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

FEED THE FUTURE
INNOVATION LAB FOR HORTICULTURE

ANNUAL REPORT 2016-2017 HIGHLIGHTS

USAID
FROM THE AMERICAN PEOPLE

HORTICULTURE
INNOVATION LAB

UC DAVIS
UNIVERSITY OF CALIFORNIA

HORTICULTURE INNOVATION LAB

ANNUAL REPORT 2016-2017 HIGHLIGHTS

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COVER PHOTO (FRONT AND BACK):
Tomatoes packed in tall crates for markets in Burkina Faso: Photo by Guy Kodjogbe for Agribusiness Associates while working on a market assessment for a Horticulture Innovation Lab project focused on improving postharvest practices for tomatoes in Burkina Faso.

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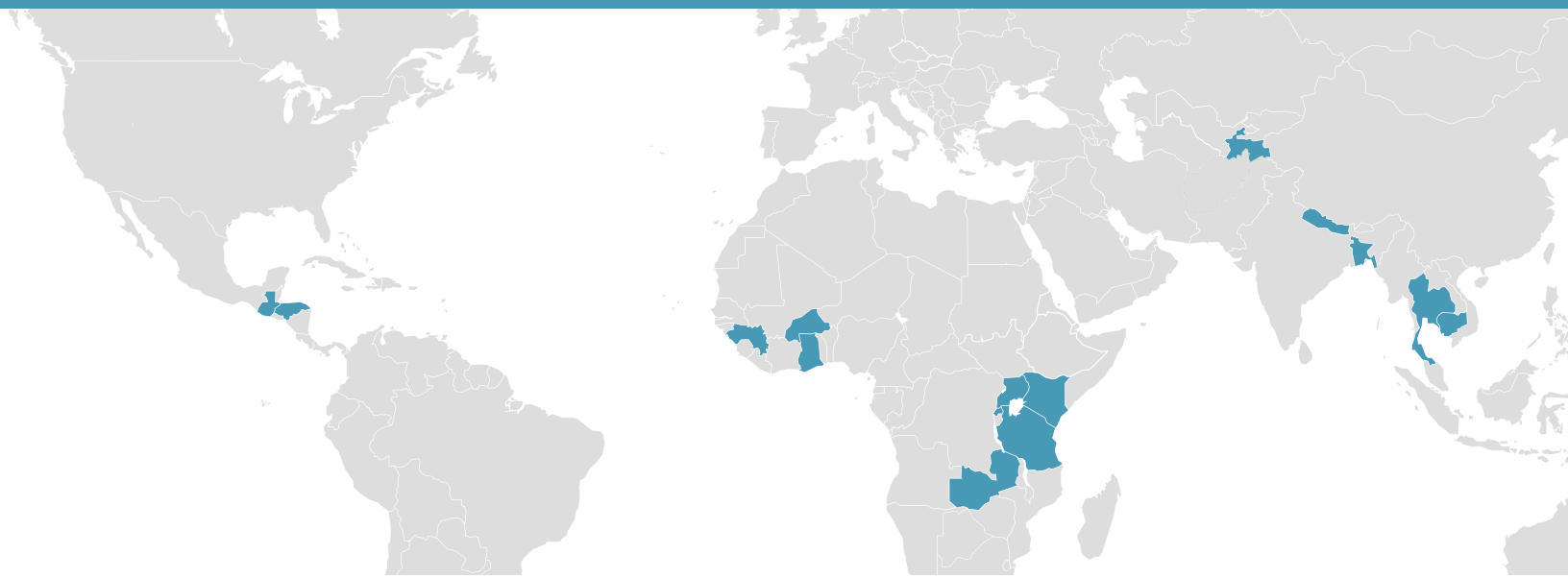
WHERE WE WORK



The Horticulture Innovation Lab currently works in:

Guatemala
Honduras

Guinea
Burkina Faso
Ghana

Kenya
Uganda
Rwanda
Tanzania
Zambia

Tajikistan
Nepal
Bangladesh
Cambodia
Thailand

ABOUT THE PROGRAM

The Horticulture Innovation Lab builds international partnerships for fruit and vegetable research to improve livelihoods in developing countries. The program began in 2009 when the U.S. Agency for International Development selected the University of California, Davis, to lead a $14.6 million, five-year program (then called the Horticulture Collaborative Research Support Program, or Horticulture CRSP). The university was awarded a subsequent phase for the Horticulture Innovation Lab for $18.75 million until 2019. The program has also been awarded nearly $5 million for additional projects.

The program helps the world's poorest people break out of a persistent cycle of poverty by improving smallholder farmers' abilities to grow and sell high-value crops. Improving livelihoods — through higher profits and diversified, nutrient-rich diets — is a primary goal for the Horticulture Innovation Lab's research efforts around the world. The program's work is guided by ensuring gender equity, improving information access, targeting innovative technologies and increasing research capacity.

Horticulture Innovation Lab projects span the value chain of fruit and vegetable production, from seed systems to postharvest processing. Individual projects are led by U.S. university researchers with collaborating partners in developing countries, with funding from $200,000 to $3 million. Collaborations have included more than 18 U.S. universities and 200 organizations in more than 30 countries of Latin America, Africa and Asia. Through partnerships and collaborative research, the program also aims to build the capacity of researchers, institutions and farmers to advance horticultural science. To scale up research results and new horticultural technologies, the Horticulture Innovation Lab funds Regional Centers in Thailand and Honduras.

WHY FRUITS AND VEGETABLES?

Fruits and vegetables are critical crops in ensuring income security and healthy diets. With a focus on high-value per land unit production and value chain efficiency, horticulture crops represent an important opportunity to improve health while also increasing income for smallholder farmers.

- **INCLUSIVE AND SUSTAINABLE AGRICULTURE-LED ECONOMIC GROWTH**
  Fruit and vegetable production and markets have a big impact. These crops generate high economic returns per unit of land, and postharvest entrepreneurial opportunities fuel agriculture supply chains. Farmers who grow high-value horticulture crops consistently earn more than those who grow other commodities, allowing smallholder farmers to derive additional income and driving agricultural and economic diversification. Innovation in horticulture crops offer increased production, value-added income, and long-term investment opportunities.
- **WELL-NOURISHED POPULATION, ESPECIALLY AMONG WOMEN AND CHILDREN**
  Horticulture has a unique role in ensuring access to and availability of diverse, nutritious food. Increased dietary diversity is highly correlated with better health, and thus reduction of malnutrition and stunting. Increases in income drive dietary shifts. While this can lead to improved human nutrition, it can also lead to increased consumption of processed, nutrient-poor foods, increasing the incidence of obesity and diabetes, alongside malnutrition. Undernutrition and overnutrition can co-exist even in the same household. Increasing fruit and vegetable consumption is one of the few dietary strategies that can help improve both situations.
- **GENDER EQUALITY AND FEMALE EMPOWERMENT**
  Women are often the main producers and marketers of horticulture crops, but women often have less access to markets, land, inputs, and education. Addressing these constraints places women growers on the path to increased control over income, increased family resiliency, and reduced time allocation and workload.

KEY ACCOMPLISHMENTS

FY2017 PERFORMANCE

At the conclusion of FY2017, the Horticulture Innovation Lab has granted all funds for the program's Phase II to develop knowledge on key information gaps across the horticulture value chain. During the past year, we have seen promising results emerge from these projects. Project teams actively engaged with more than 6,000 farmers, development practitioners, and others who benefited directly from U.S. government assistance.

- **INCREASING INCOME:** Research in Bangladesh shows the profitability of the Horticulture Innovation Lab chimney solar dryer particularly for fish and high-value crops including chili, groundnuts, and mung bean. Farmers also achieved higher profitability and reduced postharvest losses from short-term storage of high-value crops in the CoolBot cool room.
- **INCREASING PRODUCTION:** Research in Honduras demonstrated that grafted tomato plants with pathogen-resistant rootstocks can increase yields by 100 percent, reducing or eliminating the need for soil pesticides.
- **IMPROVING NUTRITION:** Two new lines of improved amaranth and two new lines of nightshades were entered into the Kenyan national new seed variety testing program. Seed from varieties that are higher in nutrients will be distributed to commercial and smallholder producers.
- **GENDER CONSIDERATIONS:** Initial analysis in Honduras of a baseline household survey emphasizes the low dietary diversity in western Honduras and issues of food security, particularly within single-female headed households. Women are disadvantaged in terms of ownership of assets and making decisions about credit. Although women in single-headed households show higher control over income-generating activities, they are less likely to consume adequate amounts of fruits and vegetables and are more likely to experience food insecurity.
- **NEW TECHNOLOGY DEVELOPMENT:** This year's research included field-testing or scaling of 60 new technologies (excluding seed varieties).
- **ADOPTION OF IMPROVED TECHNOLOGIES:** 4,000 farmers report using improved technologies and 620 hectares are under new technology.
- **BUILDING IN-COUNTRY CAPACITY:** Our program provided training to build the capacity of 2,397 government, private sector, and civil society individuals and 167 organizations in Africa, Asia and Latin America.
- **LONG-TERM AND SHORT-TERM TRAINING:** Our program is training 75 graduate and undergraduate students. Horticulture Innovation Lab researchers also provided short-term training to 6,365 individuals.
- **INVESTMENT IN YOUNG ENTREPRENEURS:** The Horticulture Innovation Lab established a new youth-led Horticulture Training and Services Center in Kindia, Guinea. Young entrepreneurs will demonstrate production and postharvest technologies at a government-led agriculture research center.

EXECUTIVE SUMMARY

The Horticulture Innovation Lab manages a portfolio of horticulture research projects in Africa, Asia and Latin America. We are proud of the accomplishments of our extensive network of researchers over the past year to advance knowledge of how to use horticulture to increase income generation and reduce malnutrition in emerging economies. We continue to see a high degree of collaboration among our project teams working across the globe, sharing effective technologies and approaches with colleagues working on other continents. This speaks to the global impact of our research and capacity building projects. Our projects are also very collaborative with other research and development organizations, both within the focus country and internationally. We also collaborate closely with several other Feed the Future Innovation Labs, including the Nutrition Innovation Lab (Bangladesh), the IPM Innovation Lab (Cambodia) and the Sustainable Intensification Innovation Lab (Cambodia). Our horticulture research is focused on the needs of small-scale farms, benefiting farmers in the United States as well as those in Feed the Future countries.

GLOBAL IMPACT OF RESEARCH OUTCOMES

Horticulture Innovation Lab researchers have field-tested or scaled 60 new technologies (not including seed varieties), and 4,000 farmer beneficiaries report using improved technologies.

Highlights from our research on horticulture production include work in Uganda, where researchers prototyped more than five agricultural tools to improve the ease and effectiveness of horticulture irrigation. Improved varieties of amaranth and two varieties of African nightshade plants were officially recommended for formal release. Other researchers are improving production of indigenous vegetables and studying their impact on human nutrition. Researchers working in Cambodia found that conservation agriculture methods reduce vegetable pests, save water, enhance soil health, and save labor. Farmers were able to increase vegetable production land sizes due to labor savings (no need to till or weed), and farmer income was increased as well as women's control over income and decision-making power.

Improving postharvest handling and reducing losses in quantity and quality after harvest are an important area of focus for the Horticulture Innovation Lab. Postharvest loss assessment studies for tomato, orange fleshed sweet potato, green chili, and plantain were completed, and postharvest training material was translated into French. The profitability of the chimney solar dryer, particularly for fish and high-value crops, was demonstrated in Bangladesh. Bangladeshi farmers also achieved higher profitability and reduced postharvest losses from short-term storage of high-value crops in the CoolBot cold room.

Progress has been made in developing the human capacity of local universities to critically think about horticulture problems, develop research questions, conduct experiments and gather data that addresses pressing horticulture problems. During the past year, the Horticulture Innovation Lab has trained 75 graduate and undergraduate students (long-term training) and 6,366 short-term trainees.

PARTNERSHIPS WITH OTHER PROGRAMS

Many of our projects have established collaborations with USAID Mission-supported Value Chain Projects and other development and research organizations. Our tomato

postharvest project in Burkina Faso formed a team from multiple organizations funded by USAID in Burkina Faso (CRS, INERA, ACDI-VOCA) to develop best practices and disseminate research outcomes. Our Regional Center in Thailand collaborates with Winrock International on their Feed the Future Asia Innovative Farmers Activity. The Winrock collaboration has helped the Regional Center to engage with additional target groups and distribute suitable technologies. Our Regional Center in Honduras has assisted Fintrac in construction of solar dehydrators, and implemented zero energy cooling chambers and a solar dehydrator in El Salvador for a project with the Ministry of Education. Our project to scale the drying bead technology, that improves the drying and dry-storage of vegetable seed, has collaborated with the Feed the Future Bangladesh Agricultural Value Chain Project (led by DAI) to introduce the technology in Bangladesh, and have received support from Winrock to identify distributors in Bangladesh and Cambodia for drying beads.

The Horticulture Innovation Lab is also collaborating with the World Vegetable Center on many activities. The World Vegetable Center provided two tomato varieties well suited for the rainy season to our partner in Burkina Faso, Environmental Institute for Agricultural Research (INERA). These two varieties, along with other INERA varieties, are under evaluation for suitability in the region. Also, 10 amaranth varieties developed by one of our projects were transferred from Rutgers University to the World Vegetable Center for inclusion in the organization's activities. Our researchers also collaborated with WorldFish on its ECOFISHBD program to assist them in introducing the UC Davis-designed chimney solar dryer to coastal fishing communities in Bangladesh.

LEVERAGING PARTNERSHIP IN PRIVATE SECTOR

Collaboration with the private sector is critical to scaling new technologies and has many benefits for small scale farmers. We have engaged with several private companies as partners on our research program. Rhino Research, based in Thailand, has collaborated on research projects and is now leading the efforts to scale the drying beads technology. They have successfully recruited several local seed companies in Bangladesh to adopt this technology, and now two of the largest, Lal Teer and Metal Seed, are disseminating the drying bead technology in Bangladesh and are strong supporters. With the help of the Bill and Melinda Gates Foundation, the Bangladesh Rice Research Institute (BRRI) is adopting the drying bead technology for its rice seed germplasm repository.

We have developed a franchise model for scaling out the DryCard™ technology developed by the Horticulture Innovation Lab management entity team. We make franchise agreements with small-scale entrepreneurs in primarily Feed the Future countries who agree to produce and sell the cards to specifications, and provide samples for quality control purposes.

DOMESTIC BENEFITS

The research of the Horticulture Innovation Lab Program contributes greatly to the body of knowledge for fruit and vegetable growers in the United States. While staple crops receive billions of dollars in domestic financial support, horticulture ("specialty crop") producers only receive about 14% in resource investment compared to U.S. commodity producers. The Horticulture Innovation Lab assists this industry by supporting U.S. university research on these crops. About 90 percent of farms in the United States are small farms, and our program invests in finding appropriate technologies for these farmers. The CoolBot, the UC Davis chimney solar dryer, and zeolite drying beads are all examples of technologies that provide higher incomes for small- and medium-sized farmers.

THOUGHT LEADERSHIP

The Horticulture Innovation Lab is committed to being a thought leader and source of information within the horticulture-for-development community. In that effort, we have hosted or co-hosted three workshops this year: Postharvest Roundtable at the first All-Africa Postharvest Conference, UC Davis Aligning the Food System: Fruits and Vegetables Conference, and Food and Nutrition Security in the Developing World Workshop at the American Society for Horticulture Science Conference. Workshops in 2016 and 2017 resulted in two white papers and one forthcoming.

PARTNER WITH US

The Horticulture Innovation Lab's global research network advances fruit and vegetable innovations for smallholder farmers with solutions that can reduce women's labor, reduce waste between the farm and the market, and increase the availability of highly nutritious fruits and vegetables at markets. This work aims to increase not only the diversity of crops grown on a farm or region, but also to increase the dietary diversity of farmers and their communities.

The program can provide expertise to assist organizations and donors, with proven success leading:

- **REGIONAL CENTERS FOR HORTICULTURE AND POSTHARVEST SERVICES**
  We partner with national universities and agricultural leaders to build hubs for horticultural education and research.
- **POSTHARVEST TRAINING**
  We educate in-country professionals on technologies and practices, to maintain quality and reduce postharvest losses for horticultural crops.
- **VALUE CHAIN ANALYSIS**
  We investigate new opportunities for partnerships and efficiency by understanding relationships between stakeholders in horticulture value chains and their context.
- **TECHNOLOGY INNOVATION**
  We have a suite of horticultural technologies that our teams have proven valuable in reducing postharvest losses, reducing pesticide use, improving soil health, reducing drudgery, improving horticultural production, advancing seed systems and expanding entrepreneurial opportunities related to horticulture. We also have experience adapting and testing new ideas or concepts in improving productivity, food quality, or postharvest practices.

The program continues to further strengthen the capacity of its network with new collaborators. While research funds for this phase have now been allocated, individuals and volunteers can connect with the Horticulture Innovation Lab by:

- **SUBSCRIBING TO OUR EMAIL NEWSLETTER**
  Our email newsletter includes program updates and the latest research results from project teams.

MANAGEMENT TEAM


Elizabeth Mitcham
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Erin McGuire
Associate Director


Michael Reid
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Angelos Deltsidis
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Amrita Mukherjee
Assistant Specialist
in Bangladesh


Débora Rivera
Chief of Party
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Gabriel Wyland
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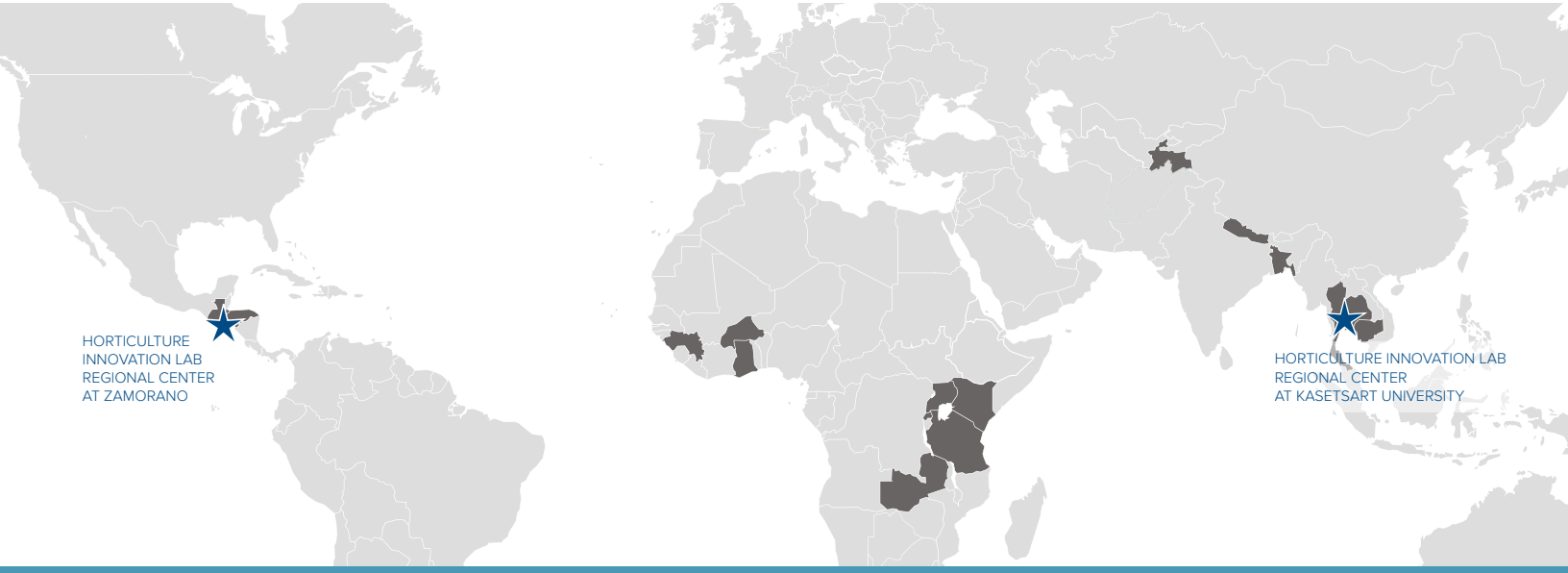
in Guinea

Student interns, assistants and scholars included: Elyssa Lewis, Emily Webster, Julia Jordan, Khush Bakht Aalia, Kari Flores, Lauren Howe, Hallie Casey, Asha Sharma, Katie von der Lieth, Michelle Boutell and Chelsea Supawit.



REGIONAL CENTERS

The Horticulture Innovation Lab supports Regional Centers at local institutions to bring together key players for horticultural development activities in nearby countries. As horticultural hubs, the centers focus on adapting innovative technologies, training farmers and exchanging information with Horticulture Innovation Lab projects and partners

The program currently has two established and active centers:

- **HORTICULTURE INNOVATION LAB REGIONAL CENTER AT ZAMORANO IN HONDURAS**
- **HORTICULTURE INNOVATION LAB REGIONAL CENTER AT KASETSART UNIVERSITY IN THAILAND**

Patricia Arce, center, discusses chimney solar dryers with visitors to the Horticulture Innovation Lab Regional Center at Zamorano. Photo by Gabriela Hernandez

HORTICULTURE INNOVATION LAB REGIONAL CENTER AT ZAMORANO (HONDURAS)

The Horticulture Innovation Lab Regional Center at Zamorano offers services to the Central American region, particularly to Honduras and Guatemala, including: adaptation and evaluation of horticulture technologies; training for technicians, promoters and farmers; the development of study plans and didactic materials for different sectors; implementation of postharvest technologies, integrated pest management, climate change mitigation technologies, efficient and sustainable production systems for fruits and vegetables; and technical assistance for small- and medium-scale farmers.

COLLABORATORS:

- Panamerican Agricultural School, Zamorano, Honduras (Lead)
- Horticulture Innovation Lab at UC Davis, USA

FEATURED ACHIEVEMENTS:

- The Regional Center has become institutionalized according to framework proposed with the Horticulture Innovation Lab and is now linked with other institutions. Collaborations and strategic alliances established include: CRS, Rikolto, FONTAGRO, DICTA, IICA, FUNDER, FAO, FHIA, Kolping-Honduras, CARE, University of Wisconsin-Madison, the Ohio State University, North Carolina State University, Kansas State University, Pennsylvania State University, the Ministry of Agriculture and Livestock of Honduras, the National Agricultural University of Honduras, the Ministry of Education of El Salvador, and the Ministry of Education of Honduras.
- 160 student interns from different educational centers, both national and international, joined the Regional Center in establishing it as a gathering place for "learning by doing" for the students of Zamorano.
- The technicians, producers and promoters who receive trainings interact with the Regional Center's various on-site technologies. This year, 1,380 individuals have been trained in horticulture production, integrated pest management, extension methodologies, good agricultural practices, family agriculture and other foci.

Team members from the Horticulture Innovation Lab Regional Center at Kasetsart University work on nethouses in Cambodia, in partnership with the Feed the Future Asia Innovative Farmers project.

HORTICULTURE INNOVATION LAB REGIONAL CENTER AT KASETSART UNIVERSITY (THAILAND)

The Horticulture Innovation Lab Regional Center at Kasetsart University in Thailand has worked on several activities with various partners to disseminate horticulture technologies to Feed the Future countries in Asia, including Nepal, Bangladesh, and Cambodia. The Center works to evaluate, adapt, and demonstrate technologies, and conducts training programs.

COLLABORATORS:

- Kasetsart University, Thailand (Lead)
- Horticulture Innovation Lab at UC Davis, USA
- Royal University of Agriculture (RUA), Cambodia
- University of Agriculture and Forestry (AFU), Nepal
- District Agriculture Development Office and Agriculture Research Center, Nepal
- Winrock International
- Erasmus+
- Bangladesh Agricultural University, Bangladesh
- DAI Bangladesh
- Sher-e-Bangla Agricultural University, Bangladesh
- Project ALBA, Cambodia
- The Horticulture Research Division, Nepal
- The Regional Agriculture Research Station, Nepal

FEATURED ACHIEVEMENTS:

- Conducted six in-country trainings, two trainings in Bangladesh, five research projects, and supported one graduate student.
- Continued collaboration with Winrock International in the Feed the Future Asia Innovative Farmers Activity project and expanded the training collaboratively to farmer groups in Cambodia and Bangladesh. The Winrock collaboration has helped the Center to engage with additional target groups and distribute suitable technologies.
- Participated, as an associate partner, in Erasmus+ and this organization's capacity building in higher education project. This collaboration will expand the Regional Center's reach to regions outside of Asia.
- Private sector groups have started studying the Regional Center's low-cost technologies and are interested in using the Horticulture Innovation Lab technologies for their contract farmers. These encounters offer good opportunities to conduct research for specific technologies with financial support from private sector.

RESEARCH PROJECTS

Horticulture is a critical component in empowering women and the most vulnerable, increasing incomes for smallholder farmers, and improving nutrition for farming communities. Thus, the Horticulture Innovation Lab is committed to the Feed the Future objectives of inclusive agricultural growth, increased resiliency, and better nutrition (particularly for women and children). We strive to assure each of our projects addresses all three of these important goals. Project reports are organized by the three highest level objectives of Feed the Future:

INCLUSIVE AND SUSTAINABLE AGRICULTURE-LED ECONOMIC GROWTH:

Growth in the agriculture sector has been shown in some areas to be more effective than growth in other sectors at lifting men and women out of poverty, increasing food availability, generating income, creating employment and entrepreneurship opportunities throughout value chains, and spurring growth in rural and urban economies. Projects include:

- Empowering women through horticulture in Honduras
- Managing nematodes and soil health in Guatemala
- Promoting conservation agriculture for vegetable growers in Cambodia and Nepal
- Scaling up drying technologies for seed in Bangladesh
- Improving postharvest practices for tomatoes in Burkina Faso
- Improving practices for dried apricots in Tajikistan
- Assessing feasibility of pest-exclusion nets in Kenya
- Expanding tomato grafting for entrepreneurship in Guatemala and Honduras

STRENGTHENED RESILIENCE AMONG PEOPLE AND SYSTEMS:

Increasingly frequent and intense shocks and stresses threaten the ability of men, women, and families to sustainably emerge from poverty. Projects include:

- Reducing postharvest losses in Rwanda
- Establishing a horticulture center in guinea
- Promoting drip irrigation and climate resilience in Guatemala (MásRiego)
- Developing farmer-led irrigation solutions in Uganda
- Trellis Fund: Engaging graduate students in international development
- Designing for horticulture development with d-labs in Thailand and Honduras

A WELL-NOURISHED POPULATION, ESPECIALLY AMONG WOMEN AND CHILDREN:

Undernutrition, particularly during the 1,000 days from pregnancy to a child's second birthday, leads to lower levels of educational attainment, productivity, lifetime earnings, and economic growth rates. Projects include:

- Improving nutrition with African indigenous vegetables in Kenya and Zambia
- Examining nutrition impacts of horticultural innovations in Bangladesh
- Investigating integrated vegetable-livestock systems in Cambodia
- Building safe vegetable value chains in Cambodia
- Franchising the DryCard™

PROJECTS BY FEED THE FUTURE OBJECTIVES

INCLUSIVE AND SUSTAINABLE AGRICULTURE-LED ECONOMIC GROWTH

Farmer and her family show team member Alejandra Cuellar, right, their home garden in Las Delicias de Concepción, Copán, Honduras. Photo by Josué Bonilla

EMPOWERING WOMEN THROUGH HORTICULTURE IN HONDURAS

The families of western Honduras are living in an economy marked by high poverty rates, poor diets, and subsistence agriculture, with prevailing disadvantages tolling hard on women and their children. This project aims to identify technologies, institutions, and policies that facilitate small-scale farmers producing horticultural products to improve their household nutrition and to seize other opportunities in the horticultural value chain for entrepreneurs and wage laborers. The research will also spotlight policies, regulations, and cultural norms that limit the participation of women and other marginalized groups in the horticultural value chain and build partnerships with local NGOs, microfinance institutions and women's organizations to develop and deliver appropriate training, technologies and financial tools to producers, NGOs, private enterprises, and research institutes.

COLLABORATORS:

- Pennsylvania State University, USA (Lead)
- Tuskegee University, USA
- Panamerican Agricultural School, Zamorano, Honduras

FEATURED ACHIEVEMENTS:

- Completed baseline data collection. Initial analysis of the baseline household survey emphasizes the low dietary diversity in western Honduras and issues of food security, particularly within single-female headed households. Although women in single-headed households show higher control over income generating activities, they are less likely to be consuming adequate amounts of fruits and vegetables and are more likely to experience food insecurity.
- In March 2017, the team held a workshop with key stakeholders at Zamorano. Participants included multi-sector representatives from organizations such as USAID/Honduras, Fintrac, the Universidad Nacional Autónoma de Honduras, as well as representatives from 18 producer organizations from the Feed the Future zone of influence.
- Ongoing partnership with Zamorano has led to an increased exposure to gender issues for students, faculty, and technicians.
- Piloted a farmer field school in the last quarter of 2017.
- Penn State faculty served as gender consultants on two other Horticulture Innovation Lab-supported projects.

Haddish Melakeberhan, right, of Michigan State University examines plant roots with a farmer in Guatemala. Photo by Erin McGuire

MANAGING NEMATODES AND SOIL HEALTH IN GUATEMALA

Plant-parasitic nematodes and soil degradation on smallholder farms reduce yields and limit food security. With smallholder potato farmers in the Western Highlands of Guatemala, a transdisciplinary research team is demonstrating and advocating for integrated practices of cover cropping, intercropping, soil amendments, bio-pesticides, and crop resistance to manage nematodes and soil health.

COLLABORATORS:

- University of Hawai'i at Mānoa, USA (Lead)
- Michigan State University, USA
- Universidad de San Carlos de Guatemala

FEATURED ACHIEVEMENTS:

- The research team established 16 demonstration/research plots with smallholder potato farmers. All materials used in the experimental plots were purchased from the Cooperative Potato Growers Association.
- Field days with local farmers have highlighted the impacts and benefits of improving soil health for nematode control and enhancing rural livelihoods.
- Researchers held a workshop on modeling at the Universidad de San Carlos de Guatemala, to build faculty and staff capacity in developing models, conducting surveys, and analyzing data.
- Researchers have partnered with Popoyán, a private company, to demonstrate biological control for nematodes. Popoyán employees have assisted in establishing demonstration plots and in demonstrating how to properly apply biological controls for effective nematode management.
- Students are involved in the project in several ways: a doctoral student at the University of Hawai'i assists with economic and social science research; a post-doctoral fellow at Michigan State University collects soil-health and nematode data; and an undergraduate intern in Huehuetenago, Guatemala, assists in collection of survey data and maintaining the demonstration plots.

Farmer Kim Chuat grows eggplant with drip irrigation and conservation agriculture practices, as part of a farmers cooperative working with Horticulture Innovation Lab researchers in Cambodia. Photo by Brenda Dawson

PROMOTING CONSERVATION AGRICULTURE FOR VEGETABLE GROWERS IN CAMBODIA AND NEPAL

In regions of Cambodia and Nepal, water can be scarce for extended periods, negatively affecting horticultural crop production and food security. This project addresses this problem through water- and labor-saving technologies, including rainwater harvest and storage, drip irrigation, and conservation agriculture systems. These technologies can boost food security and climate-change resiliency, since soil erosion can be controlled, land productivity and farmer income can be enhanced, and water quality can be improved. This project builds upon a previously completed project in Cambodia and focuses on marginalized smallholders who farm small, income-generating vegetable gardens. The project provides trainings and market pathways as incentives for the farmers to shift from traditional methods to using drip irrigation, conservation agriculture, and rainwater harvesting.

COLLABORATORS:

- North Carolina Agricultural and Technical State University, USA (Lead)
- Agricultural Development Denmark Asia, Cambodia
- Royal University of Agriculture (RUA), Cambodia
- International Development Enterprise (iDE), Nepal

FEATURED ACHIEVEMENTS:

- Researchers found that conservation agriculture practices increase yield and prolong the growing season of several vegetables, extending harvest for vegetables like eggplant, tomato, chili and string beans.
- Conservation agriculture practices allowed farmers to increase vegetable production land sizes due to labor savings (no need to till and control weeds).
- Conservation agriculture practices increased income, especially for women.
- Additional partnerships with Kasetsart University, the University of Battambang, the World Vegetable Center, ECHO Asia, Penn State, Kansas State University, the University of Florida, the University of Illinois, and the University of Tennessee.

Seed experts meet for week-long training to become certified drying specialists in Dhaka, Bangladesh.

SCALING UP DRYING TECHNOLOGIES FOR SEED IN BANGLADESH

The goal of this project is to create the foundation for diffusion and large-scale adoption of advanced drying technologies in Bangladeshi agriculture. Drying in the humid climate of Bangladesh poses a significant challenge to seed production and agricultural processing. Traditional sun drying and dry room/cold storage methods lead to a rapid deterioration of the quality of agricultural outputs and especially seeds, resulting in large postharvest losses and susceptibility to mold, fungi and insect infestations. This project will address the challenges of drying seeds and commodities in hot, humid climates by scaling up the dry chain concept for horticultural seeds and commodities that was developed through a previous project. The project team will promote the commercial adoption of drying beads technology in Bangladesh for seeds.

COLLABORATORS:

- Rhino Research, Thailand (Lead)
- University of California, Davis, USA
- Professor Jayashakar Telangana State Agricultural University, India

ACHIEVEMENTS:

- Lal Teer seed company in Bangladesh widely adopted drying beads. The company estimates that between 2016 and 2017, it has dried 21,250 kg of seed with drying beads, trained 414 farmers to use drying beads in their seed production, and potentially supplied 110,000 farmers with seed dried with drying beads.
- Completed fifth and sixth sessions of week-long trainings in a certificate series for seed experts to become drying specialists in Bangladesh seed industries.
- Presented drying beads and dry chain concept at Innovation Summit Series in Dhaka, Bangladesh, and at the first All-African Postharvest Congress in Nairobi, Kenya.
- Leveraged activities: Seed companies Lal Teer and Metal Seed are disseminating the drying beads technology and are strong supporters. With the help of the Bill and Melinda Gates Foundation, Bangladesh Rice Research Institute (BRRI) is adopting the drying beads for rice seed storage purposes. With support from DAI, Rhino Research is introducing the technology in Bangladesh. Support from Winrock has been leveraged to find distributors in Bangladesh and Cambodia for drying beads.

Issues with packaging and transportation in the tomato value chain were among the highlights of a market study in Burkina Faso, to identify market and postharvest opportunities. Photo by Guy Kodjogbe

IMPROVING POSTHARVEST PRACTICES FOR TOMATOES IN BURKINA FASO

Tomatoes are an important crop for increasing household resilience and nutrition in Burkina Faso. However, tomato farming is largely at a subsistence level, and farmers face many challenges, chiefly low bargaining power due to a supply glut. Given the current market situation, postharvest solutions that increase the quality and shelf-life of tomatoes, through improved postharvest handling, storage, packaging and processing will make the crop more lucrative for farmers. The project improves postharvest handling, storage, processing and marketing of tomatoes in Burkina Faso.

COLLABORATORS:

- Agribusiness Associates, USA (Lead)
- The Postharvest Education Foundation, USA
- USAID/Burkina Faso
- USAID/Sahel Regional Office
- Environmental Institute for Agricultural Research/Burkina Faso (INERA), Burkina Faso
- ACDI-VOCA, Burkina Faso

FEATURED ACHIEVEMENTS:

- This project has formed a team from multiple organizations funded by USAID in Burkina Faso (CRS, INERA, ACDI-VOCA). This multidisciplinary team will be working together along the information value chain to develop best practices and ultimately disseminate research outcomes.
- Completed a market study of Burkina Faso's tomato value chain, currently awaiting publication. Irrigation and inappropriate usage of cotton pesticides were found to be production issues. Poor packaging and transportation were found to be issues in postharvest practices. At the market, all of the tomatoes in good condition were sold, while over-ripe, sometimes rotting tomatoes were left behind for Burkinabe families.
- INERA sourced two tomato varieties well suited for the rainy season through the World Vegetable Center. These two varieties along with other INERA varieties are being trialed for evaluation for suitability in the region. Further, farmer field trials are currently developing rainy season varieties suitable for Burkina Faso in project region.
- Postharvest training material has been translated into French for the convenience of the local team and for general use in francophone Africa.

Rustam Bobohonov of Tajik Agrarian University discusses apricot drying at a homestead in southern Tajikistan, as part of an assessment of the state of dried apricot fruit industry. Photo by Klein Ileleji

IMPROVING PRACTICES FOR DRIED APRICOTS IN TAJIKISTAN

Apricots have the potential to be a high-value crop for small-scale farmers in southern regions of Tajikistan, but unhygienic drying conditions contaminate the fruit with soil, stones and dust thus reducing the fruit's phytosanitary condition and economic return to growers. The project aims to evaluate markets and potential for smallholder farmers to produce export-quality dried apricots, assess food safety challenges, build meaningful collaborations with local institutions and compare three solar dryers with current methods of drying in Tajikistan's Khatlon province.

COLLABORATORS:

- Purdue University, USA (Lead)
- Tajik Agrarian University, Tajikistan
- Jua Technologies International, LLC, USA
- Feed the Future Tajikistan Agriculture and Water Activity, Tajikistan

FEATURED ACHIEVEMENTS:

- Two in-country assessment teams assessed the state of the dried apricot fruit industry to determine the strategies to improve the quality and marketing of dried apricots in Southern Tajikistan.
- The team from Purdue University gave a presentation at Tajik Agrarian University, which provided the opportunity to understand current practices and allowed for the development of training materials that can be used to train growers on best practices.
- Conducted tests to evaluate quality attributes of dried apricots including moisture content, water activity, color, and microbial contamination. The project team learned that Tajikistan dries apricots to a lower moisture than apricots found in the grocery stores in the United States and sanitary conditions may be a greater issue than drying.

Farmer Sylvia Kuria, center, discusses growing vegetables inside an AgroNet with Elizabeth Mitcham, director of the Horticulture Innovation Lab during a site visit. Photo by Thibaud Martin

ASSESSING FEASIBILITY OF PEST-EXCLUSION NETS IN KENYA

This one-year pilot study examines the commercial feasibility of scaling up the use of AgroNets, also known as Eco-Friendly Nets, for sustainable production of fresh market vegetables in Kenya. Very promising research results show that netting technology leads to increased yields and increased marketable produce, while simultaneously reducing the use of synthetic insecticides or eliminating their application altogether, enhancing export compliance with European Union requirements. As such, use of the nets has generated significant interest among growers, particularly smallholder farmers, grower associations, and netting manufacturers.

COLLABORATORS:

- Michigan State University USA (Lead)
- Center for International Cooperation in Agronomic Research for Development (CIRAD)
- Center for Large Scale Social Change, LLC, USA
- A to Z Textiles, Ltd., Tanzania
- International Centre of Insect Physiology and Ecology (icipe), Kenya
- Real-IPM, Kenya
- Finlays, Kenya
- Sunripe, Kenya
- Frigoken, Ltd., Kenya

ACHIEVEMENTS:

- Farmers have been trained at all project sites on the application, advantages and availability of netting technology.
- The team collected data on farmer credit history as well as barriers to credit access. Efforts have been made to meet potential financial providers, and negotiations are under way to establish a repayment plan based on return on investment.
- Demonstrations, field days and exhibitions of netting technology have been carried out in 36 out of 47 counties in Kenya. Partnership with the SNV Netherlands development organization through its HortIMPACT project to improve awareness of the technology helped link farmers to better markets, helped farmers get access to quality seeds and exposed them to the concept of using bio-pesticides.

Farmer Francisco Gabriel Baten Ajtún shows one of his grafted seedlings during a training on grafting tomato plants in Totonicapán, Guatemala, led by a UW-Madison researcher in cooperation with Catholic Relief Services. Photo by Erick Gutierrez

EXPANDING TOMATO GRAFTING FOR ENTREPRENEURSHIP IN GUATEMALA AND HONDURAS

Tomato grafting technology is a proven technology increasingly adapted worldwide to reduce risk of soilborne pathogens. Grafting produces a physical hybrid plant, with rootstock chosen for its genetic ability to resist soil borne disease, and scion chosen based on fruit quality for commercialization. The technology is relatively simple, but can have a huge impact in providing more sustainable production and added value to small-scale growers. Grafting thus creates an opportunity for entrepreneurial groups to specialize in the production and sale of grafted tomato seedlings.

COLLABORATORS:

- University of Wisconsin-Madison, USA (Lead)
- The Ohio State University, USA
- Catholic Relief Services, Guatemala
- Panamerican Agricultural School, Zamorano, Honduras
- World Vegetable Center

FEATURED ACHIEVEMENTS:

- Final data collection and harvest is complete in Guatemala at Totonicapan, and analysis is under way. Researchers believe they have demonstrated that grafted tomatoes can increase yield by 100 percent and reduce or eliminate need for soil pesticides.

PROJECTS BY FEED THE FUTURE OBJECTIVES

STRENGTHENED RESILIENCE AMONG PEOPLE AND SYSTEMS

One value chain examined by the team for the postharvest loss assessment studies was green peppers, shown here being sorted and packed for export markets. Photo by Jesse Daystar

REDUCING POSTHARVEST LOSSES IN RWANDA

The project aims to understand and identify the most efficient ways to reduce postharvest losses in Rwanda, to ultimately increase food security. Postharvest management is a systems-based challenge and requires an integrated innovation strategy that incorporates technological and financial innovations, capacity building across the value chain, enhanced market access and other elements to achieve impact at scale. Overall, the project's work in postharvest innovations and interventions will help farmers and agribusiness enterprises gain better return on investments by adopting appropriate technology and reducing postharvest losses.

COLLABORATORS:

- Agribusiness Associates, USA (Lead)
- Ministry of Agriculture and Natural Resources, Rwanda
- The Postharvest Educations Foundation, USA

FEATURED ACHIEVEMENTS:

- The team completed postharvest loss assessment studies for tomatoes, orange-fleshed sweet potatoes, green peppers, and plantains.
- The team established a Postharvest Training and Services Center (PTSC) in Mulindi, with a soft launch during the Agrishow Exhibition in June 2017. The center is equipped with CoolBot cold room, zero-energy cool chamber, chimney solar dryer, external shade, shelves, cabinet, crates and toolkit.
- The PTSCs in Busogo and in Huye are progressing towards launch. The PTSCs are equipped with a CoolBot cold room, zero-energy cool chamber and external shade structure.
- This year, the project teams successfully trained 44 individuals on postharvest innovations and trained 20 people on agribusiness development with a focus on postharvest technology and solutions. The project trained 19 cooperatives, producers, entrepreneurs and small- to medium-scale food businesses on business development.

Young AVENIR agents work to help plant pineapples and install plastic mulch in a demonstration garden at the new horticulture center. Photo by Andra Williams

ESTABLISHING A HORTICULTURE CENTER IN GUINEA

This project establishes a Horticulture Training and Services Center on the campus of the *Institut de Recherche Agronomique de Guinée* (IRAG), with leadership from young entrepreneurs who are part of the AVENIR program (*Agents en Vulgarisation, Entrepreneuriat et Innovation Rurale*, or "agents of extension, entrepreneurship and rural innovation") with Feed the Future Guinea Agricultural Services and Winrock International. The AVENIRs will serve as extension agents and establish revenue-generating training modules at the Horticulture Training and Services Center at IRAG that will feature appropriate technologies and best agricultural practices. Technologies featured include the CoolBot, drip irrigation, the UC Davis-designed chimney solar dryer, the DryCard, plastic mulch, and others. The center's promotion of these technologies aims to address horticultural production and storage needs, improve production practices and reduce postharvest losses in Guinea — with a focus on market-based solutions.

COLLABORATORS:

- Horticulture Innovation Lab, UC Davis (Lead)
- Institut de Recherche Agronomique de Guinée (IRAG), Guinea
- Feed the Future Guinea Agricultural Services, implemented by Winrock International and Cultivating New Frontiers in Agriculture (CNFA), Guinea

FEATURED ACHIEVEMENTS:

- The project has trained four Winrock AVENIRs and two IRAG agricultural specialists from the government on best practices and techniques covering four technologies: CoolBot, DryCard, the chimney solar dryer, and drying beads.
- AVENIRs and agents have identified at least 6 interested partners who would like to install CoolBots at their cooperatives.
- The team has demonstrated and tested the DryCards on local seeds and dried local food products, resulting in an agreement with two local seed vendors to start showcasing and selling the cards.
- The AVENIRs and agricultural specialist have been trained on how to fabricate and use the chimney solar dryer. The team has identified local women's groups who already work with dried fruit and food products for training and implementation.
- The team has planted and maintained a 1-acre garden with 10 vegetable test plots. These test plots will be used to teach improved growing techniques and as a showcase for technologies.
- The project works in collaboration with the government agricultural center, IRAG, which has significantly expanded the center's ability to hold demonstrations and trainings, and to conduct research.

Technicians who work with farmers in Guatemala's western highlands learn and practice farmer field school methodologies. Photo by Ivanna Vejarano

MÁSRIEGO: PROMOTING DRIP IRRIGATION AND CLIMATE RESILIENCE IN GUATEMALA

The MásRiego project promotes private sector development and small-scale commercial horticultural production by increasing the use of low-pressure drip irrigation, conservation agriculture and improved water management practices. The international project team will train 6,000 farmers, youth and women in eight municipalities of Quiche and Totonicapan. The team will also set up self-sustaining financial systems for purchasing drip irrigation kits, with the goal of creating micro-enterprises that continue after the program is complete. The project team aims to help farmers convert at least 90 hectares into climate-smart agriculture with drip irrigation, through irrigation kits customized for small plots. The project builds upon previous Horticulture Innovation Lab research by combining conservation agriculture practices and drip irrigation to better grow vegetables on small plots. The project also grew out of the program's "Advancing Horticulture" report about opportunities for growth in the fruit and vegetable sectors in Central America.

COLLABORATORS:

- Horticulture Innovation Lab, UC Davis (Lead)
- Centro de Paz Bárbara Ford (CPBF), Guatemala
- Panamerican Agricultural School, Zamorano, Honduras
- North Carolina Agricultural and Technical State University, USA
- Kansas State University, USA

FEATURED ACHIEVEMENTS:

- Seven Guatemalan technicians are now qualified on drip irrigation and conservation agriculture by Zamorano and Kansas State University. Also 220 farmers have been trained on topics prioritized within the framework of the project. Technicians of the MásRiego project are now capable of installing medium-scale irrigation systems.
- MásRiego is now fully staffed with 14 technicians, a program coordinator, and is currently in the process of hiring a technical advisor.
- Collaboration with Zamorano and Kansas State University has significantly increased the capacity of the Centro de Paz Bárbara Ford to implement agriculture projects. Zamorano held trainings with the CPBF team on good agriculture practices, production of grafted seedlings, and extension methodologies related to farmer field schools. Kansas State University has held many trainings on conservation agriculture practices and drip irrigation.
- The project has successfully collaborated with several local institutions that work within the same scope as MásRiego, including government institutions such as the Ministry of Agriculture in Guatemala; private institutions like Eco Proyectos and Agroquiche; other USAID projects such as MásFrijol; and other entities like Mercy Corp, and the University of San Carlos.

Busitema University students work with farmers to install an irrigation system in Kyekidde, Jinja, Uganda. Photo by Abraham Salomon

DEVELOPING FARMER-LED IRRIGATION SOLUTIONS IN UGANDA

This project builds on the team's previous participatory work in Uganda to convene stakeholders to develop innovations in small-scale, dry-season vegetable production for women farmers in East Africa. The project team has developed a research and development approach that tests irrigation innovations at sites in eastern Uganda and creates a framework for local public- and private-sector organizations to develop small-scale irrigation systems.

COLLABORATORS:

- University of California, Davis, USA (Lead)
- National Semi Arid Resources Research Institute (NaSARRI), Uganda
- Buginyanya ZARDI, Uganda
- Amelioration of Agricultural Risk (AMARI), Uganda
- Teso Women's Development Initiative (TEWDI), Uganda
- Busitema University, Uganda

FEATURED ACHIEVEMENTS:

- The project team established new irrigation technologies on more than 35 acres, co-developed by farmers.
- The team developed more than six innovations that improve farmer-managed irrigation and prototyped more than five tools to improve the ease and effectiveness of irrigation for horticulture.
- Developed a prototype of an irrigation site assessment tool for farmer-managed irrigation in Uganda.
- Trained more than 20 undergraduate and four graduate students in irrigation design, management, and assessment. Hosted six undergraduate students for internship in irrigation project management. Supported two lecturers from Busitema University for training on hydrological modeling.
- Trained more than 100 farmers in horticulture and irrigation production methods.
- Improved water and land governance at six irrigation sites with clear roles and rights to empower women. Improved capacity of a local NGO on qualitative data analysis for agricultural programs

Tiare Silvasy, UH Manoa student, discusses soil testing techniques with farmers and student volunteers in Nepal during a Trellis Fund project. Photo by Saroj Khanal

TRELLIS FUND: ENGAGING GRADUATE STUDENTS IN INTERNATIONAL DEVELOPMENT

The Trellis Fund is a grant-making and capacity-building program that connects local organizations in developing countries with U.S. graduate students with agricultural expertise, generating benefits for both the students and the in-country institutions. Together they collaborate on short-term projects to address horticultural challenges faced by local farmers.

Collaborators:

- University of California, Davis, USA
- North Carolina State University, USA
- University of Hawai'i at Mānoa, USA
- University of Florida, USA
- Crops Research Institute, Ghana
- Ndibwami Integrated Rescue Project, Uganda
- Green Shoots Foundation, Cambodia
- Kenya Plant Health Inspectorate Service, Kenya
- Methodist University College Ghana, Ghana
- Himalayan Pearl Enterprise, Nepal
- National Forestry Resources Research Institute, Uganda
- Center for Agricultural Research and Development-Nepal, Nepal
- Growing Star Agri Ventures, Kenya

Featured Achievements:

- Fellows have reported that international fieldwork has been helpful for understanding current agricultural practices and gaps, as well as the cultural and economic challenges facing farmers. This real-world experience has added value to their research and encouraged many to consider a career in international development.
- Trellis has benefited small organizations, providing them with the necessary funding to start locally impactful projects. In 2017, nine organizations were funded in five countries: Cambodia, Ghana, Kenya, Nepal and Uganda.
- Across nine projects, outreach included 24 training events, reaching 839 farmers (53% men, 47% women).

D-Lab leaders at Kasetsart University discuss a rice milling machine with a representative from UC Davis D-Lab. Photo by Sean Maxson

DESIGNING FOR HORTICULTURE DEVELOPMENT WITH D-LABS IN THAILAND AND HONDURAS

This project supports satellite D-Lab courses at the Horticulture Innovation Lab's two Regional Centers. The UC Davis D-Lab team works with Regional Center teams to improve D-Lab course implementation, refine processes of appropriate technology selection, and build capacity of host-institution instructors to effectively deliver curriculum. UC Davis D-Lab continues to assist the Horticulture Innovation Lab in assessing and augmenting the portfolio of horticulture technologies.

COLLABORATORS:

- D-Lab, University of California, Davis, USA (Lead)
- Panamerican Agricultural School, Zamorano, Honduras
- Kasetsart University, Thailand

FEATURED ACHIEVEMENTS:

- Both Regional Centers have D-Lab classes that are fully functioning and embedded in the university curricula.
- The D-Lab team provided training on DryCard™ technology and is providing instruction on solar-power systems design and analysis as well as economic cost analysis with collaborators during short-term trainings.
- D-Lab's courses have helped connect Horticulture Innovation Lab partners and technologies with interested students and faculty. As part of this ongoing collaboration, UC Davis D-Lab has been sharing design methodologies and curriculum for use by Kasetsart University's D-Lab.

PROJECTS BY FEED THE FUTURE OBJECTIVES

A WELL-NOURISHED POPULATION, ESPECIALLY AMONG WOMEN AND CHILDREN

Vegetable amaranth field trials in Tanzania. Photo by Elizabeth Mitcham

IMPROVING NUTRITION WITH AFRICAN INDIGENOUS VEGETABLES IN KENYA AND ZAMBIA

This project's research supports and strengthens African indigenous vegetable industries using a market-first, science-driven approach that connects stakeholders along the value chain. The project's objectives include supporting farmer adoption of best management practices for growing and selling African indigenous vegetables; expanding availability of these vegetables in local markets; evaluating the nutritional composition of these vegetables; and evaluating the impact of these interventions on stakeholder access to and consumption of African indigenous vegetables in Kenya and Zambia.

COLLABORATORS:

- Rutgers University, USA (Lead)
- Purdue University, USA
- Moi University, Kenya
- University of Eldoret, Kenya
- World Vegetable Center, Tanzania

FEATURED ACHIEVEMENTS:

- Analyzed surveys of vegetable producers and intermediaries in Zambia and Kenya. Submitted two of the four surveys for publication.
- Two new lines of improved amaranth and two new lines of nightshades were entered into the Kenyan national new seed variety testing program.
- Finalized analytical protocols and tested anti-nutritive compounds in field-grown nightshades (*Solanum* spp.) for presence and content of toxic alkaloids in the leaves. Nightshade leaves were found to be safe to consume (though the fruit of the same varieties has high levels of glycoalkaloids).
- Surveyed households in Kenya and Zambia on nutrition and dietary diversity. The participants in these surveys will be tracked for the remainder of the project and divided into treatment groups to examine best methods that lead to sustainable, longer-term consumption of African indigenous vegetables.
- Initial behavior change communication packets on nutrition education-intervention were prepared and tested with focus groups both in Kenya and Zambia.
- Research papers on childhood nutritional status in Kenya and Zambia and also micronutrient content of vegetable amaranth were published.

Farmers share vegetables grown in a floating garden with Amrita Mukherjee of the Horticulture Innovation Lab at a field day. Photo by Mohd Rezaul Islam

EXAMINING NUTRITION IMPACTS OF HORTICULTURAL INNOVATIONS IN BANGLADESH

As a sub-contractor on this multi-Innovation Lab project, the Horticulture Innovation Lab has implemented three different technologies to test the potential of horticulture and aquaculture innovations to improve income, consumption and nutrition by increasing year-round availability of aquaculture and horticulture products. The technologies include floating gardens, cool rooms, and chimney solar dryers, each implemented at the community level. The team aims to demonstrate the value of technologies that improve shelf life of foods, thus increasing economic benefits and nutrition benefits available from aquaculture and horticulture commodities.

COLLABORATORS:

- Nutrition Innovation Lab, Tufts University, USA (Lead)
- Horticulture Innovation Lab, UC Davis, USA
- WorldFish, Bangladesh
- Bangladesh Agriculture University (BAU), Bangladesh
- Patuakhali University of Technology (PUT), Bangladesh

FEATURED ACHIEVEMENTS:

- In the southern region of Bangladesh, the project established three cold rooms, 36 floating gardens in three locations that are growing fruits and vegetables, and three solar dryers that are being used to dry locally produced fruits, vegetables and fish. Trainings have been conducted covering all new technologies in all project locations.
- Research results show the profitability of the chimney solar dryer particularly for fish and high-value crops including chili, groundnuts, and mung bean. Farmers also achieved higher profitability and reduced postharvest losses from short-term storage of high-value crops in the CoolBot cool room. Trials established that leafy green vegetables are the best fit for floating garden production.
- The project performed experiments with the assistance of the Bangladesh Agriculture University and the Patuakhali Science and Technology University to test chimney solar dryer and floating gardens with leafy greens.

Farmer in Cambodia prepares to feed morning glory to his pigs. Photo by Erin McGuire

INVESTIGATING INTEGRATED VEGETABLE-LIVESTOCK SYSTEMS IN CAMBODIA

A majority of Cambodian farmers are considered smallholder farmers, with less than two hectares of farm land per household. Many such smallholder farmers choose to have mixed farming systems, with a combination of vegetable crops, rice, and/or livestock. While a "mixed farming system" allows farmers to diversify their production, an "integrated farming system" also seeks to recycle resources efficiently between the various farming activities. However, integrated farming systems are complex and optimizing aspects of production, income, and resource recycling can be difficult. This project team is working to analyze the trade-offs inherent to such vegetable crop-livestock integrated systems, with a focus on three criteria: sustainable resource conservation; income generation; and gender and nutrition.

COLLABORATORS:

- Kansas State University, USA (Lead)
- Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN), Cambodia
- Royal University of Agriculture (RUA), Cambodia
- University of Battambang, Cambodia
- Agriculture Development Denmark Asia, Cambodia

FEATURED ACHIEVEMENTS:

- Master students have been identified and will soon be enrolling in the new graduate programs at RUA.
- The project team is collaborating with the Center of Excellence on Sustainable Agricultural Intensification and Nutrition at three sites to develop research sites. Horticulture plots have been identified at each of the technology parks and in-country partners are beginning seedling work. Plot designs are completed and planting will commence at the end of October.
- A household survey is currently being developed.

Kong Thong of the Royal University of Agriculture leads a focus group discussion among food processors, collectors and marketers about improving Cambodia's safe vegetable value chain. Photo by Karen LeGrand

BUILDING SAFE VEGETABLE VALUE CHAINS IN CAMBODIA

This project team is focusing efforts on linking smallholder vegetable farmers to other value chain actors, to connect farmer production with market demand. This effort builds on a previously completed Horticulture Innovation Lab project and integrates with the IPM Innovation Lab and other USAID-funded programs to determine how best to cultivate a sustainable, safe vegetable value chain to increase food security in Cambodia. In Cambodia a low level of trust between value chain actors is a barrier to establishing strong links within the value chain, which affects the sustainability of a safe vegetable value chain that depends upon partners developing trusted working relationships. The project team identifies and solves problems with participatory research that engages local partners in testing, assessing, refining and innovating hard and soft technologies as well as scaling strategies.

COLLABORATORS:

- University of California, Davis, USA (Lead)
- Royal University of Agriculture (RUA), Cambodia
- University of Battambang (UBB), Cambodia
- Integrated Pest Management Innovation Lab, Virginia Tech, USA

FEATURED ACHIEVEMENTS:

- UC Davis researchers trained local faculty partners on how to actively engage stakeholders at multiple levels to coordinate related projects and activities that advance development from within the local university.
- Workshops, trainings, pilot studies, field trials and some aspects of grant management and reporting were conducted by RUA and UBB faculty leaders with the support of UC Davis researchers.
- Participatory research with community members led to adaption of nethouses to fit local needs, increasing the efficacy of the nethouse in Cambodia. This has resulted in increased use of the technology in multiple regions across the country.

Color indicator strips show dryness levels in a DryCard demonstration with dried mango. Photo by Brenda Dawson

FRANCHISING THE DRYCARD

This project aims to increase awareness and adoption of the DryCard™ technology to improve storage systems and reduce postharvest losses and quality deterioration.

COLLABORATORS:

- Horticulture Innovation Lab, USA (Lead)
- Postharvest Consulting and Capacity Building Company, Tanzania
- Agrifood Business Consulting, Rwanda
- Go Organics, Thailand
- CGIAR/CIMMYT, Mexico

FEATURED ACHIEVEMENTS:

- Took first place and the grand prize of $5,000 in the Technology and Innovation Challenge at the first All-Africa Postharvest Congress and Exhibition.
- The first DryCard franchise was launched with Bertha Mjawa and the Postharvest Consult and Capacity Building Company in Tanzania. In five months, Mjawa and her team sold 2,500 DryCards to 500 local farmers and several organizations such as the IRC, FAO, and HELVETAS.
- The Horticulture Innovation Lab has received more than 50 requests from 17 countries for DryCard samples and distributed more than 1,400 cards to organizations such as the Rotary Club, USDA, FAO, CRS, IRC, Mercy Corps, and several universities.
- New partnerships with the Postharvest Consulting and Capacity Building Company in Tanzania, Agrifood Business Consulting in Rwanda, and Go Organics in Thailand to manufacture and distribute the DryCard to their respective regions. We are collaborating with CGIAR/CIMMYT and allowing them to produce and implement 25,000 cards in their Germplasm Bank while also locating potential distributors for the Central America region.

INVENTING A LOW-COST SOLUTION TO REDUCE MOLDY FOODS

'DryCard' wins Africa postharvest prize, takes guesswork out of drying

How do you see dryness? Drying food is one way many farmers preserve their harvest, but knowing when food is dry enough to store can be difficult — and mold growth on dried foods is a pervasive problem. For farmers, mold growth can mean postharvest losses and lowered market value. For consumers, aflatoxins from moldy foods can suppress the immune system, increase disease rates, and cause lifelong stunting in children.

To that end, researchers Michael Reid and James Thompson at the University of California, Davis, invented a low-cost, easy-to-use tool that farmers can use to measure food dryness, called the DryCard™.

The DryCard is the size of a business card and combines cobalt chloride paper, which indicates dryness by changing color, with a color guide on a laminated piece of paper. Repackaging the cobalt chloride paper with the color guide increases the usability of the strips and allows farmers to access this dryness indicator at just pennies per card.

To check that food is dry enough for safe storage, farmers can seal a DryCard and a sample of dried product in an airtight container. After a brief wait, the card indicator changes color based on relative humidity within the container. Matching the color of the indicator with the guide on the card shows whether food is dry enough to prevent mold growth. The DryCard is reusable as long as it is stored safely away from water.

In March, the DryCard was selected as a top emerging technology for improving postharvest practices in Africa — beating more than 200 technologies to win the grand prize at the All Africa Postharvest Technology and Innovation Challenge. Top technologies and innovations were invited to pitch to an audience of about 600 participants, including researchers, investors, extension agents, government executives, and farmers.

By combining a strip of cobalt chloride paper with a color index, the DryCard indicates by color whether dried foods are dry enough to store safely, reducing the risk of mold growth. (Horticulture Innovation Lab photo by Brenda Dawson/UC Davis)

"I have never seen such strong interest in a technology like this," said Elizabeth Mitcham, director of the Horticulture Innovation Lab, who represented the card during the competition. "This technology has high potential to make an impact — and not only with dried produce and vegetable seeds, which was our original intent. A lot of the interest we have seen is from organizations that work with staple crops too."

In the wake of the competition and resulting publicity, interest in the DryCard has been high. In response to requests for samples, the Horticulture Innovation Lab has distributed more than 1,400 cards to organizations in 17 countries. The team is also in talks with local entrepreneurs who are interested in manufacturing and marketing the cards in their own countries.

Bertha Mjawa is one of the first researchers to test out and promote the DryCard in Africa, with her Postharvest Consult and Capacity Building Company in Tanzania. Over the course of 5 months, Mjawa and her team sold 2,500 DryCards to 500 local farmers and organizations.

"The DryCard makes a promising solution for African farmers due to its cost effectiveness, clear indicators and ease of use," Mjawa said. "Both farmers and agricultural experts can benefit from this technology."

For updates, samples and more information about the DryCard, visit http://drycard.ucdavis.edu.

CAMBODIAN FARMERS REACH NEW BUYERS WITH A FRESH APPROACH

Leaning into her tuktuk in Siem Reap, Eang Chakriya opens a cooler and takes out fresh wax gourds and other vegetables that have been carefully packed and chilled, showing them to a group of neighbors. Emblazoned on the tuktuk (a kind of motorized rickshaw) are images of farmers and the marketing motto, "Grown Right, Handled Right, Community Right."

Chakriya sells nutritious vegetables directly to consumers in Cambodia as part of a farmers' cooperative working with the Feed the Future Innovation Lab for Horticulture, led by the University of California, Davis.

The project's research team is examining incentives that help farmers improve their agriculture practices. The researchers' hunch is that farmers will adopt conservation agriculture practices (or "Grown Right" practices) if the team also helps them to adopt two other types of profitable practices that will increase their success: improved postharvest handling techniques and novel marketing practices.

So far, the idea seems to be working.

Leading this project, researchers from Kansas State University introduced farmers to conservation agriculture practices: mulch use, diverse crop rotation, and no tillage. Combined with drip irrigation, conservation agriculture can help farmers grow vegetables on small plots with reduced time and labor.

With researchers from Cambodia's Royal University of Agriculture, the World Vegetable Center and UC Davis, the project team also provided consultation and farmer training in improved postharvest handling — to harvest, sort, pack, transport and store the vegetables to maintain freshness longer. A team from the Horticulture Innovation Lab's Regional Center at Kasetsart University in Thailand also helped the farmers construct a packing shed to prepare and store their produce, complete with a cold room, evaporative cooler and sorting table.

Eang Chakriya, above and left, sells vegetables grown using conservation agriculture practices under the "Grown Right, Handled Right, Community Right" banner on behalf of a local farmers cooperative.

The cooperative is using marketing techniques that are new in Cambodia to help farmers get the most profit from their crops. For example, farmers connect directly with urban customers, driving their fresh produce into city residential neighborhoods. The produce they sell has been chilled during storage and transit, which helps maintain quality and nutritional content. The farmers also clearly identify the produce as locally grown and emphasize that their crops are an outcome of good environmental practices.

One advantage of these improved practices has been intensified production with more crop rotations per year.

"We've increased yields per unit area because of conservation agriculture and the number of times they can plant in the year — from two plantings to up to six plantings per year," said Manuel Reyes, a Kansas State University research professor who also works with the Feed the Future Innovation Lab for Sustainable Intensification. "Before they finish harvesting, the farmers are already planting the next crop's seedlings, so they are saving a lot of time overall."

Confident in their ability to sell high-quality vegetables directly to consumers at higher prices, the cooperative has offered to buy vegetables from its members at a 10 percent premium over other buyers. Today, farmers are enjoying increased incomes from vegetables grown on their conservation agriculture plots, with earnings as high as $1,323 over 10 months.

DRYING BEADS HELP BANGLADESH FARMERS ACCESS BETTER SEED

Finding reliable vegetable seed in humid Bangladesh can be a challenge — a situation that can ruin a crop before a farmer's hard work even begins. But Bangladesh seed companies are rapidly adopting a new technology that can improve seed germination and plant vigor, through improved seed processing and storage. Called "drying beads," this reusable tool can help seed companies provide farmers with higher quality seed, improving the local seed industry and helping farmers maximize the potential of their own hard work.

Many of the country's leading vegetable seed companies have adopted drying beads through a multi-part training led by Rhino Research and supported by the Feed the Future Innovation Lab for Horticulture, based at the University of California, Davis. Participating organizations include Lal Teer Seed Limited, Metal Seed, Getco, A. R. Malik & Co., Ispahani Agro Limited, Bangladesh Agricultural Development Corporation and others.

"We concluded that these beads are drying our seeds faster and deeper, obtaining a better quality that results in a longer storage potential, and all this with lesser costs," said Tabith M. Awal of Lal Teer Seed Limited in Bangladesh. "Therefore Lal Teer made the executive decision to move ahead with implementing these beads for all our seeds and crops as soon as possible."

This year, more than 200 tons of vegetable seed have been dried and stored with drying beads—helping an estimated 100,000 farmers in Bangladesh access quality seed.

The in-depth training, offered for a week at a time and repeated 3-7 times over several months, has focused on 14 seed leaders in Bangladesh. They have trained more than 70 employees, who in turn have trained more than 500 seed production farmers in how to use drying beads and maintain seed quality.

In a sealed container, the zeolite-based drying beads can dry seeds to very low moisture contents—preventing mold growth, restricting insect habitation, and preserving seed quality. The beads can be regenerated in an oven for repeated use.

Above: Korshed A. Chowdhury leads a training on using drying beads to process seed with a group of farmers, seed company employees and agricultural workers in May 2017.

Left: Vegetable seed drying with drying beads in airtight containers.

Seed farmers in Bangladesh first dry their seed in the sun — and that's where many of them stop (a survey showed about 22% also used fan drying and 8% used heated air). Companies that have adopted drying beads use them in containers to transport the seed from the farmer to company storage, where they can collect the fully dried seeds and return a container with fresh drying beads to the field.

Horticulture Innovation Lab researchers have previously shown drying beads are effective for seed storage, and developed an overarching "dry chain" concept. "Make it dry, keep it dry" is the motto of the dry chain, which specifies how to maintain quality and safety of dried products — not just seed.

"What is really remarkable is the explosion of different ideas in how to use the drying beads," said Johan Van Asbrouck of Rhino Research. "But we are starting with seeds, maximizing the potential of the crop at a farmer's level. If you don't have quality seed, you start penalized and will not have the crop you could."

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