



FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative



THE U.S. GOVERNMENT'S GLOBAL FOOD SECURITY RESEARCH STRATEGY

Reducing Global Hunger, Malnutrition and Poverty
Through Science, Technology & Innovation

www.feedthefuture.gov

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Introductory Letter from the Board for International Food and Agricultural Development (BIFAD)

As the body appointed by the President of the United States to advise the U.S. Agency for International Development (USAID) on agriculture and higher education issues pertinent to food insecurity in developing countries, the Board for International Food and Agricultural Development (BIFAD) has taken an active interest in the development of the U.S. Government's Global Food Security (GFS) Research Strategy to support the goals of the 2016 Global Food Security Act.

The Global Food Security Research Strategy is based on input from the BIFAD along with feedback from U.S. university researchers and a diverse set of other U.S. and international stakeholders about what worked well under the preceding 2011–2016 Feed the Future Research Strategy and what should be adjusted to respond to emerging opportunities, constraints, priorities and best practices over the coming years. The Research Strategy also breaks new ground in reaching out to other U.S. research funding Departments and Agencies, incorporating feedback from the Department of Energy (DOE), the National Science Foundation (NSF) and the National Institutes of Health (NIH) to leverage, as appropriate, the full basic and applied U.S. research capacity to address critical issues in developing countries. The BIFAD is satisfied to see that the finished GFS Research Strategy substantively reflects the content of these consultations, integrating feedback and insights while continuing the technical leadership of USAID and the U.S. Department of Agriculture (USDA) in setting the agenda for the U.S. Government's global food security research portfolio.

The BIFAD endorses the Research Strategy's framework to bridge the divide between the U.S. Government's domestic science investments and international development priorities. The Research Strategy demonstrates how global food security research investments yield substantial domestic benefits. The U.S. scientific community gains access to plant materials and intellectual resources abroad; America's agricultural producers and processors benefit from innovations that protect and improve U.S. productivity; and domestic consumers benefit from an increased supply and diversity of internationally-traded agricultural goods. This access helps ensure that research investments yield substantial benefits to the U.S. that are sustainable and underscores that American taxpayers' support for global food security research is one of the smartest investments we can make.

As these scientific investments unfold over the coming years of the Research Strategy, the BIFAD looks forward to watching U.S. science build upon the initial successes of Feed the Future, complement objectives laid out in the 2016 Global Food Security Strategy and ultimately transform global agriculture to achieve a healthy, prosperous, food-secure future.



Brady J. Deaton
BIFAD Chair

Glossary

AGIL - Animal Genomics Improvement Laboratory
AGIN - African Goat Improvement Network
ARS - Agricultural Research Service (USDA)
ASARECA - Association for Strengthening Agricultural Research in East and Central Africa
BBSRC - Biotechnology and Biological Sciences Research Council
BIFAD - Board for International Food and Agricultural Development
CBBP - Community-based breeding programs
CDC - Centers for Disease Control and Prevention
CIMMYT - International Maize and Wheat Improvement Center
CORAF - West and Central African Council for Agricultural Research and Development
DNA - Deoxyribonucleic acid
DOE - Department of Energy
FTF - Feed the Future
GBS - Genotyping by sequencing
GE - Genetically engineered
GFS - Global Food Security
GFSA - Global Food Security Act
GFSS - Global Food Security Strategy
GPE - Global Performance Evaluation
HICD - Human and institutional capacity development
ICT - Information and communications technology
IWYP - International Wheat Yield Partnership
KLIP - Kenya Livestock Insurance Programme
M&E - Monitoring and evaluation
NARS - National Agricultural Research Systems
NIH - National Institutes of Health
NRM - Natural Resource Management
NSF - National Science Foundation
OFSP - Orange-fleshed sweet potato
R&D - Research and development
U.S. - United States
USAID - U.S. Agency for International Development
USDA - U.S. Department of Agriculture
USGCRP - U.S. Global Change Research Program
WASH - Water, sanitation and hygiene

The U.S. Government's Global Food Security Research Strategy

Reducing Global Hunger, Malnutrition and Poverty through Science, Technology and Innovation

I. Executive Summary

Research as a Part of the U.S. Response to Global Food Security Challenges

There are nearly 800 million people who suffer from chronic hunger¹ and two billion who suffer from micronutrient deficiency in the world today². A projected 702 million people still live in extreme poverty³. Much of this poverty, hunger and malnutrition is concentrated in rural areas in developing countries, where the majority of people rely on agriculture for their livelihoods. These challenges are likely to worsen in the years to come: the global population is expected to swell from 7.3 to 8.5 billion by 2030, and again to 9.7 billion by 2050⁴, placing unprecedented pressure on food systems. Rising incomes will further increase demand for food—particularly foods, such as meat, that require more resources to produce. These changes, together with widespread environmental shifts and variability, will exert increasing pressure on the natural resources on which food production relies.

Addressing these issues lies at the heart of the U.S. Government's investments in global food security. In a world of increasingly integrated agricultural markets, where agricultural pests and diseases easily cross borders and persistent hunger abroad can have geopolitical consequences at home, finding new and innovative ways to promote global food security does more than serve humanitarian goals; it is crucial to America's continued security and prosperity.

The U.S. Government launched the Feed the Future initiative in the wake of the 2007/2008 global food price spikes to reduce global hunger, undernutrition and extreme poverty. Feed the Future's results and critical contributions to the U.S.' economy, security and leadership have garnered broad bipartisan support, culminating in the enactment of the Global Food Security Act (GFSa) of 2016.

The GFSa called for a new whole-of-government global food security strategy that the 11 Feed the Future partner agencies and departments worked together to create, along with department and agency-specific implementation plans. The resulting 2017-2021 Global Food Security Strategy (GFSS) describes in detail how the U.S. intends to direct Feed the Future resources and programming to advance three strategic objectives: promoting inclusive, sustainable agriculture-led economic growth; building resilience among vulnerable populations and households; and improving nutritional outcomes, especially among women and children. To achieve these objectives, the GFSS highlighted that Feed the Future research investments should “ensure a pipeline of innovations, tools and approaches designed to improve agriculture, food security, resilience and nutrition priorities in the face of complex, dynamic challenges.”

In response, the Global Food Security Research Strategy (Research Strategy) presented here seeks to bring U.S. ingenuity to bear on the greatest challenges in achieving sustainable, global reductions of poverty, hunger and malnutrition.

The U.S. Government's Research Strategy and Thematic Research Areas

U.S. Government agencies that are part of the Feed the Future initiative (Box I) developed this strategy in 2017 to align research investments with the goals of the GFSA and GFSS. To bring U.S. scientific ingenuity to bear on the greatest challenges presented by global food security, this strategy frames research programming in terms of a Research and Development (R&D) pipeline, in which new technologies advance through phases of basic, applied and adaptive research before being transferred to technology-scaling partners for dissemination and ultimately widespread adoption by developing-country beneficiaries.

To coordinate research efforts along this R&D and technology-scaling pipeline, the Research Strategy focuses on three broad research themes. The first two themes call for development of scalable food security innovations:

- I. Technologies and practices that advance the productivity frontier to drive income growth, improve diets and promote natural resource conservation.*
- II. Technologies and practices that reduce, manage and mitigate risk to support resilient, prosperous, well-nourished individuals, households and communities.*

In addition to generating scalable products and practices that advance productivity and nutrition and mitigate risk in Feed the Future partner countries, research also increases understanding about how human behavior, the development context and the enabling environment influence progress of food-insecure households, communities and countries toward improved food security outcomes. In turn, such knowledge is critical to guide the prioritization, design and implementation of Feed the Future programming. This provides the basis for the third major theme of this strategy:

- III. Improved knowledge of how to achieve human outcomes: generating evidence on how to sustainably and equitably improve economic opportunity, nutrition and resilience.*

Together, these three research themes provide a pipeline of innovative, scalable products and practices to improve agriculture-led growth, resilience and human nutrition in Feed the Future partner countries—along with accompanying contextual information to optimize the adaptation and scaling of research outputs in the partner-country context, promote effective development programming and ultimately drive food security outcomes.

Organizing Principles for U.S. Food Security Research Partnerships

Many U.S. Government agencies make critical contributions to the three research themes of this research strategy—although they operate at different stages of the food security R&D pipeline, with different partners and stakeholders and in accordance with distinct agency mandates. To ensure the collective impact of food security investments, U.S. research funding agencies, U.S. partner agencies and departments under the Feed the Future initiative, along with their respective partners, should coordinate closely to ensure that promising innovations efficiently transit through the R&D pipeline, are applied to priority challenges in global food security and respond to feedback from partner-country stakeholders and beneficiaries.

To support improved coordination across U.S. agencies and partners, the strategy details the roles of key U.S. and international partners in designing, supporting, implementing and scaling research outputs. To facilitate coordination and maximize impact of collective food security research and development efforts across this diverse group of partners, the following core operating principles will guide implementation:

- Embrace purpose-driven research;
- Strengthen agricultural innovation systems;
- Orient research efforts to support technology scaling;
- Promote empowerment and equitable participation in science;
- Leverage data to accelerate research impact
- Generate and sustain global public research goods; and
- Continuous learning, adaptation and communication through monitoring and evaluation.

2. Introduction: The U.S. Response to the Global Food Security Challenge

There are 800 million people who suffer from chronic hunger¹ and two billion who suffer from micronutrient deficiency in the world today². A projected 702 million people still live in extreme poverty³. Much of this poverty, hunger and malnutrition is concentrated in rural areas in developing countries where the majority of people rely on agriculture for their livelihoods. And these challenges are likely to worsen in the years to come: the global population is expected to swell from 7.3 to 8.5 billion by 2030, and again to 9.7 billion by 2050⁴, placing unprecedented pressure on food systems. Rising incomes will further increase demand for food—particularly foods, such as meat, that require more resources to produce. These changes, together with widespread environmental shifts and variability, will exert increasing pressure on the natural resources on which food production relies.

What will it take to adequately nourish 7.5 billion people in the short term, let alone almost ten billion in the decades to come? How will we accomplish this without degrading dwindling supplies of available land, freshwater and other resources? And what are the consequences—to the U.S. and to the world—if we fail to meet these challenges?

Addressing these issues lies at the heart of the U.S. Government's investments in global food security. In a world of increasingly integrated agricultural markets, where agricultural pests and diseases easily cross borders and persistent hunger abroad can have geopolitical consequences at home, **finding new and innovative ways to promote global food security does more than serve humanitarian goals; it is crucial to America's continued security and prosperity.**

In response to this imperative, the U.S. Government launched the Feed the Future initiative to reduce global hunger, undernutrition and poverty. Five years later, the U.S. reaffirmed these goals with the GFSA in July 2016⁵. The GFSA called on the U.S. Government to collaborate with an array of partners to reduce global hunger, malnutrition and poverty, and explicitly called for U.S. investments to “harness science, technology and innovation.”

To guide U.S. investments in food security, the GFSA also required the creation of a U.S. Government GFSS⁶, to lay out in detail how the U.S. intends to fulfill the broad goals described in the GFSA (see Box 1). The GFSS, completed in September 2016, identified three overarching objectives to guide U.S. investments and programming of Feed the Future under the GFSA:

- **Promote inclusive, sustainable agriculture-led economic growth** that reduces global poverty, hunger and undernutrition, particularly among women and children.

- **Build resilience among vulnerable populations** and households to food shocks while reducing reliance upon emergency food assistance.
- **Improve nutritional outcomes, especially among women and children,** with a focus on reducing child stunting, including through the promotion of highly nutritious, safe foods, diet diversification and nutritional behaviors that improve maternal and child health.

To achieve these objectives, the GFSS highlighted that research investments “ensure a pipeline of innovations, tools and approaches designed to improve agriculture, food security, resilience and nutrition priorities in the face of complex, dynamic challenges.”

In response, the Research Strategy presented here seeks to bring U.S. ingenuity to bear on the greatest challenges in achieving sustainable, global reductions of poverty, hunger and malnutrition.

3. The Case for Investment: Research Today Enables Global Food Security Tomorrow

Overcoming the world’s food security challenges requires the kind of revolutionary breakthroughs that nourish billions and transform markets—new innovations on the scale of Norman Borlaug’s Green Revolution, which propelled much of Asia from food crisis to food sufficiency. Although such breakthroughs can seem singular in hindsight, in truth they emerge from long years of incremental scientific advancement and must be maintained by continual research to protect hard-won productivity gains from a constant barrage of emerging threats to food security.

In order for innovation to benefit global food security, sustained, long-term research investment is required to maintain a continual pipeline of maturing technologies with the potential to address current, near-term and long-term threats and opportunities. The case for such investment is strong: publicly funded agricultural research and development has historically delivered rates of return between 30-40 percent, among the highest of any public investment.^{7,8} In the coming decades, innovation will be all the more critical to achieve and maintain food security gains in the face of complex global challenges such as a growing population, changing consumer demands, evolving pests and diseases, shifting climate patterns and violent conflict.

Despite strong rates of return and a clear need for innovation, many countries systematically under-invest in publicly funded food security research⁹. Where sufficient market incentives exist, private-sector innovators step in to develop new agricultural products that improve productivity and deliver added value to consumers. But even where incentive exists, privately funded research often fails to generate the kind of foundational breakthroughs that drive transformative innovation—typically because high-risk, high-reward agricultural research opportunities are too risky for commercial investment or, with research timelines measured in decades rather than fiscal quarters, it takes too long to generate

Box 1. U.S. Government Partner Agencies Under the Research Strategy

Under the GFSS, 11 U.S. Government agencies committed to coordinate efforts to promote agriculture-led economic growth, build resilience and improve nutrition in selected partner countries. Referred to as “Feed the Future Partner Agencies” throughout this Research Strategy, these include the U.S. Agency for International Development (USAID), which leads implementation of the Feed the Future initiative; U.S. Departments of Agriculture (USDA), State, Commerce, and the Treasury; Executive Office of the President; Millennium Challenge Corporation; Overseas Private Investment Corporation; Peace Corps; Office of the United States Trade Representative; U.S. African Development Foundation; and U.S. Geological Survey. The GFSS also references five U.S. Government research funding agencies that support significant intra- or extramural scientific research programs relevant to food security, including USAID, USDA, the National Science Foundation, the National Institute of Health and the Department of Energy, although additional U.S. research funding bodies also contribute to this scientific agenda. This Research Strategy, developed in 2017, aims to promote greater coordination and alignment across these two U.S. Government agency communities.

dependable economic returns. Furthermore, market incentives for private-sector innovation can be weak in areas that are vital for food security. For example, many crops that are critical for smallholder food security, such as legumes or cassava, offer relatively low returns on research investment, even under ideal market conditions. Similarly, in the case of nutrition research, improvements in human nutrition are often not conceptualized as income-generating activities or as a function of the private sector, leading to consistent under-investment by both the public and private sectors. These challenges are magnified in Feed the Future partner countries, where developing agricultural markets are typically too small or too inefficient to attract substantial private R&D investment and governments may lack or choose not to allocate limited resources to food security research that primarily benefits the poor.

Weak and uneven market incentives for private-sector innovation, combined with limited commitment to publicly funded research, leaves crucial innovation gaps for food security at the global level and in developing countries. This research strategy seeks to fill these gaps by bringing to bear U.S. scientific capacities and resources that catalyze innovation in food security. The strategy aims to cultivate partnerships that encourage increased private-sector and partner-country investment in long-term research capacity, as well as to leverage parallel U.S. investments in policy, market and institutional development under Feed the Future in order to accelerate scaling and adoption of game-changing new innovations in partner countries.

In pursuing these objectives, this Research Strategy builds upon a growing evidence base that, when enabled by complementary development investments to support functional policies, markets and institutions, sustained public investment in food security research can be a powerful driver of long-term food security. For example, evidence indicates that research investments:

- **Enable the productivity gains that drive global improvements in food security.** When agricultural productivity improves, producers' incomes increase and food becomes more abundant, diverse and affordable for consumers—particularly the poor, who spend the largest portion of their income on food. In the context of enabling policies, markets and institutions, adoption of research outputs is the entry point by which smallholder farmers can achieve these foundational productivity gains. If not for the productivity gains provided by CGIAR research outputs, for example, world grain prices would have been 18-21 percent higher, developing-country food consumption per capita would be five percent less (seven percent less in the poorest regions) and as many as 15 million additional children, primarily in South Asia and Africa, would be malnourished today.¹⁰
- **Protect against tomorrow's food security risks—at home and abroad.** Whether you're a smallholder tending a half-hectare plot in sub-Saharan Africa or a U.S. agribusiness farming thousands of Midwestern acres, agriculture is a risky venture. Weather, pests, disease, market risk and other variables threaten yield and income from one season to the next, while long-term trends in climate, markets, land use and natural resource availability threaten the sustainability of farming livelihoods over years or generations. Consistent, sustained support for agricultural research is essential to protect against such risks. Under Feed the Future, for example, U.S. research investments leveraged USDA's disease lab, U.S. university leadership in wheat research and USAID-funded collaborations with developing-country researchers to create new wheat varieties and management strategies to combat wheat blast and wheat stem rust, two emerging global agricultural threats. These investments have not only mitigated potential annual ten percent losses of wheat produced by farmers in South Asia alone; they also help protect a U.S. wheat crop valued at \$10 billion per year.¹¹

When it comes to food security research, U.S. foreign assistance goals and domestic agricultural interests are well-aligned, and call for sustained, coordinated research investment at a global scale.

4. What's New? The Evolution of Global Food Security Research Under Feed the Future

Faced with the looming imperatives of population growth, global hunger and malnutrition, it is increasingly urgent that U.S. food security investments not only generate innovative solutions to food security challenges, but also translate those research outputs into development benefits as rapidly and efficiently as possible.

Under the 2011 Feed the Future Research Strategy, the U.S. Government made substantial strides in bridging the gap between agricultural research outputs and global food security impacts. Between 2011 and 2016, Feed the Future has helped **develop and deploy over 900 innovations** and is currently advancing a pipeline of **50,000 innovations** to meet dynamic and sometimes unforeseen changes that impact food security. These innovations range from the use of drying beads for horticultural seed preservation, to improved crop residue management for livestock feeding, to new transgenic rice lines tolerant to drought, salt and low soil nitrogen. Crucially, complementary investments in technology scaling helped to mobilize those research outputs from laboratory shelves into farmers' hands. By actively partnering with the private sector, extension agencies, producer groups and other local actors, Feed the Future helped 10.9 million smallholder farmers and other producers apply improved agricultural technologies to more than 6.2 million hectares across 19 focal countries in Africa, Asia and Latin America in 2016 alone¹². Accompanied by complementary development programming to support more effective local policies, markets and institutions and investments in research since the launch of the initiative, development and technology scaling have helped reduce poverty by an average of 19 percent and stunting by an average of 26 percent in the areas where Feed the Future operates¹³. As a result, more families can now afford to send their children to school, pay for medical services and save for the future, and more children have escaped the consequences of malnutrition to reach their full physical, mental, social and emotional potential.

In recognition of these achievements, the external 2016 [Feed the Future Global Performance Evaluation](#)¹⁴ praised the U.S. for a “well-developed and well-conceptualized research strategy that spans discovery and applied research [and] strikes a good balance between research on global challenges and providing relevant research findings to focus country programs.”

However, after five years of successful implementation, the 2011 Feed the Future Research Strategy required updating to reflect evolving U.S. priorities, to respond to lessons learned during implementation of Feed the Future and to accommodate new scientific priorities and opportunities. In response to these shifting dynamics, the Research Strategy introduces a number of changes—particularly with respect to:

- **The evolving inter-agency strategic landscape.** Although this Research Strategy serves the distinct, GFSA-mandated function of coordinating U.S. research investments pertaining to global food security research, a variety of other U.S. Government strategy documents address related fields and priorities. This strategy seeks to accommodate and align with these ([Appendix I](#)) in order to achieve greater cross-sectoral impact as well as fulfill the GFSA's mandate to leverage domestic U.S. science investments to support global food security efforts. Examples include the [National Plant Genome Initiative Five-Year Plan: 2014-2018](#)¹⁵; [Framework for a Federal Strategic Plan for Soil Science](#)¹⁶; [A 21st Century Science, Technology, and Innovation Strategy for America's National Security](#)¹⁷; [U.S. Global Change Research Program \(USGCRP\) Strategic Plan \(2012-2022\)](#)¹⁸; DOE's [Biological Systems Science Division Strategic Plan](#)¹⁹; [10 Big Ideas for Future NSF Investments](#)²⁰; and the nutrition strategies referenced below.
- **Technology transfer and scaling.** While praising initial efforts to promote uptake of new innovations under Feed the Future, the Global Performance Evaluation (GPE) nonetheless called for greater coordination between research and technology-scaling efforts to ensure that innovations reach farmers and yield the greatest

possible development benefits. This was echoed during consultations for the refreshed Research Strategy, with stakeholders emphasizing that research investments should be guided by a clearer understanding of the local socioeconomic and development context, including end-user demand, in order to maximize food security impacts of research outputs. In response, the updated Research Strategy incorporates technology scaling as a fundamental step in the research-to-impact pipeline, supports iterative feedback from downstream partners regarding demand for innovation (Section 5) and includes emerging best practices in technology scaling among its core operating principles (Section 8).

- **Resilience.** In response to the GFSS' adoption of increased resilience as a primary strategic objective for U.S. food security, the Research Strategy elevates the reduction, management and mitigation of food security risks as a major research theme (Section 6). This theme re-frames prior research foci and incorporates new priorities to articulate a more coherent agenda for generating technologies, practices and knowledge that will advance the GFSS resilience development agenda.
- **Nutrition.** To reflect the essential nature of nutrition innovation in driving food security development outcomes, as well as substantial learning about agriculture-nutrition linkages gained under Feed the Future, human nutrition has been integrated throughout each of the three research themes (Section 6). The Research Strategy nutrition priorities are consistent with the U.S. Government's [Global Nutrition Coordination Plan](#)²¹, the [National Nutrition Research Roadmap](#)²² and the application of shared U.S. nutrition priorities to international development efforts as articulated under the USAID [Multi-Sectoral Nutrition Strategy](#)²³. In accommodating these strategies (as well as other donor and philanthropic efforts), the Research Strategy acknowledges the need for learning on both nutrition-specific and nutrition-sensitive topics to contribute to nutrition gains under the GFSS. It places particular research emphasis on innovations to promote diet diversity, food safety and postharvest loss reduction, as well as research to enhance the relative role that complementary investments in agriculture, water, sanitation, hygiene and other equally important sectors play in reduction of malnutrition, with an emphasis on children under five and women of reproductive age. Accompanying operational research aims to develop cost-effective, accurate methods to measure human nutrition outcomes and optimize delivery of nutrition-specific and nutrition-sensitive interventions within partner-country development contexts.

5. From Research to Impact: A Vision to Mobilize U.S. Research Capacity to Advance Global Food Security Objectives

The GFSA mandates the alignment and leveraging of broader U.S. strategies and investments in science, technology and innovation as an essential component of the U.S. response to global food security challenges. In response, this research strategy lays out a framework to “leverage domestic research investments made by U.S. research funding agencies, including the U.S. Department of Agriculture, the National Science Foundation, the Department of Energy and the National Institutes of Health, as well as private sector research and development endeavors,” as articulated in the GFSS.

This strategy presents the following vision for how to link U.S. Government global food security research investments to strategic development objectives under the GFSS.



Figure 1: The R & D Pipeline, and the U.S. Government Agencies Involved in Different Stages of the Pipeline.

U.S. Government investments in global food security research (light blue) propel improved technologies and practices through the basic, applied and adaptive phases of the R&D pipeline, ultimately driving technology-scaling efforts and complementing international development programming (orange) to improve food security outcomes. Throughout the R&D pipeline, iterative feedback from systems research and operational research (blue arrows) as well as Feed the Future (Feed the Future) development partners (orange arrows) informs upstream innovation, program design and implementation. U.S. research funding agencies (dark blue bars) contribute to different phases of the R&D and scaling pipeline, while the eleven Feed the Future partner agencies (dark orange bar) primarily contribute to food security development efforts.

Under the standard “pipeline” model of scientific R&D, innovations (including new or improved technologies and practices) advance through progressive stages of refinement and into widespread use. This research strategy adopts a similar model for food security research investments (Figure 1). **Basic research** generates fundamental knowledge and innovations, providing novel tools that can be applied to address challenges and create opportunities across a variety of sectors. **Applied research** explores how these new scientific tools can be used to develop solutions to food security challenges by identifying new and better technologies and practices (including policies) to drive agriculture-led productivity growth, nutritional gains and resilience to shocks and stresses. As these innovations mature, applied research outputs undergo further, more focused **adaptive research** that tests whether and how they can be applied at scale to achieve population-level food security impacts in Feed the Future partner countries and how they fit into a specific local context, refining innovations to meet the particular demands, preferences and standards of their intended consumers or beneficiaries.

Throughout the various phases of research, innovations mature toward their intended purpose: transfer to a partner who promotes widespread, sustained adoption and use by beneficiaries in a manner that enhances food security. This process, referred to as **technology scaling**, can occur via a variety of different delivery pathways, ranging from commercialization by the private sector to dissemination by public-sector or civil-society partners (or a combination thereof). Complementary Feed the Future **development programming** intervenes in partner countries to promote policies, markets, institutions and capacities that support technology scaling and promote sustainable development. Cumulatively, the combined outcomes of development programming and widespread adoption of improved food security technologies drive population-level gains in agriculture-led economic growth, resilience to shocks and stresses and human nutrition. Although these downstream stages of the R&D and technology-scaling pipeline (indicated in orange in Figure 1) are typically implemented by development partners rather than research actors, they nonetheless should inform upstream technology development through iterative feedback and active collaboration between researchers, scaling partners and development partners.

While some research focuses on generating and advancing scalable technologies and practices through the R&D and subsequent technology-scaling pipeline, as described above, other types of research generate knowledge that informs the prioritization, design and implementation of food security research and agricultural development efforts. **Systems research**, for example, can be applied to agricultural and food systems to generate information about the policy, market, nutritional, agro-ecological and socioeconomic context of partner countries. This knowledge feeds back into upstream research phases to guide investment priorities and development of appropriate food security innovations; it also informs the design of (non-research) Feed the Future development programming. Similarly, **operational research** develops and applies analytics methods to optimize decisions regarding complex food security and nutrition challenges—ultimately improving the efficacy and efficiency of U.S. global food security programming.

Coordination Across the R&D Pipeline Advances GFSS Research and Development Objectives

U.S. research funding agencies make critical contributions to advancing food security research efforts and supporting development outcomes. However, as illustrated in Figure 1, each operates at different stages of the food security R&D and technology-scaling pipeline, in collaboration with different partners and stakeholders and in accordance with distinct agency mandates. This diversity generates tremendous potential for innovation (Box 2), but it also creates challenges in communicating feedback across partners operating at different stages of the R&D pipeline and ensuring efficient handoff of innovations as they transit from one phase to the next.

To ensure the collective impact of global food security investments, U.S. Government agencies and their partners should coordinate closely to improve mutual complementarity between research efforts by research funding agencies and development programming by Feed the Future partner agencies. This will help to:

- Transmit contextual information and feedback from downstream researchers, scaling partners and partner-country stakeholders back to upstream research partners to inform new iterations of R&D about partner-country priorities, capacities, demand and context;
- Accelerate promising basic technologies with the potential to address global food security challenges more quickly through the R&D pipeline; and
- Identify development investments that will promote sustainable innovation systems and generate an enabling environment for the scale-up of food security innovations.

To accomplish these goals, this strategy seeks to facilitate improved inter-agency coordination by articulating broadly relevant food security research themes to which diverse U.S. research funding agencies can contribute; defining key partners and roles under the strategy; and identifying common operating principles that effectively link research and development activities across diverse agencies and partners.

Box 2. U.S. Agency Coordination Accelerates Innovations through the R&D Pipeline.

Coordination across U.S. research funding agencies and their partners can accelerate the application of basic research innovations to global food security challenges. For example, USDA Agricultural Research Service scientists at Cornell University developed a high-throughput genotyping technology known as Genotyping By Sequencing (GBS), which dramatically increased the speed and reduced the cost of sequencing living organisms, with additional funding from the NSF. This opened up the possibility of applying GBS to facilitate crop breeding by sequencing large populations of plants to identify the few with agriculturally valuable genetic traits. To harness this basic research innovation to promote rapid food security gains, USAID funded researchers from the International Maize and Wheat Improvement Center (CIMMYT), Purdue University and national research partners from Feed the Future partner countries. These researchers used GBS to screen large populations of maize for genes that would protect maize yields and confer tolerance to heat—an increasing problem in Asia and Africa, as well as in the U.S. Corn Belt. Traditional breeding approaches require an average of 10 years to develop a new hybrid maize variety, but thanks to GBS, within three years, the project had developed high-yielding heat-tolerant maize hybrids that outperformed some of the best commercial varieties in India, Nepal, Bangladesh and Pakistan. Currently in its fourth year, the project has released at least six hybrids, and seed increase is underway for widespread dissemination and commercialization by private seed companies in these four countries. Heat- and drought-tolerant maize hybrids developed by CIMMYT have also been distributed to Purdue University, University of Minnesota, Iowa State University and other U.S. universities for use in domestic maize breeding programs. Coordinated efforts such as this, where U.S. research funding agencies ensure that promising basic technologies are quickly applied to global food security challenges, can bring new innovations to market years faster—and they also benefit poor farmers and consumers, as well as U.S. agriculture.

6. Food Security Research Themes to Advance Agriculture-led Growth, Nutrition and Resilience

This strategy provides a shared technical vision for U.S. Government coordination around global food security research over the coming five years (2017-2021). Under this strategy, scalable technologies and practices that advance through the R&D pipeline fall into two broad categories, which comprise the first two technical themes:

I. Technologies and practices that advance the productivity frontier to drive income growth, improve diets and promote natural resource conservation

II. Technologies and practices that reduce, manage and mitigate risk to support resilient, prosperous, well-nourished individuals, households and communities

In addition to developing scalable innovations that generate food security gains and mitigate risks in Feed the Future partner countries, research also provides key insights about partner countries that guide the prioritization, design and implementation of global food security research and Feed the Future development programming to maximize the impact and efficiency of U.S. investments. This provides the basis for the third major theme of this strategy:

III. Improved knowledge about how to achieve human outcomes: generating evidence on how to sustainably and equitably improve economic opportunity, nutrition and resilience

Ultimately, the outputs of each of these three research themes will contribute to all three of the GFSS's strategic objectives (agriculture-led economic growth, improved nutrition and increased resilience) and map onto the research strategy's pipeline model as indicated in Figure 2.



Figure 2: Diagram Showing How the Three Research Themes Map onto the R&D Pipeline.

Themes I and II of the 2017 Research Strategy push scalable innovations (technologies and practices, including policies) through the phases of the R&D and technology-scaling pipeline. Theme III provides contextual knowledge about the partner-country environment to inform research, technology-scaling and development efforts. Research under all three themes is responsive to iterative feedback from partner-country stakeholders and global development partners.

In selecting three broadly relevant food security themes with the potential to accommodate both international and domestic research priorities, this research strategy advances a truly global food security research agenda, capable of aligning efforts across diverse U.S. research funding agencies and Feed the Future partner agencies. By providing a framework for coordinated research and development investment across the full R&D and technology-scaling pipeline,

these three themes address both the supply-driven “push” factors of new scientific discoveries (Themes I and II) and demand-driven “pull” factors generated by conditions and market forces in partner countries (Theme III)—which together harness U.S. innovation, drive technology scaling and achieve a positive food security impact in Feed the Future partner countries. Further details on each theme are presented below.

I. Technologies and Practices that Advance the Productivity Frontier to Drive Income Growth, Improve Diets and Promote Natural Resource Conservation

Increased, sustainable farm productivity is a key driver of system-wide agricultural productivity, profitability, economic growth and resilience—especially in regions heavily burdened by food insecurity, malnutrition and poverty. For most Feed the Future partner countries, the productivity of crop, livestock and fish systems remains well below their potential. This leaves much room to advance the productivity frontier by expanding and fulfilling yield potential, increasing profitability and improving resource management. In turn, such gains can increase the availability, diversity and affordability of a balanced diet; improve farm profitability; and build household and ecological assets to bolster resilience against market and environmental shocks. As an entry point to this cycle, Research Theme I emphasizes development of scalable technologies, practices and policies that will generate productivity, profitability or nutrition gains—at the household, farm, community, landscape and national or regional scale.

Research priorities under Theme I of the Research Strategy may include:

- **Increase genetic yield potential of crops, fish and livestock.** Even under optimal growing conditions without pests, diseases or resource constraints, crops and animals have a limited yield potential. By evaluating and harnessing the genetic diversity of individuals or related species, breeding investments can expand these yield limits to increase the productivity of plant and animal species—particularly those with strong potential to improve dietary diversity and human nutrition, such as dairy and meat animals. Advanced technologies and genome data resources developed in upstream research can accelerate breeding of improved crops, fish and livestock. Where appropriate, biotechnology and other new approaches can further expand the genetic diversity available to improve productivity. To ensure

Box 3. Coordinated Crop Improvement Investment Promotes Cost Efficiency and Advances Research Objectives Across Multiple Sectors

Individual U.S. research funding agencies invest in research according to their distinct mandates, but through close coordination, they can leverage one another’s investments to achieve more than they could alone—and aligned philanthropic investment helps make this possible. For example, sorghum, which is grown in the U.S. and worldwide, is resistant to drought and heat stress, making it an ideal crop to meet global food demand. It also generates substantial biomass, making it a potential feedstock for bioenergy production. This allows USAID- and Department of Energy-funded (DOE) researchers to leverage complementary U.S. investments in food security and bioenergy. For example, USAID funds Kansas State University researchers to apply advanced genomic approaches to a global collection of diverse sorghum varieties to breed new varieties with improved food security traits. DOE funds similar work, but with an emphasis on improving bioenergy traits. By simultaneously collecting high-volume data relevant to both food and bioenergy production on the same sorghum fields, the two research teams increase both cost-effectiveness and sample sizes, along with the scale and power of their genomic approaches. These researchers, and many others, utilize sorghum DNA sequence data made publicly available by the DOE Joint Genome Institute’s sequencing of the complete sorghum genome. Complementing these U.S. public research investments, leveraged philanthropic funding supports the development of a sorghum genomics toolkit; this will make the genomic approaches used by these research teams more widely available to developing-country researchers who wish to apply them in their own breeding programs.

efficient and coordinated access to the genetic resources required to conduct genetic improvement research, as well as to support development of more efficient breeding methodologies, research should support collaboration among U.S. and international partners who maintain and utilize collections of germplasm and other genetic resources (see Box 3). Support for genetic resource preservation beyond plants, farm animals and fish may also extend to other sectors, including microbial and invertebrate genetic resources that are relevant to agricultural systems.

- **Improve the quality of food and feed.** One way to improve nutritional outcomes for both humans and livestock is to improve the nutritional quality of raw or processed foods without significantly increasing the cost of these inputs. For example, research may apply conventional or biotechnological methods to develop bio-fortified crops that deliver enhanced nutritional content as food and feed (see Box 4) or to improve nutritional quality through processing innovations. Research may also seek to improve food system productivity by developing crops, livestock or fish with desirable marketing or food-processing qualities, such as fast cooking time, baking quality, size or color. Similarly, research to improve the nutritional quality and availability of animal feeds is critical to support animal productivity in many GFSA partner countries. Research under this theme should link to socioeconomic research on farmer-level preferences to ensure breeders apply multi-use criteria (e.g., food, feed, fodder and forage for crop species) in the development of improved varieties and breeds that are ultimately cost-effective for producers.
- **Add post-harvest value to agricultural products.** As an agricultural product moves from farm to market, there are many opportunities for individuals and firms to provide services that add value during storage, transportation, processing or marketing. Each of these steps provides opportunities for research and innovation along the value chain. For example, improved post-harvest handling is the least expensive, most environmentally benign approach to increasing food security and safety because it does not require more land or water. Furthermore, finding ways to minimize post-harvest nutritional losses

Box 4. Bio-fortified Crops for Improved Nutrition

Sweet potato was first introduced to Africa in the 1600s. Unfortunately, the starchy white and yellow varieties that became popular across the continent are significantly lower in vitamins than the orange variety known and consumed in the Americas. This is important because vitamin A deficiency is the leading cause of childhood blindness—and although vitamin A deficiency can be addressed by other nutrition interventions, dietary forms are still needed. The varieties eaten across the continent today represent a wasted opportunity to address childhood malnutrition. To remedy this, CGIAR scientists dedicated years of research to bio-fortify locally adapted varieties, patiently breeding them to have progressively higher levels of pro-vitamin A until they had generated a new variety that better addressed African nutritional needs: orange-fleshed sweet potato (OFSP). From 2007 to 2009, the HarvestPlus project scaled the newly released OFSP to an initial 14,000 households in Mozambique and 10,000 farm households in Uganda; complementary studies suggested that the OFSP varieties improved Vitamin A intake and status among children^{24, 25, 26} and had the potential to eliminate between 38-64 percent of the health burden of Vitamin A deficiency in Uganda²⁷. Based on these promising initial results, Feed the Future programs in Kenya, Malawi, Mozambique, Zambia and Rwanda began working to bring OFSP to scale through value-chain programming such as distributing planting materials, training farmers on cultivation techniques and working with commercial food processors to increase sustainable market demand for OFSP varieties. Thanks to these efforts, today almost two million households in 10 African countries have planted, purchased or consumed OFSP, helping to increase household incomes for rural producers while providing nutrition to both rural and urban consumers. In 2016, the four scientists who led efforts to develop, pilot and scale OFSP were honored with the World Food Prize. Informed by this successful approach, U.S. research funding agencies support a variety of efforts aimed at improving the nutritional quality of crops, livestock and fish through bio-fortification, processing and other approaches. Under the Research Strategy, advancement of such efforts through the R&D and technology-scaling pipeline has the potential to generate new innovations, create market opportunities, add value to agricultural products and provide healthier options for consumers in the U.S. and developing countries alike.

and maintain quality during storage provides an important approach to generate positive impacts on nutrition. Research to reduce post-harvest losses may focus on developing technologies for optimal drying, storage and processing of foods, or for minimizing wastage during use or processing. Similarly, food processing research may identify technologies or practices—such as sorting, milling and fortification—that add value for consumers or other value-chain actors. Research to improve transport of agricultural products (such as cold chain technologies or improved packing practices) can help producers access new markets, while innovative packaging technologies, such as ICT-enabled product registration to prevent counterfeiting or adulteration of agricultural inputs and products, can promote demand among newly confident consumers. Ultimately, such research generates outputs that create new opportunities for agricultural income generation, employment, agriculture-led productivity growth and access to diverse, nutritious and safe foods.

- **Sustainably intensify production systems.** Sustainable intensification—the production of more food from existing cultivated lands while more efficiently using inputs, conserving soil and water and improving human health and livelihoods—is critical to achieving the multiple goals of the GFSA. Because the determinants of smallholder poverty and malnutrition are complex and interconnected, integration of socioeconomic and biophysical research will improve productivity, profitability and resilience. In order to achieve the yield potential of improved crops, livestock and fish, biophysical and farming systems research may identify how to most effectively integrate improved varieties and breeds with sound management practices, including soil and water management, mechanization and management of both production and post-harvest pests. Associated socioeconomic research covered in Research Themes I and II, including on household decision-making and risk reduction, can help ensure these technologies and practices successfully meet the needs of farmers and the larger food system.
- **Maintain healthy agricultural landscapes.** Agricultural productivity fundamentally relies on well-functioning nutrient and water cycles to support high levels of soil fertility and ensure water availability during critical stages of crop and livestock production. Improved natural resource management (NRM) helps protect against degradation of these essential resources; improves the overall productivity and sustainability of agricultural systems; and reduces the need for farmers to convert sensitive watersheds, wetlands and forests for crop and livestock production. Research can help identify new strategies and innovations at the household, farm, community, market and landscape scales to improve the efficacy and cost-effectiveness of management practices, ensuring that farmers can afford to implement appropriate soil and water conservation practices over the long term. Such research may include increasing water and nutrient use efficiency through improved tillage and fertilizer practices, crop rotations and water capture and reuse. Additionally, research investments support improvements in animal management and feeding practices that reduce soil erosion, nutrient runoff, inappropriate use and disposition of waste and other off-site environmental impacts. To ensure that conservation practices increase farmers' returns on their investments and household resilience, research is needed to identify the socioeconomic costs and benefits of natural resource management. A comprehensive view of sustainability also requires that research investments identify farming practices that support biodiversity on- and off-farm.
- **Identify policies to increase food system productivity.** In the majority of Feed the Future partner countries, the policy environment is one of the major factors dictating the tempo and impact of technology scaling—and by extension, productivity growth. Research is therefore essential to better

understand the impacts of differing policy approaches and identify the strongest policy options to achieve and sustain development outcomes. Such research might explore policies that improve land and resource access and tenure, especially for women; regulate the quality and safety of agricultural inputs, products and services; govern the movement and use of genetic resources; support agricultural market function and the agribusiness enabling environment (including agricultural finance and internal and cross-border trade); or promote a well-functioning private sector. The outputs of this research ultimately contribute to the design and adoption of improved policies for a strong agriculture-enabling environment in Feed the Future partner countries.

II. Technologies and Practices that Reduce, Manage and Mitigate Risk to Support Resilient, Prosperous, Well-nourished Individuals, Households and Communities

As a growing number of humanitarian crises threaten hard-won gains in global food security, resilience has emerged as a central focus of U.S. development investments. Improving the resilience of individuals and communities is necessary to escape cycles of recurrent crisis and chart a sustainable path to reduced hunger, poverty and malnutrition.

Applying current development best practices will help to achieve resilience objectives under Feed the Future programming. In many places, however, profound and destabilizing challenges are already testing the limits of current knowledge and development approaches—including weather and climate variability, characterized by increasing frequency and intensity of droughts and floods and saltwater intrusion in coastal areas; price shocks; pest and disease shocks; environmental degradation; population pressure and movements; political turmoil; fragility; and outright conflict. Beyond the short-term disruption these shocks can inflict, they can also have long-term impacts on child development and human capital, threatening future reductions in poverty, hunger and malnutrition over the years to come.

To leverage research capacity to overcome these challenges, Research Theme II emphasizes development of scalable technologies, practices and policies that will proactively reduce, mitigate and manage risks to prosperity or human nutrition—at the household, farm, community, landscape, national or regional scale. Where shocks and stresses cannot be avoided, research will emphasize development of innovative strategies to help impoverished individuals and communities adapt and recover more quickly.

Research priorities under Theme II of this strategy may include:

- **Reduce, manage and mitigate the impacts of abiotic and biotic stress.** Global agricultural productivity is significantly constrained by a combination of abiotic stresses (such as heat, drought, flood or poor soil conditions) and biotic stresses (such as pests, weeds and diseases); many of these same stresses are sources of devastating risk for poor farmers. Development of new technologies and practices to address these risks is critical to boost farm productivity, protect farmers from risk, incentivize investment in agriculture and protect the adequacy and diversity of local diets. Research may include genetic improvement to increase tolerance of crops, livestock and fish to abiotic and biotic stresses, with emphasis on identifying and integrating stress resistance traits into staple varieties and breeds. Research may also identify improved technologies and management practices to effectively combat abiotic and biotic stresses. This could include, for example, development of integrated pest and disease management strategies for smallholder agricultural production systems or new approaches to strengthen plant and animal health and extension services through diagnostics and reporting systems. In particular, infectious livestock diseases are among the greatest constraints faced by poor farmers; research may develop vaccines and other disease management strategies aimed at preventing or

eradicating disease address these risks—particularly for zoonotic diseases, which threaten both animal and human health. Research may also identify effective sanitary, phytosanitary, trade and other policies to reduce the incidence and spread of pests and disease.

- **Increase food safety.** Food safety has become a rising priority under Feed the Future, amidst growing evidence that contaminated staple foods may cause substantial harm to human health and child development, and as development practitioners strive to promote nutrient-dense yet perishable foods, such as fruits, vegetables and animal-sourced foods (e.g., meat, milk, eggs and fish) to achieve nutrition gains. Improving the sanitary and phytosanitary quality of food can also open new local and export market opportunities that enhance profitability. Technologies and practices that support correct handling and processing of staple and perishable foods at the household, farm and market level are therefore essential to maximize profits for farmers while also ensuring affordability and safety for consumers. Innovations that identify, prevent and detect the foodborne pathogens and contaminants that pose the greatest risks will also help maximize nutrition and health outcomes. Research may also identify policies that best support effective sanitary and phytosanitary practices in the context of Feed the Future partner countries.
- **Diversify farming, economic and livelihood opportunities within and beyond agriculture.** Past research has shown that diversifying economic and livelihoods strategies and risk profiles can allow farmers to better withstand agricultural shocks and stresses and increase dietary diversity. Where productivity or agricultural opportunities are constrained, such diversification can even enable a transition out of agriculture to pursue more stable, remunerative livelihoods. Building on these findings, research may investigate options for farm diversification, applying a mix of enterprise, economic and ecosystem modelling; market analyses; and biophysical research to identify technologies and practices that provide successful pathways out of poverty. In particular, identifying strategies to reduce periods of food deficit will reduce vulnerability to shocks. Research is also needed to develop, adapt and apply new technologies that provide opportunities for agricultural employment, especially for youth. These could include, for example, activities around field preparation, land leveling, custom harvesting, irrigation, post-harvest handling and storage or value-addition.
- **Design effective financial services and social protection systems.** Innovations in insurance, microfinance and

Box 5. Research Optimizes Livestock Insurance for Pastoral Households in Fragile Areas

The Feed the Future Innovation Lab for Assets and Market Access, led by the University of California, Davis, working with the International Livestock Research Institute, designed and tested a livestock insurance product which uses satellite data to generate an index for grazing conditions. Payments are triggered when conditions degrade below a certain critical level, eliminating the need for insurance agents to make field visits. Using this model, the Government of Kenya developed a Kenyan Livestock Insurance Programme (KLIP). As of February 2017, KLIP paid more than 12,000 pastoral households an average US\$170 to protect their livestock assets from the impacts of drought. According to Willy Bett, Cabinet Secretary for Kenya's Ministry of Agriculture, Livestock and Fisheries, "This is the biggest livestock payment ever made under Kenya's agricultural risk management program and the most important as well, because without their livestock, pastoralist communities would be devastated. It's also a way to ensure that pastoralists can continue to thrive and contribute to our collective future as a nation."²⁸

social safety nets all contribute to smoothing household consumption and encouraging otherwise risk-averse households to engage in higher-risk, higher-reward livelihoods and invest more to increase productivity (see Box 5). Improving the design and partnering of social safety nets, financial services (including savings, credit, insurance and blended finance) and other social protection strategies can benefit poor, food-insecure households and individuals. This includes how these approaches should be combined with other risk management strategies, such as graduation programs and contingency planning, to maximize resilience of individuals, households and communities. Accompanying operational research (under Theme III) is also needed to inform how these types of services can be rolled out programmatically to ensure efficiency and equity of access to vulnerable and underserved groups, particularly women.

III. Improved Knowledge of How to Achieve Human Outcomes: Generating Evidence on How to Sustainably and Equitably Improve Economic Opportunity, Nutrition and Resilience

Regardless of the number or quality of research outputs that emerge from Research Themes I and II, the efficacy of the Feed the Future initiative will ultimately be judged by its impact on people: to succeed, U.S.-funded innovations must help to reduce extreme poverty, hunger and the consequences of malnutrition (including stunting, underweight and wasting) among the world's poorest and most vulnerable populations. Research can help drive these impacts by generating knowledge that shapes how the U.S. tackles food security challenges in Feed the Future partner countries and informing efforts to take technologies to scale more effectively, efficiently and in ways that realize equitable development outcomes.

This research strategy therefore dedicates a third research theme to generating greater understanding about how human behavior, the development context and the enabling environment influence the progress of food-insecure households, communities and countries toward improved outcomes, and to revealing the programmatic and policy approaches that promote equitable distribution of development benefits across vulnerable populations—particularly women, children, youth and other disadvantaged groups. This includes, for example, the application of systems science to improve understanding of national and regional policy, market, agro-ecological and socioeconomic contexts of agricultural and food systems, and how these shape opportunities for technology scaling and development intervention. It also includes operational research that applies analytic methods to optimize decisions regarding complex food security challenges.

Ultimately, in combination with feedback from Feed the Future country teams and development partners, research under Theme III guides the prioritization, design and implementation of research, technology-scaling and Feed the Future development programming in order to maximize the impact of U.S. Government investments.

Research priorities under Theme III of this strategy may include:

- **Deepen understanding of the pathways from agriculture to nutrition.** Nutrition-sensitive research can improve understanding of the diverse pathways by which agricultural interventions can improve human nutrition, particularly for women and children. This includes how agricultural income growth and production diversity impact dietary diversity, diet composition, nutrient intake and, ultimately, human nutritional outcomes. In many countries, diets are changing rapidly and research is needed to better understand the relationships between shifting consumption patterns and the full food system, including policy, value chain modification, markets, agricultural productivity and

food choice. Research will aid understanding of the cultural norms, gender, policies, market access and prices that impact the choice, production, safety and consumption of foods. It may also investigate how to provide a safe, nutritious diet year-round, either through purchase or production. Research may also examine the relative influence of diverse factors on nutritional outcomes, including neglected biological mechanisms that contribute to chronic malnutrition (e.g., mother's body size and other inter-generational factors; environmental enteropathy; mycotoxins; water, sanitation and hygiene (WASH); zoonotic diseases; and others). To enhance learning through operational research and monitoring and evaluation (M&E) of U.S. nutrition programming, research may pursue development of cost-effective methodologies and indicators to measure human nutritional status in developing countries. Ultimately, nutrition research will help identify the optimal nutrition and health benefits that can be realized by agricultural initiatives and will help to define the appropriate mix of multi-sectoral policies and programs to make agri-food systems more nutrition-sensitive.

- **Promote resilience in the face of conflict and fragility.** There are multiple pathways by which food insecurity can trigger or exacerbate conflict (e.g., competition over productive agricultural resources; price shocks; or social, political or economic inequities that contribute to grievances). And in a vicious cycle, conflict and violent extremism further disrupt food production and food security, impede local access to agricultural markets and can contribute to migration (as seen in Nigeria, Honduras, El Salvador, Syria and South Sudan). Research will help understand how natural resource degradation contributes to cycles of conflict, fragility and food insecurity and help identify improved food security strategies at a variety of social, geographic and temporal scales in order to promote resilience and reduce violent conflict. Research may explore the impacts of non-agricultural livelihoods or migration as adaptive strategies. Research may also explore the context in which U.S. programming to support local livelihoods can address the “push” factors extremist groups exploit for recruitment of local populations.
- **Support information access, dissemination and use.** Access to information through pluralistic extension and advisory services, including those that make use of innovative information and communications technology (ICT) approaches, is critical for rural communities to take full advantage of the wealth of knowledge that can improve incomes, nutritional outcomes and enhance resilience. Research is needed on how to best facilitate access to and effective use of this information, including how to improve collection, processing and analysis and sharing of relevant data (such as extension, geospatial, price, market or climate information). Research may also identify optimal methods, partners and pathways to sustainably deliver data products to the public. Furthermore, better understanding how different individuals and organizations access and use information for decision-making will inform development of systems that better enable individuals, households and communities to not only access but also to act upon information.
- **Conduct policy analysis, political economy and decision research as well as research on policy impact, formulation and operational research.** In addition to identifying *what* policies generate the greatest food security benefits (as under Research Themes I and II), operational research may also build an evidence base for *how* to best achieve policy reform, with the aim of developing a toolkit for governments, the private sector, civil society and communities seeking to generate maximum benefit at manageable cost. Such policy research may analyze the impacts of alternative policy regimes, policy constraints and options. It may explore appropriate institutional architecture for policy, how governments make good policy decisions and how institutions at the

national and regional levels, within the public and private sectors and civil society, can best implement appropriate policies. In addition, specific research on the viability, sustainability and impact of nutrition-specific policies is important to optimize the expected human impact of agriculture-led initiatives. Research can illuminate which policy levers and programmatic choices most effectively foster an environment in which agriculture drives sustainable economic growth, improved nutrition and greater resilience for communities and households.

- **Empower decision-making to foster positive change.** Social science research can help understand the resources, assets and strategies needed for individuals and households to escape poverty and to remain out of poverty despite repeated shocks and stresses. Specifically, analysis is needed to better understand and leverage the socio-behavioral, socioeconomic and sociopolitical factors that influence individual, household and commercial decision-making about the adoption of food security innovations. Individually, each of these factors can be critical determinants of resilience, technology adoption, diet and other behaviors; to understand how these factors contribute to productivity, resilience and nutrition outcomes, research may span multiple scales, including household, community, national and regional levels. Research on socio-behavioral factors may, for example, examine factors such as social capital, inclusion, gendered roles and power dynamics, motivation, perceived control, confidence to adapt, hope and aspiration. Research on socioeconomic factors may examine resource constraints, risk management tools and other tradeoff considerations that influence decision-making. Research on sociopolitical factors may examine local, national and regional policy environments, as well as structural and institutional factors that shape incentives for adoption of new technologies or practices. Further examination of the interactions and synergies among these various factors will deepen our understanding about how key characteristics and risk profiles are similar or variable among various types of households, communities and development contexts across Feed the Future partner countries. In particular, research to identify the key characteristics, needs and priorities of women, youth and other marginalized groups should inform efforts across all research areas.

7. Partners in Implementing the Research Strategy

The GFSA calls for a broad coalition of partners to ensure that agricultural science and technology is applied to advance food security goals in Feed the Future partner countries. By focusing on the three research themes described above, this research strategy aims to focus the U.S. research community's unparalleled scientific capacity on generating the technologies, practices and knowledge most crucial to advance food security outcomes. To coordinate efforts across this diverse community, this Research Strategy articulates the distinct roles that U.S. Government agencies and their respective stakeholders, partners and implementers play in developing and scaling food security innovations.

U.S. Government agencies and their partners contribute to the Research Strategy in the following ways:

U.S. Government Research Funding Agencies Fuel Food Security Innovation

As described in Figure I, America's leading-edge scientific capacity in agriculture, nutrition and human health research is supported by investments from several different U.S. funding agencies (dark blue bars), which provide the resources that enable innovation throughout the R&D pipeline.

Aligned Investment from Other Research Funding Organizations Amplifies the Impact of Foundational U.S. Government Research Investments

U.S. food security research investments leverage complementary support from a wide range of public and private entities. By cultivating effective partnerships with these organizations, the Research Strategy aims to “crowd in” high-impact research investments that maximize the impact of foundational U.S. support, as well as facilitate a transition to sustainable leadership by private-sector and partner-country actors in financing, implementing and bringing to scale global food security innovation. Key partners include:

- **Host-country Governments.** Governments in Feed the Future partner countries finance national agricultural research and extension systems and universities, determining the resources allocated to support local innovation capacity and scientific partnership. They set national research priorities, which in turn inform the technical focus of research and development partnerships undertaken through Feed the Future. Partner governments also create policies, laws and regulations that shape the enabling environment for innovation and technology scaling—such as those governing intellectual property rights, agricultural market function and financial policy.
- **Other international donors.** Many other countries maintain substantial investments in global food security research, presenting opportunities for alignment and co-investment. For example, the tremendous impacts generated by the research of the CGIAR centers are supported by pooled multilateral contributions from the U.S., United Kingdom, Australia, Japan, the Netherlands and other countries, along with contributions by institutions such as the World Bank. As another example, the International Wheat Yield Partnership (IWYP), is a consortium of international funding agencies including USAID, USDA and the United Kingdom’s Biotechnology and Biological Sciences Research Council (BBSRC), along with private seed companies and international research organizations that aims to support the best science around the world to double the genetic yield potential of wheat. Recently, new collaborations have formed among USDA, USAID, the Food and Agriculture Organization, the CGIAR and other international partners to address management of Fall Armyworm in Africa. Such efforts not only help address challenges to food security in developing countries, but also help U.S. agriculture.
- **Philanthropic organizations.** Many philanthropic organizations are strong supporters of research to develop innovations for agricultural transformation, offering opportunities for aligned programming and substantial direct co-investment in food security research and coordinated development efforts to promote food security.
- **The private sector.** In the U.S. and much of the developed world, the private sector has emerged as the largest developer of commercially oriented agricultural technologies. Although profit incentives for R&D are typically more limited in developing countries, public-private partnerships can leverage financial or in-kind support from the private sector to support research for Feed the Future partner-country markets and catalyze expanded private-sector engagement and leadership in future research efforts (see Box 6).

Box 6. The U.S. Private Sector is a Crucial Partner in Supporting, Generating and Scaling Food Security Innovations

The domestic coffee industry, responsible for nearly 1.7 million American jobs and \$225 billion of U.S. Gross Domestic Product, is almost entirely dependent on overseas production.²⁹ To ensure a steady supply of the coffee on which the industry depends, U.S. coffee companies work closely with USAID to assist the world's many at-risk coffee producers. These efforts span three continents and 19 countries, and include U.S. companies such as J.M. Smucker, Keurig Green Mountain and Starbucks, as well as American institutions like Root Capital, Texas A&M University and World Coffee Research. Together, these partners implement market-oriented development efforts to help farmers connect to regional and international traders, boost productivity, improve quality control and certify their plantations so they can meet international standards and compete in global markets.

In addition to these development interventions, this public-private partnership acknowledges the crucial role of research in protecting sustainable long-term coffee production by including a research component to combat emerging pests and diseases such as the antestia beetle outbreak in Rwanda and global threat of coffee leaf rust. This generates substantial dual benefits, for both developing-country farmers and the U.S., as coffee is not only a popular beverage consumed by one-third of the world's population; it is also a critical source of income for some 25 million small-scale farmers in developing countries. By investing in efforts that help smallholder coffee producers in Africa, Latin America, the Caribbean and Asia boost their productivity and incomes—complemented by research to help sustain these gains in the face of emerging agricultural pests and disease—this public-private partnership transforms lives and supports thousands of U.S. jobs in the process.

Partners in the U.S. and Global Agricultural Innovation System Implement Research to Generate Food Security Innovations

Research partners in the U.S. and around the world are the source of ingenuity in global food security. Collectively, these organizations address food security research needs at local, national, regional and global scales. Key partners include:

- **U.S. universities.** Through their leadership of Feed the Future Innovation Labs and other scientific programs, these institutions have extensive capacity to bring research, technology and innovation to bear on global food security challenges. They are hubs for knowledge sharing and are uniquely positioned to leverage funds, broker public-private partnerships and facilitate program implementation, monitoring and evaluation.
- **U.S. Government scientists.** In addition to funding extramural research grants and contracts, some U.S. research funding agencies, such as the NIH, also maintain intramural research units that directly implement research. In particular, USDA scientists, economists and statisticians

Box 7. U.S. Government Scientists Are Innovators for Global Food Security

Created through the Improving Livestock Productivity through Enhanced Breeding Project, the African Goat Improvement Network (AGIN) is focused on obtaining sustainable solutions that merge classical breeding programs with technology accessible to African small holders, researchers and government officials. Specific outcomes include drafting a strategic plan to implement, test and evaluate a novel approach to livestock development focused on long-term sustainable solutions through integration of:

- Community-based breeding programs (CBBP), which identify breeding criteria and programs directly with smallholder farmers;
- Application of modern genomics and genetic tools based on farmer input for use within the CBBPs; and
- Multi-level networking and capacity building.

AGIN completed and adopted a strategic plan in 2016 and a listserv and resources website were created to facilitate knowledge and resource sharing, support and collaboration. Moreover, work at the USDA Agricultural Research Service (ARS) Animal Genomics Improvement Laboratory (AGIL) resulted in a groundbreaking method that will benefit all genomics research.

conduct research and capacity development activities that explicitly address U.S. agricultural challenges, enhance U.S. export opportunities and enhance global food security (see Box 7).

- **The CGIAR.** This network of international agricultural research centers allows a range of investors to jointly support critical international public goods research. Particular areas of strength include crop improvement programs targeting regional or global production systems, integrated pest management, conservation of critical agricultural genetic resources and gender-responsive research. CGIAR centers are most effective when strategically targeting efforts that link to both national research partners and advanced research institutions globally, including those in the U.S.
- **The private sector.** In the U.S. and much of the developed world, the private sector is a key source of new agricultural and food innovations. Through public-private partnerships, public-sector and host-country researchers can leverage these capacities, accessing the private sector's unique resources and expertise in developing marketable innovations that appeal to consumers.

Agricultural Innovation Systems in Feed the Future Partner Countries and Regions Adapt, Ground-truth and Transfer Research Outputs, While Ensuring the Sustainability of Food Security Innovation

Partner-country Agricultural Innovation Systems comprise the complex network of research, education, pluralistic extension and business actors whose efforts span the R&D and technology-scaling pipeline, as well as the formal and informal institutions that create an enabling environment for innovation. Increasing the effectiveness and efficiency of agricultural R&D, as required for future gains in productivity and competitiveness, must overcome complex capacity issues in research financing, organization and management, human resources and system-level linkage development.³⁰ Key partners include:

- **Regional research organizations.** Regional scientific organizations, such as the West and Central African Council for Agricultural Research and Development (CORAF) or Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), implement and coordinate research activities across their respective regions. They develop new food security innovations; collect and dispense agricultural data; strengthen and coordinate among existing regional and national agricultural systems; and present policy options to member states that can encourage agricultural growth.
- **National Agricultural Research Systems (NARS).** Research organizations in partner countries shape the global food security research agenda by identifying local scientific challenges and priorities. Through collaboration with other actors in the global research community, they contribute new innovations and pilot and adapt existing technologies to address local demands, constraints and opportunities. Their partnership is essential to identifying scientific research priorities and to achieving scientific gains under the Research Strategy. Their partnership is also essential to strengthen host countries' capacity to respond independently to new food security challenges over the long term, a crucial step toward sustainability in achieving Feed the Future development objectives and helping partner countries to graduate from U.S. development assistance.
- **Partner-country universities.** As with NARS, universities are key partners in scientific priority-setting, research and implementation. Crucially, they educate the next generation of host-country scientists, farmers,

legislators and entrepreneurs—presenting key opportunities to train a new cohort of global food security leaders.

- **Other technology-scaling actors.** Depending on both the nature of a given innovation and the local development context, new technologies and practices can reach farmers via many potential delivery pathways, involving a variety of local partners—including private-sector firms, extension agencies, producers' groups, civil-society organizations and development-implementing partners. Crucially, scaling partners are not passive recipients of finished technologies; they are active collaborators in piloting and adapting new products and practices to meet local needs, demands and preferences. Their involvement is particularly essential to reach intended development beneficiaries—e.g., smallholder farmers and low-income consumers—and to transmit feedback to researchers about the performance of new innovations in the target environment.

Feed the Future Agencies and Partners Create Pathways by which Research Drives Food Security Gains

Innovation is a crucial factor in achieving and maintaining food security, but research alone is not enough to achieve development gains. Under Feed the Future, complementary development investments to improve partner-country policies, institutions and markets create an enabling environment that supports innovation and scaling of new technologies and practices that ultimately drive food security gains. Feed the Future agencies and their respective partners also provide contextual information, expertise and feedback regarding food security research priorities and the application of new innovations in the country context. Coordination across Feed the Future partner agencies and U.S. research funding agencies (and their respective partners) facilitates essential linkages among the U.S. research community and international research collaborators, technology-scaling partners and end-users in Feed the Future partner countries. Key partners include:

- **U.S. Government inter-agency country and regional teams.** Under the GFSS, the U.S. assembles integrated, multi-sectoral teams with representatives from within and across Feed the Future partner agencies (plus additional agencies as appropriate). These teams coordinate activities at the country or regional level and promote complementary and synergistic food security programming (see Box 8). The contextual information and feedback they provide to R&D efforts is informed by long-term, geographically broad experience in Feed the Future partner countries and regions, along with consistent contact with implementing partners, local communities and partner-country government at all levels.
- **Development implementing partners.** The U.S. partners with a wide range of public, private and civil-society organizations, both international and local, to implement development activities in Feed the Future partner countries and regions. Through these partners' long-term experience working within the partner-country context, implementing partners are repositories of knowledge to inform the prioritization, design and implementation of research and technology-scaling efforts.

Box 8. Coordinated U.S. Support for Research and Capacity Development Helps Partner Countries Apply Biotechnology Responsibly

Biotechnology can offer powerful opportunities to address food security challenges that are difficult to overcome with conventional approaches, and many partner countries see it as an important tool to increase agricultural productivity and sustainability. Countries that wish to pursue these opportunities need to engage their public and private sectors to develop new products that meet the unique demands of local farmers and consumers; U.S.-based research partners are uniquely well placed in helping them achieve their goals. These countries must also develop the laws, policies and science-based regulatory processes that enable release, use, marketing and trade of such products. To support these countries' objectives, effective collaboration across U.S. Government agencies has been critical in enhancing the capacity of partner countries to responsibly regulate genetically engineered (GE) organisms. For example, USAID collaborates closely with USDA and local Embassies to provide technical support and biosafety capacity development to partner-country legislators and regulatory officials. Thanks in part to this support, a growing number of Asian and African countries have successfully developed and passed effective and transparent science-based biosafety laws, established local regulatory authorities and implemented regulations governing the testing and release of GE organisms. As these efforts establish a functional policy infrastructure for biotechnology in partner countries, complementary USAID and USDA research investments support local and U.S.-based partners in developing appropriate biotechnologies to address food security challenges—ranging from new livestock vaccines to locally adapted GE crops that improve the productivity, nutritional content and climate resilience of developing-country staple foods. Moving forward under the Research Strategy, continued coordination between relevant U.S. agencies and across host-country researchers, officials and other stakeholders will be critical to ensure that promising biotechnology products are responsibly deployed to achieve food security benefits at scale.

8. Core Operating Principles for Global Food Security Research

The Research Strategy provides a shared vision for coordinated food security research, linking efforts to generate technologies, practices and knowledge that advance GFSS development objectives across U.S. Government agencies and their respective stakeholders and partners. Given that U.S. Agencies with the capacity to contribute to global food security research each operate with a distinct mandate, stakeholders and programmatic priorities, the following shared operating principles will guide coordination under the Research Strategy:

- **Embrace purpose-driven research.** Under this strategy, research should ultimately maximize development outcomes in Feed the Future partner countries. In the context of relatively downstream research, this means that investment should prioritize the generation, piloting, adaptation and scaling of food security technologies relevant in the geographies (and associated farming systems) where poverty and malnutrition are most concentrated. In the context of upstream research, funding agencies and their partners should facilitate early identification and targeted acceleration of new technologies with promising food security applications through the R&D pipeline. Cumulatively, the collective portfolio of U.S. global food security research investments should balance longer-term, upstream research investments that have large potential for transformational global food security impact with shorter-term investments that have potential for significant and relatively rapid impact in target geographies.
- **Strengthen agricultural innovation systems.** Ultimately, international development efforts must build partner countries' capacity to meet their own needs. In the context of Feed the Future food security research investments, this means that research investments cannot simply generate research outputs. To achieve lasting transformation, support must build the capacity of country partners to identify and address their own research

needs and to take new technologies and practices to scale. This requires support for partner-country Agricultural Innovation Systems. To sustainably strengthen these systems, the U.S. approach to human and institutional capacity development (HICD) under this strategy will necessarily be flexible, to accommodate HICD practices appropriate to the funding agency and research phase involved. For example, HICD activities may include traditional approaches, such as research collaborations and exchanges between U.S. and host-country scientists as well as short- or long-term training programs. They may also include more contemporary, facilitative approaches that support individuals and organizations to develop and manage their own capacity development and learning plans through continuous improvement processes. Ideally, research capacity-development activities will leverage complementary investments from development partners by aligning with complementary regional or in-country Feed the Future investments that explicitly seek to build capacity of local agriculture innovation systems.

- **Orient research efforts to support technology scaling.** In general, innovations can only generate global food security gains if they are broadly adopted and utilized in partner countries. To ensure that this occurs, research efforts should not defer consideration of adoption pathways or beneficiary demand until the final moment of transfer to a scaling partner. Where possible, U.S. research agencies and their partners should coordinate with Feed the Future agencies' overseas development programming to link U.S. food-security innovators (at all stages of the research pipeline) with appropriate civil-society and public- or private-sector collaborators in developing countries. This promotes more effective communication of local needs, preferences and market demand to upstream innovators, helping to shape innovations and improving the chances that the resulting technology or process will achieve scale. By creating these linkages and observing best practices for technology scaling identified during Feed the Future implementation (see Box 9), research partners can develop sustainable impact pathways that plan ahead for how an innovation will reach scale—and pursue partnerships that will help realize that vision.

Box 9. Research Best Practices to Promote Successful Technology Scaling

Experience implementing technology-scaling efforts under the first phase of the Feed the Future initiative helped establish the following best practices for research:

- Explore and identify potential scaling pathways early in the R&D process.
- Cultivate active and increasing collaboration between researchers and potential scaling partners as innovations advance through the pilot and adaptive research phases.
- Use participatory research methodologies that engage intended end-users and potential public or private sector disseminators in co-design and testing of innovations.
- Solicit and respond to ongoing, iterative feedback from end-users, stakeholders and technology scaling partners to inform upstream research activities throughout the research pipeline.
- Maintain progressively lighter engagement by research partners as advisors after transferring to technology scaling partners.

- **Promote empowerment and equitable participation in science.** Wherever possible, the Research Strategy seeks to increase the participation and empowerment of host-country women, youth and disadvantaged minority groups in all levels of scientific research and innovation. This includes direct participation in research and development activities—as researchers, trainees, scaling partners and stakeholders—as well as consideration of these groups' distinct needs, interests and priorities during the prioritization, planning and procurement of research investments.

- **Leverage data to accelerate research impacts.** Coordination across U.S. Agencies allows efficiencies of scale and leveraging of complementary skills and resources—particularly when it comes to aggregating, analyzing and applying data. From wide-ranging, massive “Big Data” sources such as genome sequences, weather data and geospatial information, to U.S. Agency-specific project performance monitoring and evaluation data, this research strategy provides a platform to share analytical tools, link disparate datasets and apply data to make global agriculture more precise, productive, resilient, profitable and financially inclusive. In particular, it provides an opportunity to develop open structures for data sharing to facilitate collaboration among researchers and program implementers, reduce duplication of efforts and ensure that data that are generated in the public good are accessible to the public.
- **Generate and sustain global public research goods.** Responsible investment of U.S. Government research funds requires a firm strategic understanding of where public-sector investment is essential for scientific advancement and where the private sector is better positioned to innovate. Under this research strategy, where sufficient market opportunities and incentives exist the U.S. Government will seek to play a facilitating role to catalyze private-sector investment that generates food security research outputs with the potential to lead to broad benefits. But to maximize the long-term strategic impact of food security research, investments will primarily emphasize the generation of global public goods—research outputs that are broadly accessible for use by the global agriculture innovation system and therefore have the potential to generate the largest possible downstream food security impacts.
- **Continuous learning, adaptation and communication through monitoring and evaluation.** For all research funding agencies, tracking the long-term performance of public research investments is inherently challenging due to long development timelines for new innovations, dramatic evolution of technologies over time, handoffs between research partners at different phases of the R&D pipeline and the complex and often diffuse nature of the technology scaling process, which makes it difficult to accurately assess the eventual impact of a given innovation. The Research Strategy offers an opportunity for U.S. research funding agencies to better understand and communicate the long-term inter-related impacts of their collective research investments.

Building on the first phase of Feed the Future (2011-2016), agencies will continue to track a whole-of-government standard indicator to monitor the progress of food security technologies as they mature through the R&D and technology-scaling pipeline. The quality and relevance of research will be reviewed by tracking peer-reviewed scientific publications and evaluations. Additionally, developing a framework to rigorously evaluate the long-term, downstream food security impacts of research investments, including critical milestones that signify progress along the technology-scaling impact pathway, will be a priority of this strategy.

Impact and adoption studies will be conducted through the Feed the Future Innovation Labs, the CGIAR Standing Panel on Impact Assessment and independent evaluators. These studies will increasingly use innovative methodologies and technologies including genetic fingerprinting, remote sensing and other techniques to more accurately track impact. Cumulatively, these efforts will provide monitoring and evaluation approaches to better assess and articulate the downstream food security impacts of upstream research investments and inform programming and prioritization of future research, all over a timescale appropriate to the development and scaling of food security innovations.

9. Conclusion

In the face of pressing global food security challenges, the U.S. research community's unparalleled scientific and technological capacity has the potential to support sustainable reductions in global poverty, hunger and malnutrition. Cooperation across U.S. Government research funding agencies and Feed the Future partner agencies is required to achieve impact. The participation of key partners and stakeholders in the U.S. and in partner countries—including the private sector, other international and philanthropic donors, partner-country governments and civil society—is also key to success. Together, these partnerships will promote development of sustainable systems to generate the type of innovations that will help build a food-secure future and more stable world.

To support this process, this Research Strategy has laid out a vision for strategic U.S. coordination on food security research across the R&D and technology-scaling pipeline. It has articulated broadly relevant research themes that accommodate the respective mandates of diverse U.S. research funding agencies, defined key partners and roles in implementing this strategy and identified common operating principles to harmonize implementation across partners.

Moving forward, there are ample areas where consultation among interested U.S. agencies and their respective partners can help identify potential programmatic synergies or opportunities to coordinate research in support of GFSA objectives. Existing platforms for inter-agency and partner interaction offer an ideal starting point to explore potential complementarities and shared priorities. In addition, coordination should also be explored around learnings regarding the role of research in advancing food security in developing countries. This strategy generates novel opportunities to share information and M&E approaches to better understand and communicate the long-term food security impacts of research, providing increased accountability for U.S. Government science investment.

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Appendix I. US Government Strategy Plans Related to the Goals of this Global Food Security Research Strategy

US Government Strategic Plan	Strategies Relevant to GFS Research Strategy	Source
10 Big Ideas for Future NSF Investments	The National Science Foundation's 10 Big Ideas for Future NSF Investments will catalyze interest and investment in fundamental research, which is the basis for discovery, invention and innovation. NSF aims to strategically invest in research projects and programs that are motivated by intellectual opportunities and important societal problems, allowing everyone to benefit from the convergence of the physical sciences, biological sciences, computing, engineering, and the social and behavioral sciences. Several of the ten ideas, including phenotype prediction and harnessing of data, are relevant to GFSA Research and the overarching goals of <u>promoting inclusive, sustainable agriculture-led economic growth and building resilience among vulnerable populations</u> .	https://www.nsf.gov/about/congress/reports/nsf_big_ideas.pdf
A 21st Century Science, Technology, and Innovation Strategy for America's National Security	A 21st Century Science, Technology, and Innovation Strategy for America's National Security sets forth how the U.S. national security science, technology, and innovation enterprise should evolve to address the challenges and opportunities imposed by a new landscape of national security technology concerns in the 21st century. The Strategy describes various challenges and opportunities related to national security, including the role of science, technology and innovation in advancing the Federal Government's global-development objectives, which strengthen national security. The Strategy notes that the United States is in a unique position to help lead efforts to resolve one of humanity's most entrenched and difficult challenges by the year 2030: persistent extreme poverty. This aim, which is aligned with the GFSS objective to <u>build resilience among vulnerable populations</u> , can be achieved through a new model of development grounded in evidence-based evaluation, rapid iteration, country ownership, sustainability, and strategic public- and private-sector partnerships that catalyze talent and innovation everywhere.	http://www.defenseinnovationmarketplace.mil/resources/National_Security_ST_Strategy_2016_FINAL.PDF
Framework for a Federal Strategic Plan for Soil Science	The Framework for a Federal Strategic Plan for Soil Science identifies research and development opportunities for key threats to U.S. soil resources including land-use and land-cover change; unsustainable land management practices; and environmental change. The Framework's recommendations include support of a coordinated research effort on the interactions between soils and the global climate; and support for the expansion of, and increased investment in, long-term research programs and collaborations to better understand, document, and manage the effects of land-use and land-cover change on soils. Implementation of these recommendations will enhance the long-term sustainability of soils, which underpin agricultural productivity, and lead to improved approaches to land management, thereby <u>promoting inclusive, sustainable agriculture-led economic growth</u> .	https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ssiwg_framework_december_2016.pdf
National Global Change Research Plan 2012-2021	The USGCRP coordinates and integrates scientific research across thirteen agencies of the United States Government whose mission is focus, to some degree, on changes in the global environment and their implications for society. The strategy's goals are to advance science, inform decisions, conduct sustained assessments, and communicate and educate. All four goals are relevant to the three research themes of the	https://downloads.globalchange.gov/strategic-plan/2012/usgcrp-strategic-plan-2012.pdf

	Global Food Security Research Strategy.	
National Nutrition Research Roadmap (2016-2021)	The Interagency Committee on Human Nutrition Research (ICHNR) aims to increase the overall effectiveness and productivity of federally supported or conducted human nutrition research. ICHNR's National Nutrition Research Roadmap (2016-2021) identifies research priorities for human nutrition and describes the role of the ICHNR departments and agencies in addressing those priorities over the next five to ten years. While the Roadmap's topical selections focus primarily on reducing nutrition-related chronic diseases in the United States, the research and resource initiatives could guide other national governments, non-government organizations, or collaborative global efforts to advance human nutrition research to improve and sustain health across the globe, thereby supporting the GFSS overarching goal to improve nutritional outcomes, especially among women and children.	https://www.nal.usda.gov/sites/default/files/fnic_upload/2016-03-30-%20ICHNR%20NNRR%20%282%29.pdf
National Plant Genome Initiative Five-Year Plan (2014-2018)	The National Plant Genome Initiative (NPGI) aims to develop a basic knowledge of the structures and functions of plant genomes and to translate this knowledge into a comprehensive understanding of all aspects of economically important plants and plant processes of potential economic value. The NPGI's Five-Year Plan (2014-2018) features six objectives focused on open-access data and knowledge sharing, expansion of the interoperability of tools and databases, enhancement of the application of genomics for agriculture, acceleration of plant breeding, improvement of the practice of agriculture, reduction of the demands on environmental resources, and addressing challenges posed by global climate change. By bridging basic research and plant performance in the field, the NPGI will advance basic discovery and innovation to improve the practice of agriculture and reduce demands on environmental resources—outcomes that will <u>promote inclusive, sustainable agriculture-led economic growth and build resilience among vulnerable populations.</u>	https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/npgi_five-year_plan_5-2014.pdf
U.S. Agency for International Development Multisectoral Nutrition Strategy (2014-2025)	USAID's Multisectoral Nutrition Strategy (2014-2025) is aligned with the 2025 World Health Assembly Nutrition Targets and reaffirms USAID's commitment to global nutrition and its role as a major international partner in the fight against malnutrition. The Strategy's multisectoral approach addresses both direct and underlying causes of malnutrition, and its focus on linking humanitarian assistance with development programming helps build resilience to shocks in vulnerable communities. With this Strategy, USAID aims to decrease chronic malnutrition, measured by stunting, by 20 percent—a target that is directly in line with the GFSS goals to <u>build resilience among vulnerable populations and improve nutritional outcomes, especially among women and children.</u>	https://www.usaid.gov/sites/default/files/documents/1867/USAID_Nutrition_Strategy_5-09_508.pdf
U. S. Department of Agriculture Animal and Plant Health Inspection Service Strategic Plan (2015-2019)	The USDA Animal and Plant Health Inspection Service (APHIS) Strategic Plan for 2015-2019 focuses on reducing risk to crop and livestock production from pests and diseases—key areas of complementarity with the GFS Research Strategy. With APHIS' focus on diagnostics development and processes to harmonize diagnostic methods among governments, efforts through the GFSA Research Strategy will complement APHIS' Objective 1.2 which involves working with foreign governments and partners to prevent the spread of damaging pests and diseases. Prevention of animal and plant disease aligns with GFSS goals to <u>promote inclusive, sustainable agriculture-led economic growth and build resilience among vulnerable populations.</u>	https://www.aphis.usda.gov/about_aphis/downloads/APHIS_Strategic_Plan_2015.pdf
U.S. Department of	U.S. Department of Energy Office of Biological and Environmental	http://genomicscience.ener

Energy Office of Biological and Environmental Research Biological Systems Science Division Strategic Plan	Research Biological Systems Science Division Strategic Plan provides a solid foundation for activities aligned with the GFSA goals of improving agricultural productivity, relevant to small-scale producers farming marginal lands, particularly those seeking to increase fodder availability for livestock. For example, GFSA Research efforts will build from the Bioenergy Subgoal to “develop new approaches to bioenergy agriculture that cost-effectively provide high yields of biomass on marginal lands requiring few or no inputs with plants highly adaptable to changing environmental conditions and having minimal to no impacts on the ecosystem.” These approaches will <u>promote inclusive, sustainable agriculture-led economic growth</u> .	gy.gov/pubs/BSSDStrategicPlan.pdf
U.S. Government Global Nutrition Coordination Plan (2016-2021)	The U.S. Government Global Nutrition Coordination Plan identifies concrete opportunities for greater interagency communication and collaboration on human nutrition research and programming, facilitating a stronger whole-of-government approach to global nutrition. The Plan identifies six technical focus areas as primary but not exclusive opportunities for enhanced multiple agency coordination: food fortification, nutrition information systems, food safety, the first 1,000 days (pregnancy up to 2 years of age), nutrition-related non-communicable diseases, and HIV and nutrition. These focus areas directly support the GFSS overarching objective to <u>improve nutritional outcomes, especially among women and children</u> , through the promotion of highly nutritious, safe foods, and nutritional behaviors that improve maternal and child health.	https://www.usaid.gov/sites/default/files/documents/1864/nutritionCoordinationPlan_web-508.pdf



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