

A RESEARCH AGENDA FOR FEED THE FUTURE (FTF)

Planning Workshop at Purdue University
January 11-13, 2011



Association of Public and Land-grant Universities (APLU)

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A Research Agenda for **Feed The Future**

Summary of the Planning Workshop
at Purdue University

January 11-13, 2011

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INTRODUCTION

Global food security has emerged as one of the most important challenges of the 21st Century. Recent spikes in food prices, reminiscent of the food crisis of 2007-8, have attracted the world's attention¹ and have had significant impact on the political stability of nations.² We are poised at a unique point in history in which, within a few decades, the population will peak at over nine billion people and require 70 percent more food production to adequately support that population. Today's world is precariously balanced between supply and demand where each perturbation to food systems dramatically influences global supply and the price of food.

Consequently, there is a critical need for the global agricultural community to develop adequate, nutritious, reliable and affordable food systems that both eliminate malnutrition and support economic growth needed to reduce poverty. While the quantity of food is clearly of great importance, quality of diet is equally critical. Human capital, which underpins all economic and social development, depends on both.

Human capital is needed to generate technologies and knowledge that support agricultural productivity across the broad array of farmers (including the small-scale and resource-poor) in order to alleviate hunger and reduce poverty. This process will then engage the virtuous cycle of real income growth for the poor, better nutrition and improved human capacity development. However, current global trends present major obstacles to achieving these goals—these include food consumption trajectories, declining crop yields, limited additional farm land, water, and energy resources, environmental and natural resource degradation, constantly evolving agricultural pests and diseases, and accelerating climate change.

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Our current body of knowledge is not adequate for these complex and interdependent challenges; nor are the historic rates of food production increases sufficient to meet the accelerating food demand.³ If, however, we can reduce overall poverty and malnutrition, the projections are that population will stabilize around 2050 and then begin to decline. Of significance is that both the increased demand for food and the greatest potential to increase food supplies resides primarily in developing countries. Therefore, the United States Government's new global hunger and food security initiative, *Feed the Future (FTF)*,⁴ announced in May 2010, includes as an integral investment the development and implementation of a

¹ "The 9-Billion-People Question: A Special Report on Feeding the World." *Economist* 2/26.

² Samuelson, R. "The Global Food Crunch." *The Washington Post*. 3/13/2011

³ See Drs. K. Cassman and Fan Presentations from the Purdue University Meeting at www.aplu.org.

⁴ Feed the Future website: www.feedthefuture.gov/commitment.html

comprehensive research strategy.⁵ FTF “renews our commitment to invest in sustainably reducing hunger and poverty” and “combating food insecurity as an engine for broader economic growth, prosperity, and stability” in developing countries.⁶

The FTF Guide recognizes that “Investment in agricultural research today drives the growth and resilience of the food supply for tomorrow. When combined with other investments in agricultural development and nutrition, research-based innovations can address some of the fundamental constraints that give rise to food insecurity....”⁷

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The Feed The Future Guide

FTF is closely linked to other U.S. government investments and commitments. These investments include the Global Health Initiative, food assistance programs, and the 1,000 Days Initiative, a 2010 U.S.-led challenge to global leaders to make progress in delivering results on nutrition capacity, targeting the start of a mother’s pregnancy until a child is two years old. FTF also contributes to the global, multi-stakeholder, “Scaling Up Nutrition” effort in support of country-led nutrition strategies.

The research component of this larger FTF initiative, including how research will be integrated with education, capacity building and development, is critical to the success of the overall effort. This research, education and capacity building agenda is the subject of this white paper.

Within the federal government, the U.S. Agency for International Development (USAID) and the Department of Agriculture (USDA) have accepted leadership roles in articulating the “whole of government” response to developing the FTF research agenda.⁸ The effort will strengthen the U.S. contribution to international public goods research in ways that generate technologies and knowledge and build developing countries’ capacity to support agricultural productivity and improve food systems, both in the United States and in developing countries.

These agencies, together with the Association of Public and Land-grant Universities (APLU), the Board for International Food and Agricultural Development (BIFAD), and Purdue University, sponsored a workshop, January 11-13, 2011 at Purdue. The workshop engaged a broad spectrum of leaders in the U.S. university and international research community, as well as funding agencies, private foundations and industry representatives, in discussing the overall FTF research strategy. The participants provided perspectives on broad research challenges, integrating research with human and institutional capacity building, and developing and implementing a way forward to engage the full participation of the domestic and international research communities to

⁵ See Dr. Ann Tutwiler’s video presentation and Greg Gottlieb’s presentation at www.aplu.org.

⁶ Feed the Future website: www.feedthefuture.gov/commitment.html

⁷ Feed the Future (2010) *Feed The Future Guide*. www.feedthefuture.gov

⁸ See Dr. Gottlieb’s Purdue presentations on the website. www.aplu.org

make recommendations that support the FTF goals and research themes.

This paper summarizes the presentations and discussions at the workshop and conclusions subsequently developed by the Working Group under the direction of APLU.

BACKGROUND

In the early 1960s, south Asia's rapidly growing population was on the verge of mass famine. The region sought to stave off disaster with massive imports of PL480 grain from the United States, intensive crop research and advanced agricultural technology, hoping to replicate the previous decade's stunning transformation of Mexico's wheat industry. In Mexico, disease resistant and high-yield varieties of wheat were developed, thanks largely to leadership of U.S. scientist Norman Borlaug and his team, as well as the newly emerging International Maize and Wheat Improvement Center (CIMMYT), working in collaboration with the U.S. land-grant universities, USDA and supported by USAID and the Ford and Rockefeller Foundations. These new varieties transformed Mexico from a nation that imported almost half its wheat supply in the 1940s to a net exporter of wheat by the early 1960s. This transformation was the result of not only the strong leadership and creativity of Borlaug himself, but also his ability to draw on the great strengths of U.S. universities, USDA, and the emerging Consultative Group on International Agricultural Research (CGIAR). Many of the plant traits, including the important dwarf line that formed the basis for increased yields, came from collaborations with the U.S. land-grant universities and USDA scientists within the university system.

To meet the challenges of FTF, we need to reconstruct the collaborations that produced the first Green Revolution—the scientists of USDA, U.S. land-grant universities, CGIAR and the scientific capacity of U.S. government agencies, and developing country scientists—to produce a second revolution.

India looked to Borlaug, USAID, Ford and Rockefeller and a major effort from the U.S. land-grant universities, CIMMYT and later the International Rice Research Institute (IRRI) for the development of new varieties of rice, wheat and other grains that, with irrigation and the application of fertilizers, produced substantially greater yields. Coupled with the strong support of the Indian government, in particular M. S. Swaminathan, India's director of wheat research and later director of the India Agriculture Research Institute, the new varieties and practices enabled the country in the subsequent decades to rise to be one of the world's leading grain producers.

The effort, particularly championed by Borlaug and supported for several decades by USAID, not only produced new varieties and production systems but also established land-grant university models in India and built the capacities to produce a whole generation of agronomists and crop breeders to sustain the early production gains. The transformation of agriculture in the 1960s and 1970s in south Asia and other regions has become known as the Green Revolution, and the agricultural innovations led by Borlaug have been credited with preventing as many as a billion deaths from famine.⁹

To meet the challenges of FTF, we need to reconstruct the collaborations that produced the first Green Revolution—the scientists of USDA, U.S. land-grant universities, CGIAR and the scientific capacity of U.S. government agencies, and developing country scientists—to produce a second revolution. But we must recognize that the Green

⁹ For this work Borlaug received the Nobel Peace Prize in 1970.

Revolution had its limitations. It largely bypassed sub-Saharan Africa and parts of south Asia, generally favored farms with access to advanced infrastructure and external inputs, and did not incorporate adequate protection of the environment. Today's world has twice the population of the 1960s, the demand on natural resources has more than doubled, and the environmental challenges we face are serious.

Population growth and increased demand will place a very large burden on the capacity of developing countries to provide adequate food, water and energy for their own growing populations, as well as beyond their borders. We are seeing a reversal of long-term decreases in the real price of food and staple commodities, coupled with abrupt rises in petroleum prices and the cost of energy. Increased use of food crops for biofuel production also contributes to higher grain prices. For the first time in human history, more people live in cities than in rural areas. Vulnerable populations face increased competition for scarce water, land and energy resources; less predictable circumstances due to increased climate variability and change; increased urbanization with its resulting loss of prime agricultural lands; and the urgent need to protect and restore the natural environment. Current food price shocks and concomitant protests in the Middle East and elsewhere illustrate the fragility of the global food system and its link to societal stability.

Sustainable agricultural intensification is key to meeting the above challenges. Investment in agriculture is a proven lever for combating food insecurity and encouraging broad economic growth. The poverty reduction impact of agricultural growth is, in general, greater than the poverty reduction impact of non-agricultural growth, and is greater when agricultural growth includes the small farm sector. The challenge is to increase global agricultural productivity at an increasing rate while simultaneously maintaining or even enhancing soil and water quality, preserving natural resources, and improving climate change resilience. Together with productivity increases, we must ensure adequate food quality and nutrition; accelerate benefits to the poor and to vulnerable populations; and improve food safety, storage and distribution systems. In addition, these objectives must be integrated at all levels with global health research and other related initiatives and assessed with respect to real improvements in the lives and health of the poor.

The challenge is to increase global agricultural productivity at an increasing rate while simultaneously maintaining or even enhancing soil and water quality, preserving natural resources, and improving climate change resilience.

The bar is high and the timing is urgent. It will require a tight focus on impact-oriented research and extension, the creation of research roadmaps, structures, partnerships and include a broad range of U.S. government participation to meet the FTF expectations. We must deliver tangible, immediate results and, at the same time, ensure investments in basic and transformational research and capacity development that will continue to deliver and sustain substantial results over the long-term. Because of the unique roles of women as producers, innovators, extension agents, and in overseeing child and family nutrition, it will also be vitally important to integrate gender throughout the research planning, capacity development, and implementation processes.

The benefits of the original Green Revolution largely resulted from and were sustained

by increases in public funding for agricultural research. However, public investments in basic research, with long-term transformative potential, have largely stagnated in real terms since 1978.¹⁰ In addition, progress has been hampered by insufficient capacity in the developing world to adopt existing agricultural methods and develop new modern approaches and technologies in diverse conditions, especially when taking into account local perspectives, knowledge and culture. New and refocused public investments, such as the FTF initiative, combined with targeted and accelerated investments of private foundations, industry, and others, are essential in addressing the need for a 21st century more sustainable Green Revolution. These investments must necessarily be results-based; leverage the strength of multilateral institutions; include significant and sustained capacity building; involve new modalities of working together in all varieties of partnerships and collaborations; and ensure country and regional ownership of the research agenda, priorities and processes.

¹⁰ Fuglie, K. O. and Schimmelpfennig, D. (Eds.)(2000). *Public-Private Collaboration in Agricultural Research*. Iowa State University Press, Ames, IA.

GUIDING PRINCIPLES FOR FTF RESEARCH

The task of producing enough food for 9 billion people, while reducing hunger and poverty and reversing environmental degradation is formidable, but the global research community approaches this challenge with considerable capacity and considerable optimism. We have witnessed how the Green Revolution transformed global agriculture and led to sustained improvements in local and regional agricultural capacity, to new higher education institutions that produced research to sustain agricultural productivity, to new systems of production and distribution, and to enduring collaborative mechanisms (e.g., the CGIAR network) that continue to link the global research community with knowledge products and new technologies. In U.S. universities, the land-grant system encompasses nearly 150 years of integrating research, teaching and extension in ways that empower communities to create their own visions for the future, build on regional markets, and develop human and institutional capacities essential for lasting success.

The lessons learned over the decades point to a number of guiding principles that will shape the research strategy going forward.

PURPOSE-DRIVEN AND RESULTS-ORIENTED

We must ensure that the research strategy and implementation roadmaps ultimately accelerate sustainable benefits to both farmer and consumer. Scarce resources should be focused where there is potential for greatest positive impact, considering both the short- and long-term. The research should be integrated across scales and environments, such that potential large-scale applications and impacts are balanced with attention to small farm priorities and to regional and local differences in both challenges and strengths. We must learn from past mistakes and incorporate a greater appreciation for indigenous innovation and experimentation in the introduction of globally relevant knowledge and technologies into regional and country-based projects.

The success of our efforts is dependent on our ability to create and sustain self-perpetuating systems that link agricultural research with local communities of practice, entrepreneurs, financial resources and markets, and societal and political leaders and the institutions that support the entire value chain. Comprehensive, realistic, and on-going impact assessment should be built into projects, with attention to the entire research-development-implementation-extension pipeline and using adaptive management strategies to optimize ultimate impacts. Monitoring, evaluation and impact assessment must focus on collecting the right information and be done so that its implications for the value chain can be clearly assessed. For maximum impact, we must consider the

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Connecting Research to the People

Agricultural research can produce among the highest rates of return of all development interventions.¹ Furthermore, investment in research capacity has been a key to economic development in a number of emerging countries.² Research must play a central role in addressing global food security.

The research must be translated into knowledge applications and new technologies, and it must be extended to increase local, national, and regional capacity as well as to sustain improvements in the lives of agricultural producers and consumers in target countries. Thus, basic research must be intimately connected with applied research, technology development, education and training, information access and exchange, policy making, and deployment to end users. This pipeline from basic research to end-user must be strong at each link and it must be adaptable and responsive. There must be as much attention to shaping the direction of the basic research in response to changing requirements and constraints of the user as there is to increasing the capacities and productivity of the end user through the research results.

Additionally, creativity and initiative must be sought out and encouraged at each stage and from each player in the process, and the overall system must be flexible enough to adapt to continual change. This integration of research within an overall food security strategy is a complex task. In the past, too much emphasis on top-down processes of knowledge and technology transfer has resulted in “one size fits all” or “silver bullet” approaches that have not worked well in the very diverse landscape of developing countries, and have failed to take more advantage of indigenous creativity and locally-developed solutions.

There continues to be fragmentation of effort and multiple disconnects between research and the development systems of developing countries, between research and policy makers, and between research and the needs and priorities of the stakeholders due in large part to institutional barriers and lack of coordination among donors.

To avoid these errors of the past, the FTF research strategy must be well integrated and oriented towards achieving its goals in ways that empower communities to create their own vision of the future, build on regional markets, and develop human and institutional capabilities. Participatory approaches involving farmers’ organizations, constituent institutions, and policy makers will build priorities from the bottom-up, utilizing local expertise and encouraging innovation.

The U.S. Land-Grant University System, with its holistic emphasis that seamlessly connects basic and applied research with extension so there is a two-way flow of information between farmer and scientist, is well designed to lead the challenge of integrating FTF research within the larger initiative framework.

¹ Alston et al. 2000. *A Meta-Analysis of Rates of Return to Agricultural R&D*. IFPRI, Washington, D.C.

² See Purdue presentations by Drs Fuglie and Ejeta at www.aplu.org

potential contribution of increased efficiencies in food systems. In some cases, the introduction of the next silver-bullet technology into a production system may not have as great an impact as the diligent optimization of the efficiencies of the current system. The potential impact must be the deciding factor. In developing countries, these inefficiencies are great and may be an important initial focus to increase productivity. To paraphrase the American Society for Agronomy, the grand challenge for global food security will be to more than double agricultural productivity on existing agricultural lands within the 21st century, while ensuring food quality and environmental protection.¹¹

We are also faced with the considerable challenge of building the human and institutional capacity of developing countries that will produce and sustain the level of productivity increases required to meet the 2050 demands.¹² New research processes, different types of partnerships, and other new modalities of working together are needed but those approaches must be accompanied by a major commitment of resources to build those capacities and skills. These approaches must be flexible enough to address the very different needs of densely populated, market-connected countries and small, primarily rural countries while drawing on the unique strengths and contributions of all partners.

¹¹ American Society of Agronomy, *Grand Challenge*. (2010). www.agronomy.org/files/science-policy/asa-grand-challenge-2010.pdf

¹² See Dr. Ejeta’s and Dr. Fuglie’s Purdue presentations that emphasizes the importance of capacity building in developing countries, available at www.aplu.org.

ALL ABOUT PEOPLE

The human species has great capacity to creatively meet and overcome major challenges if the talents of the best and brightest are focused and coordinated on developing and implementing solutions. Agricultural development research once inspired and engaged a growing and highly talented workforce, supported by significant research and development funding, both in the United States and around the world. However, there has been a serious decline in investment in agricultural research in the past two to three decades, and this is reflected in stagnant and declining crop yields worldwide.¹³ The world's wealthiest countries as a group cut funding for agriculture development roughly in half between 1980 and 2006, and in the United States, funding for USAID-supported training of students who earn higher education degrees has dropped from approximately 15,000 students in the 1990s to fewer than 1,000 in 2008.¹⁴ The FTF research strategy must compellingly articulate the challenge of harnessing research to achieve sustainable intensification and identify the systems that are in place, or can be brought to the fore, to achieve the desired results. We must organize our funding, project development, implementation and capacity building mechanisms to re-engage commitment and build ownership across the spectrum of stakeholders, from the global policy development to small farm producer. Our measures of success will reflect accountability to stakeholders: reduced hunger and poverty, improved nutrition (especially for women and children), and improved health in the FTF target countries and beyond.

Activities in the research strategy must be country-led and constituent-owned, with great attention paid to in-country capabilities, successes, and expertise as well as to knowledge and capacity gaps. Accountability to end users, especially small farm holders, increases the likelihood of having the desired impacts. The benefit in developing countries from agricultural growth and increased productivity has regularly proven to be larger when small producers and marginal farmers are the focus of research and development interventions.¹⁵ Careful attention to gender, the involvement of both women and men in all aspects and at all levels of the strategy, will also be a pivotal factor in achieving these goals.¹⁶ In most developing countries, women are the primary small agricultural producers, but they may have only limited access to new technologies, funding sources, and markets. Women's health and nutritional status directly affect the health of the entire community, and when women control increases in income, they are more likely to invest in food and children's needs.

Wherever feasible, projects should pay attention to the integration of research, education and human and institutional capacity building. This will require greater

¹³ Pardey, P. G. and J.M. Alston. *U.S. Agricultural Research in a Global Food Security Setting: A Report of the CSIS Global Food Security Project*. Washington, D.C.: CSIS, January 2010. <http://csis.org/publication/us-agricultural-research-global-food-security-setting>.

¹⁴ APLU (2008). *Higher Education: A Critical Partner in Global Agricultural Development*. www.aplu.org/NetCommunity/Document.Doc?id=1148.

¹⁵ GCARD (2010). *Transforming Agricultural Research for Development*. www.fao.org/docs/eims/upload/282426/GAT_Report_GCARD_2010_complete.pdf.

¹⁶ See Dr. Anderson's Purdue presentation at www.aplu.org.

attention to and perhaps even new research focused on existing and novel modalities for working together. Public and private funders, multilateral and nongovernmental assistance organizations, private industry, university researchers, and local farmers and entrepreneurs should experiment together with collaborative frameworks that are much more consultative, engage partners on an equal basis, incorporate contemporary best practices, and ensure appropriate accountability of all involved. Additional capacity is needed at every link in the chain, including at U.S. research universities, where global leadership is no longer a given. Training cannot be just an add-on, unconnected with on-the-ground research. It must occur in settings that are fully integrated into the overall research agenda. In many cases, advanced degree training is an integral part of solving agricultural development problems. Embedding degree research within the context of the developing country problem solving effort with course training in the United States has been shown to be a highly effective training and problem solving approach. A number of other approaches have been evaluated. Clear from these analyses is the joint benefit of degree training directly linked to the problem solving and capacity building framework of a larger effort in development.¹⁷

ATTENTION TO COMPLEXITY

The research problems targeted by FTF are largely questions of dynamic, complex systems, involving aspects of numerous disciplines, varieties of scale, large communities of practice, multiple feedback loops, unknown dependencies and unique sets of local or population specific conditions. The climate change challenge is an example of how complexity can make problem solving a “wicked” exercise.¹⁸ Complex systems very often produce unintended consequences. Application of what would seem an essential nutrient supplement to a heterogeneous population solves one component of malnutrition in healthy individuals but may produce a very negative outcome in those infected with a particular disease. In complex systems, relationships are mutually interacting. The contributions of individual factors change in influence and even direction based on changes in other factors, and cannot be predicted with certainty by conducting traditional trials or experiments.

These systems will require extensive and targeted research where the complexities can be understood by establishing robust data sets from which interaction can be understood. New research employing complex systems theory can also be undertaken, but these research techniques themselves are the subject of an emerging field of inquiry.¹⁹ It will be critical to ensure that research measures multiple variables within the same systems to understand their interactions. Because it is the interaction of, for example, productivity with environmental impact, that is a key element of the challenge we face. At the systems level, progress will require simultaneous study of biological and ecological processes with production processes in the context of changing climate and natural resource availability.

¹⁷ Gilboy, A. and C. Flora, *Agriculture Long-Term Training: Assessment and Design Recommendations*, USAID (2010). Cohen, C. *Developing Institutional and Human Capacity for Agricultural Research*. USAID (2010).

¹⁸ See Dr. Doering’s Purdue presentation at www.aplu.org.

¹⁹ OECD (2009). *Applications of Complexity Science for Public Policy*. www.oecd.org/dataoecd/44/41/43891980.pdf

It will also require the integration of local priorities and indigenous innovation with a global research agenda, from the small farm to the large producer and the effects of nutrition, positive and negative, across dimensions of age, health and ethnicity.

A RESILIENCE MINDSET

A resilience mindset must permeate every aspect of the FTF research strategy. From past experience, we cannot anticipate linear and predictable change in the systems we seek to influence. Risk is a powerful element in today's world. It comes in the form of unpredictable weather, conflict, disease and external markets forces. Those with few resources are most challenged to cope. Historically, food systems that take advantage of natural processes, complementarities and efficiencies have often reduced the need for external inputs, and hence reduced vulnerability to changes in input availability and costs. Present day increases in population, natural resource degradation and climate change have greatly reduced the efficiencies of many of those indigenous/historical systems. The research strategy must encompass diverse, adaptable approaches that often break with traditions, both scientific and cultural.

Research must produce information that allows the design of effective mechanisms to deal with risk and disasters that now more frequently populate the lives of the world's poor. Some problems, such as drought risk, can be managed with either financial technologies (risk transfer through insurance contracts) or through genetic technologies (e.g., drought resistant seed). Both come at a cost and have their relative advantages. Careful consideration of the synergies between these two approaches may suggest more cost effective ways of boosting the productivity of risk-constrained farmers. In some instances, this could mean breeding for higher mean yields, which will make insurance affordable, while using insurance to manage catastrophic risk, which will make adoption of hybrids feasible. This requires that research focus as much on sustainability, adaptation, efficiencies, effectiveness, capacity, risk management, vulnerabilities, and recovery from reversals, as on continued improvements in current practices.

THE FTF RESEARCH FRAMEWORK

The overarching FTF initiative goal is to “sustainably reduce global hunger and poverty by tackling their root causes and employing proven strategies for achieving large scale and lasting impact.”²⁰ The U.S. has made impressive advances in agricultural productivity over the last 50 years due in large part to the land-grant university system, and these advances have benefitted the world in shared technologies and consistent food surpluses. However new science, technology and innovation will be needed to raise more nutritious and resilient plants and animals under increasing stresses, produce more food on existing agricultural lands and with more effective use of inputs, and deliver the resulting benefits in ways that reduce poverty and improve human nutrition and the well-being of families while protecting the environment. The good news is that opportunities for making greater scientific advances are many. The U.S. and international research and development community, innovative farmers, and the private sector serve as powerful sources of knowledge, innovation and experimentation in the development and deployment of new products and technologies for improving sustainable production systems. In developing

countries, factors critical to agricultural advances include expanding farmer and community participatory research; building human capital through continuous education; and improving farmer access to markets, infrastructure and affordable finance.

Only through a consultative process will FTF be responsive to the needs of developing countries as defined by national and regional processes that provide insight into research and development priorities. Efforts such as

the Africa Union Comprehensive Africa Agriculture Development Programme (CAADP), which define agricultural needs at the national and regional level through comprehensive peer reviewed analysis, are essential and must be matched by donor commitment to respond to those country led recommendations. USAID has been highly supportive of CADDP and other agricultural development efforts.²¹ The Global Conference on Agricultural Research for Development (GCARD), organized by the Global Forum on Agricultural Research (GFAR) in association with the reform process of CGIAR, has developed a road map that makes such a commitment.²²

The World Bank and other donors are committed to having country-led processes set the agenda for development assistance and research investments. It should be noted,

²⁰ *Feed the Future Guide* (2010). www.feedthefuture.gov/FTF_Guide.pdf

²¹ See Dr. Hill's Purdue presentation at www.aplu.org.

²² Lele, U., J. Pretty. E. Terry and E. Trigo. (2010) *Transforming Agricultural Research for Development*. http://www.fao.org/docs/eims/upload/282426/GAT_Report_GCARD_2010_complete.pdf, The Global Forum for Agricultural Research (GFAR).

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however, that higher education (human and institutional capacity building for research) has not been significantly integrated into the CAADP process. A recent ministerial meeting in Kampala,²³ the Ministerial Conference on Higher Education in Agriculture in Africa (CHEA), produced a communiqué²⁴ that made strong recommendations to increase the role of higher education in the CAADP compact process. For the first time, the agenda is being formally set by developing countries who make commitments of their own resources while donors coordinate to respond to these defined needs.

Participants at the Purdue planning workshop listened to presentations from FTF leaders at USAID and USDA who outlined the three areas of research priority identified in shaping the overall initiative.²⁵ These are: 1) advancing the productivity frontier, 2) transforming production systems, and 3) enhancing nutrition and food safety. Discussions were focused on the nature and scope of these priorities, which are by nature interlinked and will require integrated approaches. Within this general framework, participants further identified high-level research themes that will advance the goal of rapid and broadly-based agricultural growth, especially in FTF focus countries.²⁶ The three priorities, their underlying research themes, and some additional crosscutting research themes are discussed below.

At Purdue, the presentations and discussions produced additional specificity under these themes, further elaborating a challenging agenda of vitally needed research.

ADVANCING THE PRODUCTIVITY FRONTIER

Sustainable agricultural intensification, intensification while simultaneously protecting the environment and natural resource base, is key to achieving FTF goals. Agricultural intensification will increase household income, diversify diets, create jobs, push down prices for staples, and generate revenues that can fund targeted social safety net programs. The first Green Revolution produced significant advances in increasing yields, but it did so with a number of negative impacts on the environment. Future research on productivity enhancement must be conducted with a fundamental commitment to protecting the environment. The concepts of sustainability and resilience to rapidly changing natural, social, economic and political environments should be integrated across the portfolio of research projects.

Advance conventional breeding and molecular genetics research to accelerate crop and livestock improvement:

- Integrate conventional breeding with molecular genetics research to achieve results and optimize both short- and long-term impacts.

²³ www.ruforum.org/content/chea-press-release

²⁴ www.ruforum.org/sites/default/files/file/CHEA/CHEA%20FINAL/Communiques/Communique%20Final-English.pdf

²⁵ See Dr. Regmi's and Bertram's Purdue presentation at www.aplu.org.

²⁶ The FTF initiative focuses on 20 countries throughout Africa (*Ethiopia, Ghana, Kenya, Liberia, Mali, Malawi, Mozambique, Rwanda, Senegal, Tanzania, Uganda, Zambia*), Asia (*Bangladesh, Cambodia, Nepal, Tajikistan*), Latin America and the Caribbean (*Guatemala, Haiti, Honduras, Nicaragua*).

- Accelerate crop improvement for yield, yield stability, and nutritional enhancement.
- Improve crop disease, insect and weed resistance, as well as nutrient and water use efficiencies.
- Understand and improve poultry, livestock and fish stock genetics and general health management for productivity, nutritional value and disease resistance.

Sustainably increase productivity

- Achieve significant increases in the yield per unit of applied nutrient or water and per unit of energy consumed.
- Develop technologies that employ nutrient cycling, nitrogen fixation, soil regeneration and biodiversity to reduce the need for nonrenewable inputs.

Total Factor Productivity

Total factor productivity (TFP) tracks changes in total output not caused by changes in inputs. Productivity growth may result from changes in inputs (for example, amount of irrigation or the application of fertilizer) as well as from the application of new knowledge or new technologies. When all inputs are accounted for, then TFP is a measure of the true effect of new knowledge, technological change, or increases in efficiency.

The limiting factor for TFP growth in agriculture in poor countries is national research capacity. Many countries in the developing world, particularly in Africa, continue to lag far behind global averages in TFP growth. Investments in research that are intimately linked with in-country human and institutional capacity development have great potential to raise agricultural productivity in these regions.

- Achieve long-term soil and water quality improvements and land/water resource use efficiency for crops, livestock and aquaculture. Reduce agricultural greenhouse gas emissions.
- Improve low-dose and non-toxic pesticides. Seek advances in fertilizer efficiency, fertilizer chemistry and fertilizer delivery mechanisms.
- Develop improved and/or alternative livestock feed resources. Increase adoption of new or improved cropping patterns, as well as poultry and livestock management, aquaculture and capture fisheries practices.
- Optimize agricultural practices for different agro-ecological conditions and resilience to climate variability and extreme events, without harming wildlife or biodiversity.
- Provide appropriate technologies, including small-scale machinery and timely, accessible information resources for smallholder decision support.

TRANSFORMING PRODUCTION SYSTEMS

Transforming production systems will require responding to a range of demands: ecological, economic and nutritional. The production system is one part of the landscape of natural resources and one component of the overall food system that goes from the field to the consumer. The integration of basic agricultural science and technologies with research on natural resources, policy, markets and other social science research across multiple scales of systems will be essential to achieve sustainable intensification. Different scales and types of farming systems may each require a different approach and different types or combinations of technologies and management practices. However, medium to large-scale farms already have started to succeed in this effort, and can establish organized markets for their products. The real challenge is small landholders, necessitating one research theme targeted specifically to closing the small farm yield gap.

Close the small farm yield gap

In most cases, there is a yield gap greater than 30 percent between farmer yields and potential yields, but this gap can be substantially larger, especially in the developing world where smallholder agriculture is dominant.²⁷

- Bridge this gap through understanding smallholder constraints and improving the small farmer's knowledge and decision-making, acquisition and deployment of advanced technologies, and access to financial instruments and support systems.
- Ensure the quality and integrity of information available to local producers and create systems that effectively connect producers to those with the necessary advanced skills and capabilities, as well as to local systems and markets.
- Develop precision tools to help automate/control farm inputs and to access and distribute useful knowledge.
- Create new financial instruments and support systems that are relevant for smallholder farmers in developing countries to improve access to markets and reduce risk. These might include making market-based risk transfer instruments available to farmers, allowing farmers to take risks due to being insured.
- Develop mechanisms for small farmers to collectively capture economies of scale, navigate local commercial systems, and remain a part of the value chain as the chain develops and becomes successful.
- Develop new cell phone technologies and other information technologies for outreach and market information sharing.

Understand and integrate complex agricultural systems

- Identify and intensify the most beneficial and productive mixed systems of both livestock and crops, including systems modeling land use, crop rotation and crop maturity.
- Develop basic knowledge about the biophysical relationships in the food/climate nexus leading to valid measures for sustainability and resilience evaluation.
- Research practices that include effective use of locally available natural resources (water harvesting, conservation tillage, composting, use of livestock manures, and irrigation scheduling and management); intensification of production from microenvironments found in farming systems (such as gardens, orchards, and ponds); and regenerative components such as cover crop and green manures.
- Understand crop and livestock response to climate extremes and variability, and use this information to design improved crop production practices and systems and to increase efficiency.

²⁷ GCARD (2010). *Transforming Agricultural Research for Development*. www.fao.org/docs/eims/upload//282426/GAT_Report_GCARD_2010_complete.pdf

- Understand and evaluate the trade-offs between producing global staple crops vs. native crops, and determine how to most effectively introduce new crops or new varieties.
- Develop integrated system approaches to precision agriculture, focusing simultaneously on the variety of challenges in each system (right place, right time, right cultivar, right inputs to maximize yields using crop simulation models based on weather and soil data).
- Identify synergies among different management practices and barriers to adoption of different practices via integrated studies of performance and the various drivers that impact farming systems.
- Research programs need to avoid the reductionist approaches with a single focus on particular technologies and interventions.

Understand and address the larger agricultural landscape

- Integrate research approaches to include and incorporate supportive policy, economic analysis and social science research. This will involve understanding local and regional growth patterns, socio-cultural landscapes, and local policy factors, with special attention to the impacts of regulatory, cross-boundary and other policy environments.
- Develop and advance technological innovations and infrastructure in the supply chain of commodities. A critical component of the value chain is development of technologies and policies that support investment in market and trade opportunities.
- Investigate interventions for transforming raw commodities into value-added products for markets.
- Facilitate farmer and community participatory processes that strengthen connections between local, regional and global researchers, policy makers, and communities of practice.
- Build human capital through continuous education and in-country training, using extension methods that are gender aware and culturally appropriate. Improve access to markets, infrastructure and affordable finance.
- Understand the economic and social drivers and outcomes of various farming practices, especially pertaining to balancing growth with the inequity it generates and the instability resulting from that inequity.
- Enhance basic research towards understanding dynamic, complex systems and self-perpetuating systems.

ENHANCING NUTRITION AND FOOD SAFETY

The strong link between agriculture and human nutrition is one of the key and innovative concepts within FTF. We now understand the importance of diet quality as well as quantity on the formation of human capital, and the important links between agriculture, nutrition and human health.²⁸ In the case of U.S. global investments, nutrition cuts across sectors and is the focus of two major U.S. development initiatives: FTF and the Global Health Initiative. Synergies and alignment of resources between the two initiatives contribute toward the goal of reducing under nutrition in pregnancy and early childhood and support global nutrition scale-up efforts. Unless improved food availability is matched by some measure of social protection (so that poor families can maintain their nutritional spending even as they traverse droughts, economic downturns, etc.), FTF nutritional goals are unlikely to be met. FTF must enhance dietary quality and diversity; food availability, access, utilization and stability of poor families; and ensure that nutritional outcomes are considered within the context of production and market systems. Stability must be explicitly included in this priority.

Enhance nutritional quality

- Ensure the efforts to improve dietary diversity, which affects maternal and child health and development, are evidence-based, sustainable, culturally acceptable, and integrated into a comprehensive food systems approach.
- Define appropriate nutritional interventions based on an assessment of need (food quality and quantity), ecological and health context (e.g., population targets, prevalence of infectious and non-communicable diseases, social/cultural context) and resource (human, economic) capacity.
- Pay particular attention to the role of nutrition in women's health with an emphasis on pregnant and lactating mothers, infants and young children, as these groups are critical to long-term human capital development.
- Where supported by evidence of specific need, enhance biologically and ecologically safe, effective approaches to bio-fortification of indigenous staple crops.
- Understand and evaluate nutritional contributions and trade-offs between global staple crops vs. native crops.
- Develop sustainable and novel food processing technologies that generate high-value products, while enhancing quality and safety of food and preserving nutrients.
- Through transparent and collaborative research, explore new or alternative ways to ensure sustainable improvement in food and nutrient consumption patterns to ensure health promotion and disease prevention with particular emphasis on such at-risk groups as infants, young children, adolescent girls, and pregnant and lactating women.
- Investigate best approaches for development and implementation of nutrition

²⁸ See Dr. Allen's Purdue presentation on the website. www.aplu.org

education strategies targeting the importance of improved maternal nutrition; Infant and Young Child Feeding (IYCF) practices, including increased prevalence of breastfeeding; and evidence-based nutritionally safe, effective and culturally acceptable approaches to complementary feeding.

- Develop strategies for identification, development, implementation and evaluation of training and education of school children and agricultural workers to improve nutritional practices, emphasizing programs targeting improved nutritional and agricultural practices.
- Identify, develop and implement safe, effective and ecologically sustainable interventions to address the confluence of poverty, malnutrition, disease, and food insecurity in vulnerable populations, including consideration of geographic, social, economic and political contexts.
- Incorporate social science research on alternative ways to increase food nutrient intake (i.e. efficacy of school feeding programs, nutritional supplements, nutrition education, etc.).
- Understand the different geographic, social, economic and political contexts of poverty and malnutrition, and identify effective interventions for the range of different vulnerable populations.

Food safety

- Develop the means to reduce or prevent food safety hazards due to contamination of plant crops in the field and during harvest, especially mycotoxin contamination of grains.
- Develop strategies to minimize contamination of foods of animal origin (meat, poultry, dairy, and seafood) during slaughter and processing.
- Improve post-harvest storage and handling of crop and livestock products.
- Implement training programs for entrepreneurs and government officials regarding safe food production and processing practices in accordance with international sanitary and phytosanitary standards.
- Increase and stabilize access to quality nutrition.

CROSS-CUTTING RESEARCH TOPICS

In addition to the research themes centered on the three priorities identified above, challenges around the “how’s” are equally important and may involve even more difficult research questions.

Transforming research systems

- Treat innovation in collaboration and partnership modalities as a research question of its own, especially identifying effective practices for establishing working relationships between partners that have not traditionally worked, or worked well, together.

- Identify the structures and mechanisms that accelerate basic research, facilitate innovation, promote adoption and encourage capacity development.
- Achieve country-level ownership and leadership of the local and regional research agenda while realizing globally relevant, high-impact results.
- Ensure the effective and sustainable integration of research, education and human and institutional capacity development across all research themes and projects.
- Maintain progress and ensure linkages across the entire research and development pipeline.

Effective monitoring and evaluation

- Develop new, robust and accurate metrics for assessing current performance of agricultural systems with regard to both productivity and environmental protection.
- Help guide research prioritization and policies, and assess investment impact in research and outreach.
- Utilize new and innovative tools to design new metrics (e.g. remote sensing, geographic information systems and geostatistics; crop and ecosystem simulation models; soil and atmosphere sensors; long term weather databases with extensive geospatial coverage of agricultural areas worldwide; soil type databases; and biodiversity databases).
- Improve understanding of the full impact pathway of the research agenda and develop appropriate metrics for assessing impact (effect size in both scientific and socio-economic units) and accountability.
- Develop research prioritization and implementation frameworks, best practices and benchmarks that are much more inclusive, consultative and country-led.
- Develop Monitoring and Evaluation (M&E) methods which move away from the current unitary deterministic methods of evaluation, from inputs—output—outcomes—impacts, to a greater focus on building in feedback loops from clients to researchers and extension agents.²⁹
- Design research M&E systems that track the right information at each different stage and allows for adaptive management of the research process. These methodologies, which must not compromise research capacity with excessive growth of M&E, do not currently exist in the field.

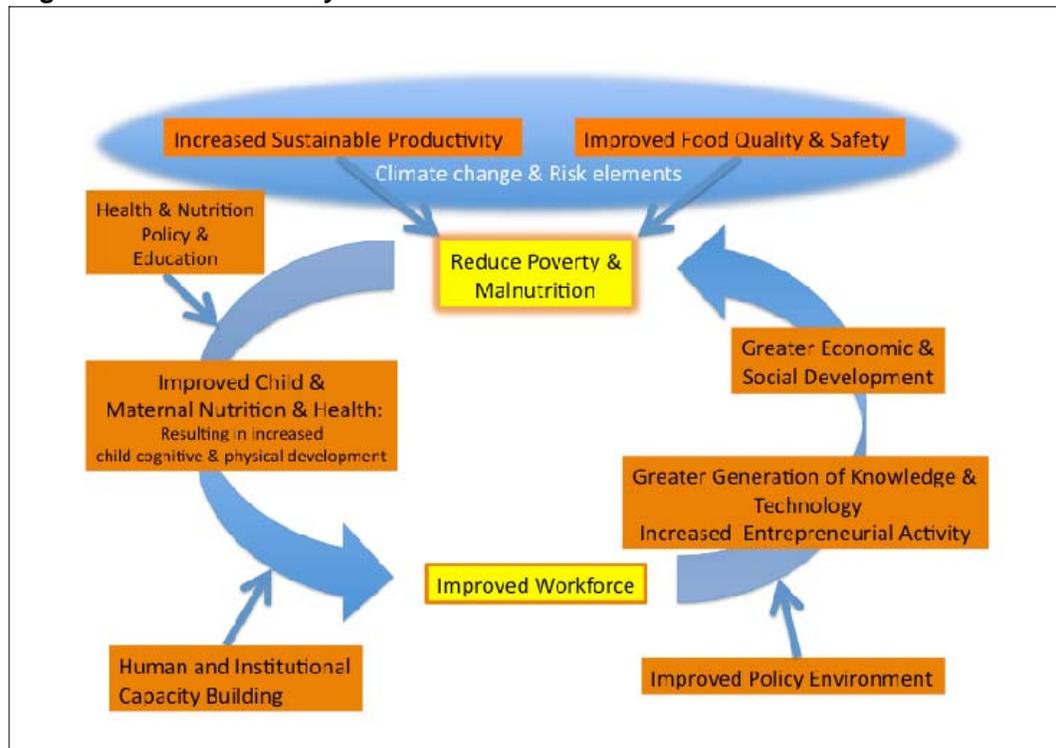
²⁹ See Dr. Maredia's Purdue presentation at www.aplu.org.

CONCLUSION

An ambitious research agenda is essential to the success of the FTF initiative. Agricultural productivity growth is strongly linked to economic growth and reduced poverty in developing countries. Yet, for sustainable global food security to be achieved, the growth must occur while simultaneously protecting the environment and ensuring access to adequate nutrition in vulnerable populations. It will require innovative new approaches in the realms of resilience thinking, complex systems science and the management of agro-ecosystems, and a better understanding of the economic, political and social drivers and outcomes of various agricultural and food systems. Investments in this research will not only address the challenges of FTF, but also strengthen the research community and agricultural sector in the United States and in developing countries, and bolster multilateral collaborative mechanisms, in particular, supporting the strategic linking of FTF to similar initiatives that advance health and nutrition goals. This white paper from the Purdue workshop provides a basis to help develop and frame a living strategic document that identifies relevant research challenges and the roadmap needed for success.

The Virtuous Cycle depicted in Figure 1 attempts to illustrate a unified overview of the FTF research landscape. This diagram depicts how the FTF goals relate to the themes identified in the FTF draft research strategy and our discussions at Purdue. The FTF goals are to reduce poverty and malnutrition. The drivers are increased sustainable productivity and improved nutrition and food safety. Even while working in an environment of climate change and other risk variables, these drivers reduce poverty

Figure 1: The Virtuous Cycle



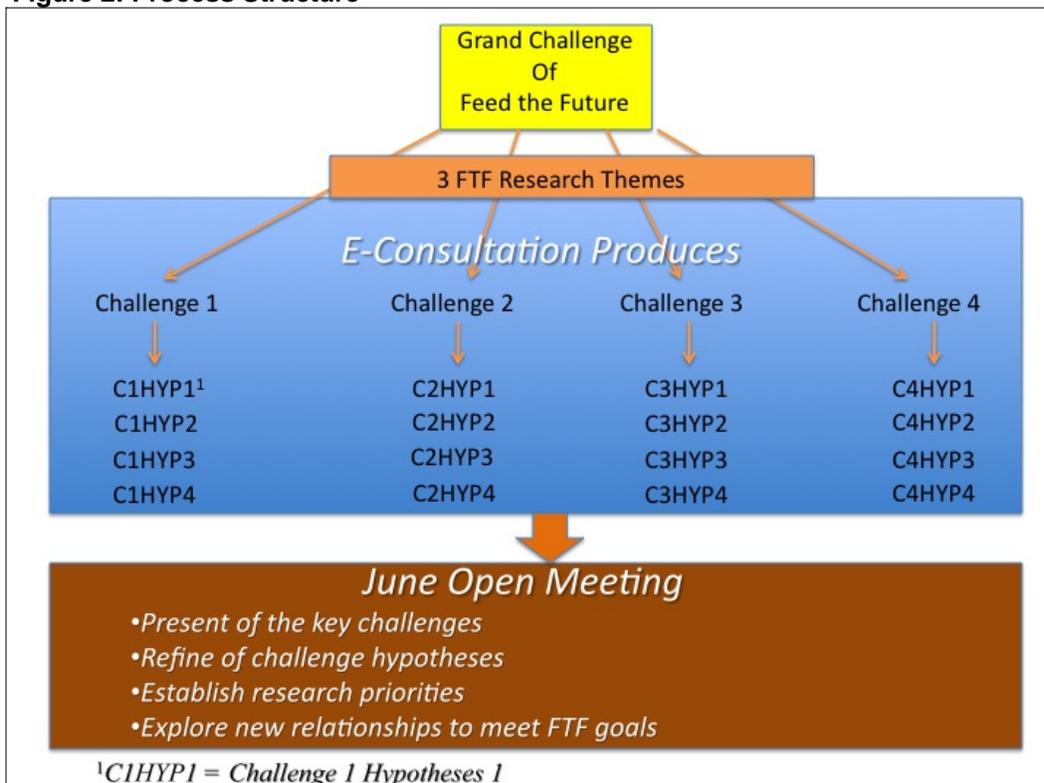
and malnutrition. Reduction in poverty and malnutrition result in improved child and maternal health, bolstered by improved health, nutrition policy and education, that in turn increase the cognitive and physical development of children with a strong focus on the first 1,000 days. The increased capacity of children is then further augmented by improved education at all levels from institutions made more relevant and effective. These efforts enhance the quality of the workforce that now functions in a better environment for agricultural business and science and technology that in turn creates greater knowledge and entrepreneurial activity spurring economic and social development. Each iteration of the cycle further reduces poverty and malnutrition.

THE WAY FORWARD

The Purdue workshop was an important first step in engaging the U.S. and international research community and their partners to help develop and support a FTF research strategy. The goal of the workshop was not to try to explicitly define research projects but to lay the groundwork for developing such priorities within the three themes presented in the draft FTF Research Strategy. It is important that the process continue to be transparent and open, involving the full participation and input of the research community. USAID and USDA fully support inclusiveness, openness and transparency in this process.

The plan is to follow the Purdue meeting with a virtual consultation (or e-consultation) leading to an open meeting in June in Washington D.C. The e-consultation will define a set of major research challenges that support the Grand Challenge laid out by FTF (see Figure 2 below) and provide a series of specific hypotheses that must be addressed to

Figure 2: Process Structure



meet the challenges. The Grand Challenge is to reduce poverty and malnutrition as the world moves to more than nine billion people without negatively impacting the environment. To achieve the goals of the FTF initiative requires a 70 percent increase in food supply by 2050. This imperative necessitates that FTF becomes a true whole-of-government initiative, much like the Plant Genome Project or the United States Group on Earth Observations (USGEO <http://usgeo.gov>). To do so, we need to build strong consensus and support around key issues that we call challenges. To engage the federal science agencies at the June meeting, we need to have those key challenges identified and developed in May. We believe that no one government agency has unique responsibility for the science, engineering and technology needed to solve the Grand Challenge. To mount the effort required to realize the President's goal, we must enlist, rally and take full advantage of the opportunities of the "whole of government," including USAID, USDA, State, Interior (USGS), NASA, NSF, NIH and others. By identifying the timely opportunities where our research can make remarkable advances in the "virtuous cycle," this white paper and the output from the e-consultation can play a role so that high-level administrators of U.S. government agencies can, on the basis of these challenges, endorse the FTF research effort.

To give an illustrative example from the Purdue meeting, increasing the efficiency of photosynthesis was suggested as an important means to increase productivity (part of the Grand Challenge). This might be a "challenge" in Figure 2 below, identified in the e-consultation. An understanding and application of photosynthesis is an important part of the missions of several federal agencies including NSF, DOE and USDA. We would wish to engage the support of these agencies and build linkages that bring their efforts and unique expertise to bear on FTF. Under the photosynthesis example, there are many scientific questions or potential hypotheses (i.e., C1HYP1 in Figure 2) that affect the efficiency of photosynthesis. Describing those within the challenges also would be a product of the e-consultation.

An e-consultation will be established by APLU. The e-consultation will provide an opportunity for the research community to propose challenges and a set of hypotheses needed to address the challenge. We encourage a rich discussion of the importance of each challenge, their characteristics and their strengths and weaknesses, and potential impact. The result will be a list of research objectives directly supporting the grand challenge and aligned with the three themes of the USAID FTF research strategy. This list will provide substantive grounds for engaging the research resources from across the whole of the U.S. government, and thus build strong and broad support for FTF, a Presidential initiative.

RELATED RESOURCES

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