How the United States Benefits from Agricultural and Food Security Investments in Developing Countries

BIFAD

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

ASSOCIATION OF PUBLIC & LAND-GRANT UNIVERSITIES

This report was prepared for the International Food Policy Research Institute by David Kraybill and Stephanie Mercier under the direction of Joseph Glauber. David Kraybill is professor emeritus, Department of Agricultural, Environmental and Development Economics, The Ohio State University. Stephanie Mercier is an agricultural policy consultant, Agricultural Perspectives. Joseph Glauber is a senior research fellow, Markets, Trade, and Institutions Division, International Food Policy Research Institute.

The authors wish to thank all reviewers and interviewees for their input, comments, and suggestions. We also thank Susan Johnson and Montague Demment at APLU, Rob Vos, Keith Wiebe, Rajul Pandya-Lorch, Pamela Stedman-Edwards, Lee Dixon, and Tracy Brown at IFPRI, and Rob Bertram and Clara Cohen at USAID. In addition, we are appreciative of staff at USAID, including Louise Fox, James Oehmke, Brendan Jinnohara, George Rowland, Jessica Anderson, Sally Abbott, Karen Duca, Jessica Bagdonis, Nora Lapitan, Carole Levin, Keith Fuglie, Ahmed Kablan, Patterson Brown, Julia Tanton, and Jennifer Cupp.

The Association of Public & Land-grant Universities (APLU) conducted two separate peer reviews in the preparation of this report. The first review was an open peer review with academic reviewers. The second review was a single-blind peer review by academics in relevant fields and private sector professionals. In addition, the paper was reviewed by members of BIFAD and the U.S. Agency for International Development.

This report is made possible by the generous support of the American people and through support provided in part by the Bureau for Food Security, United States Agency for International Development (USAID), under agreement AID-OAA-A-14-00031 to the Association of Public and Land-grant Universities (APLU). The author's opinions expressed in this publication do not necessarily reflect the views of USAID or the U.S. Government.

DOI: https://doi.org/10.2499/p15738coll2.133419

TABLE OF CONTENTS

FOREWORD

More than four decades ago, the Famine Prevention and Freedom from Hunger Act of 1975 opened a new front in the world's war against hunger. This amendment to Title XII legislation established the Board for International Food and Agricultural Development (BIFAD) and called for engagement of U.S. universities in the fight against hunger. The legislation emphasizes programs of "mutual concerns" and that are "to the benefit of aid recipient countries and of the United States."

Today, many Americans believe that far more of the nation's budget goes to nonmilitary foreign assistance than actually does. Out of our country's $4 trillion budget, it is less than one percent. The many benefits of this assistance to the nations receiving it, including developing countries, have been well-documented. Unfortunately, the very real benefits to the American economy and the American people are often overlooked.

With this report commissioned by the Board for International Food and Agricultural Development, we have sought to document the positive impact of U.S. foreign assistance in agriculture. The report highlights the very important returns this assistance provides to the American people—the U.S. farmers, companies, workers, consumers, researchers, and taxpayers who are all directly benefiting from America's investments in international development.

Our report provides a wonderful overview with specific examples of how the United States has benefited from these investments by showcasing the best of U.S. government assistance and how, through strong partnerships with our nation's outstanding universities, USAID is truly making a difference both abroad and here at home.

Members of the Board for International Food and Agricultural Development (BIFAD)

Dr. Mark E. Keenum, *BIFAD Chairman and President, Mississippi State University*

Dr. Pamela K. Anderson, *Director General Emeritus, International Potato Center*

Mr. James M. Ash, *Food and Agribusiness Group Head, Husch Blackwell LLP*

Dr. Waded Cruzado, *President, Montana State University*

Dr. Brady Deaton, *Chancellor Emeritus, University of Missouri*

Dr. Gebisa Ejeta, *Distinguished Professor, Purdue University*

Mr. Richard Lackey, *Founder and CEO, World Food Bank*

EXECUTIVE SUMMARY

U.S. foreign agricultural assistance investments bring substantial economic, health, and security benefits to the United States. This report describes food security investments of the U.S. Agency for International Development (USAID) and how improving agriculture in developing countries brings positive returns to the United States.

America's commitment to foreign agricultural aid is rooted in the dual benefits that accrue both to developing countries and to American farmers, companies, workers, and consumers. Agricultural development raises household incomes abroad, which boosts demand for U.S. agricultural and manufactured exports. New agricultural and food-system technologies developed with U.S. assistance become global goods that raise agricultural productivity both at home and abroad. And improved agricultural supply chains in developing countries contribute to a safe and steady supply of off-season fruits and vegetables, coffee, chocolate, and spices in the United States.

HOW U.S. PRODUCERS AND CONSUMERS BENEFIT

The primary objective of U.S. foreign agricultural assistance is to stimulate growth of the world's poorest regions and increase global stability. Agricultural development in poorer countries with limited access to international markets is an important pathway to economic growth, poverty reduction, and integration into the world economy. In many developing countries, agriculture is the dominant source of employment. Boosting agriculture therefore spurs the growth of entire economies and stimulates demand for U.S. exports.

Exports and Jobs

In 2018, U.S. agricultural exports totaled $140 billion, with developing countries accounting for $90 billion, or nearly two-thirds of total agricultural exports. This is an increase in the developing-country share of U.S. agricultural exports from just 50 percent in 2000. Most of the inflation-adjusted growth in agricultural exports over the last 20 years is a result of expanding exports to developing countries, up 103 percent over the period while exports to developed countries grew only 19 percent. China accounts for much of this growth in agricultural exports to developing countries, but growth in Central America, Southeast Asia, and sub-Saharan

Over the past 20 years, total U.S. agricultural exports grew by 63% in real terms. Most of the growth was in exports to developing countries.

+103% Growth in exports to developing countries

+19% Growth in exports to developed countries

All the inflation-adjusted growth of U.S. bulk exports, and most of the growth of high-value products, is due to sales to developing countries.

	Bulk Commodities	High-value Products
Developing Economies	+77%	+125%
Developed Economies	-4%	+27%

1,203,000

U.S. jobs supported by agricultural exports in 2018.

Calculations by author based on USDA, GATS database.

Africa has been important as well. The recent trade tensions between the United States and China underscore the importance of expanding export markets in other developing regions of the world.

Each dollar of agricultural exports stimulates an additional $1.87 in business activity in the United States, and every $1 billion in U.S. agricultural exports supports 8,619 full-time jobs in the American economy. **In 2018, agricultural exports generated an additional $261 billion in economic activity in the United States, resulting in a total increase in economic output of $401 billion produced by an estimated 1,203,000 full-time U.S. workers.** The $90 billion in U.S. exports to developing countries in 2018 alone generated an estimated $169 billion in additional U.S. economic activity and a total economic activity increase of $259 billion in the U.S. economy, and supported an estimated 779,000 full-time jobs in 2018.

Many U.S. agribusinesses and food and agricultural product exporters view developing regions of the world as their best opportunity for market expansion. As low-income economies grow, demand for food rises more rapidly than in high-income countries, where appetites are already largely satiated. Foreign aid that makes agriculture more productive boosts incomes throughout the economy and increases demand for U.S. exports. The end result is more jobs for Americans producing goods and services for export, and more income in the American economy.

U.S. agribusinesses invest in developing countries, benefiting from developing-country policy reforms and from markets developed through foreign agricultural assistance. Foreign investment abroad increases the earnings of American firms, increases the demand for American technology used abroad by the investing firms, and increases the supply of diverse food products in the United States. For example, agricultural equipment producers in the United States stand to gain from investment in distribution networks in Asia, currently the world's largest regional market for tractors, and in Africa, the largest remaining untapped regional market for tractors. U.S. firms investing in collection and processing facilities in developing countries that grow coffee, tea, cacao, and spices bring safe and convenient consumer products to the American kitchen.

Technology Spillovers

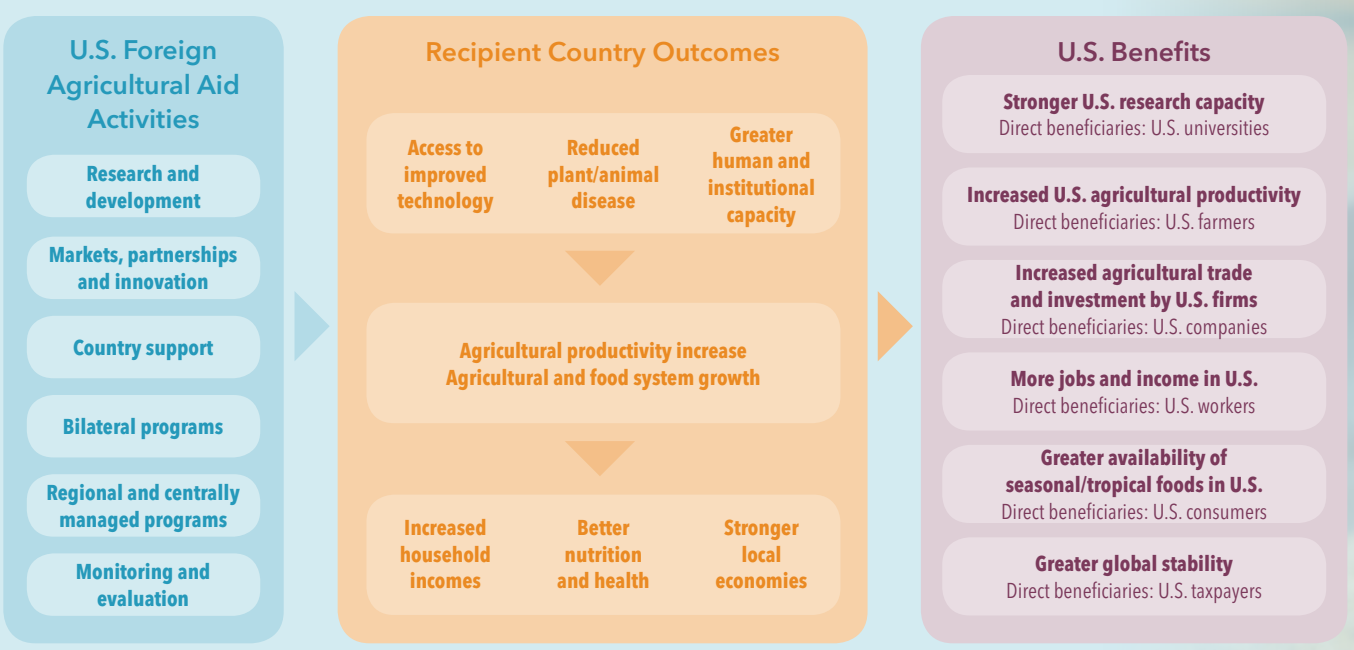
Many new agricultural technologies solve problems common to both developing countries and the United States, and reduce the international transmission of plant and animal diseases. For crops, problem-solving innovations often take the form of new varieties bred to improve the volume and quality of the harvested output.

- ***Wheat technology spillover:*** American wheat researcher Norman Borlaug and other scientists developed new high-yielding semi-dwarf wheat varieties in the 1960s and 1970s and released them in many countries. The wheat breeding was carried out in Mexico by the International Maize and Wheat Improvement Center (CIMMYT), which the U.S. Agency for International Development (USAID) began supporting financially in the 1960s. The new wheat varieties brought about a Green Revolution in wheat productivity globally, especially in South Asia. CIMMYT and U.S. support for its research played a catalytic role in the development of the dwarf wheat varieties now widely used by American farmers. By the early 1990s, about a fifth of total U.S. wheat acreage was sown with varieties with CIMMYT ancestry. Today, semi-dwarf wheat accounts for 99 percent of wheat acreage globally. **U.S. farmers received benefits estimated at $3.4 to $15.6 billion between 1960 and 1993 from new varieties of wheat and rice developed at the international agricultural research centers of CGIAR (formerly the Consultative Group on International Agricultural Research), which is supported by USAID. Each 100 dollars of benefit to the U.S. economy from higher productivity in wheat and rice production cost taxpayers only two cents. A recent study estimated that, for wheat alone, the financial impact in the United States of CIMMYT research is $140 to $180 million annually, representing a benefit-cost ratio of between 32:1 and 40:1.**

- ***Sorghum technology spillover:*** Many American producers of sorghum now plant improved varieties developed since 1979 through a USAID-supported sorghum research program at American land-grant universities. A major focus of the program is development of sorghum varieties with resistance to biologically and economically damaging insect pests, such as the greenbug aphid. Using germplasm collected by the sorghum research program from many parts of the world, researchers developed and released new sorghum varieties that are resistant to this aphid. Similar research was conducted for the sugarcane aphid, which attacks sorghum as well as sugarcane The sorghum research program laid the groundwork for understanding the genetics of sugarcane aphid resistance and, in 2018, 19 new resistant sorghum lines were released. **An economic impact study found that USAID's greenbug aphid-resistant sorghum varieties saved American farmers $389 million in 1989 alone. At that point, funding for the sorghum program had totaled $44 million (in constant 1989 dollars). Therefore, in a single year, the U.S. sorghum research generated nine times its total cumulative cost, and the benefits can reasonably be expected to have continued for many subsequent years.**
- ***Bean technology spillover:*** USAID-sponsored research on beans generates innovations that benefit U.S. bean producers and consumers. From the perspective of the U.S. bean industry, an important function of the bean research program is the collection of germplasm from around the world. The germplasm

U.S. FOREIGN AGRICULTURAL ASSISTANCE

Total U.S. nonmilitary assistance to developing countries was $33.3 billion in Fiscal Year (FY) 2017. This level of funding was 0.17 percent of total U.S. gross domestic product (GDP) and accounted for 0.84 percent of total U.S. budget authority in FY 2017. Foreign agricultural aid is a minimal percentage of total nonmilitary assistance. In 2017, U.S. foreign agricultural expenditure totaled $1.41 billion, accounting for 4.2 percent of total nonmilitary assistance and 0.04 percent of total U.S. government expenditure. The inflation-adjusted level has declined since 2011. The largest share of federal expenditure on foreign agricultural aid is implemented by the U.S. Agency for International Development (USAID). In 2017, USAID implemented 72 percent, the U.S. Department of Agriculture implemented 20 percent, and 8 percent was implemented by other government agencies. Expenditures by USAID for implementation of foreign agricultural assistance totaled $1.01 billion in 2017.



collection provides bean researchers with an expanded range of genetic options for breeding beans with desired characteristics. Using this germplasm, the researchers have developed new high-yielding bean varieties with resistance to economically important bean diseases. **USAID's long-term support of the bean breeding program has resulted in the development of 40 bean varieties now commercially grown in the United States, all with one or more parents from the program.**

Health and Nutrition

USAID agriculture-related investments in developing countries help prevent global transmission of animal diseases, protecting American producers and consumers as well as animal populations. Approximately 75 percent of all new and emerging diseases affecting humans today originated in animals. To increase scientific understanding of the causes and spread of animal diseases and to develop ways of controlling them, USAID supports animal-disease research conducted in developing countries by CGIAR, American universities, and other organizations.

American consumers also benefit from foreign agricultural aid that supports the search for solutions for soil- and plant-borne toxins, such as aflatoxin, produced by a mold that grows in peanuts, corn, and grains.

Estimated annual U.S. losses from aflatoxin in corn, wheat, and peanuts are up to $2.3 billion. USAID, an early sponsor of aflatoxin research, has supported CGIAR research centers and Feed the Future Innovation Labs at U.S. universities to find ways of reducing aflatoxin. Many of the solutions researchers have found to be effective in developing countries are also relevant for controlling aflatoxin in the United States, resulting in reduced losses.

U.S. consumers have access to tropical foods and off-season fruits and vegetables imported from developing countries. Climatic conditions prevent or limit domestic production of these foods in the United States, and importing them improves Americans' diets, making them more nutritious and diverse. Imports account for 100 percent of the coffee, cocoa, and spices consumed in the United States and 50 percent of fresh fruit and fruit juice. U.S. foreign agricultural aid contributes to improvements in the efficiency and hygienic standards of agricultural value chains in developing countries and to a safer and more reliable supply of these U.S. food imports.

Global and U.S. Security

Foreign assistance increases global stability by reducing poverty and stimulating economic growth in low-income, aid-recipient countries. Agricultural development complements U.S. global security efforts. Agriculture, as a source of employment and income for most of the working population in low-income developing countries and as a source of food for all, is closely tied to various aspects of human well-being that, if jeopardized, cause conflict. Economic growth overall, and agricultural growth in particular, improves the real income and material well-being of a large share of the population, strengthening the economic foundations of social and political stability.

Another channel through which foreign aid may contribute to global stability is by reducing international migration. A recent study found that foreign aid reduces international migration from recipient countries in the long run but not in the short run, underscoring the importance of long-term commitment by donor countries. The effectiveness of foreign aid in reducing international migration depends on the sector or subpopulation it targets. A 2018 study examines the migration effects of rural development aid versus urban development aid, finding that rural development aid reduces international emigration while urban development aid does not.

Agricultural development assistance creates an opportunity for the United States to build relationships in developing countries before global crises occur. Once a pandemic, environmental disaster, or violent conflict breaks out, it is too late to acquire the knowledge, build the trust, and establish the cooperation essential for finding and implementing solutions.

HOW AID-RECIPIENT COUNTRIES BENEFIT

At the farm level, new farming technologies and practices promoted by USAID raise the productivity of land, labor, and capital used in agricultural production. To create an economic, political, and social environment conducive to agricultural development, USAID works with local partners to improve the functioning of agricultural institutions (producer groups, markets, universities, research institutes, and government agencies). Agricultural education sponsored by USAID prepares future farmers, entrepreneurs, and agency officials to acquire the skills and competencies needed to transform the agricultural sector.

The entire agricultural and food system grows and improves when transformation at the farm and agribusiness level is supported by research and transformation at the institutional level. Where governments were once major suppliers of agricultural inputs for farmers and major buyers of their agricultural output, as markets develop and mature, private companies with the required technical expertise and financial resources expand their input distribution and raw-product aggregation systems. Where farmers once had difficulty

obtaining improved agricultural inputs and credit reliably and were able to sell only or largely to local buyers, a growing economy with developing markets means they are now connected to urban consumers. As domestic markets develop and mature, they become increasingly connected to international markets, strengthening the country's links to the global economy.

Investments in developing country agriculture raise household incomes, improve nutrition and health, and build stronger national and regional economies. As income rises, households typically increase their spending on food and other items, including healthcare and education. The composition of the diet tends to shift, bringing about consequences that are both positive (e.g., more protein intake) and negative (e.g., rising levels of obesity). Adequate nutrition contributes to improved health, which has many benefits, including lower maternal and infant mortality and greater labor productivity. More efficient and effective food systems, higher household incomes, and better human health contribute to sustainable growth of national economies. The changes in the agricultural sector and the larger economy are intertwined and mutually reinforcing.

LOOKING AHEAD

Between 2015 and 2050, 98 percent of global population growth is projected to occur in developing countries, with sub-Saharan Africa accounting for more than 55 percent of that growth. With income growth rates and urbanization rates projected to be higher in developing countries, much of the increase in global demand for meats, dairy, fruits and vegetables, and processed food products will come from these economies.

The growth of global demand for food creates opportunity for continued expansion of U.S. agricultural exports. For that to happen, the agriculture sectors and the entire economies of developing countries must continue to grow. Given that agriculture is the driver of economywide growth in countries that are the largest source of demand for U.S. exports, it is vital that American investments in foreign agriculture continue. Productivity growth still lags in many of the poorest regions of the world. While progress has been made, to be successful, foreign agricultural assistance needs to be sustained.

By strengthening agricultural and food systems in developing countries, U.S. foreign agricultural assistance contributes to global and national security. The benefit to both developing countries and U.S. producers and consumers far exceeds the costs and helps secure a better future for all.

Photo credit: G.N.B. Akash / Panos

INTRODUCTION

For 75 years, the U.S. government has invested in the growth and development of foreign agricultural and food systems. Since the 1940s, American agricultural scientists and agricultural development specialists, operating largely with federal government funding, have conducted research and provided technical assistance in low-income and war-damaged countries. The Foreign Assistance Act authorizes federally funded foreign agricultural aid, committing to "the mutual goals among nations of ensuring food security, human health, agricultural growth, trade expansion, and the wise and sustainable use of natural resources." **The mutuality of these international goals is rooted in the dual benefits generated by foreign agricultural aid, which accrue to both developing countries and to American farmers, companies, workers, and consumers.**

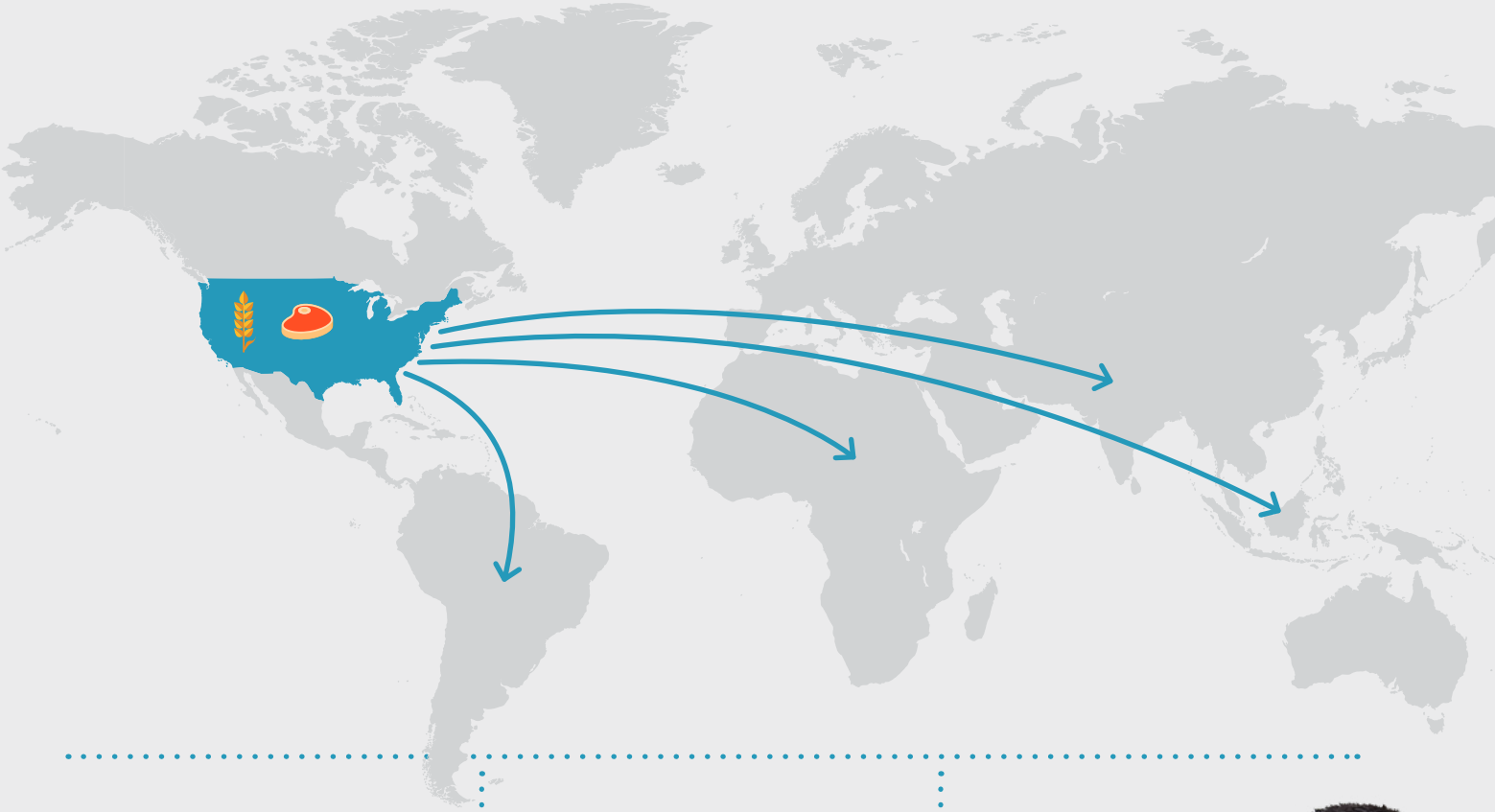
Many new agricultural technologies solve problems common to both developing countries and the United States, and reduce the international transmission of plant and animal diseases. Crop and animal agriculture is threatened continuously by emerging disease and pest perils, and therefore new knowledge and technologies are essential to maintain and improve farm productivity. American seed and agricultural input companies and American farmers have benefited enormously from knowledge generated by international agricultural research focused on developing countries and sponsored by the U.S. government, foreign governments, private firms, and private foundations. Wheat, rice, sorghum, and dry beans are among the crops whose productivity has been boosted in the United States as a result of international agricultural research originally targeted to developing countries. Improved agricultural production technologies lower production costs and make U.S. agriculture more competitive in the global economy.

Developing countries are an important source of demand for U.S. agricultural exports. Agricultural exports totaled $140 billion in 2018, with two-thirds ($90 billion) going to developing countries (Figure 1) (USDA-ERS, 2019a).[1] This reflects an increase in the developing-country share of U.S. agricultural exports from just 50 percent in 2000, an increase driven by developing countries' relatively high rates of economic growth and relatively high share of income allocated to food. Following a well-known historical pattern, as low-income economies grow, demand for food increases more rapidly than in high-income countries, where appetites are already largely sated.

The income of the majority of the population in most low-income developing countries comes from agriculture. Foreign aid that increases agricultural productivity boosts incomes throughout the economy and increases demand for U.S. exports. The end result is more jobs for Americans producing goods and services for export, and more income in the American economy.

U.S. agribusinesses invest in developing countries, benefiting from developing-country policy reforms and from markets developed through foreign agricultural assistance. Foreign investment abroad increases the earnings of American firms, increases the demand for American technology used abroad by the investing firms, and increases the supply of food products that cannot be produced in the United States. For example, agricultural equipment producers in the United States have much to gain from investment in distribution networks in Asia, currently the world's largest regional market for tractors, and in Africa, the largest remaining untapped regional market for tractors. U.S. firms investing in collection and processing facilities in developing

Figure 1: Real growth of U.S. agricultural exports, 1999–2018



Over the past 20 years, total U.S. agricultural exports grew by 63% in real terms. Most of the growth was in exports to developing countries.

+103% Growth in exports to developing countries

+19% Growth in exports to developed countries

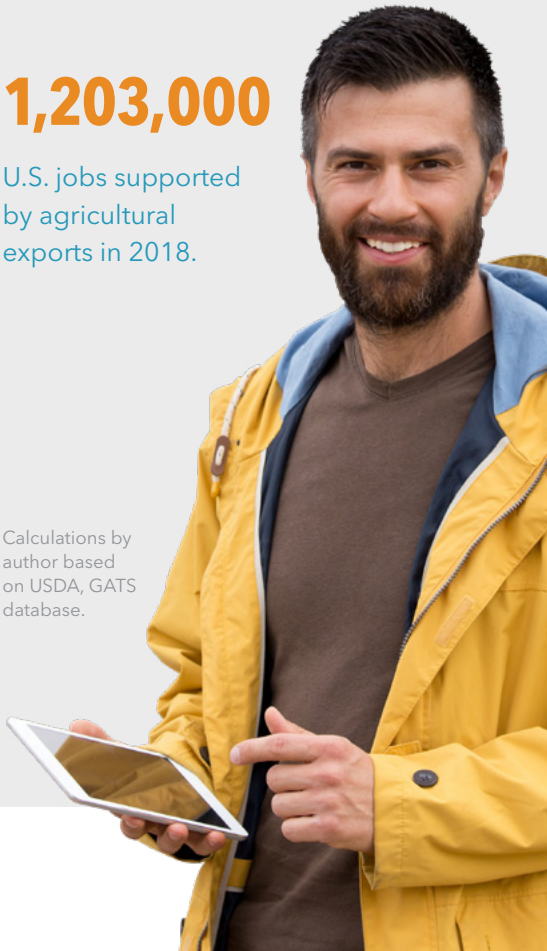
All the inflation-adjusted growth of U.S. bulk exports, and most of the growth of high-value products, is due to sales to developing countries.

	Bulk Commodities	High-value Products
Developing Economies	+77%	+125%
Developed Economies	-4%	+27%

1,203,000

U.S. jobs supported by agricultural exports in 2018.

Calculations by author based on USDA, GATS database.

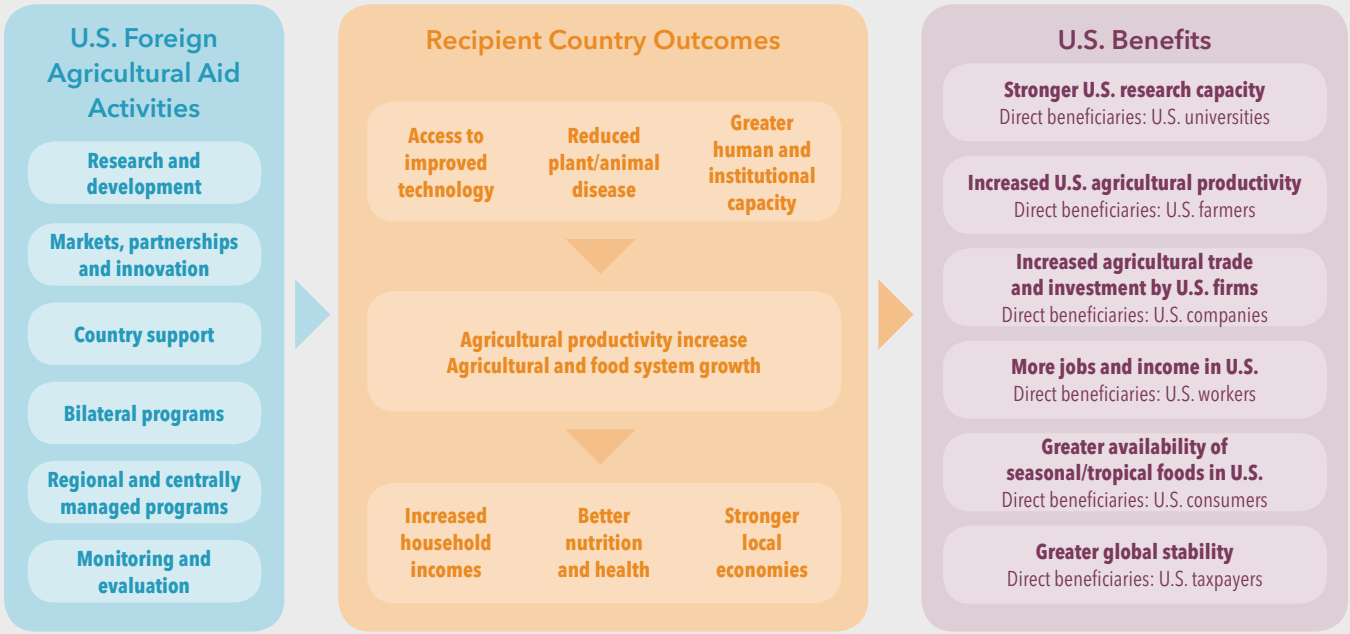


countries that grow coffee, tea, cacao, and spices bring safe and convenient consumer products to the American kitchen.

Foreign agricultural aid promotes national and global security, complementing other security-related efforts of the U.S. government. U.S. aid programs targeting economic growth are more likely to be successful in countries with an adequate supply of nutritious food, an important factor in worker productivity, and the income needed to acquire it. Nutrition and health are interrelated, and programs that promote wellness and disease prevention are more effective when households have access to healthful and affordable foods. On the other hand, poverty and food price spikes that lead to food insecurity can contribute to and exacerbate civil unrest. Costly intervention by the U.S. military is less likely to be necessary in countries with stable food supplies.

This report reviews the links, illustrated in Figure 2, between U.S. foreign agricultural aid for developing countries and the U.S. economy. The report begins with background information on foreign agricultural aid and the associated recipient country outcomes and then focuses primarily on the benefits to the United States. Information for the report was gathered through a literature review and interviews with agricultural scientists and agricultural development specialists. Over the past two decades, researchers have rigorously measured and quantified some types of benefits to the United States, such as improved crop varieties, and those estimates are reviewed here. Many of these benefits, however, arise from agricultural and food system changes that are too complex to allow attribution to a single source. Consequently, many of the benefits discussed in the report are described in qualitative terms and narrative form. This report was prepared at the request of the Board for International Food and Agricultural Development (BIFAD), a presidentially appointed federal advisory committee established in 1975 under Title XII of the Foreign Assistance Act.[2]

Figure 2: U.S. Benefits from Foreign Agricultural Assistance



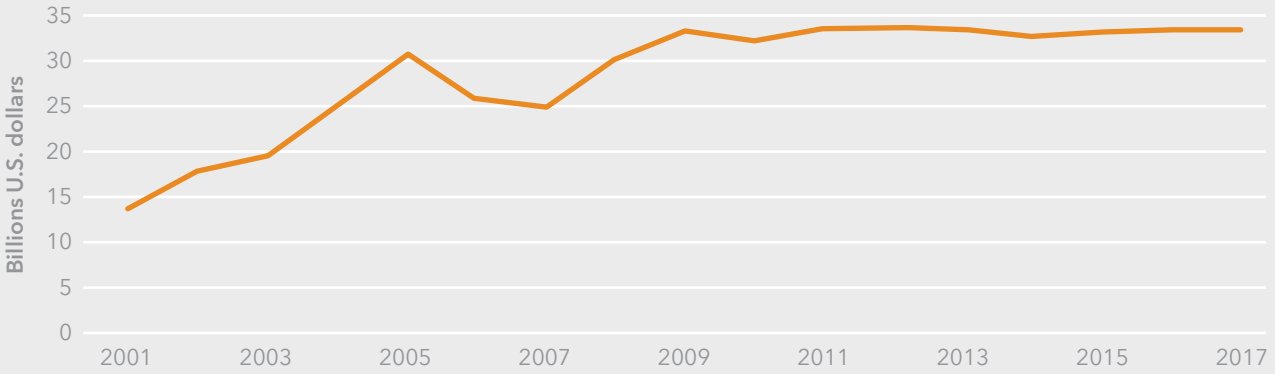
Agricultural exports totaled $140 billion in 2018, with two-thirds ($90 billion) going to developing countries (USDA, 2019).This reflects an increase in the developing-country share of U.S. agricultural exports from just 50 percent in 2000, an increase driven by developing countries' relatively high rates of economic growth and relatively high share of income allocated to food.

Photo credit: Alfredo DAmato / Panos

OVERVIEW OF U.S. FOREIGN AGRICULTURAL AID

U.S. foreign nonmilitary aid expenditure was $33.3 billion in Fiscal Year (FY) 2017 (USAID, 2019a).[3] This level of funding was 0.17 percent of total U.S. gross domestic product (GDP) and accounted for 0.84 percent of total U.S. government expenditure in FY 2017. Nonmilitary assistance programs include agriculture, commodity assistance, economic growth, education, governance, health, humanitarian assistance, and infrastructure. Adjusted for inflation, nonmilitary assistance expenditures have been flat since 2009 (Figure 3).

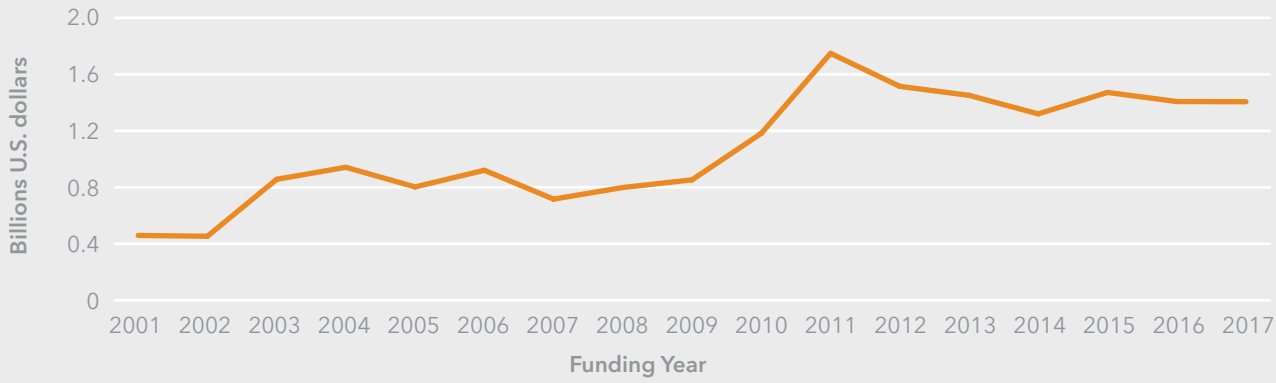
Figure 3: U.S. nonmilitary assistance expenditures, constant 2017 dollars, 2001–2017



Source: Foreign Aid Explorer (https://explorer.usaid.gov/data.html). Sort categories: assistance category = economic, transaction type = disbursement, fiscal year = 2000-2017, constant amount.

Foreign agricultural aid is a minimal percentage of total nonmilitary assistance. In 2017, U.S. government foreign agricultural aid expenditure totaled $1.41 billion, accounting for 4.2 percent of total nonmilitary assistance and 0.04 percent of total U.S. government expenditure (USAID, 2019a).[4] The inflation-adjusted level has declined since 2011 (Figure 4). The largest share of federal expenditure on foreign agricultural aid is implemented by the U.S. Agency for International Development (USAID). In 2017, USAID implemented 72 percent, the U.S. Department of Agriculture (USDA) implemented 20 percent, and 8 percent was implemented by other government agencies (USAID, 2019a).[5]

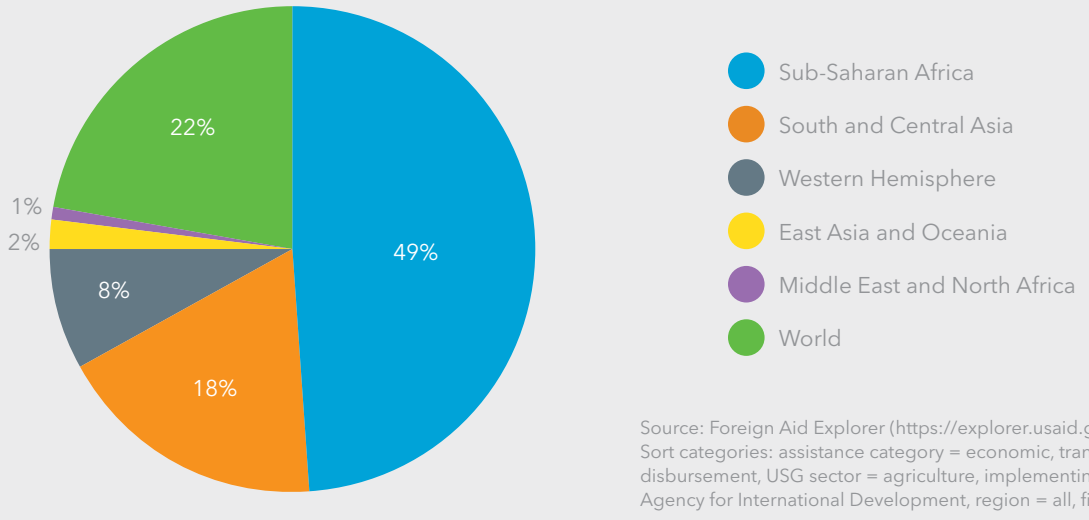
Figure 4: U.S. foreign agricultural assistance expenditures, constant 2017 dollars, 2001–2017



Source: Foreign Aid Explorer (https://explorer.usaid.gov/data.html). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, fiscal year = 2000-2017, constant amount.

Expenditures by USAID for implementation of foreign agricultural assistance totaled $1.01 billion in 2017 (USAID, 2019a).[6] Regionally, $492 million or 49 percent of total agricultural assistance went to sub-Saharan Africa (USAID, 2019a).[7] South and Central Asia received $181 million or 18 percent, and $78 million or 8 percent went to the Western Hemisphere (primarily Central and South America). A total of $224 million or 22 percent went to world activities that are not region-specific (Figure 5).

Figure 5: Global distribution of USAID agricultural expenditures, 2017



Source: Foreign Aid Explorer (https://explorer.usaid.gov/data.html). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, implementing agency = U.S. Agency for International Development, region = all, fiscal year = 2017.

USAID implemented agricultural development projects and activities in 55 countries in 2017 (USAID, 2019a).[8] The agency's agricultural assistance funding was distributed primarily through U.S. private enterprises (25 percent), U.S. nongovernmental organizations (22 percent), multilateral organizations (15 percent), and U.S. universities and research institutes (12 percent). Smaller shares of funding were distributed to church and faith-based organizations, public and private partnerships, U.S. government agencies, and other organizations. Only a small share of USAID foreign agricultural assistance is distributed to foreign governments, amounting to 1.7 percent in 2017 (USAID, 2019a).[9] The subsequent sections describe USAID's spending categories related to agriculture and food security.

RESEARCH AND DEVELOPMENT

Investments in agriculture and food security research respond to critical global and regional priorities and generate a continuous flow of new technologies and other innovations—and better host country policies—that lead to higher levels of productivity, nutritional security and incomes for small- and medium-scale producers in Feed the Future countries (U.S. Department of State, 2017). The Feed the Future Research Strategy guides USAID's agriculture and food security research investments and promotes expanded collaboration among U.S. university–led Feed the Future Innovation Labs, CGIAR (formerly the Consultative Group on International Agricultural Research), national and regional agricultural research systems, and the private sector. Human and institutional capacity development interventions through fellowship programs, organizational strengthening mechanisms, and the Feed the Future Innovation Labs help to build sustainable partner country capacity to support the agricultural sector.

A large body of literature confirms that agricultural research funding yields a high return in increased productivity. For agricultural research in developing countries, Alston et al. (2000) calculated an average rate of

return of 54 percent per year in a statistical meta-analysis of 1,181 impact estimates from 289 previous studies. Evenson (2001) found a median annual rate of return of 120 percent in Asia, 80 percent in Latin America, and 44 percent in Africa in a review of 244 previous studies of the impact of agricultural research on agricultural productivity.

U.S. government support for overseas agricultural research began in the 1950s, with funds managed by various federal agencies until the creation of USAID in 1961. USAID's funding for agricultural research peaked in 1985 at $429 million (constant 2017 dollars) but dropped steadily thereafter, reaching a low of $69 million in 2008 (Alex, 1997).[10] Since then, agricultural research funding has risen under the Feed the Future initiative, as shown in Table 1. In 2017, the budget total for USAID-sponsored agricultural research and development was $142 million.[11] Agricultural research funds have been distributed primarily to three groups of research institutions: U.S. universities, foreign universities and research institutes, and CGIAR.

Table 1: USAID agriculture budget, millions U.S. dollars

	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Grand Total	1,173	1,198	1,116	1,070	1,064	938	902
BFS - Country support	60	103	107	119	136	127	100
BFS - Markets, partnerships and innovation	24	32	46	44	42	36	31
BFS - Monitoring and evaluation	15	14	13	13	18	18	17
BFS - Research and development	120	135	151	144	146	130	142
Bilateral programs	841	845	744	684	653	565	549
Regional and centrally managed programs	113	70	56	67	68	62	64

Note: Figures reflect USAID budget levels for Program Area 4.5/EG.3 Agriculture from the following accounts: Development Assistance (DA), Economic Support Fund (ESF), and Assistance for Europe, Eurasia, and Central Asia (AEECA).

Activities supported by the USAID/Bureau for Food Security (BFS) are further described in the BFS portion of the Congressional Budget Justification.

From 1977 to 2012, U.S. universities' primary source of funding for agricultural research focused on developing countries were the Collaborative Research Support Programs (CRSPs) (Alex, 1997). Authorized by a Congressional amendment to the Foreign Assistance Act in 1975, the CRSPs supported agricultural research on crops, animals, nutrition, and natural resources. The programs had the dual aim of bringing scientific knowledge from U.S. land-grant universities to developing countries while at the same time building human and institutional capacity in universities and government ministries of the host countries. Effectiveness of the capacity development investments was underpinned by the long-term nature of the partnerships between the American and foreign institutions. A key part of the capacity development was the training of thousands of young foreign scientists who pursued advanced degrees in agricultural disciplines at U.S. universities. In 2013, upon the ending of the CRSPs, USAID launched the Feed the Future Innovation Lab program, also led by U.S. universities. The aim of the Innovation Labs is to develop science-based solutions to be scaled up by USAID to reduce global hunger, poverty, and undernutrition (USAID, 2019b). The Congressional directive for the Innovation Labs was $50 million in FY 2017.[12]

CGIAR, an international partnership of 15 agricultural research centers, has received funds for research from USAID since 1969 (Alex, 1997). Each research center has a unique topical or geographic research

specialization related to developing-country agriculture. The research centers conduct agricultural research in partnership with national governments, academic institutions, global policy bodies, private companies, and NGOs. Many CGIAR research projects invest in human capacity development by mentoring young scientists. CGIAR, from its origin in the Green Revolution—during which several of the founding centers played a key role in the development of high-yielding varieties of wheat and rice—conducts research on a wide range of agriculture-related topics. CGIAR identifies its research themes as: living within planetary boundaries, sustaining food availability, promoting equality of opportunity, securing public health, creating jobs and growth, big data, climate, biodiversity, genomics, and nutrition (CGIAR, 2019b). USAID funding for CGIAR was $43.8 million in 2017 and $88.7 million in 2018, down from average annual funding of $157 million during the period 2012–2016 (CGIAR, 2019a).

MARKETS, PARTNERSHIPS, AND INNOVATION

Feed the Future aims to sustainably reduce hunger, poverty, and malnutrition (U.S. Department of State, 2017). This requires improving agriculture-led growth, strengthening resilience, and boosting nutrition, especially among women and children. Success requires strengthening the entire food system, including the system that facilitates access to inputs, finance (including tools for managing risk), and markets for all stages of the value chain. By leveraging private-sector resources and expertise, Feed the Future increases commercialization of innovations (including research outputs), improves the agriculture and nutrition enabling environment, and promotes inclusive market growth. The budget total for markets, partnerships, and innovation was $31 million in 2017.

COUNTRY SUPPORT

USAID's Bureau for Food Security (BFS) provides overall leadership on regional and country food security issues such as agricultural inputs and financing, and increasing the role of women in agriculture. BFS supports technical analysis, training, knowledge management, and global learning exchanges; and helps USAID Missions design and implement agricultural, resilience, and nutrition assistance programs. Funding for country support was $100 million in 2017.

BILATERAL PROGRAMS

These programs focus on sustainability and scaling up of food security efforts by encouraging greater public and private sector investment in the agriculture sector and supporting policy reforms that promote an effective business-enabling environment; help smallholder farmers access high-quality inputs; strengthen land and resource rights; manage risk; and promote efficient and competitive markets and trading systems. These efforts help partner countries sustainably develop their own agriculture sectors, utilizing increased economic growth and trade to reduce hunger, poverty, and malnutrition, and help countries increase their self-reliance. The budgeted total for bilateral programs was $549 million in 2017.

REGIONAL AND CENTRALLY MANAGED PROGRAMS

Regional programs promote expanded access to regional markets; mitigate risks associated with drought, disaster, and disease; and develop the long-term capacity of regional organizations to address regional challenges. Centrally managed programs address cross-cutting issues such as youth, gender, natural resource

management, and policy to advance solutions that transform agricultural systems to reduce global hunger, poverty, and malnutrition. The USAID budget total for regional and centrally managed programs was $64 million in 2017.

MONITORING AND EVALUATION

BFS leads the monitoring and evaluation function for the Feed the Future initiative, including coordinating interagency reporting into the Feed the Future Monitoring System. Funding supports program evaluation, performance monitoring, reporting on results, and knowledge-sharing activities that provide critical empirical evidence to inform programming and investment decisions. USAID budgeted $17 million for monitoring and evaluation in 2017.

U.S. AGRICULTURAL INVESTMENTS AND RECIPIENT-COUNTRY OUTCOMES

Foreign aid has a positive impact on aggregate economic growth of recipient countries, according to a number of recent statistical studies (Arndt, Jones, & Tarp, 2016; Galiani et al., 2017). A widely cited study finds that a one percentage-point increase in aid (as a share of GDP) boosts investment (as a share of GDP) by 0.3–0.5 percentage points and raises growth of real per-capita GDP by 0.1–0.2 percentage points within several years after the aid is received (Clemens et al., 2012). The strength of the impact varies with the amount of time that has elapsed since the aid was received and with the subpopulations or sectors that the aid targets.

The rationale for foreign aid to target agriculture is that growth of this sector has potential to drive growth of the entire economy and reduce poverty (McArthur & Sachs, 2019; Johnston & Mellor, 1961). Agriculture is important as a source of the food and fiber required by households, industry, and export markets. Agriculture is also important because, in many low-income developing countries, it employs more than half the workforce, so that increasing agricultural productivity boosts incomes of large numbers of households. Furthermore, agricultural workers released from agriculture as farm labor productivity rises become available to meet the growing labor needs of other economic sectors, a well-known development pattern observed in the United States and many other countries over the past two centuries. In addition to stimulating economic growth, agriculture is the key to poverty reduction. Agricultural growth in low-income countries has more than twice the impact on poverty reduction as growth in other economic sectors (Ivanic & Martin, 2018).

INVESTMENTS IN FARMS, FIRMS, AND INSTITUTIONS

Agricultural assistance provided by USAID is designed to improve farming and agribusiness methods and strengthen institutions that support agricultural development. Innovations developed and promoted by USAID increase access of developing-country farmers and agribusinesses to improved technologies that raise productivity and reduce the burden of plant and animal disease. At the farm level, new farming technologies and practices promoted by USAID raise the productivity of land, labor, and capital used in agricultural production. To create an economic, political, and social environment conducive to agricultural development, USAID works with local partners to improve agriculture-related policies and the performance of diverse types of agricultural organizations (producer groups, markets, universities, research institutes, and governments). Agricultural education sponsored by USAID prepares future farmers, entrepreneurs, and agency officials to acquire the skills and competencies needed to transform the agricultural sector.

AGRICULTURAL AND FOOD SYSTEM OUTCOMES

USAID investments increase agricultural productivity and stimulate growth of agricultural and food systems of recipient countries. A two-pronged approach of investing at the farm and agribusiness level and at the institutional level is essential for transformation of food and agricultural systems. Farms and agribusinesses are small relative to the scope of the larger economic, political, and social forces that shape the agricultural sector. Widespread and sustainable adoption of productivity-enhancing technologies occurs only if farmers and entrepreneurs are supported by agricultural institutions that provide essential extension, credit, and market development services and that give them collective influence with governments and large-scale enterprises. Agricultural research also plays a critical role in increasing productivity. Empirical studies of the impact of agricultural development assistance on agricultural productivity focus primarily on research. A review of statistical studies by CGIAR, which is supported in part by USAID, confirms that its applied agricultural research has boosted agricultural productivity, thereby contributing substantially to poverty reduction in Africa, Asia, and Latin America (Evenson & Gollin, 2003; Hazell, 2010).

When transformation at the farm and agribusiness level is supported by research and transformation at the institutional level, the entire agricultural and food system grows and improves (Reardon et al., 2018). Where governments were once major suppliers of agricultural inputs (e.g., seeds and fertilizers) for farmers and major buyers of their agricultural output, as markets develop and mature, private companies with the required technical expertise and financial resources expand their input distribution and raw-product aggregation systems. Where farmers once had difficulty obtaining improved agricultural inputs and credit reliably and were able to sell only or largely to local buyers, a growing economy with developing markets means they are now connected to urban and international consumers. Urban consumers benefit from the growing supply and improved quality of food as distribution systems expand and marketing standards emerge. Food processing firms seize the opportunity to fill market niches for high-value processed and packaged food products, increasing their purchases from farmers and increasing consumer choice (Tschirley, Reardon, Dolislager, & Snyder, 2015). As domestic markets develop and mature, they become increasingly connected to international markets, strengthening the country's links to the global economy.

HOUSEHOLD AND ECONOMYWIDE OUTCOMES

Investments in developing country agriculture raise household incomes, improve nutrition and health, and build stronger national and regional economies. The dominance of agriculture as a livelihood in many developing countries means that improving agricultural productivity raises the income of a large share of households (Ivanic & Martin, 2018). As income rises, households typically increase their spending on food and other items, including healthcare and education. The composition of the diet tends to shift, bringing about consequences that are both positive (e.g., more protein intake) and negative (e.g., rising levels of obesity). USAID's approach to maternal and child nutrition focuses on increasing the equitable provision and utilization of high-quality nutrition through nutrition-specific and nutrition-sensitive services and commodities as well as social and behavior change strategies for nutrition activities (USAID, 2019e). It also focuses on building country capacity and commitment to nutrition at the institutional, political, stakeholder, and systems levels (USAID, 2014).

Together, more efficient and effective food systems, higher household incomes, and better human health contribute to sustainable growth of national economies. The changes in the agricultural sector and the larger economy are intertwined and mutually reinforcing. This broad-based growth and development, fueled by the transition in agriculture, brings food and income security at the household level and contributes to social and political stability at national, regional, and global levels.

U.S. PRODUCER AND CONSUMER BENEFITS FROM FOREIGN AGRICULTURAL AID

EXPANDED RESEARCH CAPACITY AND THE SPILLOVER OF TECHNOLOGY

Agricultural producers face a continuing series of potential threats arising from plant and animal diseases and pests, soil fertility changes, extreme weather events, water availability, shifts in the cost of inputs, and other factors. Because new threats are constantly emerging, agricultural research leading to new solutions must be undertaken continually to keep the food supply safe and secure.

Agricultural research funded by U.S. foreign assistance increases the supply of agricultural and food technologies in the United States. For crops, problem-solving innovations often take the form of new varieties bred to improve the volume and quality of the harvested output. Plant breeding is a never-ending task because field conditions and consumer demand are ever-changing. The likelihood of developing a new variety that exhibits the particular traits targeted by plant breeders is much higher when they have access to germplasm from diverse environments and that exhibits a wide range of characteristics. For many decades, CGIAR has played a key role in the international exchange of germplasm, and both CGIAR and U.S. land-grant universities have made the United States part of an exchange that has been enormously valuable to American agriculture. Over the period 1985–2009, the United States provided 6,300 genetic samples to other countries and in return received 40,000 samples through exchanges facilitated by CGIAR (Galluzzi et al., 2016). This section describes how plant breeding and other types of research on wheat, rice, sorghum, dry beans, and peanuts have, while targeting developing countries, also helped solve important challenges faced by U.S. farmers.

> *Direct spillover benefits of U.S.-funded agricultural R&D in developing countries come from international research efforts to develop nutrient-enriched and disease-resistant seed strains.*
>
> *American Farm Bureau Federation, 2019*

Wheat Research and Transfer of Technology to the U.S.

Research supported by U.S. foreign agricultural assistance has produced new wheat technologies now widely adopted by American farmers. Wheat is the third most important field crop in the United States in planted acreage, production, and gross farm receipts and is produced at large scale in 29 states, with the largest production occurring in Kansas, North Dakota, Montana, Washington, and Oklahoma (USDA-NASS, 2019; USDA-ERS, 2019c).

A Green Revolution in wheat productivity occurred globally, and most pronouncedly in South Asia, in the 1960s and 1970s. Much of the improvement in productivity came from the development of new high-yielding wheat varieties bred from semi-dwarf wheat from Japan (Dalrymple, 1980). American wheat researcher Norman Borlaug and other scientists at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico developed the new varieties and released them in many countries, including the United States. CIMMYT is one of the founding research centers of CGIAR, which USAID began supporting financially in the 1960s. Compared

to conventional varieties of the time, the new varieties were more responsive to fertilizer and shorter in stature, which reduced losses from lodging (falling over) of the stalk as the grain head matured. Though the research had originally targeted wheat production in developing countries, semi-dwarf breeding lines developed by CIMMYT were used by plant breeders developing wheat varieties for the United States. By the early 1990s, about a fifth of total U.S. wheat acreage was sown to varieties with CIMMYT ancestry (Pardey et al., 1996b). Today, semi-dwarf wheat accounts for 99 percent of wheat acreage globally (CropLife International, 2019). While not all these varieties have CIMMYT parentage, CIMMYT and U.S. support for its research played a catalytic role in the development of this new wheat technology now widely used by American farmers.

Historically, wheat stem rust has been the most damaging disease for wheat (FAO, 2010). Within weeks, a healthy-looking crop near harvest can be largely destroyed, reducing yields by 70 percent. An estimated 90 percent of the world's wheat production is vulnerable to wheat stem rust (Singh et al., 2011). Nine outbreaks of wheat stem rust occurred in the United States during the 20th century. In 1935, 1953, and 1954, wheat stem rust destroyed up to 50 percent of the wheat crops in Minnesota and North Dakota and at least 20 percent of the wheat crops in South Dakota (Leonard, 2001). Researchers identified a wheat gene, Sr31, that suppressed wheat stem rust, and new wheat varieties based on this research kept the disease under control for three decades. However, in 1999, a virulent strain of wheat stem rust known as Ug99, which cannot be suppressed by the Sr31 gene, was discovered in Uganda. Since then, Ug99 has spread to 12 countries in Africa and Asia (CIMMYT, 2019). Wheat industry experts believe the disease could spread to North America and pose a serious threat to the wheat industry (Hein, 2015).

Research is an important part of the U.S. government's action plan to minimize the risk of Ug99, and USAID is one of the agencies funding the research. The plan involves monitoring, germplasm enhancement, gene discovery, development of molecular markers for rust resistance, and wheat variety development. Some of the research is conducted at the Cereal Disease Lab operated by the USDA Agricultural Research Service at the University of Minnesota. Scientists there are breeding new rust-resistant wheat varieties suitable for agronomic conditions in the United States. A cooperative agreement between USAID and USDA provided funding for a state-of-the-art greenhouse at the lab. Researchers at the lab, funded in part by USAID, have identified wheat genes resistant to wheat stem rust (Nirmala et al., 2017). This is an important step toward the development of wheat varieties that can save the wheat harvest in the United States and other countries from the ravaging damage of wheat stem rust.

USAID-supported wheat research programs at Kansas State University and Washington State University are using cutting-edge scientific methods to reduce the length of the wheat breeding cycle. This financial support has enabled the labs to build infrastructure and systems to refine research tools and disseminate them to wheat breeders in both developing countries and the United States. An important goal of both labs is to develop heat-tolerant wheat varieties. Heat stress is a major limiting factor for wheat varieties commonly planted worldwide, including in the United States. The labs' researchers, by investigating heat stress in even hotter climates such as those of India, gain greater understanding of the genetic factors that affect heat tolerance. This knowledge, together with the use of genomic, molecular, and physiological methods, speeds up the development of heat-resistant wheat varieties and ultimately will benefit American farmers in the form of new breeding lines and new released varieties that maintain or improve productivity.

> *The effects of climate change and [weather] extremes impact all agriculture. The more we can learn how to develop wheat varieties that are resilient to heat and drought, the better Kansas farmers will be positioned to have improved yield stability and productivity.*
>
> *Justin Gilpin, CEO of Kansas Wheat, formed by cooperative agreement between the Kansas Wheat Commission and Kansas Association of Wheat Growers*

The USAID-funded Kansas State wheat lab has analyzed over 45,000 lines of wheat from around the world to increase plant breeders' accuracy in predicting traits at different stages of the breeding cycle. Improved prediction of wheat traits reduces the time and cost of producing new varieties.

Sorghum Research and Transfer of Technology to the U.S.

Many American producers of sorghum now plant improved varieties developed through a sorghum research program sponsored by USAID. The new varieties were developed by the International Sorghum and Millet CRSP (INTSORMIL), a research program managed by the University of Nebraska in collaboration with other land-grant universities from 1979 to 2013. It then transitioned to become the Feed the Future Innovation Lab for Sorghum and Millet, now managed by Kansas State University. A major focus of the lab is development of sorghum varieties with resistance to biologically and economically damaging insect pests.

In the 1980s, the greenbug aphid emerged as a serious threat to sorghum farming in the United States. Through the use of germplasm collected by INTSORMIL from many parts of the world, one of the INTSORMIL researchers, Gary Peterson of Texas A&M University, worked with a group of researchers to screen thousands of sorghum lines in search of greenbug resistance (Kansas State University, n.d.). The outcome was the development and release of new varieties that greatly reduced damage from the greenbug aphid.

While conducting INTSORMIL-funded research in Africa over a 30-year period, Peterson had become familiar with the sugarcane aphid, a pest causing damage in both sugarcane and sorghum (Fannin, 2018). A Botswanan student at Texas A&M University conducting dissertation research on sorghum had identified a breeding line, Tx2783, that is resistant to the sugarcane aphid. Although this pest had not previously been a problem in U.S. sorghum production, in 2013, a massive sugarcane aphid outbreak on sorghum fields in Texas and other states caused yield losses of up to 50 percent and an estimated economic loss of $8 million in 2013 alone (Kansas State University, n.d.). Since then, the sugarcane aphid has spread to all major sorghum-producing states. Knowing that Tx2783 is resistant to the aphid, Peterson and his colleagues at Texas A&M University brought their expertise to bear in fighting it. Research conducted by these INTSORMIL-supported scientists laid the groundwork for understanding the genetics of sugarcane aphid resistance. In 2018, 19 new sorghum lines with sugarcane aphid resistance were released, 15 of which were derived from Tx2783.

> *INTSORMIL is pretty important to us. It's another tool to get better lines and better products out to the U.S. farmer and the rest of the world.*
>
> *Donnie Swink, Executive Vice President, Crosbyton Seed Company, Crosbyton, Texas*

In 2013, a massive sugarcane aphid outbreak on sorghum fields in Texas and other states caused yield losses of up to 50 percent and an estimated economic loss of $8 million in 2013 alone (Kansas State University, n.d.). Since then, the sugarcane aphid has spread to all major sorghum-producing states.

Mutually beneficial collaboration with private seed companies was a feature of the INTSORMIL program. The researchers needed up-to-date information on sorghum traits desired by farmers, and Crosbyton Seed Company of Crosbyton, Texas, shared insights on the agronomic challenges faced by its customers in Central America, Africa, and the United States. INTSORMIL researchers at Texas A&M University then set out to develop new breeding lines possessing the targeted traits, using germplasm collected through INTSORMIL. After the lines were developed, the university and company entered into a "material transfer agreement," and INTSORMIL became a prime source of germplasm for Crosbyton for use in its own commercial seed breeding (Conley & Johnsen, 2011). By 2006, INTSORMIL had released 213 sorghum breeding lines to private industry, and 60 percent of sorghum hybrids grown in the United States had a least one parent from INTSORMIL (Yohe, 2011).

Bean Research and Transfer of Technology to the U.S.

USAID-sponsored research on beans generates innovations that benefit U.S. producers and consumers of beans. Farmers in the United States grow nearly three million acres of dry beans and related crops, such as lentils and chickpeas, in the pulse family (Bond, 2017). American consumer demand for pulse-based food products, such as hummus, has grown from $10 million in the late 1990s to $700–$800 million in recent years.

USAID has long supported a bean research program at several American universities whose scientists have developed most bean varieties grown commercially in the United States.

At least 13 common bean varieties and 2 blackeye pea varieties were developed by researchers in the USAID bean program, registered as intellectual property, made available to growers, and are being commercially grown in the U.S. (beans in Michigan, Minnesota, Nebraska, and North Dakota and cowpea in California).

The program, originally known as the Bean/Cowpea CRSP (1978–2012) and now known as the Feed the Future Innovation Lab for Legume Systems Research (2013 to present), is based at Michigan State University. From the perspective of the U.S. bean industry, an important function of the bean research program is the collection of germplasm from around the world. The germplasm collection provides the bean researchers with an expanded range of genetic options for breeding beans with desired characteristics. Using this germplasm, the researchers have developed new high-yielding bean varieties with resistance to economically important bean diseases. USAID's long-term support of the bean breeding program has resulted in the development of 40 bean varieties now commercially grown in the United States, all with one or more parents from the program (Michigan State University, 2018). Among these new varieties, the Zorro variety accounts for an estimated 35 percent of total U.S. black bean acreage, while the Zenith variety accounts for 20 percent of the acreage.[13] These varieties are attractive to farmers because of an estimated yield gain of 10 percent over other black bean varieties.

State and national dry bean industry associations in the United States (Michigan Bean Commission, US Dry

Bean Council, and American Pulse Association) composed of growers, traders, and processors are strong supporters of the USAID-sponsored bean research program because of research and specific initiatives that have contributed to the growth and future viability of the bean industry. Funding for bean research is scarce, and no other federal agency provides this level of support for public-university bean research in the United States. The USAID funding has enabled administrators of U.S. universities to make strategic faculty hires who support the dry bean industry in their regions while enhancing the international engagement of the universities.

Peanut Research and Transfer of Technology to the U.S.

Peanut research funded by USAID creates technologies and knowledge that increase the production, quality, and consumption of peanuts in the United States. Previously known as the Peanut CRSP and now the Feed the Future Innovation Lab for Peanut, the program is based at the University of Georgia. Research sponsored by the program has focused on plant breeding, pest and disease management, food safety, and nutrition (Cummins, 2012).

Many new varieties developed by the USAID program have been released in the United States. High oleic oil content, which delays the development of rancidity, is a desirable trait successfully bred into new peanut varieties by the program's scientists. A high-yielding and high-oleic variety released in 2014 also has excellent disease-resistance properties, making it suitable for the U.S. organic market, which pays premium prices. Another desirable trait in peanut varieties developed and released by the program is fungal disease resistance, reducing the need for fungicide, a major expense in peanut farming. Successful plant breeding was possible because of the program's collection and analysis of peanut genetic material from around the world, including germplasm from wild peanut species with resistance to rust, leaf spot, and other diseases. Recently, the program evaluated 1,300 African lines of peanuts, and is now evaluating 2,500 U.S. lines, an effort that is co-funded by USAID and a U.S. peanut growers association.

Research on aflatoxin, a deadly and costly threat to food safety in peanuts and other crops, has been a major focus of the peanut program. Aflatoxin is a natural carcinogen found on peanuts and other agricultural crops. Symptoms of aflatoxin exposure include acute liver damage, edema, digestive problems, and other conditions. One line of the program's aflatoxin research has focused on the effects of aflatoxin on children and on women during pregnancy. Researchers in the peanut program have also analyzed the aflatoxin-reducing properties of a type of clay, now widely used in animal feeds to reduce the aflatoxin exposure of livestock and poultry. In the United States, handling practices (such as rigorous cleaning, shelling, sorting, and blanching), regulation, and testing keep aflatoxin in peanuts under control, but the cost of implementing these measures is high. Therefore, cost-reducing solutions for aflatoxin control are particularly relevant. One such solution is a new peanut variety that is resistent to the mold that produces aflatoxin. The natural resistance of this variety is estimated to lower aflatoxin levels by 15 percent, bringing substantial savings to farmers. However, the potential for genetic control of aflatoxin remains limited because of its complex biology and therefore crop management techniques remain important. For this reason, the program's research on management of insects and soil pests that exacerbate the production of aflatoxin-producing mold in the field is also relevant to U.S. peanut growers. Other USAID research programs have conducted research on aflatoxin. The Nutrition Innovation Lab contributed to the evidence showing the impact of aflatoxin on child development, and the Innovation Lab for the Reduction of Post-Harvest Loss developed technologies to reduce aflatoxin contamination.

> *The Peanut Lab [funded by USAID] has long been at the forefront of improving yields and reducing aflatoxin in African countries and many of these innovations carry over to the U.S. industry.*
>
> *Jeff Johnson, ex-CEO, Birdsong Peanuts Inc., large-scale buyer and processor of peanuts in 10 southern U.S. states*

The peanut research program has been a pioneer in nutrition. Americans, in the 1980s, tended to view oil in foods much more negatively than they do now. Research published by the program's nutrition scientists showed that peanuts are a healthful food and a valuable part of a low-carbohydrate diet. The publication of these findings by the peanut research program stimulated further research on nutritional aspects of peanuts by other researchers and by the peanut industry.

ECONOMIC IMPACT OF TECHNOLOGY SPILLOVERS IN THE U.S.

The American agricultural sector benefits financially from agricultural technologies that spill over from U.S.-sponsored research in developing countries. Evidence of the return to U.S. agriculture comes from studies of individual components of USAID's agricultural research portfolio. The preceding section described USAID-supported wheat research by CIMMYT. Beginning in the 1960s, USAID also supported rice research at the International Rice Research Institute (IRRI), another of the founding research centers of CGIAR. Measured in terms of improved yields and reduced input costs from the use of new varieties of wheat and rice, the return on U.S. investment in CIMMYT and IRRI research generated cumulative benefits to U.S. farmers estimated at $3.4 billion to $15.6 billion between 1960 and 1993 (Pardey et al., 1996a). **Each 100 dollars of benefit to the U.S. economy from higher productivity in wheat and rice production cost taxpayers only two cents.** Benefits of USAID support to CGIAR research centers continue to flow to the United States. A recent study estimated that, for wheat alone, the financial impact in the United States of CIMMYT research is $140 to $180 million annually (Lantican et al., 2016), representing a benefit-cost ratio of between 32:1 and 40:1.

USAID-funded agricultural research at U.S. universities also generates economic benefits for the U.S. agriculture sector. The sorghum research CRSP, INTSORMIL, first received funding from USAID in 1979. An economic impact study found that INTSORMIL's greenbug-resistant sorghum varieties saved American farmers $389 million in 1989 alone (Eddleman, Chang, & McCarl, 1991). At that point, INTSORMIL had received a total of $44 million (in constant 1989 dollars) in USAID support since its founding (Alex, 1997). Therefore, in a single year, the sorghum research generated nine times its total cumulative cost, and the benefits can reasonably be expected to have continued for many subsequent years. **A recent study estimated that the sorghum and millet research sponsored by USAID through INTSORMIL generated an average annual rate of return on investment of 49 percent, based on impacts in the United States and developing countries** (Zereyesus & Dalton, 2017).[14]

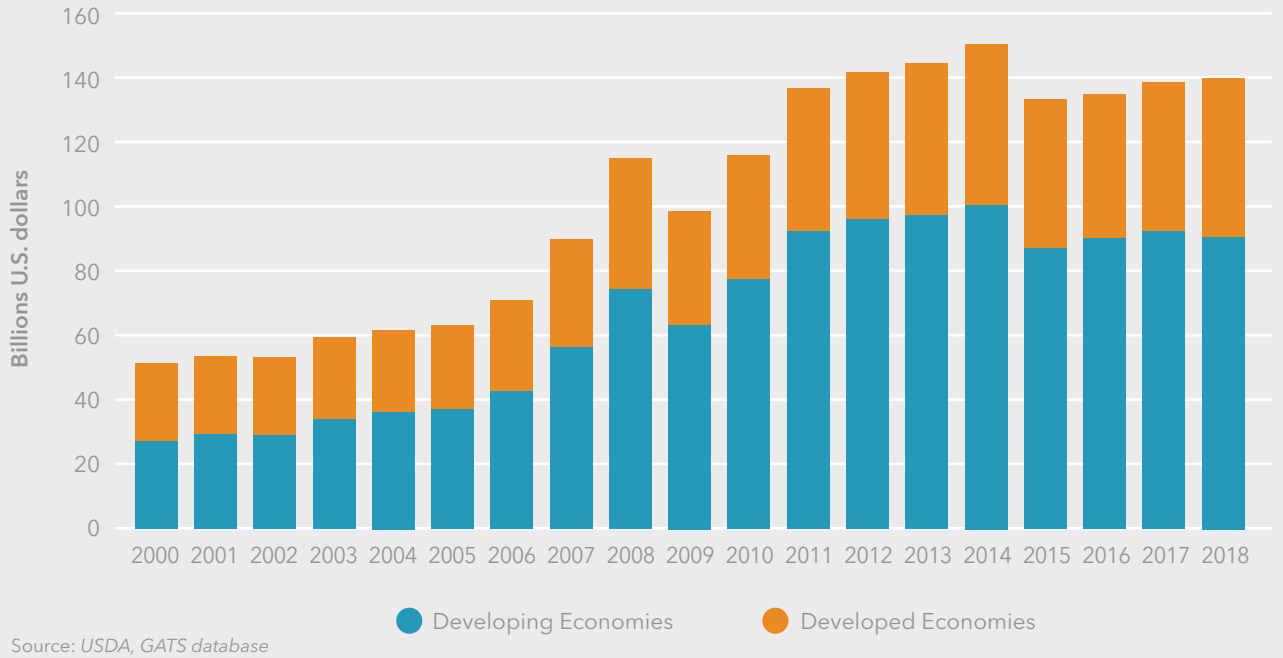
The economic impact estimates presented above are indicative of the domestic economic impact of technologies that spill over from research sponsored by U.S. foreign agricultural assistance, but they are not comprehensive. A reason for the lack of comprehensive estimates is that many of the technologies that spill over and are adopted by U.S. farmers are aimed at avoiding the spread of plant and animal diseases and pests. When damage is avoided completely or suppressed before it reaches epidemic levels, it is difficult to estimate how much damage would have occurred if the technology had not been adopted. The economic impact of an "avoidance technology" can be estimated only by making assumptions about the likely transmission and spread of the disease or pest. Thus studies of the economic impact of avoidance technologies typically define multiple scenarios based on likely patterns of transmission and then estimate the costs and benefits of the new technology under each scenario. The net benefits of the technology are then presented as a range of values rather than a single value.

An example of the economic impact of an avoidance technology comes from a recent study of the potential losses in the United States if U.S. wheat were infected by the Ug99 wheat stem rust. As described in the previous section, wheat stem rust is a disease that is not currently active in the United States but has been spreading globally and represents a potential threat to the U.S. wheat industry. Four different scenarios of the potential arrival and spread of the disease were analyzed (Paarlberg et al., 2014). The scenarios vary by vector of transmission (wind versus human), the duration and extent of its spread, and the response of U.S. wheat export customers to the outbreak. The projected cost to the U.S. agricultural sector would range between $1.5 billion (for a one-year outbreak in North Dakota only due to human transmission) to $9.8 billion (for a multiyear outbreak in several Great Plains states, with U.S. wheat assumed to be widely banned by export customers who do not yet have Ug99 in their countries).

INCREASED U.S. AGRICULTURAL EXPORTS

Agricultural exports from the United States are highly dependent on economic growth in developing countries. In 2000, U.S. agricultural exports totaled $53 billion and developing countries accounted for half of those

Figure 6: U.S. agricultural exports, 2000–2018 (nominal values)



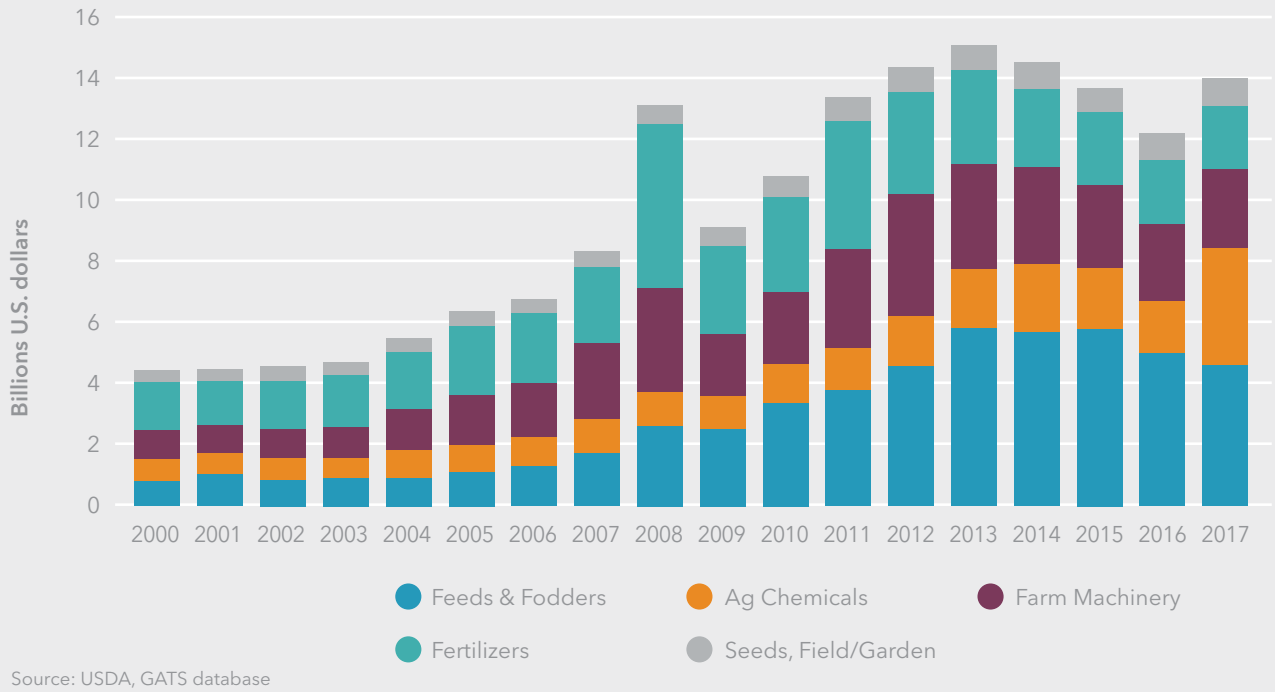
Source: *USDA, GATS database*

exports (Figure 6). By 2018, total U.S. agricultural exports had grown to $140 billion, with developing countries accounting for $90 billion, or nearly two-thirds of total agricultural exports. Most of the inflation-adjusted growth in agricultural exports over the last 20 years is a result of expanding exports to developing countries, up 103 percent over the period while exports to developed countries grew only 19 percent. China accounts for most of the growth in agricultural exports to developing countries, but growth in Central America, Southeast Asia, and sub-Saharan Africa has been important as well. The recent trade tensions between the United States and China underscore the importance of expanding export markets in other developing regions of the world.

In addition to bulk agricultural commodities, meat, and manufactured food products, the United States also exports agricultural inputs such as seed, fertilizer, and farm machinery to developing countries. Figure 7 shows the growth of U.S. exports of selected agricultural inputs to developing countries since 2000. Exports to developing countries slowed over the past few years as the dollar strengthened—but data for the first half of 2018 show an increase of 9 percent over 2017 levels which, if maintained for the year, would mean record (nominal) exports for those items.

Many U.S. agribusinesses and food and agricultural product exporters view developing regions of the world as their best opportunity for market expansion. The companies are attracted by the large and rapidly growing population in those regions, the high rates of economic growth in many developing countries, and the well-known shift by consumers to higher-quality and higher-priced food products as incomes rise. This shift in consumption patterns occurred decades ago in today's high-income countries, and growth in the demand for

Figure 7: U.S. exports of agricultural inputs to developing countries, 2000–2017 (nominal values)



Source: USDA, GATS database

food has leveled off. In contrast, developing countries are still at the beginning of this transition toward higher-quality and higher-priced foods as a growing share of the population joins the middle class, creating market opportunities for U.S. exporters.

U.S. agricultural exports to China, from a low level in 1990, are 2,300 percent higher today, driven by income-induced changes in food consumption patterns and changes in Chinese imports following the country's

entrance into the World Trade Organization in 2001. U.S. agricultural exports to India, where incomes have risen but not yet to the level of China's, have increased by 1,693 percent since 1990. Similar potential for growth of U.S. exports exists in many other developing countries where U.S. foreign aid is designed to boost incomes. Africa is a world region where U.S. exports have grown, but there is potential for far higher growth. Grain imports in sub-Saharan African countries grew by almost 6 percent annually over the period 2000 to 2018. Vegetable oil imports grew by 6.6 percent and meat imports by 8 percent annually over the same period. Those trends are expected to continue. Poultry imports to sub-Saharan Africa are projected to account for 17 percent of global poultry trade by 2027, up from13 percent in 2015. Rice imports in the region are expected to grow to 35 percent of global rice trade by 2027, up from 29 percent in 2015 (USDA, 2019).

Income is not the only channel through which U.S. foreign agricultural aid boosts U.S. exports to developing countries. Another export-enhancing channel is the introduction of industrial food and feed standards, which are essential both for hygiene and for orderly growth of agricultural and food systems. Such standards have long been in place in high-income countries and, over time, processes and technologies for manufacturing and handling of food and feed have been designed to meet these standards. In many developing countries, processing and handling standards are still rudimentary but, as incomes rise, customers demand higher quality, and the food and feed manufacturing industries typically respond by adopting "mature" industrial standards from other parts of the world. The particular standards that are adopted, ultimately, have a large effect on the raw materials and equipment used in food and feed manufacturing.

USAID's Feed the Future Innovation Lab for Soybeans is introducing standards for the livestock feed and culinary oil industries in developing countries. The program advocates soybean as the international industrial protein standard for livestock feed and oil standard for the food industry. The use of soybean as the protein standard in these industries is sound on nutritional grounds and also builds demand for U.S. machinery and technical expertise. Currently, some developing countries restrict importation of genetically modified crops but, if that restriction is lifted, exporters could benefit from the established market for soybeans. Similarly, the introduction of food fortification standards in developing countries addresses nutritional deficiencies and, at the same time, helps shape food manufacturing standards, processes, and technologies in ways that

Multi-layer, hermetic grain storage bag developed by a CRSP bean research program at Purdue University with partial support from USAID. The technology is now exported globally by a private American company.

increase the demand for U.S. goods and services. USAID has assisted more than 30 countries in scaling up micronutrient fortification of staple foods, beverages, and condiments to increase vitamin and mineral content (USAID, 2019c). Some of the fortification assistance focuses on industrial fortification of wheat flour, rice, oil, and other processed and packaged food, stimulating demand for machinery exports from the United States (Alavi, 2008).

In addition to boosting agricultural exports, U.S. foreign agricultural assistance stimulates export of agriculture-related services. An example is PICS Global, Inc., an American company that manufactures and distributes postharvest technologies targeted to smallholder farmers.[15] The company's primary product is a low-priced grain storage bag originally developed by Purdue University and partially funded through the CRSP bean research program.[16] USAID funds supported field research in Cameroon on weevils that destroy stored beans and laboratory research at the Purdue University campus in Indiana on hermetic plastic bags designed to kill the insects through oxygen deprivation. To design bags that were effective and yet as inexpensive as possible, the researchers developed an ultrasonic device capable of monitoring insect activity inside the sealed bag. After the technology was perfected, the university began licensing manufacturers to produce and distribute the Purdue Improved Crop Storage (PICS) bag. In 2017 PICS Global, a private company that describes itself as a social enterprise, was formed to handle the technology licensing and to provide technical and marketing services to the licensees. Currently, PICS bags are produced by seven companies, sold annually to three million farmers in 58 countries, and used to store many crops including beans, corn, sorghum, rice, and coffee.

EFFECT OF EXPORTS TO DEVELOPING COUNTRIES ON U.S. OUTPUT AND EMPLOYMENT

USDA's Economic Research Service estimates that each dollar of agricultural exports stimulates an additional $1.87 in business activity in the United States (USDA-ERS, 2018). The economic multiplier effect is due to multiple rounds of income and spending that circulate through the entire economy, including the manufacturing, trade, and transportation sectors, as farmers purchase fuel, fertilizer, and other inputs to produce commodities for export. In 2018, total agricultural exports of $140 billion are estimated to have produced an additional $261 billion in economic activity in the United States, resulting in a total increase in economic output of $401 billion. In terms of jobs, every $1 billion in U.S. agricultural exports supported 8,619 full-time U.S. jobs, meaning that agricultural exports in 2018 supported an estimated 1,203,000 full-time jobs in the United States (USDA-ERS, 2018). Approximately 379,000 of these jobs were on the farm, and 824,000 were in nonfarm sectors including food processing, services, trade, and transportation.

The value of exports to developing countries alone was $90 billion in 2018, generating an estimated $169 billion in additional economic activity and a total economic activity increase of $259 billion in the U.S. economy, and supporting 779,000 full-time U.S. jobs in 2018.

CONSUMER BENEFITS IN THE U.S.

Climatic conditions prevent or limit domestic production of certain foods consumed in the United States. Importing these foods helps improve American diets, making them more nutritious and diverse. Most of the tropical foods and off-season fruits and vegetables imported into the United States are produced in developing countries. Imports account for nearly 100 percent of the coffee, cocoa, and spices consumed in the United States and 50 percent of fresh fruit and fruit juice (USDA-ERS, 2019a). **U.S. foreign agricultural aid contributes to improvements in the efficiency and hygienic standards of agricultural value chains in developing countries and to a safer and more reliable supply of U.S. food imports.**

American coffee consumers benefit from USAID investments in the financial and environmental sustainability of small-scale coffee production in 17 developing countries in Africa, Asia, and South America (USAID, 2018). For example, in Colombia, USAID helps coffee farmers boost productivity, promotes good postharvest handling methods that improve quality and taste, and helps connect coffee producer organizations to external buyers. Coffee development programs are implemented by American development contractors such as TechnoServe and Tetra Tech in collaboration with American coffee companies such as J.M. Smucker, Keurig Green Mountain, and Starbucks. In addition to providing a sought-after beverage, the coffee industry in the U.S. is a source of employment and income for 1.7 million workers (National Coffee Association USA, 2019).

Cacao is the key ingredient in the chocolate consumed by millions of Americans, and USAID cacao-producer programs help ensure a sustainable supply. In Ghana, where cacao production has contributed to deforestation, USAID and an American chocolate manufacturer, Hershey Company, help small-scale cacao farmers reduce the land required for cacao production by improving yields and assist them in acquiring secure land rights for their farms, which increases their incentive to conserve and plant cacao trees (USAID, 2017). In the Dominican Republic, USAID has formed a partnership with Kraft Foods to increase the cacao yields and production quality of small-scale cacao farmers and to promote production of fair-trade cacao (USAID, 2011).

USAID agriculture-related investments in developing countries help prevent global transmission of animal diseases. This is important for protecting the health of both animal and human populations in the United States. Approximately 75 percent of all new and emerging diseases affecting humans today are zoonotic, meaning they originated in animals (USAID, 2019d). To increase scientific understanding of the causes and spread of animal diseases and to develop ways of controlling them, USAID supports animal-disease research conducted in developing countries by CGIAR, American universities, and other organizations.

The Emerging Pandemic Threats program of USAID strengthens the capacity of developing countries to prevent, detect, and control infectious diseases in animals and people. Early warning systems are essential to detect animal-borne pathogens before they reach pandemic levels. To this end, USAID supports collaboration between animal health experts from the United States and developing countries, building long-term working relationships to ensure that disease monitoring and control are effective. For example, the program has sponsored research on African swine fever, a deadly viral disease that threatens swine production in countries around the world, particularly in sub-Saharan Africa (Achenbach et al., 2017). African swine fever has recently spread through China, Mongolia, and Viet Nam, as well as within parts of the European Union.

USAID provides financial support for organizations involved in One Health, a transdisciplinary approach to public health initially spearheaded by the American Veterinary Medical Association. The approach recognizes the interconnection of animal health, human health, and the environment. Investments by USAID include training of health workers in Asia and Africa through long-established links between American universities and universities on the two continents (USAID, 2014). In Viet Nam, USAID has supported One Health initiatives of various national and regional partners to promote early detection of influenzas, including avian influenza, and to develop quick-response capacity in case of outbreaks. To combat antimicrobial resistance, especially to antibiotics, USAID has joined 64 other countries in a global One Health initiative to develop regulations for antimicrobial use.

American consumers also benefit from foreign agricultural aid that supports the search for solutions for soil- and plant-borne toxins that threaten the safety of human foods and animal feeds. Mycotoxins are naturally occurring toxins produced by molds (fungi) in corn, peanuts, cereals, and other foods and crops, which accumulate in the field, in transportation, and in storage (Alshannaq & Yu, 2017). Aflatoxin is the most important mycotoxin in crops because of its widespread occurrence and the health damage it causes, including liver cancer, immune system malfunction, and child stunting. In many developing countries, aflatoxin contamination is widespread in the food system and exacerbated by heat, humidity, and lack of control

measures. In the United States, regulation and testing by the U.S. Food and Drug Administration (FDA) protects American consumers from health-damaging exposure to aflatoxin, but large economic losses occur. Harvested crops affected at levels above the FDA maximum of 20 parts per billion cannot be sold for human consumption and, consequently, lose monetary value. Instead, they are sold for animal-feed manufacture, if aflatoxin levels are moderate, or destroyed if levels exceed those allowed in the feed industry. A taskforce of the Council for Agricultural Science and Technology estimated U.S. losses from aflatoxin in corn, wheat, and peanuts to be $418 million to $1.7 billion annually, equal in 2018 dollars to $570 million to $2.3 billion (CAST, 2003). A recent estimate of future U.S. losses from aflatoxin in corn alone is $52 million to $1.7 billion annually, depending upon climate trends (Mitchell et al., 2016).

USAID, an early sponsor of aflatoxin research, has supported CGIAR research centers and Feed the Future Innovation Labs at U.S. universities to find ways of reducing aflatoxin. Many of the solutions researchers have found to be effective in developing countries are also relevant for controlling aflatoxin in the United States. Solutions include preharvest measures (agricultural field practices, biocontrol, genetic enhancement of plant resistance) and postharvest measures (improved sorting, drying, and storage) (Wu, 2016).

GREATER GLOBAL AND NATIONAL SECURITY

Food security contributes to global stability. Food is essential for human survival, and evidence shows that there is a two-way causality between conflict and food insecurity (Holleman et al., 2017; Martin-Shields & Stojetz, 2019). Therefore, by improving food security in countries where food is scarce, U.S. foreign agricultural aid programs contribute to stability and address related drivers of conflict, such as economic grievances and competition over scarce resources. This is important not only for humanitarian reasons but also because conflict in fragile states is costly to those who are affected directly and to the international community, including U.S. taxpayers. A recent study published jointly by the United Nations and World Bank (2018) estimates that for every dollar invested in measures to prevent conflict, the international community saves $16 in crisis response and reconstruction expenditures.

The conflict-reducing benefits of agricultural development go far beyond the food supply and address some of the other causes of conflict. Agriculture, as a source of employment and income for most of the working population in developing countries and as a source of food for all, is closely tied to other aspects of human well-being that, if jeopardized, cause conflict (Pinstrup-Andersen & Shimokawa, 2008). When populations that are already disadvantaged or marginalized experience food insecurity, deprivation of basic needs fuels frustration and grievance, furthering a vicious cycle that often sparks violence (United Nations & World Bank, 2018). When conflict becomes violent, food security is nearly always in jeopardy (Martin-Shields & Stojetz, 2019). Farms are destroyed, fields are abandoned, food distribution systems are disrupted, and food prices soar (Breisinger, Ecker, Francois, &Tan, 2015). The damage is often structural, requiring long-term agricultural development to restore food security. Agricultural development in such situations is an important complement to other conflict-mitigating programs.

Foreign assistance has potential to increase global stability by stimulating economic growth in low-income, aid-recipient countries. Economic growth that is broad-based improves the real income and material well-being of a large share of the population, strengthening the economic foundations of social and political stability. Empirical studies document that investments in foreign aid yield a positive impact on economic growth of recipient countries, though the impact is generally lagged and not immediate (Clemens et al., 2012). As with most investments, achieving a high return on foreign aid takes time. This underscores the importance of long-term planning and long-term financial commitments if aid is to have a stabilizing effect on the economies of developing countries.

Another channel through which the growth-inducing effect of foreign aid may contribute to global stability is by reducing international migration. The few available studies of this relationship have measured it over relatively short time periods. These studies find conflicting effects of aid on migration, some positive and some negative (Clemens & Postel, 2018). A more comprehensive study, covering aid to 141 countries, examines the aid–migration relationship over a longer period (Dreher, Fuchs, & Langlotz, 2019). Again, the conclusion is that return on investment takes time. The researchers find that foreign aid reduces international migration from recipient countries after 11 or more years but not in the short run.

The effectiveness of foreign aid in reducing international migration may vary depending on the sector or subpopulation it targets. A 2018 study examines the migration effects of rural development aid versus urban development aid, finding that rural development aid reduces international emigration while urban development aid does not (Gamso & Yuldashev, 2018). The study was conducted using data from 103 countries over a 15-year period, a relatively large and long sample. The authors conclude that their results are driven by the employment effects of rural development aid targeting agriculture, the dominant economic sector in rural areas. Urban development aid, in contrast, has a lesser impact on employment.

Agricultural development assistance creates an opportunity for the United States to build relationships in developing countries before global crises occur. Once a pandemic, environmental disaster, or violent conflict breaks out, it is too late to acquire the knowledge, build the trust, and establish the modalities of cooperation that are essential for finding and implementing solutions. While it may be possible to "surge" military force, relationships and trust cannot be surged. They are built slowly and require long-term interactions of the kind built by U.S. universities, CGIAR research centers, and USAID. Through collaborations with individuals and groups of agricultural scientists, agricultural policymakers, farmers, agribusinesses, and civil society groups in developing countries over multiple decades, these organizations have built ties that serve a vital function in the prevention and mitigation of crises in global agricultural and food systems.

LOOKING AHEAD

American foreign agricultural assistance improves global food security through a focus on smallholder farmers in developing countries. Foreign agricultural development investments made by the United States raise agricultural productivity, increase household incomes, reduce poverty, and stimulate economic growth. Economic growth in aid-recipient countries boosts demand for American agricultural and manufactured products, increasing exports produced by U.S. farmers and businesses and creating jobs for Americans. Further benefits to U.S. agriculture come from the spillover of agricultural technologies developed with support of foreign assistance programs and from preventing the spread of plant and animal diseases and pests. U.S. consumers gain as well. Improved agricultural and food systems abroad are better able to provide U.S. consumers with a reliable, nutritious, and safe supply of tropical foods and off-season fruits and vegetables.

Global food demand is expected to increase by as much as 50 percent from 2012–2013 levels by 2050, as trends in population growth, urbanization, and income growth are projected to continue in developing countries. Population projections by the United Nations suggest that 98 percent of global population growth between 2015 and 2050 will likely come from developing countries, with sub-Saharan Africa accounting for more than 55 percent of that growth. With income growth rates and urbanization rates projected to be higher in developing countries, much of the growth in global demand for meats, dairy, fruits and vegetables, and processed food products will come from these economies.

The growth of global demand for food creates opportunity for continued expansion of U.S. agricultural exports. For that to happen, the agriculture sectors and the entire economies of developing countries must continue to grow. Given that agriculture is the driver of economywide growth in countries that are the largest source of demand for U.S. exports, it is vital that American investments in foreign agriculture continue. Productivity growth still lags in many of the poorest regions of the world and while progress has been made, to be successful, foreign agricultural assistance needs to be sustained.

U.S. foreign assistance is intended to benefit both the targeted countries and the United States, according to the Foreign Assistance Act. By strengthening agricultural and food systems in developing countries, U.S. foreign agricultural assistance contributes to global and national security. The benefit to both developing countries and U.S. producers and consumers far exceeds the costs and helps secure a better future for all.

METHODOLOGICAL NOTE

This report was prepared on the basis of (1) a literature review of the economic effects of agricultural development assistance, including the literature on the impacts of research and development on agricultural productivity; (2) interviews with selected experts, including academics, research scientists, development program managers, representatives of commodity and farm groups, and business owners and managers; and (3) a review of reports and evaluations of USAID-funded projects and programs.

The Board for International Food and Agricultural Development (BIFAD) held a public meeting on August 8, 2018, at the Marriott Wardman Park Hotel in Washington, DC, at which members of the Agricultural and Applied Economic Association (AAEA) and other interested individuals engaged in a dialogue and provided feedback on a new study commissioned by BIFAD and USAID. For minutes of that meeting, see https://www.usaid.gov/bifad/documents/bifad-pubic-meeting-minutes-washington-dc-august-8-2018. Persons with names followed by an asterisk below gave presentations at the meeting.

The authors had conversations with and received comments, documents, and data from the individuals listed below. While their input greatly enhanced this study, all omissions and errors are the responsibility of the authors.

Julian Alston, University of California-Davis
Chris Barrett, Cornell University
Dieudonné Baributsa, Purdue University
Nathan Childs, USDA/ERS
Ben Connor, US Wheat Associates
Constance Cullman, Farm Foundation
Timothy Dalton, Kansas State University
Brenda Dawson, University of California-Davis
Alan deBrauw, IFPRI
Karen Edwards, WISHH
Hillary Egna, Oregon State University
Mark Erbaugh, Ohio State
Keith Fuglie, USDA/ERS*
Peter Goldsmith, University of Illinois
Liz Hare, WISHH
Jagger Harvey, Kansas State University
Paul Heisey, USDA/ERS
Tim Herrman, Texas A & M University
David Hoisington, University of Georgia
James Kelly, Michigan State University
Carrie La Jeunesse, LaJeune Consulting
Jeff Johnson, Birdsong Peanuts, Inc.
Laurie Kitch, PICS Global, Inc.
Martin Kropff, CIMMYT
David Laborde, IFPRI
Sherry Larkin, University of Florida
Jess Lowenberg-DeBoer, Purdue University
Will Martin, IFPRI
Erin McGuire, University of California-Davis
Rangaswamy Muniappan, Virginia Tech
Larry Murdock, Purdue University
John Newton, American Farm Bureau Federation*
George Norton, Virginia Tech*
Wilmer Otto, Agro Capital Management, LLC
Phil Pardey, University of Minnesota
Barry Pittendrigh, Michigan State University
Jesse Poland, Kansas State University
Carl Pray, Rutgers University*
Joe Schultz, Minority Chief Economist, Senate Committee on Agriculture, Nutrition and Forestry
Melinda Smale, Michigan State University*
Vince Smith, Montana State University
Paul Varner, Treasure Valley Seed Co.
Irvin Widders, Michigan State University
Brian Wright, University of California-Berkeley
Teale Yalch, Global Alliance for Improved Nutrition
Bob Young, American Farm Bureau Federation (retired)
Huaijun Zhou, University of California-Davis

ENDNOTES

[1]USDA defines agriculture to include live animals, meat, and products of livestock, poultry, and dairy; hides and skins (but not leather products); animal fats and greases; food and feed grains and grain products; oilseeds and oilseed products; fruits, nuts, and vegetables and products of these; juices, wine, and malt beverages (not distilled spirits); essential oils; planting seeds; raw cotton, wool, and other fibers (not manufactured products of these); unmanufactured tobacco (not manufactured tobacco products); sugar and sugar products; coffee, cocoa, tea, and products of these; rubber and allied products; stock for nurseries and greenhouses; spices; and crude or natural drugs. Fish, shellfish, and forestry products are not included.

[2]The Board for International Food and Agricultural Development (BIFAD) is an advisory board to USAID on agriculture and higher education issues pertinent to global food security in developing countries. BIFAD recognizes the critical role of US land-grant institutions in agricultural development, domestically and abroad, and the importance of their engagement in USAID development programs. BIFAD is supported by a USAID-based secretariat and a USAID-funded cooperative agreement to the Association of Public and Land-grant Universities (APLU).

[3]At the time of preparation of the report, 2017 was the most recent year for which complete foreign aid data were available. U.S. foreign nonmilitary aid expenditure was extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, fiscal year = 2000–2017, constant amount.

[4]Foreign agricultural aid expenditure was extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, fiscal year = 2000-2017, constant amount.

[5]The distribution of foreign agricultural aid across federal agencies was calculated from data extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, implementing agency = all, fiscal year = 2017.

[6]USAID foreign agricultural assistance expenditure for implementation was extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, implementing agency = U.S. Agency for International Development, fiscal year = 2017.

[7]The regional distribution of USAID foreign agricultural assistance expenditure was extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, implementing agency = U.S. Agency for International Development, region = all, fiscal year = 2017.

[8]The count of countries where USAID incurred expenditures for implementation of agricultural assistance in 2017 was calculated using data extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, implementing agency = U.S. Agency for International Development, country name = all, fiscal year = 2017.

[9]The distribution of USAID foreign agricultural assistance to implementing entities was calculated from data extracted from the Foreign Aid Explorer database (2019a). Sort categories: assistance category = economic, transaction type = disbursement, USG sector = agriculture, implementing agency = U.S. Agency for International Development, channel subcategory = all, fiscal year = 2017.

[10]Figures presented here for agricultural research are for USAID Washington funding and do not include Mission-funded activities. The funding estimates for 1950-1996 were obtained from Alex (1997).

[11]Note that the research and development figures presented here for 2011–2017 are not comparable to the research funding data presented earlier in this paragraph for the period prior to 2011 because different definitions and methods were used to calculate the two series.

[12]Annual Congressional directives (earmarks) for Feed the Future Innovation Labs/Collaborative Research Support Program were: FY 2017 - $50 million, FY 2016 - $50 million, FY 2015 - $32 million, FY 2014 - $32 million, FY 2013 - $31.5 million, FY 2012 - $31.5 million, FY 2011 - $31.5 million. Source: annual Congressional appropriation bills for each year.

[13]Estimate provided in personal communication on August 6, 2019, with Paul Varner of Treasure Valley Seed Co., a major commercial supplier of dry bean seeds in the United States.

[14]The 49 percent figure is the mean of nine previous estimates of rate of return to INTSORMIL sorghum and millet research.

[15] Information obtained from Murdock & Baoua (2014) and personal communication with Larry Murdock, Professor Emeritus of Entomology and former CRSP researcher at Purdue University; Dieudonné Baributsa, Associate Professor of Entomology and Director of PICS Program at Purdue University; and Laurie Kitch, CEO and Co-founder of PICS Global, Inc.

[16]After the initial hermetic technology was developed, funding for moving the technology to the commercialization stage was provided by the Bill & Melinda Gates Foundation.

REFERENCES

Achenbach, J. E., et al. 2017. "Identification of a New Genotype of African Swine Fever Virus in Domestic Pigs from Ethiopia." *Transboundary and Emerging Diseases* 64 (5): 1393–1404.

Alavi, S., et al., eds. 2008. *Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility*. Washington: AED.

Alex, G. 1997. USAID and Agricultural Research: Review of USAID Support for Agricultural Research—1952–1996. Environmentally Sustainable Development, Agricultural Research and Extension Group, Special Report No. 3. Washington, DC: World Bank

Alshannaq, A., and J. H. Yu. 2017. "Occurrence, Toxicity, and Analysis of Major Mycotoxins in Food." *International Journal of Environmental Research and Public Health* 14 (6): 632.

Alston, J. M., et al. 2000. "Research Returns Redux: A Meta-Analysis of the Returns to Agricultural R&D." *Australian Journal of Agricultural and Resource Economics* 44 (2): 185–215.

American Farm Bureau Federation. 2019. "Benefits of Investing in Global Agricultural R&D Spill Over to U.S. Farmers." *Market Intel*, July 23.

Arndt, C., S. Jones, and F. Tarp. 2016. "What Is the Aggregate Economic Rate of Return to Foreign Aid?" *World Bank Economic Review* 30 (3): 446–474.

Bond, J. K. 2017. "Pulses Production Expanding as Consumers Cultivate a Taste for U.S. Lentils and Chickpeas." *Amber Waves*. February 6. US Department of Agriculture. https://www.ers.usda.gov/amber-waves/2017/januaryfebruary/pulses-production-expanding-as-consumers-cultivate-a-taste-for-us-lentils-and-chickpeas/

Breisinger, C., O. Ecker, and J. F. Trinh Tan. 2015. "Conflict and Food Insecurity: How Do We Break the Links?" In 2014–2015 Global Food Policy Report, 51–60. Washington, DC: International Food Policy Research Institute.

CAST (Council for Agricultural Science and Technology). 2003. *Mycotoxins: Risks in Plant , Animal , and Human Systems Council for Agricultural Science and Technology*. Task Force Report 139. Ames, IA.

CGIAR. 2019a. CGIAR Trust Fund Contributions. https://www.cgiar.org/funders/trust-fund/trust-fund-contributions-dashboard/

CGIAR. 2019b. Research Themes. https://www.cgiar.org/research/

CIMMYT. 2019. "Pathotype Tracker – Where is Ug99?" RustTracker. https://rusttracker.cimmyt.org/?page_id=22

Clemens, M. A., and H. M. Postel. 2018. "Deterring Emigration with Foreign Aid: An Overview of Countries." CGD Policy Paper 119. Washington, DC: Center for Global Development.

Clemens, M. A., et al. 2012. "Counting Chickens When They Hatch: Timing and the Effects of Aid on Growth." *Economic Journal* 122 (561): 590–617.

Conley, A., and C. Johnsen. 2011. "Seed Companies Take INTSORMIL Science to the World." In *INTSORMIL: More Than 30 Years of Excellence*, 23–27. Lincoln: University of Nebraska.

CropLife International. 2016. "Semi-Dwarf Wheat: The Game Changer." https://croplife.org/news/semi-dwarf-wheat-the-game-changer/

Cummins, D. G. 2012. *History of the Peanut Collaborative Research Support Program from the 1980–1982 Planning Effort through the 1982–2012 Research Program*. Peanut Collaborative Research Support Program, University of Georgia.

Dalrymple, D. G. 1980. *Development and Spread of Semi-dwarf Varieties of Wheat and Rice in the United States: An International Perspective*. Agricultural Economic Report Number 455. Washington, DC: USDA.

Dreher, A., A. Fuchs, and S. Langlotz. 2019. "The Effects of Foreign Aid on Refugee Flows." *European Economic Review* 112: 127–147.

Eddleman, B. R., C. C. Chang, and B. A. McCarl. 1991. "Economic Benefits from INTSORMIL Grain Sorghum Variety Improvements in the United States." College Station, Texas: USAID Title XII Collaborative Research Support Program on Sorghum and Pearl Millet.

Evenson, R. E. 2001. "Economic Impact Studies of Agricultural Research and Extension." In *Handbook of Agricultural Economics,* edited by B. Gardner and G. Rausser. Cambridge, MA: Elservier Press.

Evenson, R. E., and D. Gollin. 2003. "Assessing the Impact of the Green Revolution, 1960 to 2000." *Science* 300 (5620): 758–762.

Fannin, B. 2018. "AgriLife Researcher Sorghum Breeder Gary Peterson Retires After 36 Years." https://today.agrilife.org/2018/08/31/agrilife-research-sorghum-breeder-gary-peterson-retires-after-36-years/

FAO (Food and Agriculture Organization of the United Nations). 2010. "Ug99 Factsheet." http://www.fao.org/agriculture/crops/rust/stem/rust-report/stem-ug99racettksk/en/

Galiani, S., et al. 2017. "The Effect of Aid on Growth: Evidence from a Quasi-Experiment." *Journal of Economic Growth* 22 (1): 1–33.

Galluzzi, G., et al. 2016. "Twenty-Five Years of International Exchanges of Plant Genetic Resources Facilitated by the CGIAR Genebanks: A Case Study on Global Interdependence." *Biodiversity and Conservation* 25 (8): 1421–1446.

Gamso, J., and F. Yuldashev. 2018. "Does Rural Development Aid Reduce International Migration?" *World Development* 110: 268–282.

Gollin, D. 2010. "Agricultural Productivity and Economic Growth." In *Handbook of Agricultural Economics,* vol. 4, edited by P. Pingali and R. Evenson, 3825–3866. Amsterdam: North Holland.

Hazell, P. B. R. 2010. "An Assessment of the Impact of Agricultural Research in South Asia Since the Green Revolution." In Handbook of Agricultural Economics, vol. 4, edited by R. Evenson and P. Pingali, 3469–3530. Amsterdam: Elsevier.

Hein, T. 2015. "Ug99 Wheat Stem Rust Update." Top Crop Manager. https://www.topcropmanager.com/ug99-wheat-stem-rust-update-17948/

Holleman, C., J. Jackson, M. V. Sánchez, and R. Vos. 2017. "Sowing the Seeds of Peace for Food Security—Disentangling the Nexus between Conflict, Food Security and Peace." FAO Agricultural Development Economics Technical Study 2. Rome, FAO.

Ivanic, M., and W. Martin. 2018. "Sectoral Productivity Growth and Poverty Reduction: National and Global Impacts." World Development 109: 429–439.

Johnston, B. F., and J. W. Mellor. 1961. "The Role of Agriculture in Economic Development." *American Economic Review* 51 (4): 566–593.

Kansas State University. n.d. *Battling Sorghum's Newest Enemy*. https://www.k-state.edu/smil/techcatalog/Sugarcane Aphid_Final.pdf

Lantican, M., et al. 2016. *Impacts of International Wheat Improvement Research: 1994-2014*. Mexico, DF: CIMMYT.

Leonard, K. 2001. "Black Stem Rust Biology and Threat to Wheat Growers." Presentation made to the Central Plant Board, Lexington, KY, February 1–5. https://www.ars.usda.gov/midwest-area/stpaul/cereal-disease-lab/docs/barberry/black-stem-rust-biology-and-threat-to-wheat-growers/

Martin-Shields, C. P., and W. Stojetz. 2019. "Food Security and Conflict: Empirical Challenges and Future Opportunities for Research and Policy Making on Food Security and Conflict." *World Development* 119: 150–164.

McArthur, J. W., and J. D. Sachs. 2019. "Agriculture, Aid, and Economic Growth in Africa." *World Bank Economic Review* 33 (1): 1–20.

Mercier, S. 2012. "U.S. Agricultural Development Assistance and Food Aid: Programs and Issues." AGree.

Michigan State University. 2018. T*en-Year Legacy Report, 2007-2017: Dry Grain Pulses CRSP (2007–2012) and the Feed the Future Innovation Lab for Collaborative Research on Grain Legumes (2013–2017)*. East Lansing, MI.

Mitchell, N. J., et al. 2016. "Potential Economic Losses to the US Corn Industry from Aflatoxin Contamination." *Food Additives and Contaminants - Part A Chemistry, Analysis, Control, Exposure and Risk Assessment* 33 (3): 540–550.

Murdock, L. L., and I. B. Baoua. 2014. "On Purdue Improved Cowpea Storage (PICS) Technology: Background, Mode of Action, Future Prospects." *Journal of Stored Products Research* 58: 3–11.

National Coffee Association. 2019. Infographic. http://www.ncausa.org/Industry-Resources/Economic-Impact

Nirmala, J., et al. 2017. "Discovery of a Novel Stem Rust Resistance Allele in Durum Wheat that Exhibits Differential Reactions to Ug99 Isolates." *G3: Genes, Genomes, Genetics* 7 (10): 3481–3490.

O'Sullivan, R. 2017. "USAID, Hershey's and ECOM Help Cocoa Farmers Increase Production, Strengthen Land Rights, and Protect Forests." USAID Landlinks (blog). March 7. https://www.land-links.org/2017/03/usaid-hersheys-ecom-help-cocoa-farmers-increase-production-strengthen-land-rights-protect-forests/

Paarlberg, P., A. Seitzinger, and T. Vo. 2014. "Estimating the Potential Economic Impact of Puccinia Graminis F. Sp. Tritici Ttks Race (UG99) (Wheat Stem Rust)." Purdue University, Working Paper #14-1, February 7.

Pardey, P. G., et al.. 1996a. *Hidden Harvest: US Benefits from International Research Aid*. Food Policy Report. Washington, DC: International Food Policy Research Institute.

———. 1996b. "Summary of a Productive Partnership: The Benefits from U.S. Participation in the CGIAR." EPTD Disscussion Paper 18. Washington, DC: International Food Policy Research Institute.

Pinstrup-Andersen, P., and S. Shimokawa. 2008. "Do Poverty and Poor Health and Nutrition Increase the Risk of Armed Conflict Onset?" *Food Policy* 33 (6): 513–520.

Reardon, T., R. Echeverria, J. Berdegué, B. Minten, S. Liverpool-Tasie, D. Tschirley, and D. Zilberman. 2018. "Rapid Transformation of Food Systems in Developing Regions: Highlighting the Role of Agricultural Research & Innovations." *Agricultural Systems* 172: 47–59.

Singh, R. P., et al. 2011. "The Emergence of Ug99 Races of the Stem Rust Fungus Is a Threat to World Wheat Production." *Annual Review of Phytopathology* 49 (1): 465–481.

Tschirley, D., T. Reardon, M. Dolislager, and J. Snyder. 2015. "The Rise of a Middle Class in East and Southern Africa: Implications for Food System Transformation." *Journal of International Development* 27: 628–646.

United Nations and World Bank. 2018. *Pathways for Peace: Inclusive Approaches to Preventing Violent Conflict*. Washington, DC: World Bank.

USAID (U.S. Agency for International Development). 2011. "Sweet Deal Signed by USAID and Kraft Foods: Five-year Partnership to Raise Incomes for 10,000 Small-scale Cacao Famers." Press Release. Oct. 17.

———. 2014. *One Health Workforce: Developing a Global Workforce to Prevent, Detect, and Respond to Infectious Disease Threats*. St. Paul, MN: One Health Workforce Project.

———. 2014. Multi-Sectoral Nutrition Strategy 2014-2025. Washington, DC.

———. 2018. *How USAID Works to Make the Coffee Supply Chain Sustainable*. https://www.usaid.gov/sites/default/files/documents/1867/CoffeeFactSheet.pdf

———. 2019a. Foreign Aid Explorer. https://explorer.usaid.gov/

———. 2019b. Feed the Future Innovation Labs. https://www.feedthefuture.gov/feed-the-future-innovation-labs/

———. 2019c. *Nourishing Lives & Building the Future: The History of Nutrition at USAID*. Washington, DC.

———. 2019d. USAID. "Emerging Pandemic Threats." USAID Factsheet. https://www.usaid.gov/news-information/fact-sheets/emerging-pandemic-threats-program

———. 2019e. "Nutrition." https://www.usaid.gov/global-health/health-areas/nutrition

USDA-ERS (United States Department of Agriculture-Economic Research Service). 2018. "Effects of Trade on the U.S. Economy." https://www.ers.usda.gov/data-products/agricultural-trade-multipliers/effects-of-trade-on-the-us-economy/

———. 2019a. U.S. Agricultural Trade Data Update. https://www.ers.usda.gov/data-products/foreign-agricultural-trade-of-the-united-states-fatus/us-agricultural-trade-data-update/

———. 2019b. "American Diet Includes Many High Value Imported Products." https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=58398

———. 2019c. "Wheat Sector at a Glance." https://www.ers.usda.gov/topics/crops/wheat/wheat-sector-at-a-glance/

USDA-NASS (National Agricultural Statistics Service). 2019. "Crop Production 2018 Summary." February. https://www.nass.usda.gov/Publications/Todays_Reports/reports/cropan19.pdf

U.S. Department of State. 2017. *Congressional Budget Justification*, Foreign Operations, Appendix 2, Fiscal Year 2017. Washington, DC.

Wu, F. 2016. "Aflatoxin as a Global Food Safety Problem: Health Effects, Market Impacts, Interventions." Presentation made at the MSU Center for Research on Ingredient Safety (CRIS) Annual Meeting, October 5. https://www.canr.msu.edu/cris/documents/Wu_CRIS_presentation.pdf

Yohe, J. 2011. *INTSORMIL: More Than 30 Years of Excellence*. INSTORMIL and USAID.

Zereyesus, Y. A., and T. J. Dalton. 2017. "Rates of Return to Sorghum and Millet Research Investments: A Meta-Analysis." *Plos One* 12 (7): 1–17.

How the United States Benefits from Agricultural and Food Security Investments in Developing Countries

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

A world free of hunger and malnutrition

1201 Eye Street, NW, Washington, DC 20005 USA

T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info