2.4
Angola	15	24	44	78	252	314	467	701	5.0	9.3	10.4	1.4	5.0	6.7
Benin	395	511	531	720	780	1,105	1,066	1,505	6.2	1.2	7.0	1.5	0.0	2.4
Botswana	8	8	9	11	1,071	724	752	916	–0.8	1.5	4.6	–2.2	–0.7	3.6
Burkina Faso	110	147	171	223	297	305	317	374	3.2	3.9	6.2	1.0	0.5	4.0
Burundi	490	528	620	764	406	342	288	333	–0.5	1.2	5.4	0.2	–2.3	3.6
Cameroon	238	325	468	597	713	842	1,169	1,531	3.2	5.4	5.1	0.6	2.9	2.8
Central African Republic	108	152	170	200	526	669	735	798	3.7	1.8	2.3	2.1	0.5	1.2
Chad	17	23	28	33	446	456	464	506	2.9	2.9	3.1	0.1	–0.1	2.2
Congo, Rep.	20	26	35	43	466	547	706	832	2.8	4.3	3.6	–0.3	4.5	1.1
Congo, Dem. Rep.	172	150	148	169	493	346	300	311	–1.5	–0.1	2.4	–1.2	–1.4	1.0
Côte d'Ivoire	209	289	277	342	1,520	1,975	2,094	2,596	3.7	0.1	3.6	1.9	–0.5	2.1
Ethiopia	82	144	196	255	255	217	261	296	1.8	6.1	5.1	1.1	2.7	1.4
Gabon	39	49	51	60	949	1,227	1,345	1,586	2.3	0.6	2.9	0.6	0.8	1.5
Gambia	132	227	189	208	233	288	175	194	4.9	–4.1	5.1	1.8	–5.8	4.7
Ghana	160	294	352	494	567	902	974	1,196	7.7	3.6	6.1	4.6	0.4	3.3
Guinea	73	111	132	152	415	430	481	490	3.8	3.3	2.6	–0.8	–0.6	1.7
Guinea-Bissau	105	130	157	209	450	527	568	684	3.4	2.6	5.1	1.1	1.8	3.2
Kenya	150	168	245	273	513	417	525	527	1.1	5.7	2.1	0.0	3.6	0.4
Liberia	103	152	165	148	457	548	521	419	4.4	1.3	–1.3	–3.7	0.3	2.3
Madagascar	69	65	79	86	612	491	480	441	0.4	2.9	1.8	–0.6	0.5	0.2
Malawi	244	409	524	641	302	491	574	684	6.5	4.4	5.9	2.8	1.1	2.4
Mali	46	47	70	87	822	837	1,101	1,207	2.1	6.7	4.0	–0.3	3.7	1.8
Mauritania	9	10	11	13	767	672	635	628	1.5	2.1	2.5	–0.9	–0.7	0.7
Mauritius	2,144	2,437	2,601	2,795	3,174	3,970	4,693	5,930	0.3	–0.4	0.3	–0.8	0.1	0.4
Mozambique	24	34	45	63	221	230	266	332	3.5	4.4	6.1	0.6	2.6	3.1
Namibia	10	10	12	11	1,689	1,528	1,848	1,580	0.4	2.6	–1.9	–1.4	5.9	–1.1
Niger	34	46	63	70	500	544	703	647	4.3	7.2	2.2	1.0	4.0	–0.1
Nigeria	275	393	631	869	968	1,312	1,891	2,259	5.2	7.5	5.1	2.8	4.8	3.6
Rwanda	590	742	870	1,379	387	369	393	531	1.1	3.7	8.1	1.8	–2.1	4.3
Senegal	101	139	113	158	378	400	268	326	3.1	–3.1	6.5	1.4	–4.1	2.6
Sierra Leone	155	117	202	303	400	317	582	929	–2.8	12.1	9.2	–2.1	4.6	6.8
Somalia	33	33	36	43	816	707	674	695	–0.1	1.4	2.9	–0.1	0.9	1.8
South Africa	96	111	119	142	5,713	7,316	8,863	12,289	1.6	0.8	3.0	1.6	0.9	3.4
Sudan	31	55	68	76	773	1,151	1,315	1,394	6.4	3.7	1.9	3.7	1.5	–0.9
Swaziland	220	204	225	258	1,958	1,686	1,979	2,286	–0.9	1.4	2.3	–1.6	1.4	1.9
Tanzania	116	129	186	234	374	325	422	518	1.1	6.0	6.2	–0.2	1.8	3.9
Togo	151	176	211	223	512	571	580	601	2.9	2.1	2.6	1.0	1.3	0.1
Uganda	322	395	427	442	584	585	564	516	2.5	2.3	1.4	–0.6	0.2	–0.5
Zambia	36	39	52	84	339	330	396	565	1.6	4.5	9.0	0.8	3.2	3.1
Zimbabwe	121	138	95	104	551	636	486	487	2.8	–4.1	1.5	1.3	–2.3	0.5

Note: Land productivity is agricultural gross production per hectare of agricultural land; labor productivity is agricultural gross production per economically active person in agriculture. Both types of agricultural gross production are measured in constant 2004–2006 US dollars.

Table 6 continued

Region/country	Land productivity				Labor productivity				Output growth (%)			TFP growth (%)		
	1990	2000	2007	2013	1990	2000	2007	2013	1991–2000	2001–2007	2008–2013	1991–2000	2001–2007	2008–2013
Latin America and Caribbean	260	343	439	505	5,759	7,918	11,205	14,033	3.2	4.0	2.5	2.0	2.9	2.0
Argentina	192	252	297	302	16,822	22,219	30,008	32,629	2.8	4.1	0.8	2.2	2.5	0.4
Bahamas	1,656	1,776	2,238	2,593	3,312	4,618	5,819	7,259	1.5	3.4	3.8	–0.4	6.8	–3.4
Barbados	2,847	2,778	3,095	3,393	6,011	7,144	9,903	11,876	–0.8	–0.1	–0.7	–0.0	2.6	0.2
Belize	725	1,043	1,131	1,176	5,076	6,474	5,926	5,701	5.5	1.4	1.5	2.5	0.0	–1.8
Bolivia	48	65	87	103	1,388	1,507	1,711	1,796	3.6	4.3	3.0	0.9	0.7	3.0
Brazil	253	341	467	562	4,341	6,685	10,647	15,172	3.9	5.2	3.4	2.4	4.2	2.8
Chile	279	411	485	556	4,747	6,444	7,833	9,196	3.4	3.0	2.4	1.4	1.7	2.9
Colombia	216	255	329	349	2,907	3,186	3,897	4,295	1.6	2.9	1.1	0.4	1.3	0.5
Costa Rica	707	1,236	1,516	1,641	5,292	6,956	8,344	9,822	3.4	2.6	2.1	2.7	1.8	2.1
Dominican Republic	629	753	1,004	1,189	2,563	3,439	5,064	6,873	1.7	3.9	3.1	0.7	2.9	3.7
Ecuador	479	732	887	969	3,412	4,808	5,164	5,737	4.6	1.5	1.7	3.4	1.2	–0.2
El Salvador	599	676	745	739	1,287	1,529	1,829	2,014	1.8	1.4	0.5	0.1	0.1	0.6
Guatemala	469	635	899	1,111	1,355	1,906	2,060	2,249	3.5	5.1	3.5	1.7	1.0	3.8
Guyana	105	186	195	255	3,138	5,671	6,168	8,219	5.7	0.4	4.6	6.1	–0.2	5.0
Haiti	582	568	605	661	521	486	505	504	0.3	2.0	1.0	–2.0	0.2	1.2
Honduras	355	442	613	670	1,747	1,762	2,865	3,268	1.0	5.9	1.9	0.6	2.6	1.1
Jamaica	1,031	1,118	1,204	1,287	1,785	2,158	2,504	2,777	0.9	0.6	0.6	0.6	0.8	0.6
Mexico	216	278	330	364	2,640	3,346	4,210	4,963	2.7	2.5	1.6	2.0	2.1	1.5
Nicaragua	162	201	258	338	1,667	2,640	3,658	5,020	4.7	3.7	4.2	1.9	2.6	4.8
Panama	383	373	418	442	3,202	3,101	3,552	3,938	0.2	1.8	1.0	–1.5	0.7	0.6
Paraguay	156	143	218	279	4,638	4,061	5,603	6,952	0.8	6.4	5.0	–1.0	4.0	2.9
Peru	156	256	322	410	1,223	1,760	2,083	2,637	5.7	3.6	4.6	2.8	2.2	3.4
Suriname	1,343	1,073	1,606	1,745	4,076	3,147	3,513	4,388	–2.2	2.5	4.3	–2.2	4.6	0.1
Trinidad and Tobago	1,743	2,189	2,910	2,672	2,632	2,993	3,274	3,206	0.9	1.0	–1.4	2.1	2.3	–0.8
Uruguay	147	191	237	293	11,776	14,499	18,477	24,306	2.7	2.8	4.3	1.3	1.4	2.7
Venezuela	196	263	312	362	4,914	6,986	8,886	11,367	2.9	2.4	2.5	1.7	1.8	1.2
Asia	653	930	1,169	1,368	762	974	1,247	1,505	3.9	3.6	3.0	2.4	2.5	1.5
Afghanistan	54	67	86	95	823	631	642	618	2.0	3.6	1.7	1.2	–0.4	1.0
Armenia	495	466	620	699	4,355	3,546	6,869	8,173	–0.3	8.4	1.4	1.4	5.6	1.8
Azerbaijan	509	334	474	613	2,536	1,628	2,144	2,716	–3.0	5.2	4.4	–2.7	1.5	2.9
Bangladesh	1,073	1,633	2,072	2,558	355	473	582	726	3.3	3.3	3.3	2.1	1.6	2.6
Bhutan	229	195	297	280	650	611	603	434	–0.1	7.1	–2.3	–0.0	4.9	–2.8
Cambodia	275	397	555	779	411	479	636	844	4.5	6.9	6.8	1.7	3.6	2.6
China	457	737	947	1,148	472	756	957	1,178	5.2	3.4	3.3	3.4	3.0	1.1
India	719	930	1,192	1,451	624	709	831	951	2.6	3.5	3.3	1.2	2.2	2.3
Indonesia	670	808	1,004	1,181	726	804	1,082	1,334	2.4	4.9	3.8	0.6	2.9	1.6
Kazakhstan	51	27	40	44	7,864	4,402	6,874	8,003	–6.8	5.7	1.6	–1.8	3.5	5.3
Korea, DPR	1,532	1,287	1,383	1,533	1,065	989	1,134	1,355	–1.6	1.3	1.9	2.1	0.1	3.0
Kyrgyzstan	157	161	169	189	3,568	3,183	3,543	3,978	0.5	0.7	1.6	2.3	0.0	2.5
Laos	428	627	703	877	472	613	690	815	5.0	4.1	5.9	2.3	–0.1	1.2
Malaysia	1,100	1,405	1,828	1,979	3,894	5,333	8,003	10,323	2.7	4.2	2.6	1.7	3.0	2.3
Mongolia	7	7	6	8	3,827	3,990	3,135	4,516	0.1	–4.2	5.3	2.6	–3.7	1.9

Region/country	Land productivity				Labor productivity				Output growth (%)			TFP growth (%)		
	1990	2000	2007	2013	1990	2000	2007	2013	1991–2000	2001–2007	2008–2013	1991–2000	2001–2007	2008–2013
Myanmar	596	976	1,508	1,624	401	572	914	977	5.4	8.0	2.1	3.0	4.2	1.1
Nepal	704	910	1,086	1,431	463	469	448	511	2.9	2.3	4.5	1.5	0.9	0.8
Pakistan	808	1,098	1,330	1,182	1,398	1,584	1,561	1,234	3.5	2.7	–1.8	1.4	0.5	–2.9
Philippines	1,146	1,389	1,713	1,778	1,172	1,252	1,525	1,615	2.0	3.7	1.5	0.3	2.5	0.9
Sri Lanka	900	992	1,054	1,233	589	641	636	827	1.0	1.1	4.7	0.6	0.6	3.8
Tajikistan	251	173	275	390	1,655	1,292	1,640	2,119	–3.5	7.4	6.6	–1.3	1.1	4.8
Thailand	844	1,268	1,536	1,617	856	1,268	1,574	1,988	3.4	2.8	2.5	2.8	2.1	1.4
Turkmenistan	26	54	91	85	2,586	3,052	4,643	3,938	4.4	7.4	–1.5	3.7	3.6	0.4
Uzbekistan	201	255	369	514	2,557	2,645	3,632	5,065	2.0	5.1	5.7	3.1	1.1	4.3
Viet Nam	1,590	2,138	2,614	3,018	459	704	904	1,063	5.8	4.9	3.7	1.5	1.0	2.1
Middle East and North Africa	1,066	1,325	1,584	1,733	2,698	3,693	4,372	5,302	2.7	2.7	2.6	1.7	1.8	2.1
Algeria	74	94	123	208	1,438	1,334	1,581	2,541	2.9	4.3	9.2	1.6	2.1	6.6
Bahrain	2,424	2,855	2,907	5,143	4,849	8,755	6,104	11,058	3.1	–1.0	10.4	2.1	0.2	6.8
Egypt	4,179	5,234	6,304	6,603	1,719	2,780	3,487	3,800	4.5	3.8	1.1	2.1	1.9	–0.4
Iran	217	303	542	563	2,568	3,269	4,028	4,170	3.6	4.6	1.0	2.4	3.8	–0.1
Iraq	332	318	302	460	4,833	4,931	6,054	8,634	–1.5	0.7	4.1	1.1	–2.6	5.8
Israel	3,504	4,122	5,362	5,622	31,214	38,248	51,448	61,284	1.4	2.5	1.0	0.8	3.2	1.3
Jordan	554	741	1,056	1,283	5,760	6,768	8,920	11,241	3.2	3.6	4.7	1.4	2.6	3.5
Kuwait	643	971	1,272	2,021	10,072	13,068	13,715	18,073	4.7	4.2	8.1	1.6	2.3	7.4
Lebanon	1,762	2,082	1,845	1,658	16,654	30,209	36,751	45,014	1.5	0.1	–0.5	1.0	0.2	–1.6
Libya	53	66	75	78	6,557	10,024	14,911	20,980	2.2	1.7	0.7	2.8	1.2	2.1
Morocco	167	170	225	320	1,557	1,551	2,190	3,346	0.3	3.7	6.3	–0.6	3.3	5.2
Oman	173	265	231	287	749	1,097	1,147	1,005	5.3	1.2	3.8	3.2	–1.8	–1.4
Qatar	448	708	737	861	3,902	11,682	7,988	6,288	5.5	0.4	2.8	3.0	0.4	–0.6
Saudi Arabia	20	16	20	21	2,491	4,110	5,797	7,843	1.2	3.5	0.7	–0.3	2.6	0.5
Syria	272	408	466	397	3,803	4,888	4,901	4,035	4.3	2.1	–2.6	2.3	–1.0	–3.3
Tunisia	282	303	366	402	3,771	3,783	4,492	4,939	1.7	3.2	2.0	–0.2	1.9	1.6
Turkey	677	784	839	1,092	2,600	3,504	3,978	5,439	1.7	0.6	4.0	1.6	1.3	4.8
Yemen	33	48	67	80	583	604	745	848	3.8	5.0	2.8	1.4	2.6	1.1

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CHAPTER 3

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Agricultural Total Factor Productivity (TFP)

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