FEED THE FUTURE
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FEED THE FUTURE
INNOVATION LAB FOR HORTICULTURE
ANNUAL REPORT 2017-2018

USAID
FROM THE AMERICAN PEOPLE

HORTICULTURE
INNOVATION LAB

UC DAVIS
UNIVERSITY OF CALIFORNIA

HORTICULTURE INNOVATION LAB

ANNUAL REPORT 2017-2018

OCT. 31, 2018

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COVER PHOTO:

Angelos Deltsidis collects dried mango slices from a chimney solar dryer.
Horticulture Innovation Lab photo by Brenda Dawson.

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HORTICULTURE INNOVATION LAB

UC DAVIS UNIVERSITY OF CALIFORNIA

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 until 2019 for $18.75 million. The program team and its projects help 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.

MANAGEMENT ENTITY

The Horticulture Innovation Lab is managed by a team in the UC Davis College of Agricultural and Environmental Sciences, under the Department of Plant Sciences and the International Programs Office.

Members of the management entity:

- Elizabeth Mitcham, Director
- Erin McGuire, Associate Director
- Michael Reid, Leader of Technology and Innovation
- Ashley Carr, Financial Analyst
- Archie Jarman, Program Manager
- Angelos Deltsidis, International Postharvest Specialist
- Beatriz Rodriguez Abogado, Executive Assistant
- Brenda Dawson, Communications Coordinator
- Anthony Phan, Project Analyst
- 2017-18 paid, unpaid student staff, and scholars: Lauren Howe, Michelle Boutell, Corey Rodda, Lisa Artuso, Kevin Hudnell, Asha Sharma, Hallie Casey, Kari Floras, Camila Bonilla Cedrez, Martin Kailie
- Special projects staff: Amrita Mukherjee and Mohamed Rezaul Islam, *Examining nutrition impacts of horticulture innovation in Bangladesh*; Débora Rivera, *Promoting drip irrigation and climate resilience in Guatemala - MasRiego*; Gabriel Wyland and Mamadou Alpha Thiam, *Establishing a horticulture training and service center in Guinea*

- Jim Thomspon is an emeritus agricultural engineer who has helped the Horticulture Innovation Lab develop technologies to reduce postharvest loss.

TECHNICAL AND/OR ADVISORY COMMITTEE INFORMATION

The Horticulture Innovation Lab's International Advisory Board (IAB) is the program's senior advisory council. The IAB ensures that Horticulture Innovation Lab priorities are met and integrated for maximum effectiveness. The IAB helps set priorities and ensure that USAID and Horticulture Innovation Lab objectives are met.

Members of the Horticulture Innovation Lab International Advisory Board:

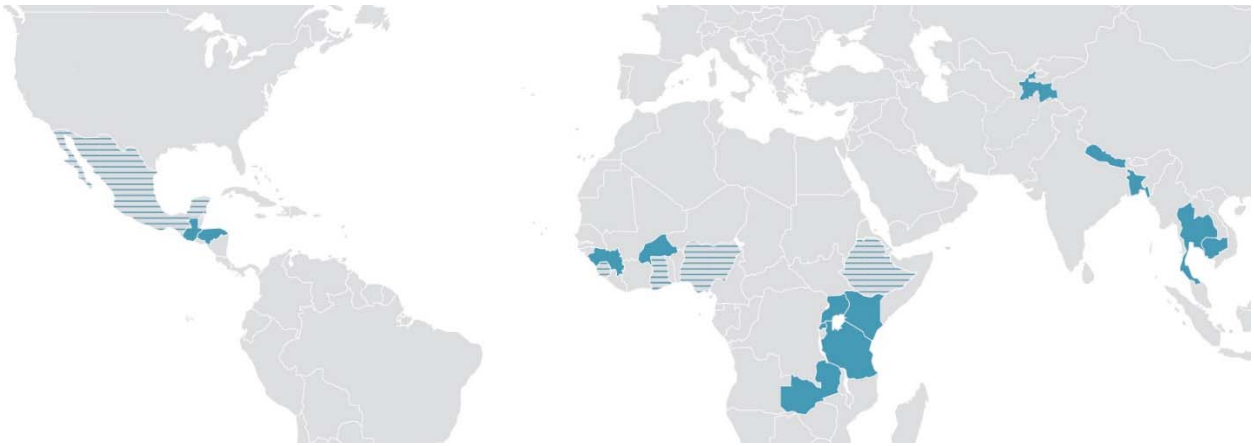
- Guillermo Alvarado-Downing, GOAL Global, Market Development Initiatives, Chair
- John Edward Bowman, USAID Agreement Officer's Representative
- Cecilia Chi-Ham, HM. Clause
- Jan Hopmans, UC Davis College of Agricultural and Environmental Sciences, International Programs Office
- Rose Koenig, University of Florida, Partner Representative
- Eric Kueneman, Global Agriculture Consultant
- Josette Lewis, Environmental Defense Fund
- Julio López Montes, Pan-American Agricultural School, Zamorano, Regional Center Director
- Poon Kasemsap, Kasetsart University, Regional Center Director
- Robert Paull, University of Hawai‘i at Mānoa, Partner Representative
- Detlef Virchow, Plan International Germany
- L. George Wilson, North Carolina State University, Partner Representative
- R. Shanthi Wilson Wijeratnam, Industrial Technology Institute
- Marco Wopereis, The World Vegetable Center

2017 – 2018 PROJECT ACTIVITIES

LOCATIONS

The Horticulture Innovation Lab currently works in Bangladesh, Burkina Faso, Cambodia, Guatemala, Guinea, Honduras, Kenya, Nepal, Tajikistan, Rwanda, Tanzania, Thailand, Uganda and Zambia.

In addition to research projects, this year the Horticulture Innovation Lab has Trellis Fund projects in Ghana and Ethiopia, and has partners working to scale the DryCard in Mexico, Nigeria and Sierra Leone.



In the map above, countries where Horticulture Innovation Lab research is taking place are indicated with solid blue, and additional countries where only Trellis Fund projects and/or DryCard scaling are taking place are indicated with stripes.

PROGRAM PARTNERS

United States – Agribusiness Associates; Kansas State University; Michigan State University; North Carolina Agricultural & Technical State University; North Carolina State University; The Pennsylvania State University; Purdue University; Rutgers University; Texas A&M; Tufts University; Tuskegee University; University of California, Davis; University of Florida; University of Hawai'i at Mānoa; University of Wisconsin-Madison; IPM Innovation Lab; Store it Cold, LLC; The Postharvest Education Foundation

Bangladesh - WorldFish; WinRock; Bangladesh Agricultural University; Patuakhali University of Technology (PSUT)

Burkina Faso - USAID/Burkina Faso; USAID/Sahel Regional Office; Environmental Institute for Agricultural Research/Burkina Faso; ACDI-VOCA

Cambodia - Agricultural Development Denmark Asia; Royal University of Agriculture (RUA); Green Shoots Foundation; Community-based Integrated Development Organization; Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN); University of Battambang

Ghana (Trellis and Drycard only) – Council for Scientific and Industrial Research; Crops Research Institute; Methodist University College Ghana; Ofori Agrochemical Services; University of Cape Coast; Kumasi Institute of Tropical Agriculture; Tip Top Foods

Guatemala - Catholic Relief Services; Centro de Paz Bárbara Ford; Universidad de San Carlos de Guatemala

Guinea –Winrock International; The Agriculture Research Institute of Guinea; ACDI-VOCA, Cultivating New Frontiers in Agriculture

Honduras - Pan-American Agricultural School, Zamorano; Fundación Hondureña de Investigación Agrícola; FINTRAC

India - Telangana State Agricultural University

Kenya – Academic Model Providing Access to Healthcare Family Preservation in Kenya; Kenya Agriculture and Livestock Research Organization; University of Eldoret; Kenya Plant Health Inspectorate Service; Growing Star Agri Ventures; Agricultural Research for Development (CIRAD); A to Z Textile Mills; Center for Large Scale Social Change, LLC; International Centre of Insect Physiology and Ecology Real-IPM; Finlays; Sunripe; Frigoken, Ltd.; Moi University

Mexico (DryCard only) - CGIAR/CIMMYT,

Nepal – Center for Agriculture Research and Development-Nepal; International Development Enterprise (iDE); Himalayan Pearl Enterprise; University of Agriculture and Forestry; District Agriculture Development Office and Agriculture Research Center; Aythos

Nigeria (DryCard only) - TSM Alpha Ventures

Rwanda – Ministry of Agriculture and Natural Resources; University of Rwanda; National Agriculture Export Development Board; Rwanda Agriculture Board; Agrifood Business Consulting; SYBASH, Ltd.

Taiwan – The World Vegetable Center

Tajikistan –Tajik Agrarian University; Feed the Future Tajikistan Agriculture, Water Activity; Jua Technologies International, LLC

Tanzania –The World Vegetable Center; Horti-Tengeru; Postharvest Consulting and Capacity Building Company; Sokoine University of Agriculture

Thailand – Kasetsart University; Rhino Research; Go Organics; Erasmus+

Uganda – Amelioration of Agricultural Risk; Buginyanya Zonal Agricultural Research and Development Institute; Busitema University; Commonwealth Scientific and Industrial Research Organisation; Teso Women's Development Initiative Uganda, National Forestry Resources Research Institute, Ndibwami Integrated Rescue Project; National Semi Arid Resources Research Institute; Mwino Group, Uganda Rural Information and Communication Technology/Educational Center (URICT-Uganda), Eco Agric Uganda,

Zambia – University of Zambia, Center for International Cooperation in Agronomic Research for Development

Sierra Leone (Drycard only): Desert Water

Ethiopia (Trellis only): Send a Cow Ethiopia

ACRONYMS

ACDI-VOCA: Agricultural Cooperative Development International-Volunteers in Overseas Cooperative Assistance

ADDA: Agricultural Development Denmark Asia

AFU: University of Agriculture and Forestry

AIV: African Indigenous Vegetable

AMPATH: Academic Model Providing Access to Healthcare

AMIR: AMIR: Asociación de Mujeres Intibucanas Renovadas

AOR: Agreement Officer's Representative

ASHS: American Society for Horticultural Science

BAU: Bangladesh Agriculture University

BMP: Best Management Practices

BRRI: Bangladesh Rice Research Institute

CA: Conservation Agriculture

CARD-Nepal: Center for Agricultural Research and Development

CE SAIN: Center of Excellence on Sustainable Agricultural Intensification and Nutrition

CGIAR: Consultative Group on International Agricultural Research

CIMMYT: International Maize and Wheat Improvement Center

CIRAD: Center for International Cooperation in Agronomic Research for Development

COPEFL: Cooperative of producers and exporters of Friguiagbé fruits and vegetables

CRS: Catholic Relief Services

CRSP: Collaborative Research Support Program

CSIRO: Commonwealth Scientific and Industrial Research Organisation

DAI: Development Alternatives Incorporated

DDL: Development Data Library

DICTA: Directorate of Science and Technology

EMMP: Environmental Management and Mitigation Plan

FAO: Food and Agriculture Organization

FFS: Farmer Field School

FHIA: Fundación Hondureña de Investigación Agrícola

FONTAGRO: Regional Fund for Agricultural Technology

FUNDER - Foundation for Rural Business Development

GAPs: Good Agricultural Practices

GIZ: German Corporation for International Cooperation

HORTI-Tengeru: Horticultural Research and Training Institute

IAB: International Advisory Board

ICCA: Inter-American Institute for Cooperation on Agriculture

iDE: International Development Enterprise

INERA: Environmental Institute of for Agricultural Research

IPM: Integrated Pest Management

IRAG: Agriculture Research Institute of Guinea

KALRO: Kenyan Agriculture and Livestock Research Organization

KEPHIS: Kenya Plant Health Inspectorate Service

KSU: Kansas State University

NaSARRI: National Semi Arid Resources Research Institute

NGO: Non-Governmental Organization

NIRP: Ndibwami Integrated Rescue Project

PI: Principal Investigator

PICS: Purdue Improved Crop Storage

PSTU: Patuakhali Science and Technology University

RDMA: Regional Development Mission for Asia

RFP: Requests for Proposal

RISE: Resilience in the Sahel-Enhanced

RUA: Royal University of Agriculture

SIIL: Sustainable Intensification Innovation Lab

SNV: Dutch Volunteers Foundation

TEWDI: Teso Women Development Initiatives

UBB: University of Battambang

UC: University of California

USAC: University of San Carlos

USAID: United States Agency for International Development

USDA: United States Department of Agriculture

ZARDI: Zonal Agricultural Research and Development Institute

ZECC: Zero Energy Cool Chamber

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I. EXECUTIVE SUMMARY

The Horticulture Innovation Lab improves how smallholder farmers grow and sell fruit and vegetable crops, with research activities targeting all stages of the horticultural value chain from seed systems to marketing. The Horticulture Innovation Lab manages a portfolio of horticulture research projects primarily led by researchers at U.S. universities and actively working in 14 countries, including Uganda, Rwanda, Burkina Faso, Tanzania, Kenya, Zambia, Guinea, Guatemala, Honduras, Tajikistan, Bangladesh, Nepal, Thailand and Cambodia. 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. Engagement in horticulture value chains enhances resiliency by diversifying income streams and diets. The short growing period for vegetable crops mean that vegetables can contribute to food security and resiliency in times of conflict or following weather-related crop failures. There are also many employment opportunities within horticultural value chains. Our projects have enhanced their engagement of youth, supporting youth development as entrepreneurs. As our program enters the final year of its five year cycle, our research projects and our management entity are emphasizing information delivery to share program learnings broadly.

GLOBAL IMPACT OF RESEARCH OUTCOMES

During this year, Horticulture Innovation Lab researchers have field-tested or scaled 57 new technologies (not including seed varieties), and 8,314 farmer beneficiaries report using improved technologies with more than half of these being women. Highlights from our production research include the following. In collaboration with the World Vegetable Center, the *Improving postharvest practices for tomatoes in Burkina Faso* project introduced a rainy season tomato variety for farmers to grow during the typically off-season period for tomato production. A Guatemalan women's farming cooperative, which received training through the *Expanding tomato grafting for entrepreneurship in Guatemala and Honduras* project, has started producing grafted seedlings to sell to other farmers in their area.

Improving postharvest handling and reducing losses in quantity and quality of fruits and vegetables after harvest are important areas of focus for the Horticulture Innovation Lab. Several projects have scaled the Postharvest Training and Services Center (PTSC) model, wherein improved practices for handling of produce after harvest are demonstrated and related supplies are sold. The *Improving postharvest practices for tomatoes in Burkina Faso* project is building one PTSC, the *Reducing postharvest losses in Rwanda* project has already established three PTSCs, and the *Building safe vegetable value chains in Cambodia* project has built one PTSC-like center they call the Hub for Safe Vegetables.

The two Horticulture Innovation Lab Regional Centers continue to expand their influence in their respective regions, and develop strategic alliances to better position the Centers for sustainability through strategic leveraging of funds. The Centers are engaging with local industry, USAID Mission projects, Horticulture Innovation Lab projects, and university students to share the research outcomes of Horticulture Innovation Lab projects within their regions. Of particular note, Kasetsart University has continued their collaboration with Winrock's Feed the Future Asia Innovative Farmers Activity project. In Honduras, the Panamerican Agricultural School, Zamorano, has continued collaborations with Fintrac, the Directorate of Science and Technology (DICTA), Fundación Hondureña de Investigación Agrícola (FHIA), the Food and Agriculture Organization (FAO), the Inter-American Institute for Cooperation on Agriculture (ICCA), the Foundation for Rural Business Development (FUNDER), and Catholic Relief Services (CRS).

HUMAN AND INSTITUTIONAL CAPACITY BUILDING

Progress has been made in developing the human and institutional capacity of local universities to critically think about horticulture problems, develop research questions, conduct experiments and gather data that addresses pressing horticulture problems. At Sokoine University of Agriculture in Morogoro, Tanzania, a mini packhouse, fabricated using old marine containers, was established and equipped with a CoolBot controller and air conditioner, and research has been conducted by Sokoine University of Agriculture students utilizing the CoolBot cold room. In addition, the project team is working with Sokoine to upgrade their horticulture curriculum. In Bangladesh, as a result of project activities, Patuakhali Science and Technology University submitted a proposal and secured a grant from Bangladesh's Ministry of Science and Technology to further study the efficiency of the UC Davis-designed chimney solar dryer. A final round of Trellis Fund projects linked 16 U.S. graduate students with 15 small organizations in Feed the Future countries to address horticulture challenges and provide international experiences for U.S. students and enhanced capacity for local organizations. During the past year, our network trained 79 graduate and undergraduate students (long-term training) and 10,514 short-term trainees.

YOUTH ENGAGEMENT IN HORTICULTURE

There are many employment and entrepreneurial opportunities for youth within horticultural value chains given the perishable nature of these nutritious products. Our projects have stepped up their engagement with youth. A few highlights include the "Postharvest Innovation Competition", through which the *Reducing postharvest losses in Rwanda* project team is growing and nurturing startups working on postharvest innovations and helping them to commercialize their ideas. Young Guinean AVENIR agents trained by our project team focused on establishing a youth-led Horticulture Training and Services Center have built and sold more than 20 chimney solar dryers that reduce waste of fruits and vegetables and increase the availability of dried products in Guinea. The *Developing farmer-led irrigation solutions in Uganda* project has built the capacity of young agricultural and engineering professionals to work effectively on small, farmer-managed irrigation and horticulture projects.

LEVERAGING PARTNERSHIP WITH THE PRIVATE SECTOR

Collaboration with the private sector is critical to scaling new technologies and practices, and has many benefits for small-scale farms. We have engaged with several private companies as partners on our research program. Agribusiness Associates Inc., a strategic agribusiness advising company in Davis, CA, leads two projects in the Horticulture Innovation Lab portfolio. As a private company, Agribusiness Associates' expertise in entrepreneurship in horticulture, and specifically postharvest handling of horticulture products impacted 70 private enterprises, 19 producer organizations, 4 trade and business associations, and 21 community-based organizations. The Horticulture Innovation Lab has developed a franchise model for scaling out the DryCard, a technology developed just last year. DryCards are now available in Thai, Khmer, Spanish, Amharic, Kinyarwanda, Swahili, French, English, and Bengali and commercially sold by 8 partners in Tanzania, Rwanda, Uganda, Guinea, Ghana, Sierra Leone, Thailand, Mexico, Guatemala, and the United States. The DryCard team was recognized as the UC Davis Chancellor's Innovators of the Year and was awarded $10,000 for continuing scaling efforts.

THOUGHT LEADERSHIP BY OUR NETWORK

The Horticulture Innovation Lab and its global network is committed to being a thought leader and source of information within the horticulture-for-development community. This year, the management team was invited to present at the Global Goods Event in Seattle; Global Food Security Conference in South Africa; Rwanda Postharvest Week, Rwanda: the International Conference on Food Safety and Food Security, Cambodia; Royal University of Agriculture (CE-SAIN), Cambodia; ILSI Research Foundation conference on Protected Production of Fruits and Vegetables, Washington, DC; the Dry Chain Workshop at the University of California, Davis; the American Society for Horticultural Sciences Annual Conference, Washington, DC; the International Horticulture Congress in Turkey; the Food Tank Summit

on Food Loss and Waste in New York City; Scale Up Conference at Purdue University; World Congress of Food Science and Technology, Elevator Pitch Contest. At the World Food Prize Borlaug Dialogue, the Horticulture Innovation Lab took the initiative to co-host a side event in collaboration with WorldVeg and CRS called "The Power of Produce," to highlight the importance of fruits and vegetables for global nutrition and poverty alleviation.

Our research network has also contributed to thought leader in horticulture for development. A few examples include the research by Penn State University in the *Empowering women through horticulture in Honduras* project that spotlight policies, regulations, and cultural norms that limit the participation of women and other marginalized groups in the horticultural value chain. The project is also creating a Gender and Agriculture certificate program at Penn State. The University of California, Davis is developing a locally relevant toolkit and policy recommendations for organizations in the horticulture sector of Uganda based on the results from their *Developing farmer-led irrigation solutions in Uganda* project.

The Horticulture Innovation Lab completely redesigned its website to be more outward-facing. The new website launched in spring 2018 with more than 300 information product webpages, which has grown to nearly 400. The website also highlights each Horticulture Innovation Lab project and our network experts affiliated with these projects. Several high-value information products were published this year and are featured on the website:

1. Bradford, K.J., P. Dahal, J.V. Asbrouck, K. Kunusoth, P. Bello, J. Thompson, F. Wu. 2018. The drychain: Reducing postharvest losses and improving food safety in humid climates. Trends in Food Science & Technology. 71:84-93. doi:10.1016/j.tifs.2017.11.002 - https://horticulture.ucdavis.edu/information/dry-chain-reducing-postharvest-losses-and-improving-food-safety-humid-climates
2. Michael Reid and James Thompson. "The UC Davis Chimney Dryer and DryCard – tools for implementing the dry chain." *Chronica Horticulturae.* No. 3, 2017. https://doi.org/10.17660/ActaHortic.2018.1205.18
3. University of California, Davis. Horticulture Innovation Lab. *Chimney Solar Dryer Manual.* 2018. https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual
4. Postharvest loss assessments across four value chains in Rwanda – tomato, sweet potato, banana and green chilies. https://horticulture.ucdavis.edu/information/postharvest-loss-assessment-tomatoes-rwanda

In the final year of our current grant, the management entity will focus on continuing to build the capacity and sustainability of all these successful initiatives and support projects' efforts to transform research into impact for smallholder farmers. The Horticulture Innovation Lab has engaged an independent evaluator to assess the outcomes and impacts from our program within our new research impact framework and the Feed the Future framework. Results of this assessment will be presented in 2019.

II. PROGRAM ACTIVITIES AND HIGHLIGHTS

PROJECT SUMMARY

The Horticulture Innovation Lab improves how smallholder farmers grow and sell fruit and vegetable crops, with research activities targeting all stages of the horticultural value chain from seed systems to marketing. The program's work is guided by targeting innovative technologies, increasing research capacity, ensuring gender equity, and improving information access.

SUCCESSES AND CHALLENGES IN FY2018

Successes - In FY2018 the Horticulture Innovation Lab successfully turned toward broad information dissemination and began program evaluation. The program launched a new website to expand its capacity for delivering information in ways that are highly accessible, clear and attractive. The new website merged the program's blog with more than 300 "information product" webpages that are categorized by countries, crops, value chain stages, technologies, and other categories. This year also saw advances in the Horticulture Innovation Lab's use of **videos as a communications tool**. Each of the program's research projects created a 90-second video to present during the Horticulture Innovation Lab's annual meeting, which continue to be shared on the program's YouTube channel with ongoing plans to embed the videos in future blog posts. The management team also **created a three-part video series on the chimney solar dryer**, as complementary pieces to its new Chimney Solar Dryer Manual document.

To monitor and evaluate management entity activities, a new framework was developed and designed to capture the "information value chain." These goals, objectives, and indicators track the high-level purpose of the Horticulture Innovation Lab to identity key information gaps, research solutions, and disseminate that information (See Appendix C). Furthermore the Horticulture Innovation Lab has hired an independent evaluator to report on the program's impact on gender empowerment, youth, resilience, and nutrition, track leveraged activities, and assess Regional Centers and scaling pathways for Management Entity technologies.

Twenty-two new technologies were introduced and tested and 26 prepared for transfer. Specifically the Horticulture Innovation Lab has continued to see incredible success with the **DryCard**. During FY2018, the program has partnered with businesses in Tanzania, Rwanda, Uganda, Ghana, Guinea, Sierra Leone, Thailand, Mexico and Guatemala, and distributed more than 20,000 DryCards. The Zion Camp Maize Growers Association in Ghana, who estimate at least 1,500 kg of food is lost each harvest, implemented DryCard use and farmers were able to store their harvest for the past three months with no problems. The DryCard has been accepted and presented at the Food Science Showcase at UC Davis, Scaling Up Conference at Purdue University, the 19th World Congress of Food Science at Technology in Mumbai, India, and the Postharvest management for better food security conference in Hanoi, Vietnam. In May 2018, the DryCard team was recognized as the UC Davis Chancellor's Innovators of the Year and was awarded $10,000 for continuing project activities.

Horticulture Innovation Lab projects are **increasing in-country capacity**. The "Rwanda Postharvest Week" was organized by the project team *Reducing postharvest loss in Rwanda* to bring together public and private sector partners and drive action through collaborative learning to reduce postharvest losses in horticulture. The events were held at different locations in Kigali, Rwanda. The highlight of the week was the "Postharvest Innovation Competition," through which the project is growing and nurturing startups working on postharvest innovations and helping them to commercialize their ideas. Thirteen winners were

selected and $50,000 in funding was divided between their businesses. In Tanzania, the *Increasing postharvest capacity* project developed modules for the short course outreach program in the area of postharvest physiology and management of fruits and vegetables have been developed and conducted two "Training of Trainers" courses. A total of 60 trainers from the government, private and civic societies were trained between May and August. Technologies promoted by the Horticulture Innovation Lab, including the CoolBot, chimney solar dryer, and Zero Energy Cool Chamber were established, and the postharvest lab at Sokoine University of Agriculture was equipped with new instruments for postharvest analysis. Broadly, the Horticulture Innovation Lab has implemented an **outreach strategy to further build the capacity of in-country partners that is based on greater direct communication** from the Management Entity. This plan includes sharing academic opportunities and information resources, as well as platforms for networking.

Innovation Lab Leadership: The Horticulture Innovation Lab chaired the Innovation Lab Directors Committee in 2017-2018. This included a meeting in Uganda and Washington, DC. This year we facilitated presentation of videos about a technology by each Innovation Lab that will serve as a resource for development partners and USAID to supply innovative technologies broadly. The program also created the Associate Directors email listserv which connects the Innovation Labs to discuss regulatory requirements, annual budgets, and potential regional and topical partnerships.

Challenges - The greatest challenge the Management Entity faced in FY2018 was unstable budget forecasts from USAID. Uncertainty and changes in expected funding strained research and activities. Logistically the Management Entity struggled with turnover in our financial analyst position. We hired two new staffers and both were promoted to higher positions within the university within months of being hired. UC Davis is in general experiencing a scarcity of financial managers; to mitigate this challenge the program has altered the position description to be a contract analyst, allowing us to more easily hire outside of the university system.

DESCRIPTION OF EXPECTED FY2019 ACTIVITIES

This year the Horticulture Innovation Lab will host its annual meeting in Washington DC to have a broader conversation around horticulture research for development. This two-day conference aims to promote learning across development stakeholders on the benefits of, need for and current success of horticultural research for development activities. By convening key funders, implementing partners and other development stakeholders, the conference seeks to support new partnerships and opportunities for continued funding and prioritization of horticulture research for development. In its final year, the Horticulture Innovation Lab will also host a Trellis Fund conference that will gather many diverse voices to reflect on the first six rounds of Trellis, and will allow Trellis alumni and organization to participate in the Annual Meeting as well. Finally, the Horticulture Innovation Lab will prepare for final project close out for all 22 projects and all Management Entity activities.

III. KEY ACCOMPLISHMENTS

FY2018 PERFORMANCE

The Horticulture Innovation Lab has launched all projects for Phase II to develop knowledge on key information gaps across the horticulture value chain. Approaching the final year of Phase II, projects are successfully disseminating the results of effective research addressing information gaps to stakeholders, with FY2018 exceeding expectations in terms capacity building.

- **Capacity building**: The Horticulture Innovation Lab significantly exceeded the target for individuals benefitting from project short-term trainings, including over 10,000 producers, government staff, and individuals from civil society and private sector. Additionally, 79 graduate and undergraduate students received long-term trainings and 432 organizations received development assistance from program activities.

- **Curriculum development:** Several Horticulture Innovation Lab projects are developing curricula and training programs that are designed either for in-country universities to build their capacity or for U.S. universities to disseminate knowledge gained through funded activities. For example, Kansas State University, University of Florida, and Sokoine University of Agriculture (SUA) are collaborating to develop a new master's program in horticulture at SUA with the *Building postharvest capacity in Tanzania* project. Additionally the *Promoting drip irrigation and climate resilience in Guatemala – MasRiego* project developed a technical training program that was implemented at the University of San Carlos, Guatemala. Finally, Pennsylvania State University is developing a Gender and Agriculture certificate program at their university as part of the *Empowering women through horticulture in Honduras* project.

- **Increased production:** In collaboration with the World Vegetable Center, the *Improving postharvest practices for tomatoes in Burkina Faso* project introduced a rainy season tomato variety for farmers to grow during typically off-season period for tomato production. The *Developing farmer-led irrigation solutions in Uganda* project, in collaboration with farmers, has developed more than ten technologies and practices that have been validated and adapted by farmers in different agro-ecologies, improving production outcomes.

- **Increasing income:** A Guatemalan women's farming cooperative which received training through the *Expanding tomato grafting for entrepreneurship in Guatemala and Honduras* project has started producing grafted seedlings to sell to other farmers in their area. In the *Reducing postharvest losses in Rwanda* project, the team has worked with seventy-three agribusinesses to increase their capacity to offer postharvest solutions as a commodity.

- **Improving nutrition:** In FY2018, farmer adoption of food processing and preparations significantly increased due to trainings provided through the *Trellis Fund*. Farmers in Uganda were enabled to make passionfruit juice and tomato sauce in their homes post-training and in Ethiopia farmers were enthusiastic when trained on the health benefits of sweet potato leaves. The *Establishing a horticulture center in Guinea* project engaged youth as leaders and has built and sold over twenty chimney solar dryers that reduce waste of fruits and vegetables and increase the availability of dried products. The *Improving nutrition with African Indigenous Vegetables in Kenya and Zambia* project started a series of production modules for African indigenous vegetables, impacting close to 2,400 households, by encouraging farmers, families and communities to produce African indigenous vegetables year-round.

- **Gender considerations:** In FY2018, a significant portion of short-term training participants, nearly 70 percent, were female. Additionally, gender topics have been integrated into the actual curricula of the trainings. For example, the *Empowering women through horticulture in Honduras* project led by Pennsylvania State University, incorporated topics such as time use, division of labor, self-esteem, and leadership into a four-month horticulture production-based farmer field school.

- **Adoption of improved technologies:** Over 8,000 farmers report using improved technologies, and 520 hectares are under new technology; a two-fold increase from FY2017. Additionally, close to 300 organizations have applied improved technologies and practices in FY2018. The DryCard has continued to scale effectively, with DryCard franchises having sold and distributed 13,000 DryCards and the Horticulture Innovation Lab having passed out 5,000 DryCards to over 80 organizations.

- **New technology development:** Horticulture Innovation Lab researchers are field-testing or scaling over 50 new technologies.

- **Investment in young entrepreneurs:** The Horticulture Innovation Lab's project, *Establishing a horticulture center in Guinea* has graduated four Feed the Future "AVENIRs" who are young Guinean entrepreneurs. Graduates of the AVENIR program start their own businesses. A former AVENIR agent trained at the center has developed a dried fruit company using the solar chimney dryer. The project has accepted four more AVENIR agents that are working at the center alongside international students from the United States, Central America, and South America who are hosted at the center as part of a global internship program.

- **Establishing training centers:** Along with the Regional Centers, which are continuing to operate as effective training and expertise hubs, several other projects have established new training centers or cemented recently created centers in FY2018. The *Building postharvest capacity in Tanzania* and *Reducing postharvest losses in Rwanda* projects have postharvest innovation centers for technology demonstrations, trainings and adaptive research. The *Building safe vegetable value chains in Cambodia* project now has two centers, the Earthworm Compost Research and Training Center and the Hub for Safe Vegetables. Finally the Horticulture Training and Services Center in Guinea, established by the Horticulture Innovation Lab, now houses several horticulture technologies related to production and postharvest handling that are utilized for demonstrations, trainings and adaptive research.

IV. RESEARCH PROGRAM OVERVIEW AND STRUCTURE

SUMMARY

A collaborative team at UC Davis manages the Horticulture Innovation Lab, with the mission of building international partnerships for fruit and vegetable research to improve livelihoods in developing countries. Currently entering Year 5 of Phase II, the Horticulture Innovation Lab has been able to launch many planned initiatives and made room for new opportunities, such as leveraged funds for large mission projects and technology competitions. In the future, the Horticulture Innovation Lab hopes to continue to improve upon our methodologies, partnerships, capacity building, and sharing project deliverables as results are finalized.

RATIONALE FOR HORTICULTURE RESEARCH

Investment in horticulture is important because of the close link between poverty and hunger and malnutrition. Horticulture development offers the opportunity to meet food needs and improve nutrition and health in the developing world, while providing prospects for income diversification and economic advancement of the rural poor. In addition, women are, in many regions, the main producers and marketers of horticulture crops, so increased horticultural production often leads to an improved income stream for women and their children. Typically, horticulture crops are both highly nutritious and economically valuable. Horticulture research is crucial to enable small-scale producers to overcome agronomic market barriers and realize the benefits offered by horticultural development.

TECHNICAL LEADERSHIP

UC Davis and its partner institutions- University of Florida, North Carolina State University, and University of Hawai'i at Mānoa - continue as the management entity of the Horticulture Innovation Lab. We have strong relationships with university and organizational entities worldwide. In addition, the partners' faculty expertise and diversity of crops addressed by their research, teaching and outreach makes us ideal collaborators to promote horticulture research and education in the developing world.

PILLARS IN PHASE II

The Horticulture Innovation Lab remains committed to building international research partnerships to sustainably reduce global poverty and hunger. To achieve this goal, we focus on the following areas:

Horticultural value chain research. We support research projects along the entire horticultural value chain.

Innovation and scaling. We work with our projects and the Regional Centers on the dissemination and scaling of innovative horticultural technologies. An important strategy we have employed is bolstering promising technologies with further resources and expertise. This model has been similarly adopted at varying scales across several projects.

Capacity building. We build the capacity of researchers, institutions, students, and other actors in the horticulture sector worldwide. Capacity building is integrated into all Horticulture Innovation Lab activities, and one project focuses specifically on capacity building.

Nutrition-sensitive horticulture. We support research that improves understanding and availability of nutritious crops from production to consumption. Nutrition is a cornerstone of poverty reduction. We work with all projects throughout their lifecycle to ensure that they are nutrition-sensitive and seek to identify the possible nutrition-related impacts that their research or innovations will have on human nutrition at the household, community, local and/or regional levels.

Empowering women and the most vulnerable. In many regions, women and other vulnerable people are the primary producers and marketers of horticultural crops. The management entity works with collaborators to ensure that all Horticulture Innovation Lab projects are gender-sensitive and encourage the meaningful participation of women and other vulnerable populations. We have funded one major research project that researches gender equity.

Sharing information. We make our projects' research results easily accessible to multiple stakeholders, from local community members in project focus areas to university scientists. In addition, we work with our project partners to help them effectively package and disseminate information for wide impact. We collaborate with others to disseminate materials that are of use to them, including regional projects and USAID partners.

RESEARCH APPROACH

The Horticulture Innovation Lab issued six types of Requests for Proposals (RFPs) during Phase II, each with a different scope and focus. All RFPs aimed to be competitive, and applications were evaluated by a combination of management entity and external reviewers. In cases where a call for proposals did not result in adequate candidates, the management entity sought exceptional candidates and worked with stakeholders to develop the best proposal. Most projects are collaborations between U.S. university researchers and focus country partners; however, in FY2016 we expanded our lead project partners to include private entities.

In years one and two, we funded three major projects, one each for research on postharvest, nutrition, and gender equity ($1.5-$2 million each over five years). We also funded five projects designed for scaling of Phase I technologies and to address new research needs identified in Phase I. We also expanded our project portfolio to include three technology projects; a nutrition project with the Nutrition Innovation Lab led by Tufts University, a $3 million mission buy-in with USAID/Guatemala to implement and evaluate new irrigation systems, and finally, a $655,000 mission buy-in project, *Establishing a horticulture center in Guinea*, with USAID/Guinea.

Efforts to effectively disseminate research results are increasing as the Horticulture Innovation Lab enters its final year of Phase II. For example, a recent increase in mission buy-in funding in Guinea for the *Establishing a horticulture center in Guinea* project resulted in an expansion in training activities and the establishment of international internships at the center in Guinea, for U.S. students and students from Zamorano University. As another example, the Horticulture Innovation Lab recently awarded the D-Lab at UC Davis $60,000 to develop a toolkit from existing D-Lab curriculum to be disseminated widely to partner universities and stakeholders. Finally, projects in FY2018 reported significant numbers of short-term trainings and attendees, reflecting the focus on dissemination of research as Phase II winds down.

REGIONAL CENTERS

The success of the Regional Centers at Zamorano in Honduras and at Kasetsart University in Thailand as information hubs has influenced the establishment of training and research centers within several of the Horticulture Innovation Lab's projects. Similar to the Regional Centers, the projects' centers offer both "Hard" technology (devices, prototypes and designs) and "Soft" technology (innovation in systems, behaviors, and methods) solutions, impacting the entire horticulture value-chain. At the Regional Center at Zamorano, specifically, the Center is recognized as a service hub by government ministries in both Central and South America and has recently provided expertise to projects in Colombia and El Salvador. The Regional Center at Kasetsart University has built on their reputation as hard technology, technical experts by continuing its collaboration as technology evaluators for Winrock's "Feed the Future Asia Innovative Farmers Activity" and developing low-cost monitoring devices, including a cold room remote monitoring system, for farmers and researchers in the field.

In the final year, the management entity will focus on continuing to build the capacity and sustainability of these successful initiatives and support projects' efforts to transform research into impact for smallholder farmers.

V. RESEARCH PROJECT REPORTS

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 agriculture 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.

Projects are organized by their primary contributions to the three highest level objectives of Feed the Future –

I. ***Inclusive and sustainable agricultural-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 from production, creating employment and entrepreneurship opportunities throughout value chains, and spurring growth in rural and urban economies.*

II. 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.*

III. 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.*

An entire project portfolio is attached as Appendix A.

I. INCLUSIVE AND SUSTAINABLE AGRICULTURAL-LED ECONOMIC GROWTH PROJECTS

EMPOWERING WOMEN THROUGH HORTICULTURE IN HONDURAS

Location: Intibuca, Honduras
Description: The families of western Honduras live in an economy marked by high poverty rates, poor diets, and subsistence agriculture. 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 also will 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: Penn State University (lead), USA, Zamorano, Honduras

Achievements: This year the project completed a gender-integrated Farmer Field School (FFS) from design to implementation to evaluation. The four-month long FFS incorporated gender topics such as time use, division of labor, self-esteem, and leadership into a horticulture production based field school that covered content from seed selection to postharvest and consumption. The FFS includes the horticulture technical training to produce a vegetable home farm with enough production to feed a family of four for a year with increased dietary diversity to include nutrient rich sweet potatoes and iron fortified beans. The completion of the FFS was culminated by a graduation ceremony that reinforced the importance of participation, highlighted the zero attrition rate among the 64 students, and shared the FFS results with a local audience as well as a broader audience. The FFS was evaluated through in-depth interviews with participants. The qualitative analysis of this data will inform future recommendations. The project is also progressing with the Gender and Agriculture certificate program at Penn State.
Capacity Development: The project's partnership with the Associación de Mujeres Intibucanas Renovadas (AMIR) has included supporting their mission through FFS and improving their production and food safety capacity through intern work. The project had participation in its FFS from leaders in AMIR who are planning to share the training with other members, thus scaling the inclusion of the gender curriculum. Student exchange included three undergraduate Honduran interns from Zamorano who conducted their fieldwork with the project in early 2018. At Penn State, the interns sat in on classes, learned about local agriculture, and worked on their theses. They were able to improve their technical knowledge and dramatically increased their English language ability, better preparing them for a global career in the future. The project's partner lead in Honduras, Arie Sanders, is also finishing his Ph.D. at Penn State with his field research linked to the project. Furthermore, the progress towards the creation of the Gender and Agriculture Certificate program at Penn State is providing opportunities for graduate students to engage in scholarship at the critical nexus of gender and agriculture.
Lesson learned: The importance of partnerships remains paramount as the project has continued to work with AMIR to identify opportunities for their growth. The success of the project's three-way partnership can provide an important example of how to negotiate partner interests, develop trust, and offer sustainable programming with lasting impact. The project has found some challenges that are critical to the successful adoption of the technology, practices, and knowledge. This includes issues of time-use (notably added burden to women's already heavy workload), and access to water (with the support of drip irrigation technology).
Presentations and Publications

A) Presentations (6 presentations, 1 highlighted)
   i) Castellanos, P., Larson, J., Jensen, L., & Garner, E. (July 2018). She said, he said: insights from a survey of smallholder couples in Honduras. Presentation at Rural Sociological Society Annual Conference, Portland, Oregon

MANAGING NEMATODES AND SOIL HEALTH IN GUATEMALA

Location: Huehuetenango, Guatemala; Quiche, Guatemala; Totonicapan, Guatemala; and San Marcos, Guatemala.

Description: Plant-parasitic nematodes and soil degradation on smallholder farms reduce yields and limit smallholder 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 amendment, biopesticides, and crop resistance to manage nematodes and soil health.

Collaborators: University of Hawai‘i at Mānoa, USA; Michigan State University, USA; Universidad de San Carlos de Guatemala, Guatemala.

Achievements: The project has continued to engage small-holder potato farmers in Guatemala. The team's efforts have focused on helping the farmers to recognize and address their soil health and potato cyst nematode problems. Farmers are now more aware of what is limiting their potato production and appreciate the support. The project plans to plant demonstration plots in the final year of the project. Additionally, the project has designed and planned two winter workshops on soil health and potato cyst nematodes that will be held in FY2019. The team has communicated the findings to the farmers at the workshops, at scientific meetings, and in seminars at universities. Finally, the project has started writing peer-reviewed publications with drafts nearly ready for internal review.

Capacity Development: The project has partnered with Popoyan, a private firm offering biological control products, to tackle the potato cyst nematode problems. The team has and will continue to explore collaborations with Papais, a certified potato firm in Guatemala. The project is working closely with potato cooperatives in San Juan, Paquix, and Clemintoro to inform farmers and motivate them towards the adoption of improved soil health tactics. The project has employed a University of San Carlos intern to assist with field demonstrations and data collection. The intern is learning about field demonstrations, plant diseases, nematodes, and how to conduct economic surveys.

Lessons Learned: Farmers continue to seek quick responses and easy solutions. Building soil health to control nematodes is not as quick of a solution as they would like. Farmers are disappointed in the yield response from the first year's demonstrations. They expected substantial rather than incremental increases in yield. Farmers are anxious for the project to share the results of the cognitive mapping work, which will occur during the winter of 2018-2019.

Presentations and Publications

a) Presentations (4 presentations, 2 highlighted)
   i) Sipes, B., Chan, C., Melakeberhan, H., Sanchez, A., LaPorte, P., & Sacbaja, A. (July 2018). Assisting Smallholder Farmers in Adopting Integrated Nematode-Soil Health Management: Fuzzy Cognitive Mapping Identifying Gaps between Experts and Farmers. Presentation at Society of Nematologist Annual Meeting, Albequerque, NM
   ii) Sipes, B., Chan, C., Melakeberhan, H., Sanchez, A., Sacbaja, A., Kakaire, S., & Lee, C. (July 2018). Changes in Soil Biophysiochemistry. Presentation at Society of Nematologists Annual Meeting, Albequerque, NM

BUILDING POSTHARVEST CAPACITY IN TANZANIA

Location: Morogoro, Morogoro Region, Tanzania

Description: This project is a collaboration of researchers and extension specialists building capacity at Sokoine University of Agriculture (SUA) in postharvest specialization of horticultural crops. The main goal is to provide students, farmers, traders, marketers, and agriculture extension educators that are working with fresh produce, the tools necessary to improve the quality and shelf life of their products and consequently reduce postharvest losses in Tanzania.

Collaborators: Kansas State University (KSU), University of Florida (UF), and Sokoine University of Agriculture (SUA) Tanzania

Achievements: Dr. Romadhani Majubwa, professor of Agriculture, Crop Science and Horticulture at Sokoine University of Agriculture (SUA), attended a curriculum development course at the University of Florida (UF) in Gainesville for two weeks under the supervision of Dr. James Bunch, Assistant Professor in Agricultural Education. Modules for the short course outreach programs in the area of postharvest physiology and management of fruits and vegetables have been developed and two "Training of Trainers" (ToT) courses have been conducted. A total of sixty trainers from the government, private and civic societies were trained between May and August. Horticulture Innovation Lab promoted technologies (The CoolBot, chimney solar dryer, and Zero Energy Cool Chamber (ZECC)) were established and the postharvest lab at SUA was equipped with new instruments for analysis. A draft of the curricula for a new master's of science (MS) in Horticulture program at SUA as well as the postharvest courses were developed. The MS curriculum is now being reviewed for approval. A mini packhouse, fabricated using old marine containers, was established and equipped with a CoolBot and research has been conducted by SUA students utilizing the CoolBot cold room.

Capacity Development: As part of institutional capacity development, the project has established and improved the basic training facilities for postharvest training and research at SUA. The project managed to establish a mini packhouse, cold storage facilities (cold room with a CoolBot and a ZECC), vegetable/fruit drying facility (chimney solar dryer), and equipped the postharvest lab at SUA with the potential tools for various analysis. One SUA staff member participated in a two week course at UF covering curriculum designing and development. That staff member, Dr. Romadhani Majubwa, is now directly involved in the development of the new MS in Horticulture curriculum and the improvement of the postharvest course at SUA. The project, using its SUA,UC Davis, KSU, and University of Florida teams, managed to conduct two ToT courses to agriculture extension officers, agronomists, marketing managers (from both the government and private sector) on postharvest handling of fresh fruits and vegetables. The trainees were from the Tanzania Horticulture Association, Sustainable Agriculture Tanzania, Fintrac (Mboga na Matunda project), Helvetas Tanzania, Sokoine University Graduate Entrepreneurs Cooperative, Association of Mango growers, Integrated Pest Management Innovation Lab project (East Africa), SUA, and Local Government Authority (LGA).

Lessons Learned: Maintaining engagement with trainers who have completed ToT has been valuable for the project to track the tangential impact of the ToT courses. The project designed a feedback form through which trainees of ToT can give insight to the SUA project team via emails on numbers of farmers trained and the topic of training. The project team has already received feedback from the trainees of the two ToT detailing that forty farmers have received training.

SCALING UP DRYING TECHNOLOGIES FOR SEED IN BANGLADESH

Location: Bangkok and Phichit, Thailand; Dhaka, Bangladesh

Description: The goal of this project is to create the foundation for spontaneous diffusion and large-scale adoption of advanced drying technologies in Bangladeshi agriculture. Drying in the hot, humid climate of Bangladesh, as with much of South and South East Asia, 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. Bangladeshi seed companies estimate that they lose 5-10% or more of their seeds due to poor drying, worth tens of millions of dollars in horticultural seeds alone. The high cost and unreliable quality of improved, high-yielding, stress-tolerant seed varieties are major factors that cause less than half of Bangladeshi farmers to buy commercial horticultural seeds; an even lower share buy commercial cereal seeds. In addition, insufficient drying of agricultural products leads to rapid deterioration after harvest and often development of aflatoxins within the products.

Collaborators: Rhino Research, Thailand (Lead); University of California, Davis, USA; Professor Jayashakar Telangana State Agricultural University, India; Bangladesh Rice Research Institute, DAI

Achievements: Rhino Research trained several private seed companies and government organizations during this project. However, Lal Teer Seed Ltd, which is the largest high-value seed producing company in Bangladesh, was the most invested in maximizing the impact of both the Drying Beads and storage technologies. Lal Teer estimated that over 450 seed-producing farmers that the company purchases seed from received drying kits and training. Rhino Research has reorganized its business and is working to establish franchises in Asia and Africa to disseminate Drying Beads and storage technologies. A U.S. based branch will handle sales to Central America.

Capacity Development: Over the course of the project, fourteen people received training through the project's "Train the Trainer" capacity building model. These training recipients proceeded to conduct trainings that have impacted 70 private entity individuals and more than 500 seed-production farmers. Two hundred tons of seed have been dried using the Drying Beads, resulting in improved access for farmers to higher quality seeds.

Lessons Learned: Effective training should start with motivated individuals that occur frequently and include long-term support of the trainees. This ensures further information dissemination upstream and downstream. Additionally, selling the technologies, rather than donating the technologies, increases the likelihood of sustained adoption. Finally, import duties can be high, impacting the affordability of the technology.

IMPROVING POSTHARVEST PRACTICES FOR TOMATOES IN BURKINA FASO

Location: Kaya, Sanmatenga, Burkina Faso

Description: Tomatoes are an important crop for increasing household resilience and nutrition in Burkina Faso. However, the farming of tomatoes is largely at a subsistence level and farmers face many challenges, chief among which is low bargaining power due to a supply glut. Given the current market situation, postharvest solutions that increase the quality and postharvest life of tomatoes, through postharvest handling, storage, better packaging as well as processing, will alleviate many farmer challenges and make the crop more lucrative. 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 Fas;, USAID/Sahel Regional Office; Environmental Institute for Agricultural Research/Burkina Faso (INERA); ACDI-VOCA, Burkina Faso.

Achievements: In the past year, the project has made significant advances. The project is working to set up a "Postharvest Training & Services Center." The site for the Postharvest Training & Services Center has been identified by the Environmental Institute for Agricultural Research/Burkina Faso (INERA). The project has worked hard to build the capacity of local agronomists in tomato postharvest handling. The first postharvest training was organized in October 2017 at Kaya, for the extension staff of ACDI/VOCA, Catholic Relief Services (CRS) and Burkina Faso government extension workers. Forty-two participants had an opportunity to be trained and interact with experts with both postharvest handling and processing backgrounds. After the training, more than 30 people signed up for a postharvest learning, follow-up program. The trainees were guided by experts from the Postharvest Education Foundation (PEF) team, through emails, to work on various assignments. A refresher training for agronomists who had signed up was organized in Kaya, Tougouri and Manni in February 2018. Fifty-three people were trained including local producers. A third training focused on a Commodity Systems Assessment Methodology was conducted in March 2018 and had 38 participants. Additionally, INERA planted and evaluated rainy season tomato varieties which they received from the World Vegetable Center. Out of six varieties, AVTO 112 and Mongal were identified as varieties with very good growth ability and production.

Capacity Development: The project has focused on building the institutional capacity of INERA so they can provide trainings in postharvest management as well as increase the availability of tomato seed varieties suitable for rainy season production in Burkina Faso. The project has organized three trainings in which we have trained agronomists, government officers and lead farmers on how to reduce postharvest losses in tomatoes**.**

Lessons Learned: The project has proceeded smoothly. No lessons to report at this time.

IMPROVING PRACTICES FOR DRIED APRICOTS IN TAJIKISTAN

Location: Khatlon District, Tajikistan

Description: Apricots have the potential to be a high value crop for small 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 the potential for smallholder farmers to produce and export quality dried apricots. It also hopes to assess food safety challenges, build meaningful collaborations with local institutions and compare three solar dryers with current methods of drying in Khatlon province, Tajikistan.

Collaborators: Purdue University, USA; Tajik Agrarian University, Tajikistan; Jua Technologies International, LLC, USA; Feed the Future Tajikistan, Agriculture and Water Activity, Tajikistan

Achievements: The team has developed a draft of a manuscript with insights on the apricot value chain in Tajikistan. The manuscript provides insights on the main players, main challenges and potential opportunities for improving the quality and market access of apricots grown in the Khatlon region. The team also presented main findings from the project's baseline assessment at the American Society of Horticulture Sciences (ASHS) Conference in Washington D.C. in July 2018. The team will conduct entrepreneurship, food safety, and drying workshops for farmers in the Khatlon region in 2019. The workshops will be conducted before harvest season (entrepreneurship and food safety) and during harvest season of apricots in the South (drying). Exact days will be determined once the harvesting season can be predicted (depends on length of previous winter).

Capacity Development: Connections established with Professors at the Tajik Agrarian University and Sarob representatives have been maintained and leveraged to fill data gaps from baseline assessment conducted in 2017.

Lessons Learned: There are important challenges to improve the supply chain of dried apricots grown in Khatlon; however, climatic and market favorable factors can help push this chain greatly. As well, a trip to Tajikistan in 2018 for training on Good Agricultural Practices (GAPs) did not occur due to timing conflicts with apricot growers in the both the north and the south. The Purdue Team understood that the best times for trainings, as we do in the U.S., would be in the fall and winter months when growers had more time available to attend the trainings. However, it was determined that apricot growers would benefit the most from GAPs trainings if they were held immediately before harvest, such as in mid-April to early May. A Good Postharvest and Food Safety Handbook was planned to be developed after the trainings were completed in order to incorporate any regionally specific growing and harvesting challenges that were observed or learned during the trainings. By not offering trainings in 2018, the Good Postharvest and Food Safety handbook will now be completed before the GAPs trainings are offered in the spring of 2019. Edits will be incorporated following the trainings to still capture any regional variations and opportunities in Postharvest and Food Safety for apricot production.

Presentations and Publications

A) Presentation
   i.) 2018. Torres A. Baseline assessment of Tajik apricot production and postharvest handling. American Society of Horticulture Sciences Conference, Washington DC

ASSESSING FEASIBILITY OF PEST-EXCLUSION NETS IN KENYA (SEMI-ANNUAL REPORT, PROJECT COMPLETED IN EARLY FY2018)

Location: Kirinyaga, Uasin Gishu, Kajiado, Migori, Nakuru, and Embu Counties, Kenya

Description: A 1-year pilot study examining the commercial feasibility (principally user acceptability and the return on their investment) of scaling-up the use of AgroNets for sustainable production of fresh market vegetables in Kenya. Research results show that netting technology leads to increased yields (with a higher percentage of marketable produce), while simultaneously reducing the use of synthetic insecticides or eliminating their application altogether (enhancing exporter compliance with strict EU requirements relative to pesticide minimum residue levels). As such, their use 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, Kenya; Real-IPM, Kenya; Finlays, Kenya; Sunripe, Kenya; Frigoken, Ltd., Kenya; Smart Development Works, Holland

Achievements: The project engaged a total of 30 growers and provided each with an 8m wide x 20m long x 2m tall, metal-framed nethouse producing three crops (i.e., French bean, tomato and cabbage) over two growing cycles in five regions across Kenya. In addition, biopesticides/beneficial insects were utilized. The nethouses were paired with open-field production of the same crops by the same five grower groups. Each grower chose a crop to grow for the first production cycle, and they were trained in the use and care of the AgroNets. The growers invested in drip irrigation systems, and one group also used their own funds to acquire additional training from Real-IPM (biopesticide supplier).

Capacity Development: The project partnered with Dutch Volunteers Foundation (SNV), the prime manufacturer of the AgroNets. The project team participated during SNV's trainings and demonstrations. Two of the project's most-dedicated, small-holder farmers (of the thirty engaged in the project) in Kiambu were empowered to train NGO farmers on how to manage a crop inside the net house, and thus benefit from the advantages provided by the technology - including an understanding of the expected return on investment in the technology. The SNV participants were enthusiastic about the testimonials from our project growers, and therefore were more willing to take up the technology. The leaders of each farmer group participated in exchange programs, and are expected to pass down this information to their farmers.

Lessons Learned: When medium-scale farmers are supported, they too invest in other complementary technologies to enhance success. The project's 30 farmers were only issued nethouses with no irrigation system. Out of these, 16 were of medium scale and all of them invested in drip irrigation to support the nethouse technology. Farmers in the project were at liberty to manage the crop as they would normally do. Organic farmers continued as such and others learned from them that nethouses support organic farming. Those that had an experience with plastic greenhouses opted for an indeterminate tomato variety that is high yielding and prolonged harvest. Other farmers understood difference and were willing to pay slightly more for the seed and gain even more from the bumper harvest. All the SNV farmers were issued a complete package that included nethouses, seed, fertilizer, pesticides, but those farmers failed to "own" the project. SNV provided the determinate variety that is suited for open field production depriving farmers of the opportunity to visualize yield change that is attributable to seed variety.

EXPANDING TOMATO GRAFTING FOR ENTREPRENEURSHIP IN GUATEMALA AND HONDURAS

Location: Siguatapeque, Guatemala and Francisco Morazan, Honduras

Description: Tomato grafting represents a proven technology that is increasingly adapted world-wide in both temperate and tropical countries to reduce risk of soil-borne pathogens and provide more sustainable production. In many tropical countries, tomato production is not simply reduced, but often a complete loss due to soil borne pathogens, impacting the livelihood, stability and nutrition of families in rural areas. Grafting produces a physical hybrid plant – the rootstock is chosen for its genetic ability to resist soil borne disease, and the scion is chosen based on fruit quality for commercialization. The technology is relatively simple, but can have a huge impact in providing more sustainable production to small-scale growers. Grafting represents added value to the producer and creates a unique opportunity for entrepreneurial women's groups to specialize, as do many new small greenhouse-based businesses in the US, in the production and sale of grafted tomato seedlings.

Collaborators: University of Wisconsin, USA; The Ohio State University, USA; Catholic Relief Services, Guatemala; Zamorano University, Honduras; World Vegetable Center, Taiwan.

Achievements: The project designed an easily-assembled acclimatization chamber using accessible materials for small vegetable producers. The farming cooperative the project supports in Guatemala started producing grafted seedlings to sell to other farmers in their area. Erick Gutiérrez obtained his master's in Plant Breeding and Genetics, and is currently employed by Zamorano University. Erick devotes part of his work to researching and promoting grafting. The project has developed new tomato hybrids that the team will use in a pattern selection program to evaluate resistance to soil pathogens and abiotic stresses.

Capacity Development: Erick Gutiérrez obtained his master's degree in Plant Breeding and Genetics from the University of Wisconsin-Madison under the grant. With the hiring of Mr. Gutierrez, Zamorano now has an expert in grafted vegetables along with the needed infrastructure and trained personnel to conduct expanded research trials of grafts. Additionally, Zamorano now has germplasm of varieties with resistant patterns to the main soil pathogens and viral infestations affecting tomato and chili production. These are available to be distributed to horticultural producers in Honduras to reduce their production costs and improve yield. The project team developed a workshop on grafting vegetables for fourth-year students at Zamorano and held the training in May 2018. Dr. Ravishankar Manickam, who was in charge of grafting research at the World Vegetable Center (Taiwan), participated in the training. Zamorano intends to maintain a close collaboration with the World Vegetable Center to research and promote grafted vegetables in Central America. Training was also provided to production managers of the Hogar Pequenos Hermanos home, located in La Venta Francisco Morazán, Honduras. Germplasm and materials needed to be able to graft the rootstock and scion were provided. Finally, the project has also worked with farmers in tomato production areas in Honduras to introduce grafted tomatoes in areas infested with bacterial wilt.

Lessons Learned:
Implementing new production techniques, even simple techniques like grafting, can achieve significant improvement in the quality of life of smallholder farmers. The women's farming group in Momostenango, Guatemala that has already started producing grafts to sell to others is a great example of this.

PROMOTING CONSERVATION AGRICULTURE FOR VEGETABLE GROWERS IN CAMBODIA AND NEPAL (SEMI-ANNUAL REPORT, PROJECT ENDED EARLY FY2018)

Location: Puok Soutniko, Prasat Bakong District, Cambodia; Banke, Surkhet, Lalitpur and Dadeldhura, Nepal

Description: Horticulture crop production is susceptible to yield losses due to water deficiency. In regions of Cambodia and Nepal, water is scarce for extended periods, negatively affecting food security. This project addresses this problem through labor, water and soil saving technologies (LWSST), storing water through rainwater harvesting, and by efficient water use through drip irrigation and conservation agriculture (CA) production systems. This project builds on a previous Horticulture Innovation Lab project to scale CA practices through incentives to smallholders, and research to identify pathways for smallholders to market vegetables. The project focuses on marginalized smallholders who farm small, income-generating vegetable gardens of no more than 200 m^2 and whose families likely suffer from chronic malnutrition, and limited market access.
Collaborators: North Carolina A & T State University USA (Lead); Kansas State University; Agricultural Development Denmark Asia (ADDA), Cambodia; Royal University of Agriculture (RUA), Cambodia; International Development Enterprise (iDE), Nepal

Achievements: In Cambodia, about 90 farmers are practicing conservation agriculture (CA) in commercial vegetable home gardens in Siem Reap. Team monitored income of 54 during a ten-month period. Farmers had an average income of $1.79 cents per square meter. Total net income of all the 54 farmers was $26,171. Forty-three farmers increased area in commercial vegetable home gardens under conservation agriculture greater than the 100 m2 initially recommended by the project to as high as 350 m2 with average land size increased to 176 m2. The cooperative had a gross income of $1100 for nine months or $122 a month. Most of the operating cost of the cooperative including depreciation of CoolBot and TuktukBot was paid by the project. In Nepal, conservation practices have helped farmers save labor time (land preparation, weeding and irrigating), saved water, saved soil, decreased pest, increased yield and increased income. In the 2nd year of tomato farming, hole-makers were used for transplanting vegetable seedlings in conservation practice, which had decreased the labor time (no tillage). By seeing the difference in the trial sites, farmers have adopted mulching, hole-makers, drip irrigation and IPM technologies in their fields. 600 farmers adopted mulch based technology, a part of CA.
Capacity Development: Two sustainable intensification innovation lab funded projects will continue research with farmers in Siem Reap through the "Appropriate Scale Mechanization Consortium," and "Women in Agriculture and Nutrition" projects. Rice in conservation agriculture was added into the system, with mulch coming from rice and grown on the paddy fields will be used in commercial vegetable home gardens, as livestock feed, and enhanced soil quality on the paddy field. This will further build the capacity of women in Siem Reap. The partnerships have extended not only with RUA, Kasetsart University and Agricultral Development Denmark Asia; but has now reached to the ministry of agriculture, fisheries and forestry, the university of Battambang, the World Vegetables Center, and ECHO Asia. In Nepal, iDE started scaling up CA innovations for commercial vegetable home gardens with women farmers in Nepal who are not part of the project through Food for Peace and other projects in Nepal.
Lessons Learned: In providing incentives for adoption, make the incentive simple. The team started with a very elaborate sharing of income method and it did not work. The project changed it to just buying CA farmer's produce 10% higher than middle person's offer.
Publications:

A) 2018 Edralin, D. I., Sigua, G., Reyes, M., Mulvaney, M., & Andrews, S.. Yield and Weeding Activity in Conservation Agriculture with Low-Cost Drip Irrigation in Seam Reap, Cambodia. Agronomy for Sustainable Development

II. STRENGTHENED RESILIENCE AMONG PEOPLE AND SYSTEMS

REDUCING POSTHARVEST LOSSES IN RWANDA

Location: Mulindi, Busogo and Rubona, Rwanda
Description: The Rwandan National Horticulture Strategy (Dec 2014) estimates that 1 million rural households in Rwanda grow horticulture commodities, "principally for home use and sale. For most rural households, home produced fruits and vegetables proved an important source of the micro- nutrients necessary for a healthy balance diet." 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. The project aims to understand and identify the most efficient ways to reduce postharvest losses in Rwanda, to ultimately increase food security. 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: Ministry of Agriculture and Natural Resources; Rwanda, National Agriculture Export Board; University of Rwanda; Rwanda Agriculture Board; the Postharvest Education Foundation.

Achievements: In FY2018 the project has engaged over 1000 people and shown improvement in practices on the ground. The "Rwanda Postharvest Week" was organized by the project to bring together public and private sector partners and drive action through collaborative learning to reduce postharvest losses in horticulture. The events were held at different locations in Kigali, Rwanda. The highlight of the week was the "Postharvest Innovation Competition", through which the project is growing and nurturing startups working on postharvest innovations and helping them to commercialize their ideas. Thirteen winners were selected and have shared various amounts of the USD$50,000 in prize money as well as business coaching. Additionally, the project has continued to build the entrepreneurial capacity of the agriculture industry and has successfully motivated many entrepreneurs to invest in postharvest solutions. The project is also advancing research at Postharvest Innovation Centers, as well as supporting the research of University of Rwanda students.
Capacity Development: The project's primary focus has been to ensure that its partner institutions are able to step up their engagement with postharvest issues across the board. This focus has resulted in - the Rwanda Agriculture Board (RAB) increasing its dedication to postharvest management; National Agricultural Export Development Board (NAEB) employing food science graduates to work closely with priority cooperatives; and, the University of Rwanda introducing postharvest research to current students and planning to offer a new master's program in Postharvest Management. Additionally, the project has worked to increase the institutional capacity of cooperatives that are engaged by other USAID projects – specifically the Hinga Weze and Private Sector Driven Agricultural Growth (PSDAG) projects. Finally, the project has worked with 73 agribusinesses to increase their capacity to offer postharvest solutions and has worked with the 13 postharvest competition-winning start-ups. In FY2018, 463 people have been trained in postharvest management and 86 people have been trained in agribusiness. Outreach campaigns conducted by the University of Rwanda and NAEB are on-going activities, and the team expects that over 1000 additional people will be recorded, as a total of 13 sites are being visited by these two partners.
Lessons Learned: None to report
Presentations and Publications

a) Publications (5 published; 2 highlighted)
   i) 2018. Gill, G. S., Vasanthakaalam, H., Mukantwali, C., Kabayiza, E., Kitinoja, L. Postharvest Loss Assessment of Green Chilies in Rwanda
   ii) 2018. Gill, G. S., Vasanthakaalam, H., Mukantwali, C., Kabayiza, E., Kitinoja, L. Postharvest Loss Assessment of Green Bananas in Rwanda

TRELLIS FUND (ROUND 6)

Location: Ethiopia, Ghana, Nepal, Rwanda, Tanzania and Uganda

Description: The Trellis Fund is part of the Feed the Future Innovation Lab for Collaborative Research on Horticulture, led by the University of California, Davis. The Trellis Fund is a grant making and capacity building program that connects local organizations in developing countries with U.S. graduate students who have agricultural expertise, generating benefits for both the students and the in-country institutions. They, in turn, collaborate on short-term projects to address horticultural challenges faced by local farmers.

Collaborators: University of California, Davis, North Carolina State University, University of Hawai‘i at Mānoa, University of Florida, Send a Cow Ethiopia, University of Cape Coast (Ghana), Methodist University College Ghana, Kumasi Institute of Tropical Agriculture (Ghana), Tip Top Foods (Ghana), Aythos (Nepal), Center for Agricultural Research and Development-Nepal, SYBASH (Rwanda), University of Rwanda, HORTI Tengeru (Tanzania), Ndibwami Integrated Rescue Project (NIRP - Uganda), Uganda Rural Information and Communication Technology/Educational Center (URICT-Uganda), Mwino Group (Uganda), Eco Agric Uganda and Teso Women Development Enterprise (Uganda)

Achievements: *Sustainable local organizations created and strengthened:* This year, local organizations received support from fellows on essential skills to continue seeking funding for future projects. Local organizations supported the establishment of farmer groups that will support improved socio-economic outcomes for farmers. During this year, 12 new organizations were formed, including 11 producer groups and 1 marketing association, and Trellis fellows are supporting the development of business plans with two partner organizations in Uganda. *Improved nutrition and reduced food loss for households:* This year, Trellis Fund projects witnessed remarkable farmer adoption of food processing and preparations from trainings, which would support improved household nutritional outcomes and food loss reduction. In Uganda, NIRP reported that farmers were juicing passionfruit and making tomato sauce in their homes within months of the training. In Ethiopia, initial reactions from farmers to the sweet potato leaves as a reliable, drought-tolerant and nutritious food source were overwhelmingly positive. Both organizations will be tracking the continuity of these practices.

Capacity Development: During round 6 of Trellis (2018), 15 organizations were funded. The Trellis Fund sought opportunities to build institutional capacity by funding 10 “alumni” organizations which included CARD-Nepal, NIRP, Methodist University College of Ghana, Kumasi Institute of Tropical Agriculture, URICT-Uganda, Mwino Group, University of Cape Coast, Eco Agric Uganda, Tip Top Foods and Teso Women Development Enterprise. When funding alumni organizations, Trellis funding supported the continuation of previous projects, expanded support to new farmers or communities, and initiated a new project. This year, students also assisted organizations in expanding their networks. Send a Cow Ethiopia and Eco Agric Uganda were introduced to their respective USAID country Missions.

Lessons Learned: Flexibility on the part of Trellis staff, local organizations and fellows remains essential to successful projects. Students and organizations reported working together to identify other resources to supplement Trellis funding to continue activities. Students and organizations prioritize demonstrations and applied training wherever possible. Organizations have appreciated receiving materials prior to training. Materials translated into local languages improves farmers’ learning.

Presentations and Publications

Presentations (2):

a. Krishna Bhattarai from University of Florida presented his Trellis Fund experience working with Eco Agric Uganda at the UF/IFAS Gulf Coast Research and Education Center on August 17, 2018.
b. Russell Galanti from University of Hawai‘i at Mānoa presented his Trellis Fund experience working with CARD-Nepal at the Komohana Research and Extension Center "lunch and learn" series on August 28, 2018.

DEVELOPING FARMER-LED IRRIGATION SOLUTIONS IN UGANDA

Location: Mbale and Jinja District, Uganda
Description: The University of California, Davis is working on a research project developing and evaluating small-scale irrigation and water management technologies for Uganda and East Africa as a whole. The objectives are to develop first a number of innovative designs and approaches in small-scale irrigation suited to common agroecological conditions in the country, and second an evaluation toolkit that can be used by district and region level staff of local government and private organizations to identify opportunities to upgrade local irrigation sites.
Collaborators: National Semi Arid Resources Research Institute (NaSARRI), Uganda; Buginyanya ZARDI, Uganda; Amelioration of Agricultural Risk, Uganda; Teso Women's Development Initiative, Uganda; Busitema University, Uganda

Achievements: The project has three main accomplishments in terms research and development of smallholder irrigation for Uganda and East Africa. First, the team has developed technologies and organizational approaches in collaboration with farmers that fit the context of small, farmer-managed agricultural systems, including more than ten technologies and practices that have been validated and adapted by farmers in different agro-ecologies. The project is now training local organizations on how the technologies can be used and scaled as well as spreading information more widely in digital formats. Second, the team has identified the major constraints farmers face to improving their irrigation systems, both in general and with a specific focus on women farmers. The results are being developed into a locally relevant toolkit and as policy recommendations for organizations in the sector. Third, the project has built the capacity of young agricultural and engineering professionals to work effectively on small, farmer managed irrigation and horticulture. These trainings included students and professionals in agriculture, engineering, and economic development. The project trained over 20 students and young professionals, many of whom have earned careers in irrigation and horticulture development organizations from the experience they gained in the project.
Capacity Development: The project has worked closely with a local NGO focused on women's economic empowerment. The organization, Teso Women Development Initiatives (TEWDI), is now working more actively in supporting women farmers to become economically and socially empowered in the project sites and beyond. The project has built capacity in local government and civil society (NGOs) in the six innovation sites. In each of these sites, the team has trained local staff to improve horticulture and irrigation systems. The team has improved the practical experience for agriculture engineering students at Busitema University by training over 20 young professionals working in: technology design, horticulture management, irrigation principles and management, qualitative/quantitative data collection, and technology evaluation. Additionally, the project has trained over 150 farmers in irrigation and horticulture management. These farmers' skills have also greatly improved due to the technology and organizational development process in which they innovate solutions to their local challenges with the support of the project.
Lessons Learned: The project needs to continue to work with a number of students and young professionals in entry-level positions, to evaluate who can be moved into positions with higher responsibility. As a practice, engaging many of them in short, lower-cost employment can help identify the high potential young professionals. Another lesson is that for smallholder technology development, it is more appropriate to engage engineers to solve specific technical challenges rather than allowing them a large influence in driving the design process. This is important to give farmers the room to develop their own approaches.
Presentations and Publications

A) Presentation

i) Scow, K. (September 2018). Participatory Research to Address Sustainable Development Challenges. Presentation at 2018 International Research Conference at UC Davis Program, Davis, CA, USA

III. A WELL-NOURISHED POPULATION, ESPECIALLY AMONG WOMEN AND CHILDREN

IMPROVING NUTRITION WITH AFRICAN INDIGENOUS VEGETABLES IN KENYA AND ZAMBIA

Location: Eastern province, Zambia; Western and Rift Valley Regions, Kenya
Description: The goal of this program is to improve the production of, and increase access and consumption of African indigenous vegetables in communities in Kenya and Zambia as an effort to improve nutrition, income and health outcomes of people at risk for malnutrition.
Collaborators: Rutgers University, USA; Purdue University, USA; Moi University, Kenya; University of Eldoret, Kenya; World Vegetable Center, Tanzania; Center for International Cooperation in Agronomic Research for Development; Hantambo Women's Group
Achievements: This year was a watershed year in building the foundation for the planned dietary diversity studies, including creating, developing and pretesting the nutritional intervention approaches and materials. The project introduced a series of production modules for African indigenous vegetables aimed at encouraging farmers, families and communities to produce the vegetables for formal and informal markets for year round production and scale-up. This year showed a record increase in the number of trainings conducted, a rise in the number of household benefiting from this project (2162 continuing with the project and 261 new households for the first time); and continued support toward the 83 full time employees and over 200 organizations with whom this project has been involved. As a result of the trainings, in addition to growing African indigenous vegetables, farming families have expanded their production of other traditional fresh market vegetables. Consequently, their incomes have increased. During the course of this year, the nutritional profile and chemical characterization of several native vegetables continued with the greatest new findings reported and published on amaranth and edible nightshades. A subcontract with the Center for International Cooperation in Agronomic Research for Development (CIRAD) was formalized and will be implemented this fall. This includes a new field trial to evaluate sustainable pest management practices and the development of extension recommendations for smallholder farmers.
Capacity Development: The site at the University of Zambia was being fenced and made secure so that the improved facilities (pump and irrigation, CoolBot, ShadeBot, Zero Energy Cooling Chamber, drying racks, and solar dryers) could be stored securely and field studies could be conducted. The project involved 20 students (graduates and undergraduates from Kenya, USA and Zambia) and two graduate students who completed their thesis work in support of this African indigenous vegetable project including a PhD and a master's student.
Lessons Learned: Field trials were delayed in Zambia this year and that has slowed down the ability for US researchers to chemically profile and nutritionally analyze dried African indigenous vegetables. We have had some minor challenges in developing a robust data analysis workflow with the "genetic environment" field trials on African indigenous vegetables. That appears to be solved now but has been difficult during this period of time.
Presentations and Publications:

A) Presentation (4 presentations, 1 highlighted):
   i. Simon, J. E., Byrnes, D., Yuan, B., & Wu, Q. (March 2018). Characterization of polyphenols, alkaloids and saponins in *Solanum scabrum* leaves and berries using HPLC-UV/vis-MS. Presentation at Rutgers Global International Research Graduate Symposium, Rutgers University, New Brunswick, NJ
B) Publication
   i. Yuan, B., Giurleo, D., Villani, T., Simon, J., & Wu, Q. (November 2017). Rapid screening of toxic glycoalkaloids and micronutrition in edible nightshades (Solanum spp.)(pp.751-760). Journal of Food and Drug Analysis, 26(2), Taiwan, Republic of China. doi:https://doi.org/10.1016/j.jfda.2017.10.005

INVESTIGATING INTEGRATED VEGETABLE-LIVESTOCK SYSTEMS IN CAMBODIA

Location: Siem Reap**,** Battambang**,** Penomh Penh**,** Cambodia

Description: A majority of Cambodian farmers are considered smallholder farmers, with less than two hectares of farmland 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. Due to the complexity and interdependent nature of an integrated farming system, optimizing aspects of production, income, and resource recycling can be difficult. This project aims to understand how integrated animal-horticulture systems are most feasible for smallholders by rigorously addressing, through interdisciplinary research, the potential of these systems with regard to sustainable production capacity, income generation, and gender dimensions. The project will provide useful recommendations for smallholder farmers.

Collaborators: Kansas State University (KSU), USA; Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN); Royal University of Agriculture (RUA), Cambodia; University of Battambang (UBB), Cambodia; Agriculture Development Denmark Asia (ADDA), Cambodia.

Achievements: The project team completed a survey of 111 households in the Siem Reap region in January. A second survey of 118 households in the Battambang region was conducted in March. The surveys collected information on costs, earnings, labor, horticulture production, and perceptions for small scale farms. This data was analyzed to evaluate potential differences in farm outcomes across horticulture cooperative members and non-members. The results of the analysis were cataloged in a working paper that is currently under review at Global Food Security, a peer reviewed journal. The timeline for the project is on track and data collection for the entire project will be completed in early 2019. Horticulture and conservation agriculture research is in its final season and will be completed soon. The livestock studies have been completed and data is currently being analyzed. Food safety has completed the wet season data collection and will complete dry season data collection in January of 2019. Students are currently working on their theses and setting defense dates. Project activities will shift to the building of the extension decision-support tool and development of educational materials in 2019.

Capacity Development KSU and RUA have begun to see many opportunities to begin to strengthen and define their extension work. Based upon this project and another project at KSU funded by the Livestock Systems Innovation Lab, the project team has been able to work with the faculty and staff from the Veterinary Medicine Department to work on pathways to strengthen their outreach and extension in regards to swine production. The project has two technicians and four interns that take part in this research. The role of the technicians and interns are to help support day-to-day activities at each of the technology parks. Furthermore, the project currently has four graduate students being trained as a part of this project. Six enumerators were trained in survey collection and employed for the Siem Reap survey. Another six were trained and employed for the Battambang survey, including university students.

Lessons Learned: KSU and RUA continue to build a very strong relationship, and have learned the importance of having strong partnerships. The success of this project has been a result of the exceptional communication between project members. The team has enjoyed its time with undergraduate and graduate students. Much was learned about the structure and functioning of horticulture cooperatives in Battambang during the writing of the paper documenting the results of the household surveys collected in January and March.

Presentations and Publications

A) Presentation
   i) Vipham, J., Hok, L., Stewart, Z., DeRouchey, J., Sath, K.. Multidimensional Trade-Off Analysis of Integrated Animal-Horticulture Farming Systems for Improved Smallholder Farmer Adoption Recommendations (Poster)

BUILDING SAFE VEGETABLE VALUE CHAINS IN CAMBODIA

Location: Battambang, Cambodia

Description: This effort builds on a previous Horticulture Innovation Lab project to determine how best to cultivate a sustainable safe vegetable value chain to increase food security in Cambodia. Safe vegetables promote health and are free of chemical and microbiological hazards. Safe vegetable value chains include input providers, farmers, collectors, food distribution and value-added processing facilities, and marketers. As key actors in safe vegetable value chains, smallholder farmers are primed to increase their incomes and improve their food security.

Collaborators: University of California at Davis, USA; Royal University of Agriculture (RUA), Cambodia; University of Battambang (UBB), Cambodia; IPM Innovation Lab, USA.

Achievements: The project has produced extension bulletins on earthworm production, "Raising Earthworm Compost", to share with smallholder farmers and trainees. This year, 1200 bulletins have been distributed. Additionally, the team worked with the Cambodian government's extension program and promoted the Safe Vegetable Value Chain (SVVC) project even to the highest positions in government, including His Excellency Veng Sakhon, Minister of Agriculture, Forestry and Fisheries. His Excellency visited the SVVC team's project sites in Battambang where the team guided him in a technical tour. The Minister visited the Earthworm Compost Research and Training Center and the Hub for Safe Vegetables that includes a packinghouse, cold room and nethouses as part of the Agricultural Learning Center in Thmor Koul District.

Capacity Development: The SVVC project team applied for joint funding through the National Science Foundation's Partnerships for Enhanced Engagement in Research (NSF-PEER) program. This program links U.S. researchers with developing country researchers. The project team submitted four proposals for this grant, which helped develop the capacity of Cambodian researchers to plan and solicit funding for multi-institution research projects. U.S. researchers also conducted laboratory training, project development training, and project management training tofurther develop capacity at the Royal University of Agriculture (RUA) for independent research. At both centers in Battambang, the SVVC project team conducted training and participatory research with local and regional community members to innovate new ideas for improving the safety and quality of vegetables in Cambodia. Two U.S. master's students and 14 Cambodian undergraduate students have been trained in the project which has built research capacity, honed cross-cultural written and verbal communication skills, and developed leadership skills among the next generation of professionals.

Lessons Learned: The SVVC project team has gained better understanding from farming communities about the factors that affect adoption of new technologies or practices. The project team conducted surveys with two farming communities and observed interesting differences. One community began adopting new nethouse technology and adapting their practices to meet market demand several years ago. These farmers were more eager to participate in training about production standards than farmers who have not had the same length of history using nethouses, adapting their practices and connecting with new markets. It illustrated to the project team that when new innovations are first introduced, farmers feel more risk averse because they do not yet have a confident understanding in how the new innovations will work or how they will affect their income, schedule and market connections.

Presentations and Publications

A) Presentations (4 presentations, 1 highlighted)
   i. Young, G., LeGrand, K. (August 2018). Food Safety Innovations. 4th AFSA International Conference on Food Safety and Food Security

B) Publication
   i. Young, G., LeGrand, K., Trexler, C. J., Miller, G. D., Buntong, B., Chuong, T., & Kong, T. (September 2018). Leveraging shared interests to advance sustainable food safety systems in Cambodia (pp.167-191). Journal of Rural and Community Development, 13(3), Brandon, Canada. 1712-8277

DRYCARD FRANCHISE PROJECT

Location: USA, Tanzania, Rwanda, Nigeria, Thailand, Mexico
Description: The goal of this project is to increase awareness and adoption of the DryCard technology to improve storage systems and reduce postharvest losses. The Horticulture Innovation Lab is forming partnerships with organizations, businesses, and entrepreneurs to supply the DryCard to local communities of developing countries.

Collaborators: Postharvest Consulting and Capacity Building Company, Tanzania; Agrifood Business Consulting, Rwanda; TSM Alpha Ventures, Nigeria; Go Organics, Thailand; CGIAR/CIMMYT, Mexico; Ofori Agrochemical Services, Ghana; Mwino Group, Uganda; and Desert Water in Sierra Leone

Achievements: DryCards are now available in Thai, Khmer, and Bengali and commercially sold by 8 partners in Tanzania, Rwanda, Uganda, Guinea, Ghana, Sierra Leone, Thailand, Mexico, Guatemala, and the United States. Collectively, the franchises have sold and distributed 13,000 DryCards and the Horticulture Innovation Lab has handed out 5,000 DryCards to over 80 organizations. Furthermore, several of the DryCard entrepreneurs are now eager to incorporate a whole dry chain portfolio - chimney solar dryer and Purdue Improved Crop Storage (PICS) hermetic bags - in their inventory. In May 2018, the DryCard team was recognized as the UC Davis Chancellor's Innovators of the Year and was awarded $10,000 for continuing project activities. Additionally, in 2018, the DryCard was featured at the UC Davis Dry Chain Workshop held in Davis, CA.

Capacity Development: Partnerships have been established with Earth Empower in Mexico and Guatemala, the Horticulture Training and Services Center in Guinea, Ofori Agrochemical Services in Ghana, the Mwino Group in Uganda, and Desert Water in Sierra Leone to set up local production and marketing of the DryCard. Franchises and sample recipients have been meeting with farmers, agricultural government officials, and institutions to introduce the DryCard and train people on how to use them.

Lessons Learned: The process for establishing agreements with the in-country businesses and entrepreneurs should be simplified so that the partner fully understands their responsibilities and conditions. A complex and legal process and document may be inaccessible for local businesses and can slow down the establishment of production and marketing. The DryCard is just one part along the dry chain and its value can be significantly increased when paired with other related technologies such as solar driers or hermetic storage containers which the franchises can also sell. The DryCard introduces the dry chain concept in an easily understandable way and can be used as a marketing tool for other drying technologies by alerting the user that they have a problem with drying or dry storage. DryCard has the potential to also have impact in the US, and demand has been shown, mostly for seed storage.

Presentations and Publications

a) Presentations (3 presentations, 1 highlighted)
    i. Phan, A. (April 2018). Scaling the DryCard. Presentation at Dry Chain Workshop, Davis, Calif.
b) Videos (4 Videos, 1 Highlighted)
    i. Phan, A. & Leung, S. Introducing drying technologies to rural farmers.

IV. REGIONAL CENTERS

HORTICULTURE INNOVATION LAB REGIONAL CENTER AT ZAMORANO, HONDURAS

Location: Honduras – Serves Honduras, Guatemala, El Salvador, and Colombia
Description: The Regional Center at Zamorano, established by the Horticulture Innovation Lab, offers services to the Central American region, particularly to Honduras and Guatemala, including the following: 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, finally, technical assistance for small and medium-scale farmers.
Collaborators: University of California, Davis USA: University of Wisconsin, USA; Pennsylvania State University, USA; MasRiego Project, Guatemala.

Achievements: The Regional Center has continued to form strategic alliances with collaborators during this past year. These strategic alliances better position the Center for sustainability and reflect a strategic leveraging of funds. The Center, additionally, has continued to receive constant visits from representatives of NGOs, universities, government and private institutions. The visits have been key to fostering these alliances with the Center. As an example, partnerships in El Salvador and Colombia have led to the installation of Zero Energy Cooling Chambers (ZECC), cold rooms, and chimney solar dryers that were built by the Regional Center team. With smallholder farmers in the region, the Center continues to provide technical assistance on the installation of technologies to improve postharvest outcomes. Finally, the Center has continued to test and develop novel technologies, including macro and micro-tunnel production, utilizing Canavalia crops as green manure for family gardens, and a new Zero Energy Cooling Chamber constructed of recycled tiles that will be tested as a Zamorano student's thesis project.
Capacity development: During this year, the Regional Center has continued collaborations with government agencies, private industry, and NGOs including: FINTRAC, the Directorate of Science and Technology (DICTA), Fundación Hondureña de Investigación Agrícola (FHIA), the Food and Agriculture Organization (FAO), the Inter-American Institute for Cooperation on Agriculture (ICCA), the Foundation for Rural Business Development (FUNDER), and Catholic Relief Services (CRS).
During this year, the Horticulture Innovation Lab has formed technical teams to conduct training courses. Trainings this year covered postharvest handling, good agricultural practices, food security, food safety, nutrition, gender equity, integrated crop management, climate-intelligent family agriculture, and soil and water conservation. Additionally, the Center team has continued supporting Zamorano students' thesis projects and provided professional development guidance. The Center is currently developing the curricula and agenda for the sixth International Postharvest Course that will be attended by farmers, extensionists, NGO staff, and others. During the year, approximately 200 Zamorano students participated in the Integrated Crop Management and Climate Change Module. Finally, the Center continues the production of vegetables for the Zamorano students' dining hall including; tomatoes, bell pepper, yellow onion, sweet potato, hibiscus, lettuce, plantain, malanga invitro, and cassava.
Lessons Learned: Achieving strategic alliances has been fundamental for the strengthening of the Regional Center. Additionally, being an institutionalized center in Honduras, with expertise, has allowed to the Regional Center to expand its influence effectively.
Presentations and Publications

A) Thesis/Dissertations (6 supported thesis, 1 highlighted)
   i. Sanchez, G. (November 30, 2017). Effect of sowing distance and growth habit in pepper production under protected structure. Zamorano University
B) Presentation (3 presentations, 1 highlighted)
   i. Diaz. R., S Cost-benefit study of the use of the cold room with CoolBot technology in the storage of red pepper (*Capsicum annuum*) in Zamorano, Honduras

HORTICULTURE INNOVATION LAB REGIONAL CENTER AT KASETSART UNIVERSITY, THAILAND

Location: Bangkok, Thailand: Serves Bangladesh, Cambodia, Nepal
Description: The Horticulture Innovation Lab's 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 activities range from evaluating, adapting, and demonstrating technologies to training programs.

Collaborators: Horticulture Innovation Lab at UC Davis, USA; Royal University of Agriculture (RUA) Phnom Penh, Cambodia; University of Agriculture and Forestry (AFU), Chitwan, Nepal; Nepal's District Agriculture Development Office and Agriculture Research Center, Nepal; WinRock International; Erasmus+; and Department of Horticulture, Bangladesh Agricultural University

Achievements: In FY2018, the Regional Center continued its collaboration with WinRock's Feed the Future Asia Innovative Farmers Activity (AIFA) project. The goal of the project is to evaluate technologies and their effectiveness on the farm. The Regional Center team evaluated six solar pumps for irrigation installed at six different villages in Southern Nepal during two trips. Additionally, at the International Sustainable Agricultural Intensification and Nutrition Conference in Phnom Penh, Cambodia, the Regional Center team gave a presentation covering project activities and technologies. CoolBot cold rooms provided to the Royal University of Agriculture (RUA) in Siem Reap, Cambodia and a local farming community were evaluated during the visit - all are now in working order and a cold room monitoring unit designed by Dr. Jate Sathornkich was installed at the community farm. Dr. Sathornkich has continued working on a cold room monitoring system that can be accessible through WiFi and over cellular phone data plan. The cell data unit was designed to run on minimum power and can be installed in places with no WiFi coverage. The first unit has been installed in the CoolBot cold room at the Regional Center demonstration site at Kasetsart University, Bangkok, Thailand. The second unit was sent to UC-Davis for testing. A third unit was installed at the Mulindi Postharvest Training and Services Center (PTSC) in Rwanda.
Capacity development: Faculty at Kasetsart University have requested low-cost tools to monitor the environmental conditions for crops grown in greenhouses and in field experiments. The Regional Center team has modified the cold room monitoring system to be an offline version that fits the needs of the students and could be used in the field by farmers. The Regional Center plans to create other low-cost monitoring systems that have a variety of agricultural sensors to be used for crop monitoring by farmers. Two graduate students from the Royal University of Agriculture, Cambodia, joined the Regional Center team for one semester at Kasetsart University. The students learned about the Center during the First International Sustainable Agricultural Intensification and Nutrition Conference in Cambodia. Additionally, there are two students from Malaysia enrolled at Kasetsart University using Regional Center support for research. The students are evaluating the genetic diversity of okra accessions available in Malaysia and Thailand.
Lessons Learned: During the First International Sustainable Agricultural Intensification and Nutrition Conference in Cambodia and the trip with WinRock in Nepal, the Regional Center team learned that technologies the Center promotes and technologies promoted by other NGOs require consistent follow up with the farming communities. Additionally, paring effective technologies with financial support increases the likelihood of farmer adoption.

Presentations and Publications

A) Presentation
   i) 2018 - Horticulture Innovation Lab Regional Center at Kasetsart University, International Sustainable Agricultural Intensification and Nutrition Conference in Phnom Penh, Cambodia

VI. ASSOCIATE AWARD RESEARCH PROJECT REPORTS

PROMOTING DRIP IRRIGATION AND CLIMATE RESILIENCE IN GUATEMALA - MASRIEGO

Location: Quiche and Totonicapan, Guatemala

Description: 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 project builds upon previous Horticulture Innovation Lab research, with 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 (in USA and Guatemala); Centro de Paz Bárbara Ford, Guatemala; Panamerican Agricultural School, Zamorano, Honduras; North Carolina Agricultural and Technical State University, USA; Kansas State University, USA.

Achievements: The MásRiego project is now operating in ten municipalities in the Feed the Future Zone of Influence (eight municipalities in Quiche Department and two municipalities in Totonicapán department). In these municipalities, drip irrigation has been installed on 43 hectares, 47 % of the total goal for the project. In each municipality, a team made up of a specialist technician, field technician, commercialization technician and an M&E specialist works with local farmers. Additionally, farmers have become more receptive to applying for credit from the youth-led credit shop started by the project. So far, 294 farmers (229 men and 65 women) have utilized credit. With the hiring of new, experienced staff, the project has established nine operative guidelines for the project covering topics including drip line installation, training methodology, technical assistance, warehouse management, and marketing.

Capacity development: At the Barbara Ford Peace Center, an "Extension Strategy Model" has been applied successfully in the Guatemalan Western Highlands. The Kansas State University (KSU) team has developed a technical training program that was taught to University of San Carlos (USAC) students and faculty in both USAC's campuses in Quetzaltenango and Nebaj. The team from KSU has also established demonstration sites in Xecaracoj, Quetzaltenango together with Buena Milpa (USAID Project) and the German Corporation for International Cooperation (GIZ). Zamorano University has supported institutional capacity at Barbara Ford Peace Center by teaching their staff the "Farmer Field School" methodology, which is currently being implemented by Barbara Ford technicians. Additionally, the team from Zamorano has built institutional capacity of other USAID projects, extension agents of Guatemala Ministry of Agriculture, and private companies in effective use of fertilizers, pesticides and irrigation. A technical assistance training has been delivered to nineteen agriculture organizations. Training includes an evaluation of organizational strengths and weaknesses and training in marketing and finances - 1,322 association members were impacted. Finally, in human capacity building, over 3000 people, farmers and students, were trained in soil conservation, good agriculture practices, good postharvest practices and water management. 800 university students were trained on conservation agriculture by the KSU team.

Lessons Learned: The drip line installation process has required more time than planned because of the long distances from communities and municipality centers. Credit recovery from the Youth Credit Cooperative Junam needs more resources than expected and consequently the 8% interest charged is now not sufficient to fully cover expenses when payments are not received on time.

Presentations and Publications

A. Publication
   a. Reyes, M. (January 2018). Comparing Vegetable Yield of Conventional versus Conservation Agriculture Production Systems in Eight Countries. Presentation at First International Conference on Sustainable Agricultural Intensification and Nutrition, Royal University of Agriculture, Phnom Penh, Cambodia

EXAMINING NUTRITION IMPACTS OF HORTICULTURAL INNOVATIONS IN BANGLADESH

Location: Dhaka and Barisal, Bangladesh
Description: As a sub-contractor on this multi-Innovation Lab project, the Horticulture Innovation Lab will implement 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 used for this will be floating gardens, cold 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 of aquaculture and horticulture commodities.
Collaborators: World Fish Bangladesh; Bangladesh Agriculture University (BAU), Bangladesh; Patuakhali Science and Technology University (PSTU), Bangladesh

Achievements: The UC Davis solar chimney solar dryer is a low-cost technology with great potential for developing countries such as Bangladesh. This is becoming apparent not only from the preliminary cost-benefit analysis results but also from the interest shown by stakeholders. WorldFish (a project collaborator) has already built six chimney solar dryers in Nidararchar village for their Ecofish project. It is evident that this dryer can help the farmers of this community to dry fish as an income generating activity. Patuakhali Science and Technology University (PSTU) has also built a chimney solar dryer to test its efficiency and use it in future experiments. Additionally, PSTU submitted a proposal and secured a grant from The Ministry of Science and Technology, Bangladesh to further study the efficiency of the UC Davis chimney solar dryer. The Horticulture Innovation Lab team and PSTU are working towards increasing the capacity of the chimney solar dryer and working on a new design which will be able to dry three times more product than the existing design.
Capacity development: The Horticulture Innovation Lab supported one graduate student from each of two local institutions - Bangladesh Agriculture University (BAU) and PSTU - by financially supporting their project and stipend. The Horticulture Innovation Lab is collaborating with Nexleaf and Cisco, installing their proprietary ColdTrace system to increase cold room efficiencies by monitoring temperature, usage and power availability. In the month of December 2017 Nexleaf (India) conducted a hands-on training on installation and troubleshooting of the ColdTrace 5 device for the Horticulture Innovation Lab teams in Bangladesh. The Horticulture Innovation Lab staff have been conducting trainings on the technology in all the cold room locations. Furthermore, an Agribusiness training with a specialist from India was delivered in the month of September 2018 for farmers operating two cold rooms in the Barisal area to increase sustainability and financial viability of the technologies after project completion.
Lessons Learned: The main concern for the farmers involved in the drying process is the need for a larger-sized chimney solar dryer. Due to higher volumes of product at times, there is a need to operate a larger sized UC Davis chimney solar dryer for commercial drying of high-value crops like fish, mango, and chilies. It is important to select the most suitable location and community for the larger chimney solar dryer, where during most of the season lands are inundated by water. The floating garden was not well appreciated by beneficiaries due to small amount of produce produced and need to get into the pond to maintain the garden. Reducing the cold room construction cost is important for scaling up of this technology (significant primary establishment cost). Possible ways to reduce this cost is build smaller cold rooms and use more affordable insulation materials.

Presentations and Publications

A) Publications

a. Mitcham, E. J., Reid, M., Deltsidis, A., Mukherjee, A., Islam, M., Wheeler, L., & Thompson, J. (June 2018). New chimney dryer design results in faster drying due to higher air speeds (pp.157-164). Acta Horticulturae, 1205, Cairns, Queensland, Australia. doi:10.17660/ActaHortic.2018.1205.18

ESTABLISHING A HORTICULTURE CENTER IN GUINEA

Location: Kindia, Guinea

Description: The goal is to achieve inclusive and sustainable agriculture-led economic growth among local agribusinesses through the training and extension of appropriate, market-based, and proven profitable agricultural technologies that can be rapidly brought up to scale. The technologies include the CoolBot, a drip irrigation system, the chimney solar dryer, the DryCard, plastic covering for weed control, and other technologies. Most of these technologies focus on postharvest improvements. The young entrepreneurs (AVENIRs) and Peace Corps volunteers will serve as extension agents and will establish revenue-generating training modules at the Horticulture Training and Services Center at IRAG that will feature appropriate technologies and best agricultural practices.

Collaborators: Horticulture Innovation Lab, UC Davis, USA; the Agriculture Research Institute of Guinea (IRAG); WinRock Guinea; Cultivating New Frontier in Agriculture (CNFA), Guinea; ACDI/VOCA, Guinea

Achievements: By using a raised bed nursery technology, the project has produced healthy seedlings of tomatoes, peppers, eggplants, cucumbers and watermelons to enhance production. Eggplants had twice the yield in half the time as traditional production techniques. The raised bed utilizes only chicken manure as fertilizer and adheres to a production protocol. The tomatoes are supported by a trellis system that increases the plants' health, reducing the need for pesticides, and increasing production of healthy fruits. The project has built and sold over twenty chimney solar dryers that reduce waste of fruits and vegetables and increases the availability of dried products. Using the DryCard, the dried product can be tested for correct moisture content. The Center sells DryCards on its own, as well as alongside the chimney solar dryer. Installed in FY2018, the Charcoal Cool Room and the CoolBot cold room offer examples of food storage that are accessible and cost effective in Guinea. Demonstrations and trainings held at the Center allow farmers to see that with locally sourced, readily available inputs, and with minimal resources, a farmer can increase his/her production and have a competitive advantage in the open market.

Capacity development: In the last year and one half, the team has been working on establishing the Horticulture Training and Services Center and promoting itself with agriculture technical schools, agriculture universities, farmers and other government and non-governmental partners. Collaboration with Guinea Ministry of Agriculture (through IRAG), other implementing partners (Winrock International, CNFA, ACDI/VOCA) has helped the Center leverage scarce resources. Additionally, the Center has worked with multiple local NGOs to combine trainings and showcase different agriculture value-chains while incorporating business and entrepreneurial skills. The Center is also focusing on an exchange program where students from around the world come and work in the field and innovate applicable solutions for the advancement of the horticulture, youth and gender empowerment, and encourage entrepreneurship and self-empowerment. The Center has graduated four Feed the Future Avenirs and has taken on another four who currently train and work alongside the Center staff and American interns and they help conduct trainings all over Guinea. Each Avenir has a specialty that the Center enhances to improve their own skills and interests and these Avenirs, post-internship, will start their own businesses. The Center has hosted four international students from various universities in United States and Europe. The student interns come with some experience in the field, but most importantly bring leadership, self-motivation, innovation and entrepreneurship that they share with young Guineans and other farmers.

Lessons Learned: Young entrepreneurs recruited by Winrock International and CNFA under their AVENIR program are hosted by the Center and acquire experience with technologies offered by the Center. One of the former Avenir agents has developed her own dried fruits company using the chimney solar dryer. She has built a business and plans to continue to promote her enterprise and products. In contrast with other NGOs and public funded projects, the Center has managed to focus on providing needed solutions to proactive, motivated entrepreneurs that seek success through hard work.

Presentations and Publications:

i) 2018, Center Brochure

VI. HUMAN AND INSTITUTIONAL CAPACITY DEVELOPMENT

FY2018 SHORT TERM TRAINING

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	Proper postharvest management of horticultural crops	Producers, Private Sector	13	4	17
Bangladesh	Enhance farmers' knowledge on floating garden management	Producers	11	15	26
Bangladesh	Proper drying processes of vegetables and fruits using the chimney solar dryer	Producers	9	6	15
Bangladesh	Proper drying processes of vegetables and fruits using the chimney solar dryer	Producers	1	14	15
Bangladesh	Agribusiness	Producers	20	5	25
Burkina Faso	Global Post-harvest Training of Trainers in Horticulture	Civil Society	36	6	42
Burkina Faso	Practical training in postharvest handling of tomato	Producers, Government	48	5	53
Burkina Faso	Practical training in postharvest handling of tomato	Government	31	4	35
Cambodia	Use of cold room using CoolBot technology and earthworm compost	Producers, Government, Private Sector	20	70	90
Cambodia	Earthworm composting	Government	5	0	5
Cambodia	Experimental design	Private Sector	3	2	5
Cambodia	Postharvest technology and earthworm composting	Private Sector, Civil Society	8	0	8
Cambodia	Vermicomposting and producing earthworm compost	Producers, Civil Society	19	11	30
Cambodia	Establishing a vegetable shop, packinghouse and cold storage.	Producers, Civil Society	5	0	5
Cambodia	Horticulture technologies and safe vegetable production practices	Civil Society, Private Sector	35	45	80
Cambodia	Nethouse use	Producers	3	1	4
Cambodia	Harvesting vegetables in the field through proper processing and storage	Private Sector	3	3	6
Cambodia	Stakeholder education training program to promote safe vegetables	Private Sector, Civil Society	34	56	90

Cambodia	Packing house and cold room construction	Producers, Private Sector	4	1	5
Cambodia	Nethouses, Cold storage and CoolBot technology, Earthworm composting	Private Sector, Civil Society	59	34	93
Cambodia	Nethouses, Cold storage and CoolBot technology, Earthworm composting	Government, Private Sector, Civil Society	25	16	41
Cambodia	Reducing postharvest loss during harvest, storage and transportation and pest control	Producers, Government, Private Sector	23	10	33
Cambodia	Training on Earthworm Compost to students from University of Battambang	Producers, Government, Civil Society	5	2	7
Cambodia	Training on Compost Making by Indigenous Microorganism	Civil Society	4	0	4
Cambodia	Training/Meeting on Capacity Building on Scaling Up Safe Vegetable Production	Government, Civil Society	3	2	5
Cambodia	Training on Public Private Dialogue on Horticulture Sub-sector	Civil Society	3	2	5
Cambodia	DATA collection Training	Civil Society	5	0	5
Cambodia	Food Safety and Postharvest Innovations Training	Government, Civil Society	6	11	17
Cambodia	The second exhibition about Nat Market safe vegetable and safe products in Battambang Province	Government, Private Sector	10	7	17
Cambodia	Cool room with CoolBot design and operation	Producers, Civil Society	9	3	12
Cambodia	Integrated farming systems (Sillage Making)	Producers	18	31	49
Ethiopia	Training of Trainers on Processing and Utilization of Sweet Potato Leaves for Human Consumption	Government, Civil Society	19	6	25
Ethiopia	Sweet potato leaves harvesting, nutritional benefits & preparation of recipes for human consumption	Producers	9	21	30
Ghana	Seedling Production System in Plastic Cell Tray and Transplanting	Producers, Civil Society	34	52	86
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers, Government, Private Sector, Civil Society	34	5	39
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	4	12	16
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	43	28	71
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	82	42	124

Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	38	39	77
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	33	28	61
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	22	18	40
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	109	32	141
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	13	10	23
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	18	35	53
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	11	9	20
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	42	43	85
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	32	31	63
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	30	24	54
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	9	8	17
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	150	115	265
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	22	13	35
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	59	65	124
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	14	12	26
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	14	9	23

Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	72	69	141
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	7	6	13
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	14	4	18
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	10	0	10
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	18	11	29
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	12	3	15
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	17	11	28
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	15	10	25
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	7	10	17
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	30	9	39
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	12	11	23
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	7	3	10
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	26	27	53
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	158	70	228
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	20	21	41
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	15	6	21

Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	24	19	43
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	8	17	25
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	8	11	19
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	8	10	18
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	8	25	33
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	44	35	79
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	5	26	31
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	12	17	29
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	6	17	23
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	6	4	10
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	10	12	22
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	14	1	15
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	56	31	87
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	23	26	49
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	38	30	68
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	14	15	29

Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	6	24	30
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	9	10	19
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	31	17	48
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	273	151	424
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Government	30	9	39
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Government, Civil Society	110	72	182
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	88	45	133
Guatemala	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Civil Society	23	22	45
Guatemala	Soil health and potato cyst nematode management	Producers	101	26	127
Guatemala	Potato cyst nematode management	Producers	61	9	70
Guatemala	Seedling growth and tomato grafting.	Producers, Government	24	23	47
Guinea	Solar Dryer Training	Producers	25	10	35
Guinea	Solar Dryer Training Fougou	Producers	24	11	35
Guinea	Solar Dryer Training - Labe	Producers	21	11	32
Guinea	Postharvest Short course	Producers, Government	26	11	37
Guinea	Mamou Solar Dryer and DryCard Training	Producers, Government	32	1	33
Guinea	2nd AVENIR Cohort	Producers	27	12	39
Guinea	Training on solar dryers and DryCard	Producers	8	13	21
Guinea	Postharvest Training with Trias	Producers	17	9	26
Guinea	Agriculture School of Tolo Dry Value Chain Training	Producers, Government, Private Sector	109	45	154
Honduras	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Government, Private Sector, Civil Society	31	3	34
Honduras	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Government, Private Sector, Civil Society	18	4	22

Honduras	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	8	22	30
Honduras	Drip irrigation, Integrated Pest Management, Good Agriculture Practices	Producers	0	35	35
Honduras	Seedling growth and tomato grafting.	Producers, Private Sector	25	25	50
Honduras	Integrated livestock/horticulture production	Private Sector	13	11	24
Honduras	Nutrition	Private Sector	13	10	23
Honduras	Carrot and leafy green production	Producers, Private Sector	18	2	20
Honduras	Family garden production	Producers	19	46	65
Honduras	Climate smart horticulture	Private Sector	13	11	24
Indonesia	How to control foodborne diseases	Producers, Private Sector, Government	5	20	25
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	0	19	19
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	1	28	29
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	3	8	11
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	0	31	31
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	0	20	20
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	16	4	20
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	8	19	27
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	15	26	41
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	5	11	16
Kenya	Developing skills on protecting vegetables from insect-pest damage.	Producers	22	15	37
Kenya	Land Preparation and Seedbed Establishment	Producers	0	20	20
Kenya	Land Preparation and Seedbed Establishment	Producers	0	42	42
Kenya	Land Preparation and Seedbed Establishment	Producers	1	22	23
Kenya	Land Preparation and Seedbed Establishment	Producers	0	22	22
Kenya	Land Preparation and Seedbed Establishment	Producers	1	28	29
Kenya	Crop management for seed production, processing and storage.	Producers	3	8	11

Kenya	Land Preparation and Seedbed Establishment	Producers	2	14	16
Kenya	Land Preparation and Seedbed Establishment	Producers	5	11	16
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	3	3
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	2	7	9
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	5	5
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	1	1	2
Kenya	Land Preparation and Seedbed Establishment	Producers	0	13	13
Kenya	Land Preparation and Seedbed Establishment	Producers	9	10	19
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	5	9	14
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	9	1	10
Kenya	Crop management for seed production, processing and storage.	Producers	8	7	15
Kenya	Land Preparation and Seedbed Establishment	Producers	1	12	13
Kenya	Land Preparation and Seedbed Establishment	Producers	1	1	2
Kenya	Land Preparation and Seedbed Establishment	Producers	0	8	8
Kenya	Land Preparation and Seedbed Establishment	Producers	4	9	13
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	7	7
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	6	10	16
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	7	11	18
Kenya	Crop management for seed production, processing and storage.	Producers	3	7	10
Kenya	Crop management for seed production, processing and storage.	Producers	0	14	14
Kenya	Land Preparation and Seedbed Establishment	Producers	9	18	27
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	2	1	3
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	3	8	11
Kenya	Crop management for seed production, processing and storage.	Producers	4	11	15
Kenya	Land Preparation and Seedbed Establishment	Producers	2	8	10

Kenya	Land Preparation and Seedbed Establishment	Producers	3	16	19
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	3	13	16
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	3	15	18
Kenya	Crop management for seed production, processing and storage.	Producers	0	21	21
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	16	16
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	4	17	21
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	13	13
Kenya	Crop management for seed production, processing and storage.	Producers	1	11	12
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	16	16
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	6	6
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	1	10	11
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	15	15
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	1	10	11
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	21	21
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	3	12	15
Kenya	Land Preparation and Seedbed Establishment	Producers	0	29	29
Kenya	Land Preparation and Seedbed Establishment	Producers	3	14	17
Kenya	Land Preparation and Seedbed Establishment	Producers	7	15	22
Kenya	Land Preparation and Seedbed Establishment	Producers	2	12	14
Kenya	Land Preparation and Seedbed Establishment	Producers	3	16	19
Kenya	Land Preparation and Seedbed Establishment	Producers	8	3	11
Kenya	Land Preparation and Seedbed Establishment	Producers	5	10	15
Kenya	Land Preparation and Seedbed Establishment	Producers	1	17	18
Kenya	Land Preparation and Seedbed Establishment	Producers	8	9	17
Kenya	Land Preparation and Seedbed Establishment	Producers	0	18	18

Kenya	Principles of harvesting and postharvest handling	Producers	3	14	17
Kenya	Principles of harvesting and postharvest handling	Producers	5	17	22
Kenya	Principles of harvesting and postharvest handling	Producers	3	17	20
Kenya	Principles of harvesting and postharvest handling	Producers	2	13	15
Kenya	Land Preparation and Seedbed Establishment	Producers	2	20	22
Kenya	Land Preparation and Seedbed Establishment	Producers	4	15	19
Kenya	Land Preparation and Seedbed Establishment	Producers	0	22	22
Kenya	Land Preparation and Seedbed Establishment	Producers	7	9	16
Kenya	Principles Crop Management and pest management	Producers	2	14	16
Kenya	Principles Crop Management and pest management	Producers	5	11	16
Kenya	Principles Crop Management and pest management	Producers	0	17	17
Kenya	Principles Crop Management and pest management	Producers	9	10	19
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	0	12	12
Kenya	Principles Crop Management and pest management	Producers	1	11	12
Kenya	Principles Crop Management and pest management	Producers	5	16	21
Kenya	Principles Crop Management and pest management	Producers	0	16	16
Kenya	Principles Crop Management and pest management	Producers	4	19	23
Kenya	Principles Crop Management and pest management	Producers	6	15	21
Kenya	Principles Crop Management and pest management	Producers	3	16	19
Kenya	Principles Crop Management and pest management	Producers	5	11	16
Kenya	Principles Crop Management and pest management	Producers	9	18	27
Kenya	Principles Crop Management and pest management	Producers	3	14	17
Kenya	Principles Crop Management and pest management	Producers	5	17	22
Kenya	Principles Crop Management and pest management	Producers	3	17	20
Kenya	Principles Crop Management and pest management	Producers	2	13	15

Kenya	Principles Crop Management and pest management	Producers	2	20	22
Kenya	Principles Crop Management and pest management	Producers	4	15	19
Kenya	Sack garden training at school center to increase consumption and sales of AIVs	Producers	0	30	30
Kenya	Principles of harvesting and postharvest handling	Producers	2	14	16
Kenya	Principles of harvesting and postharvest handling	Producers	5	11	16
Kenya	Principles of harvesting and postharvest handling	Producers	0	17	17
Kenya	Principles of harvesting and postharvest handling	Producers	7	10	17
Kenya	Principles of harvesting and postharvest handling	Producers	0	16	16
Kenya	Principles of harvesting and postharvest handling	Producers	4	12	16
Kenya	Principles of harvesting and postharvest handling	Producers	0	14	14
Kenya	Principles of harvesting and postharvest handling	Producers	2	7	9
Kenya	Principles of harvesting and postharvest handling	Producers	4	8	12
Kenya	Principles of harvesting and postharvest handling	Producers	3	13	16
Kenya	Principles of harvesting and postharvest handling	Producers	5	11	16
Kenya	Principles of harvesting and postharvest handling	Producers	9	18	27
Kenya	Principles Crop Management and pest management	Producers	7	15	22
Kenya	Principles Crop Management and pest management	Producers	3	14	17
Kenya	Principles Crop Management and pest management	Producers	4	18	22
Kenya	Principles Crop Management and pest management	Producers	5	2	7
Kenya	Principles Crop Management and pest management	Producers	9	2	11
Kenya	Principles Crop Management and pest management	Producers	2	10	12
Kenya	Principles Crop Management and pest management	Producers	1	15	16
Kenya	Principles Crop Management and pest management	Producers	0	16	16
Kenya	Participants learned in-depth about seed production, storage, processing, and laws	Producers	4	15	19
Kenya	Seed production, storage, processing, and laws	Producers	6	7	13

Kenya	Seed production, storage, processing, and laws	Producers	0	20	20
Kenya	Seed production, storage, processing, and laws	Producers	4	10	14
Kenya	Seed production, storage, processing, and laws	Producers	7	18	25
Kenya	Seed production, storage, processing, and laws	Producers	4	14	18
Kenya	Seed production, storage, processing, and laws	Producers	3	12	15
Kenya	Seed production, storage, processing, and laws	Producers	3	6	9
Kenya	Seed production, storage, processing, and laws	Producers	1	13	14
Kenya	Seed production, storage, processing, and laws	Producers	1	16	17
Kenya	Seed production, storage, processing, and laws	Producers	2	9	11
Kenya	Seed production, storage, processing, and laws	Producers	2	5	7
Nepal	Solar pump technology evaluation for WinRock AIFA Project	Producers, Private Sector	28	14	42
Nepal	Technology evaluation for WinRock AIFA Project	Producers, Private Sector	35	15	50
Nepal	Soil and plant health schools for improving vegetable production and small land-holder farm economy	Producers, Civil Society	21	19	40
Nepal	Plant health camp: Soil and plant health schools for improving vegetable production	Producers, Civil Society	10	16	26
Nepal	Soil and plant health management and soil health camp	Producers, Civil Society	3	19	22
Nepal	Preparatory meeting for starting plant and soil health school	Producers, Civil Society	4	32	36
Nepal	Crop selection, treatment selection, and field layout	Producers, Civil Society	8	37	45
Nepal	Damping off and cutworm management	Producers, Civil Society	9	39	48
Nepal	Summer Pruning Training	Producers	44	42	86
Nicaragua	Seedling growth and tomato grafting.	Producers, Government	8	12	20
Rwanda	Reducing postharvest losses in horticulture	Producers, Government, Private Sector, Civil Society	49	11	60
Rwanda	Reducing postharvest losses in horticulture	Government	21	4	25
Rwanda	Reducing postharvest losses in horticulture	Government, Private Sector, Civil Society	18	10	28
Rwanda	Reducing postharvest losses in horticulture	Producers, Government	17	18	35

Rwanda	Reducing postharvest losses in horticulture	Civil Society	45	24	69
Rwanda	Reducing postharvest losses in horticulture	Private Sector	23	17	40
Rwanda	Postharvest Awareness for Food Science Graduates	Private Sector	37	30	67
Rwanda	Reducing postharvest losses in horticulture	Producers, Government, Private Sector	17	16	33
Rwanda	Building the entrepreneur capacity in horticulture stakeholders across the horticulture value chain	Civil Society	10	11	21
Rwanda	Building the entrepreneur capacity in horticulture stakeholders across the horticulture value chain	Private Sector	20	12	32
Rwanda	Reducing postharvest losses in horticulture	Producers, Government, Private Sector	18	12	30
Rwanda	Reducing postharvest losses in horticulture	Government, Civil Society	9	6	15
Rwanda	Reducing postharvest losses in horticulture	Producers, Government, Private Sector, Civil Society	27	15	42
Rwanda	Reducing postharvest losses in horticulture	Producers	17	13	30
Rwanda	Reducing postharvest losses in horticulture	Producers, Civil Society	11	14	25
Rwanda	Cool room monitoring system installing and testing	Civil Society	20	10	30
Rwanda	Training to Smallholder Farmers on Production of Selected Tropical Fruits	Producers, Private Sector	5	17	22
Rwanda	Training to Smallholder Farmers on Production of Selected Tropical Fruits	Producers, Private Sector	4	20	24
Tanzania	Training course on postharvest handling of fruits and vegetables	Government, Private Sector, Civil Society	18	10	28
Tanzania	Training course on postharvest handling of fruits and vegetables	Government, Private Sector, Civil Society	17	15	32
Tanzania	Project inception in Nduruma	Producers, Government, Private Sector	22	21	43
Tanzania	Nursery establishment	Producers, Government	29	7	36
Tanzania	Nursery establishment	Producers, Government, Civil Society	39	10	49
Tanzania	Nursery establishment	Producers, Government	21	20	41
Tanzania	Nursery establishment	Producers, Government, Private Sector	24	25	49

Tanzania	Farmer motivator training on Nursery establishment	Producers, Government, Civil Society	8	9	17
Tanzania	Theoretical training on transplanting, mulching, irrigation, fertilization, weeding and postharvest handling-Mlangarini	Producers, Government, Civil Society	30	13	43
Tanzania	Theoretical training on transplanting, mulching, irrigation, fertilization, weeding and postharvest handling-Nduruma	Producers, Government, Civil Society	19	26	45
Tanzania	Practical training on transplanting-Nduruma	Producers, Government, Civil Society	21	18	39
Tanzania	Practical training on transplanting-Mlangarini	Producers, Government, Civil Society	27	13	40
Thailand	Industrial engineering and agriculture	Producers, Government, Private Sector	35	19	54
Thailand	Technology evaluation for WinRock AIFA Project	Private Sector, Civil Society	4	3	7
Thailand	Cool room with CoolBot and cold room monitoring system introduction for Thai farmers	Producers, Private Sector	8	2	10
Thailand	Cool room with CoolBot and cold room monitoring system introduction for Thai farmers	Producers, Private Sector	3	1	4
Uganda	Installation, use, and troubleshooting of water powered spiral pump	Producers, Private Sector	5	6	11
Uganda	Train farmers on how to set up and use pipe and furrow irrigation method	Producers, Civil Society	7	4	11
Uganda	Training farmer technicians on water pump service and repair	Producer	1	0	1
Uganda	Training farmers how to use piping system to feed furrow irrigation plots.	Producer	5	4	9
Uganda	Training farmers on handling and use of pesticides	Producer, Civil Society	5	6	11
Uganda	Training scheme attendants on repair and re-connection of water intake	Producer	2	0	2
Uganda	Farmers learn how and when to apply selective herbicide to onions.	Producer, Civil Society	2	8	10
Uganda	To train farmers on alternative methods of bringing water to furrows, using a pump and piped system.	Producer, Civil Society	2	14	16
Uganda	Training farmers on how to make, plant, and irrigate micro basins	Producer, Civil Society	7	5	12
Uganda	Training farmer technicians on burial and repair of pipe system	Producer, Civil Society	3	2	5

Uganda	Training farmers on different ways of distributing water to gardens with pumped irrigation systems	Producer, Civil Society	10	8	18
Uganda	Training farmers on different methods of using water pumps for irrigation	Producer, Civil Society	8	7	15
Uganda	Training Women's subgroup in Kyekidde site on installing manual pivot system	Producer, Government	3	12	15
Uganda	Train farmers in Tente site how to make and manage micro basins and furrows for manual irrigation	Producer, Private Sector, Civil Society	8	5	13
Uganda	Training farmers in Tente site how to use a bicycle-carried irrigation system with rain gun sprinkler.	Producers, Civil Society	11	9	20
Uganda	Training farmers in Kabos site on planting cabbage and onion directly without transplanting	Producers	8	4	12
Uganda	Training Aloet site farmers on how to transplant, control disease, and prepare land for irrigated onions	Producers, Civil Society	0	9	9
Uganda	Community managed MicroFinance (CMMF)	Producers	7	13	20
Uganda	The training covered group dynamics and leadership.	Producers, Civil Society, Government	5	14	19
Uganda	Making of pineapple jam	Producers, Civil Society, Government, Private Sector	30	13	43
Uganda	Making of Tomato Sauce	Producers, Civil Society, Government, Private Sector	25	15	40
Uganda	Making of Passion fruit squash	Producers, Civil Society, Government, Private Sector	16	24	40
Uganda	Propagating mango/orange fruit value addition knowledge, skills and technologies to small scale fruit farmers in Teso region	Producers, Civil Society	55	17	72
Uganda	Causes of food losses in each of the following segments in the food chains i.e Pre-harvest, Harvest, Post-harvest handling and storage, Processing, Distribution	Producers	4	20	24
Uganda	Training in harvesting and field handling to reduce postharvest losses	Producers	1	20	21
Uganda	Good practice in management and operation of a fresh produce packhouse	Producers	2	16	18

Uganda	Leadership Training for Women Representatives	Producers	1	18	19
Uganda	Training in vegetable packhouse operations	Producers	0	11	11
Uganda	Demonstration of construction of ZECC.	Producers	0	9	9
Uganda	Training and demonstration on irrigation farming	Producers	4	32	36
Uganda	Training and demonstration on irrigation farming	Producers	5	56	61
Uganda	Training and demonstration on irrigation farming	Producers	4	18	22
Uganda	Training and demonstration on irrigation farming	Producers	1	46	47
Uganda	Training and demonstration on mushroom production	Producers	6	54	60
Uganda	Training on vegetable farming	Producers	3	10	13
Uganda	Training on postharvest handling and value addition	Producers	3	11	14
Uganda	Training on postharvest handling and value addition	Producers	4	55	59
Uganda	Training on postharvest handling and value addition	Producers	1	30	31
Uganda	Training on postharvest handling and value addition	Producers	5	31	36
Uganda	Training on postharvest handling and value addition	Producers	3	46	49
Uganda	Training on solar dryer construction and its operation	Producers	3	60	63
Uganda	Training on solar dryer construction and its operation	Producers	4	45	49
United States	Trellis Fund Seminar	Civil Society	8	9	17
Zambia	African Indigenous Vegetable production	Producer, Government, Private Sector	21	36	57
Zambia	Seed transplanting	Producers	0	20	20
Zambia	Seed transplanting	Producers	0	10	10
Zambia	Nursery management, crop management, planting, pest and disease control	Producers, Government, Private Sector	1	26	27
Zambia	Harvest and postharvest management	Producers, Government	1	19	20
Zambia	Marketing of fresh produce, sorting and grading	Producers, Government	5	19	24

FY2018 LONG TERM TRAINING

Home Country	Name	Sex	University	Degree	Major	Graduation Date (Mo/Yr)
Cambodia	Pun Put	Male	Royal University of Agriculture	Bachelor's	Agronomy	Sep-18
Cambodia	Bunthi Bou	Male	Royal University of Agriculture	Other	Agronomy	Aug-19
Cambodia	Phany Vouer	Female	University of Battambang	Bachelor's	Agronomy	Sep-18
Cambodia	Lina Suy	Male	Royal University of Agriculture	Internship	Agronomy	Sep-18
Cambodia	Phearak Doem	Male	Royal University of Agriculture	Internship	Agronomy	Sep-18
Cambodia	Sophorlkun Yim	Female	Royal University of Agriculture	Internship	Agro-Industry	Sep-18
Cambodia	Phura Chhorn	Male	Royal University of Agriculture	Internship	Agro-Industry	Sep-18
Cambodia	Solaihim Mom	Female	Royal University of Agriculture	Internship	Experiment Design	Apr-18
Cambodia	Panha Chip	Female	Royal University of Agriculture	Internship	Experiment Design	Apr-18
Cambodia	Ousa Sam	Female	Royal University of Agriculture	Internship	Experiment Design	Apr-18
Cambodia	Sreyra Vuthy	Female	Royal University of Agriculture	Internship	Experiment Design	Apr-18
Cambodia	Ahtith Somnang	Male	Royal University of Agriculture	Internship	Experiment Design	Apr-18
Cambodia	Ratsin Nop	Male	Royal University of Agriculture	Internship	Experiment Design	Apr-18
Cambodia	Nith Bu	Male	Royal University of Agriculture	Internship	Agronomy	Oct-18
Cambodia	Huy Meng	Male	Royal University of Agriculture	Internship	Agronomy	Oct-18
Cambodia	Channy Ngor	Male	Royal University of Agriculture	Internship	Agronomy	Oct-18
Cambodia	Neng Lun	Male	Royal University of Agriculture	Internship	Agronomy	Oct-18
Cambodia	Sim Chork	Female	Royal University of Agriculture	Internship	Agro-industry	Sep-18
Cambodia	Da Ouk	Female	Royal University of Agriculture	Internship	Agro-industry	Sep-18
Cambodia	Han Socheat	Male	Royal University of Agriculture	Internship	Soil Science	Dec-18
Cambodia	Rathana Nai	Female	Royal University of Agriculture	Internship	Food Science	Dec-18

Cambodia	Koemorn Chea	Female	Royal University of Agriculture	Master's	Crop Science	Oct-19
Cambodia	Sacheat Han	Male	Royal University of Agriculture	Master's	Crop Science	Oct-19
Cambodia	Sreng Samorn	Male	Royal University of Agriculture	Master's	Animal Science	Oct-19
Cambodia	Visoth Ly	Male	Royal University of Agriculture	Master's	Food Safety	Oct-19
Chile	Karin Albornoz	Female	University of California, Davis	Ph.D.	Postharvest Biology and Physiology	Sep-19
China	Bo Yuan	Male	Rutgers University	Ph.D.	Food Science	May-19
China	Yao Guan	Female	University of California, Davis	Master's	M.S. International Agricultural Development	Dec-17
Costa Rica	Andrey Vega Alfaro	Male	Instituto Tecnologico de Costa Rica	Bachelor's	Agriculture Engineering	Dec-17
Costa Rica	Andrey Vega Alfaro	Male	University of Wisconsin, Madison	Internship	Pepper grafting	Nov-17
Greece	Konstantinos Batziakas	Male	Kansas State University	Ph.D.	Horticulture	Dec-19
Guatemala	Roberto Campollo	Male	Centro de Paz Barbara Ford	Internship	Agricultural Engineering	Aug-18
Guatemala	Keenner Estrada	Male	Centro de Paz Barbara Ford	Internship	Agricultural Engineering	Aug-18
Guatemala	Abraham Menchu	Male	Centro de Paz Barbara Ford	Internship	Agricultural Engineering	Aug-18
Guatemala	Didier Rodriguez	Male	Centro de Paz Barbara Ford	Internship	Agricultural Engineering	Aug-18
Guatemala	Rehina Pacheco	Female	Centro de Paz Barbara Ford	Internship	Technical Professional in Natural Resources	Nov-18
Honduras	Sheyla Ramos	Female	EAP Zamorano	Internship	Agricultural Sciences and Production	May-18
Honduras	Juan Jose Rivas	Male	EAP Zamorano	Internship	Agribusiness Management	May-18
Honduras	Erick Gutierrez Benites	Male	Univ. of Wisconsin – Madison	Master's	Plant Breeding and Genetics	Jan-18
Kenya	Angeline Mnene	Female	University of Eldoret	Master's	Entomology	May-19
Kenya	Diana Mongina	Female	Baraton University	Master's	Agricultural Economics	May-18

Kenya	Marion Lagat	Female	Mt. Kenya University	Master's	Natural resource management	May-18
Kenya	Daniel Kirui	Male	Egerton University	Bachelor's	Horticulture	May-18
Malaysia	Zamir Hadi Bin Ismail Mohamad	Male	University of Putra Malaysia	Master's	Tropical Agriculture	Sep-18
Malaysia	Nadzirah Mat Sulaiman Nur	Female	University of Putra Malaysia	Master's	Tropical Agriculture	Sep-18
Nepal	Sadikshya Sharma	Female	University of Florida	Master's	Environmental Horticulture	Aug-18
Nigeria	Ibukun Timothy Ayankojo	Male	University of Florida	Ph.D.	Soil and Water Sciences	Aug-20
Rwanda	Emilien Kwitonda	Male	University of Rwanda	Bachelor's	Crop Science majoring in Horticulture	Jun-18
Sierra Leone	Martin Kailie	Male	University of California, Davis	Humphrey's Fellow	Horticulture	Jun-18
Uganda	Tom Gashali	Male	Busitema University	Master's	Irrigation Engineering and Water Management	Dec-18
United States	David Byrnes	Male	Rutgers University	Ph.D.	Plant Biology	Jun-18
United States	Emily Merchant	Female	Rutgers University	Ph.D.	Plant Biology	May-21
United States	Mara Sanders	Female	Rutgers University	Master's	Plant Biology and Business of Global Agriculture	May-18
United States	Bernard Sanders	Male	Rutgers University	Ph.D.	Medicinal Chemistry	Jun-19
United States	Ariane Vasilatis	Female	Rutgers University	Ph.D.	Plant Biology	May-19
United States	Martin Zorde	Male	Rutgers University	Ph.D.	Plant Biology	May-21
United States	Cardell Belton	Male	Rutgers University	Bachelor's	Plant Science	May-18
United States	Lara Brindisi	Female	Rutgers University	Ph.D.	Plant Biology	May-21
United States	Jerry Nkhoma	Male	UNZA	Bachelor's	Plant Science	Aug-19
United States	William Reichert	Male	Rutgers University	Internship	Plant Biology	Nov-18
United States	Daniel Giurleo	Male	Rutgers University	Master's	Plant Biology	May-17

United States	Elisabeth Garner	Female	Penn State University	Ph.D.	Rural Sociology and Women's Studies (dual-title)	Jan-18
United States	Meredith Field	Female	Penn State	Ph.D.	Rural Sociology and Women, Gender and Sexuality Studies	May-18
United States	Michelle Einstein	Female	University of California, Los Angeles	Internship	Urban Planning	Aug-18
United States	Victor Vargas	Male	EAP Zamorano	Internship	Food science and Nutrition	May-18
United States	Patricia LaPorte	Female	University of Hawaii at Manoa	Ph.D.	Natural Resource and Environmental Management	May-20
United States	Sean Kiely	Male	University of California Davis	Master's	International Agricultural Development	Sep-18
United States	Jessamyn Wead	Female	University of California, Berkeley	Internship	Graduate Student of Public Health Nutrition	Aug-18
United States	Meghan Mize	Female	University of California, Davis	Internship	Graduate Student of International Agricultural Development	Sep-18
United States	Pete Nelson	Male	North Carolina State University	Ph.D.	Entomology	May-18
United States	Tiare Silvasy	Female	University of Hawaii	Master's	Tropical Plant & Soil Sciences	Aug-17
United States	Nick Reitz	Male	University of California, Davis	Ph.D.	Food Science	May-21
United States	Jonathan Reil	Male	University of Hawaii	Ph.D.	Entomology	May-20
United States	Kelly Gude	Female	Kansas State University	Ph.D.	Horticulture	Dec-20
United States	Lauren Howe	Female	University of California, Davis	Master's	International Agriculture Development	June-19
United States	Hallie Casey	Female	University of California, Davis	Master's	International Agriculture Development	June-18
United States	Kari Flores	Female	University of California, Davis	Master's	Horticulture and Agronomy	Jun-18

United States	Asha Sharma	Female	University of California, Davis	M.S.	International Agricultural Development	Jun-18
United States	Lisa Artuso	Female	University of California, Davis	Master's	International Agricultural Development	Jun-20
United States	Corey Rodda	Female	University of California, Davis	Master's	Community Development	June-20
United States	Michelle Boutell	Female	University of California, Davis	Bachelor's	International Agricultural Development	June-20
Zambia	Amukena Mukololo	Female	UNZA	Bachelor's	Plant Biology	Aug-19
Zambia	Cecilia Nsomfi	Female	UNZA	Bachelor's	Plant Biology	Aug-19
Zambia	Royd Sarenje	Male	UNZA	Bachelor's	Plant Biology	Aug-19
Zambia	Innocent Siampande	Female	UNZA	Bachelor's	Plant Biology	Aug-19

MANAGEMENT ENTITY INSTITUTIONAL DEVELOPMENT

The Horticulture Innovation Lab's efforts toward institutional capacity building ensure the sustainability and scalability of all of the projects' interventions and efforts, even after the project ends. Additionally, establishing sustainable, ideally permanent, resource centers within universities and institutes promotes the resiliency of local smallholder farmers in terms of improving their ability to adapt to climate change, improve familial nutrition, and to establish reliable sources of income. Finally, within the framework of institutional capacity building, particular focus is placed upon women and children in terms of promoting equality and health.

Entering the final year of Phase II, the management entity is striving to disseminate research outputs to development agencies, in-country universities, government ministries, and other critical intermediaries that will continue to scale and share the information with smallholder farmers on the ground. Key information deliverables (publications, factsheets, videos, extension bulletins) are promoted on the Horticulture Innovation Lab website. The recently funded project, *Advancing Horticulture Technologies through Design, Education, and Outreach,* led by UC Davis' D-Lab, will produce a universal toolkit for in-country universities based on D-Lab curricula, covering project framing, feasibility studies, and prototyping. Finally, at the Horticulture Innovation Lab annual meeting in FY2018, participants supported the creation of a listserv to improve networking with projects' in-country staff who are commonly linked to in-country universities, NGOs and institutes.

During the past year, the Horticulture Innovation Lab's Demonstration Center at UC Davis continued to integrate with other departments on campus and in the local community and to build the capacity of visiting institutions. The chimney solar dryer was used by the UC Davis Department of Animal Science to dry broccoli leaves for a chicken-feed experiment and Lauren Howe, from the management entity, built a chimney solar dryer on an International Rescue Committee farm site in Sacramento, California with Nepali refugees. As part of a "Sustainable Island Competition", dozens of local high school students visited the Demonstration Center to learn about low-cost methods for fruit and vegetable production and preservation. Amongst the numerous international visitors to the Demonstration Center were fellows from

the Mandela Washington Fellowship and Cochran Fellowship programs, and journalists with the Consortium of African Journalists.

The *Regional Centers at Kasetsart in Thailand and Zamorano in Honduras* have enhanced the capacity of smallholder farmers, universities, local governments, and NGOs that participate in on-site and remote trainings. The Regional Center at Zamorano's recent partnerships with ministries in El Salvador and Colombia have led to the installation of Zero Energy Cool Chambers (ZECC), cold rooms, and chimney solar dryers at in-country demonstration sites. The Center at Kasetsart, Thailand continues to support technologies installed at universities and farming cooperatives in Cambodia and Nepal through their collaborations with the Horticulture Innovation Lab project, *Promoting conservation agriculture for vegetable growers in Nepal and Cambodia* and Winrock. Although the *Horticulture Innovation Lab Regional Center at AgriSmart in Zambia* project was not renewed for FY2018, the site established at the University of Zambia, along with the technologies, have been utilized by the *Improving nutrition with African Indigenous Vegetables in Kenya and Zambia* project.

PROJECT INSTITUTIONAL DEVELOPMENT

- ***Improving postharvest practices for tomatoes in Burkina Faso***
  In FY2018, a tomato postharvest handling course attended by forty-two local agronomists was organized for the extension staff of ACDI/VOCA, Catholic Relief Services (CRS) and Burkina Faso government extension workers.

- ***DryCard franchise project***
  In FY2018, partnerships were established with Earth Empower in Mexico and Guatemala, the Horticulture Training and Services Center in Guinea, Ofori Agrochemical Services in Ghana, the Mwino Group in Uganda, and Desert Water in Sierra Leone to set up local production and marketing of the DryCard. In total, the DryCard is commercially sold by eight partners in Tanzania, Rwanda, Uganda, Guinea, Ghana, Sierra Leone, Thailand, Mexico, Guatemala, and the United States, which have distributed 13,000 DryCards.

- ***Examining nutrition impacts of horticultural innovations in Bangladesh***
  In collaboration with the Horticulture Innovation Lab, Patuakhali University of Science and Technology (PSTU) has built a chimney solar dryer, based on UC Davis' design, to test its efficiency and use it in future experiments. Additionally, PSTU secured a grant from The Ministry of Science and Technology, Bangladesh to conduct additional tests on the efficiency of the chimney solar dryer.

- ***Trellis fund round 6***
  Of the 15 organizations that were funded in FY2018 by the Trellis Fund, 10 were "alumni" organizations. The funding allowed organizations to build on previous projects. Organizations included: CARD-Nepal, NIRP, Methodist University College of Ghana, Kumasi Institute of Tropical Agriculture, URICT-Uganda, Mwino Group, University of Cape Coast, Eco Agric Uganda, Tip Top Foods and Teso Women Development Enterprise. Finally, Send a Cow Ethiopia and Eco Agric Uganda met with their USAID Missions thanks to Trellis fund students.

- ***Reducing postharvest losses in Rwanda***
  Due to project efforts in FY2018, the National Agricultural Export Development Board (NAEB) is now employing food science graduates to work with Rwandan cooperatives; the Rwanda Agriculture Board (RAB) is increasing its involvement in postharvest management; and the University of Rwanda has introduced postharvest research to current students and intends to offer a postharvest management master's program.

- ***Building safe vegetable value chains in Cambodia***
  The project collaborated with Cambodian government's extension program, advancing the Safe Vegetable Value Chain (SVVC) project to His Excellency Veng Sakhon, Minister of Agriculture, Forestry and Fisheries. The Minister visited the SVVC team's project sites in Battambang, the Earthworm Compost Research and Training Center, and the Hub for Safe Vegetables.

- ***Empowering Women through Horticulture in Honduras***
  Through farmer field schools and internships, the project enhances the capacity of the Associación de Mujeres Intibucanas Renovadas (AMIR). Leaders from AMIR have participated in farmer field schools and are now planning to share the training, which incorporates gender curricula, with other members. Zamorano University interns with the project have conducted their fieldwork and at Penn State University, these interns worked on their theses, attended classes, and learned about local agriculture.

- ***Expanding tomato grafting for entrepreneurship in Guatemala and Honduras***
  A workshop on grafting vegetables was held for Zamorano University students. Dr. Ravishankar Manickam, head of grafting research at the World Vegetable Center, assisted in instruction. Zamorano University plans to maintain a close collaboration with the World Vegetable Center to research and promote grafted vegetables in Central America.

- ***Investigating integrated vegetable-livestock systems in Cambodia***
  In 2018, the project team was able to work with the faculty and staff from the Veterinary Medicine Department at the Royal University of Agriculture to develop the department's effectiveness in outreach and extension for swine production.

- ***Developing farmer-led irrigation solutions in Uganda***
  The project increased the capacity of Busitema University by providing practical experiences for agriculture engineering students. The project has also collaborated with the Teso Women Development Initiatives (TEWDI), which is now more effectively supporting women farmers to become economically, and socially empowered.

- ***Promoting drip irrigation and climate resilience in Guatemala - MasRiego***
  In collaboration with Buena Milpa (USAID Project) and the German Corporation for International Cooperation, the project has established demonstration sites in Xecaracoj, Quetzaltenango. Zamorano University staff working on the project have increased institutional capacity at the Barbara Ford Peace Center through trainings on the "Farmer Field School" methodology. Finally, 19 agriculture organizations received technical assistance training to evaluate organizational strengths and weaknesses and improve the organizations' capacity in marketing and finances.

VII. INNOVATION TRANSFER AND SCALING PARTNERSHIPS

The Horticulture Innovation Lab supports the development of disruptive innovations and technologies to stimulate and facilitate horticultural development worldwide. The Horticulture Innovation Lab has seen that specific technologies and innovations have the ability to solve problems and to reduce barriers within the horticulture sector. With proper needs assessment, research, input and support, these technologies have the potential to change the lives of the world's smallholder farmers for the better. The Horticulture Innovation Lab focuses on technologies that reduce on-farm costs, reduce postharvest losses, use labor more efficiently, empower women, and use limited natural resources more sustainably. Technologies and innovations come in a variety of forms. "Hard" technologies are devices, prototypes and designs that improve our lives and in some way change the current system. "Soft" technologies encompass innovation in systems, behaviors, and methods within the horticulture sector. Assemblies of ideas and thought processes make up a soft technology.

MANAGEMENT ENTITY TECHNOLOGIES

The Horticulture Innovation Lab has been scaling the DryCard technology, which is an inexpensive dryness measurement tool. The DryCard is a wallet-sized card, with printed color index scales combined with a strip of relative humidity indicator paper inside a protective plastic sleeve. With the visual scale and relative humidity indicator paper combined into a reusable card, farmers and traders can easily check the dryness of their stored products. Materials to create each card cost approximately 10 cents. While the DryCard has been translated into a number of languages, a pictorial version of the card is being developed for illiterate users. The goal is to preserve product quality and reduce the danger of aflatoxin contamination in dried produce (vegetables, fruit, grains, pulses), and to maintain vigor and germination rates of stored seeds. The DryCard was the winner of the 2018 UC Davis Chancellor's Innovator of the Year Award. We are in the first phase of scaling out the DryCard, and have settled on a model where we make 'franchise' agreements with small-scale entrepreneurs in target countries (mostly Feed the Future) around the world who agree to produce and sell the cards to our specifications and provide the Lab samples of their DryCards for quality control purposes.

The management entity has successfully installed and operated a solar-powered cooling system for horticultural products, using the CoolBot operated cold room at the Horticulture Innovation Lab Demonstration Center at UC Davis as our test-bed. The CoolBot unit controls a 48V DC air conditioner that is powered by a set of solar panels. Cooling overnight and in cloudy periods is provided by batteries that are charged, during the day by the solar panels. A battery charge controller was installed to avoid overcharging or undercharging the set of Lithium Ion batteries. Continuing improvements in Lithium Ion battery technologies and reduction in costs for the batteries and control systems promise a simple and robust battery solution for smallholder farming communities in the developing world.

Experiments at the Horticulture Innovation Lab Demonstration Center in collaboration with the UC Davis D Lab have been focusing on discovering the insulation capacity of low cost, locally available materials as alternatives to high-density polyurethane foam panels. These materials can be used to insulate cold rooms in the developing world to replace high cost, imported materials that are often hard to find in many locations.

In Bangladesh, we have refurbished cold rooms constructed during an earlier project from Phase I and installed ColdTrace (CT5) remote sensing devices (in collaboration with Nexleaf Analytics) to provide on-line information and alarm services to farmers related to operation of the cold rooms when temperatures rise above or drop below the set-point. Our team is collecting produce spoilage data in order to quantify the effectiveness of the ColdTrace technology in reducing postharvest losses.

The Guinea horticulture training and services center at IRAG hosts activities in horticulture development specially in production post-harvest management. On a 1,000 square meter (approximately .25 acres) the center demonstrate good agricultural practices. The production training includes soil management, mulching, drip irrigation watering techniques, and composting. The dry chain features UC-Davis's Chimney Drier and the DryCard. The cold chain features the Charcoal cool room and the CoolBot. These technologies and techniques are being promoted by the center to boost youth entrepreneurship and better agriculture techniques.

The management entity and Regional Centers continue to conduct research and trainings on the Chimney Solar Dryer. We completed a comprehensive instruction manual for construction and operation of the dryer along with a series of three videos which are available online in our website. The innovative solar dryer design has been tested in a range of environments and has been proven effective in drying a variety of products. As one example of the adaptability of this dryer, following our demonstration of its effectiveness in drying small fish, WorldFish Bangladesh is fostering construction of Chimney Solar Dryers by smallholder fisherfolk in Bangladesh.

PROJECT TECHNOLOGIES IN PHASE 1: UNDER RESEARCH

Investigating integrated vegetable-livestock systems in Cambodia

- **Nutrient management for vegetable crops**: The efficiency of recommended nutrient application amounts for vegetables is highly variable, and profitability is often low. Farmers often feel unsure of how much manures and/or mineral fertilizers should be supplied to maximize the vegetable crop's yield and profitability. Manure availability for application varies greatly depending on the magnitude of livestock integration in the production systems. Meanwhile, mineral fertilizers are available at a high cost that is not usually affordable by subsistence-oriented farmers. The project aims to develop nutrient management decision-making support tools for smallholder farmers to adopt to maximize profitability.
- **Living Mulch:** Morning glory and *Arachis pintoi* are being used as living mulches for chili peppers, as an alternative approach to traditional mulches. This method allows farmers to collect these legume plants in a cut-and-carry approach to feed livestock. Additionally, these legumes are expected to support soil fertility.

PROJECT TECHNOLOGIES IN PHASE 2: UNDER FIELD TESTING

Improving nutrition with African Indigenous Vegetables in Kenya and Zambia

- **AIV Variety Trials (nightshade, creome, Ethiopian mustard, Amaranthus, rossel, chilies, cherry tomatoes):** AIV trials were planted at the Mitengo women's site with the assistance of two students. One student (Jerry Nkhoma) worked on the "Agronomic performance of Nightshade" and the other (Amukena Mukololo) worked on the "Agronomic performance of Amaranthus."
- **Nutrition Variety Trial Amaranth: World Vegetable Center:** Twelve amaranth lines from Rutgers University (RU), in addition to three from the World Vegetable Center, were space-planted for a nutrient content variation assessment within each line. The number of plants grown per line ranged from 37 to 55 plants. The differences were due to the variation in the number of seeds available for planting and seedling establishment. Leaf samples were collected from 300 individual plants randomly selected from the 15 lines, having 20 plants per line. The leaf samples were oven-dried and sent to Rutgers University for nutrient analysis. Individual plants from the harvested leaf samples were grown to set seed, and the seeds from each plant were thrashed in separate bags. Other data collected included plant height, number of branches, leaf length, width and flowering dates. Plants with high nutrient quality will be grown for further nutrient evaluation and other desirable horticultural traits.
- **Sensory evaluation and field trial - Ethiopian mustard variety**: A sensory evaluation was conducted among four farmer groups: Chamba Valley, Kasisi, Mitengo, and the Foxdale farmer cooperative (4 male, 27 female). Dr. Fekadu of the World Vegetable Center involved four farmer groups (Mitengo, Shantumbu, Kanyanja, Kasisi) with a total of 26 farmers (7 male, 19 female). A solar dryer was installed at Turbo farm demonstration site in Eldoret, Kenya in order to preserve AIV's through dehydration as a value-added processing method.
- **Variety trials on late-bolting spider plant - World Vegetable Center:** A selection for late-bolting (flowering) spider plant was conducted within 13 lines. A total of 8 individual plants that took more than 45 days to flower were retained for further evaluation. Seeds were harvested separately from the retained plants. Each of these plants formed a new line in the next generation.
- **Variety trials - multiple AIVs World Vegetable Center:** A farmers' participatory variety selection was conducted in Zambia on Ethiopian mustard, African nightshade, and vegetable cowpea. The World Vegetable Center provided the designs for the experiments and protocols, traveled there, and led the selection process. Seed mutiplication was conducted for one variety each of amaranth, African nightshade and Ethiopian mustard. The crops are currently in the field.
- **Compost soil amendment:** Adding composted chicken manure to the soil to increase soil food web complexity. Sixteen farmer cooperator fields were planted using this technology.

Developing farmer-led irrigation solutions in Uganda

- **Water powered pump:** A water-powered pump uses the force of the current in a stream to turn a wheel, which generates pressure to pump water upslope. It is installed inside a stream or river, and is connected to a delivery pipe to take water to a nearby plot. It is low pressure and low flow, so it is suitable for relatively nearby gardens without too steep of a slope (<6m vertical head, <100m lateral distance). The pump works continuously, so some water storage at the plot is needed as well as a method for distributing water. This can include watering cans, drip, or any other low-pressure method.

Building safe vegetable value chains in Cambodia

- **Composting:** Compost made from locally available materials to boost yield, reduce chemical usage and increase farmer access to niche markets.
- **Earthworm Compost**: Compost made by earthworms with locally available materials to boost yield and reduce chemical usage.
- **Packinghouse:** Packinghouse for aggregating products and conducting good postharvest practices to improve quality and reduce postharvest loss and improve market connections.
- **CoolBot:** CoolBot technology has been installed in combination with a household air conditioner to provide inexpensive, effective cooling to reduce postharvest losses and extend shelf life.

Horticulture Innovation Lab Regional Center at Kasetsart University, Thailand

- **Online cold room monitoring system:** Low cost data logging system that can record power consumption, temperature, humidity, door status (open/closed), and displays real-time data on an LED screen. The system also sends all the data to the web server for storage, and the user can view and download data real-time using a browser on their computer or mobile phone. This technology can provide data to farmers and extension personnel regarding how efficiently the cool room is operating.

Trellis Round 6

- **Application of biochar in Anloga, Volta Region, Ghana for improved crop yield:** Application and applied research on the incorporation of biochar into the sandy soils of Anloga, in the Volta region of Ghana, at two levels of concentration. Implemented with other traditional agronomic practices, as well as the farmers' practices with several selected crops, in order to compare values for yield, disease incidence, and shelf life.
- **Promotion of mulching technology in vegetable production to support yields and nutrition in Northern Tanzania:** Vegetable production and moisture conservation improved via a combination of mulching techniques and good economic practices on tomatoes, African eggplants, and African nightshade. This project was implemented in the Nduruma and Mayire villages in the Arumeru district of the Arusha region of Northern Tanzania. In order to test mulching technologies and promote their adoption, the Tengeru Horticultural Research and Training Institute (HORTI Tengeru) established demonstration plots in order to compare the results of mulches, provide infield training, and spread information through farmer groups and educators.

Improving postharvest practices for tomatoes in Burkina Faso

- **Tomato seeds for rainy season production:** One of the largest constraints of tomato production in Burkina Faso is the lack of adaptability of most tomato varieties to the summer rainy season. Because of the wet conditions, most of the local and imported varieties are susceptible to diseases and pest infestations, resulting in a significant loss in yield. Consequently, the price of tomatoes from the months of June to December is very high, due to the low availability. Because of a lack of seed varieties and adequate postharvest options, Burkina Faso will export its tomatoes to coastal countries in the surrounding region (mainly Ghana, Togo, and Cote d'Ivoire), and import them from Morocco and Tunisia in December.

PROJECT TECHNOLOGIES IN PHASE 3: MADE AVAILABLE FOR TRANSFER

Improving nutrition with African indigenous vegetables in Kenya and Zambia

- **Improved AIV seed varieties:** Amaranths; Madiira 2, AC 45 and Ex- zan, Spider plant; PS, ML-SF-23, and ML-SF-15, African nightshade; Ex hai, SS 52 and SS 04.2

- **Postharvest technologies - Solar Dryer:** Communities around lake regions and other parts of Kenya normally experience lots of postharvest loss of vegetables during the rainy season, when an excess of vegetables is produced. Due to the high production levels during this period of time, huge volumes of vegetables spoil or are thrown away due to lack of a market and appropriate postharvest handling skills. The project constructed two prototype solar dryers in KALRO Alupe–Busia and in Kisumu regions for farmer groups to use as a learning point in sun-drying vegetable preservation.
- **Sack Garden Training:** The project worked with communities dwelling in peri-urban slums. The women's groups have worked through two key modules on AIV's, covered sack garden construction, manure, and soil mixing seedling germination techniques. The women's training taught participants how to use germination trays, transplant seedlings onto sack gardens, vegetable management, harvesting techniques, crop protection technologies, sack garden construction and management, and vegetable marketing.
- **Farmer Capacity Building on Improved Seed Distribution:** Enrolled groups were trained on both theory and practice on their respective demonstration farms. Each group was provided with a seed kit that included the seeds of three vegetables with each vegetable having three lines of cultivars. The seeds were then used to establish a demonstration farm that the groups used in their training sessions.

Developing farmer-led irrigation solutions in Uganda

- **Flexible rain gun irrigation for large, regular plots:** Uses a minimum of sub-main pipe, with a flexible PVC lateral pipe to set a rain gun anywhere in a regular shaped plot. It uses a small engine pump or another adequately pressurized water source.
- **Gravity irrigation system for montane East Africa:** Diverts water from an upslope stream using a reinforced tank build into a rock, and pressurizes water through a pipe grid for farmers to use with a drag hose or sprinkler irrigation system.
- **Multiple-use pumping system in distributed sub-areas for irrigation groups:** This system includes a short length of pipe for five different primary irrigation user groups, allowing each user to connect the system to a different water spreading method: hand held hosepipe, short-furrows, or multiple-head sprinklers. All these methods are designed for the small, irregular plots found commonly in Uganda.
- **Raised canal furrow system for poorly drained valleys:** This irrigation system is positioned on raised beds separated by deep drains fed by a raised canal filling furrows, using spiles made from local materials.

Assessing feasibility of pest-exclusion nets in Kenya

- **Biopesticides:** Nethouse growers in the five locations have met with project personnel and representatives of biopesticide companies to learn how to use biopesticides to produce high quality crops with low or no use of chemical pesticides. In some cases, the farmer groups have paid for additional training in the use of the biopesticides and beneficial insects. Using a nethouse in addition to this has additional pest management advantages to open field growing.

Reducing postharvest losses in Rwanda

- **Chimney solar dryer:** The chimney solar dryer combines solar heat collection with rapid airflow to dry fresh produce. The chimney solar dryer ensures continuous airflow around the product, thus increasing the drying speed as compared to other designs. This design's large heat-collection area (the drying table) ensures high temperatures and rapid water removal. Furthermore, the design is flexible enough to allow users to modify tray depth and size to fit local demands.
- **CoolBot:** Temperature management is the key tool for reducing postharvest losses. Very few smallholder farmers in the developing world have access to cold storage facilities, and refrigerated

transportation is rare. The CoolBot is an innovative cooling device system, which uses an intelligent thermostat system to control a standard room air conditioner to create a small-scale cooler out of a well-insulated room.

- **Crates:** Reusable plastic crates decrease damage during packing and transportation and offer good ventilation compared to traditional baskets and sacks. Sturdy crates were also built out of locally available materials.
- **DryCard:** The DryCard™ is an inexpensive device developed by UC Davis researchers for determining if food is dry enough to prevent mold growth during storage. Moldy food can have a bad taste and may be contaminated with harmful toxins. The DryCard uses a cobalt chloride humidity indicator strip that changes color with changing relative humidity. When a dry product is stored in a sealed container, mold will not grow on it if the equilibrium relative humidity within the container is lower than 65 percent.
- **Zero Energy Cool Chamber:** This simple brick and sand structure can help cool fresh produce inexpensively in conditions where evaporative cooling is effective. It is a double brick-wall structure, structure, the cavity is filled with sand and walls of the chamber are soaked in water. Cool chambers can reduce temperature by 10-15 °C and maintain high humidity of about 95% that can extend shelf life and retain quality of horticultural produce. The ZECC is appropriate for on-farm storage as well as collection points.

Scaling up seed-drying technology in Bangladesh

- **Dry Chain Concept:** This dry chain focuses on high value vegetable seeds and dried commodities such as grains and other products such as spirulina, chilies, and black pepper.

- **Dry Store Technology:** Drying beads allow farmers to dry their product to a sufficiently low moisture content in an easy and cost-effective way. The technology was first adopted by participating seed companies in Bangladesh, who disseminated the technology to their seed production farmers. Other farmers, companies, and institutes are becoming interested and the technology has been requested for a multitude of different uses.

Building safe vegetable value chains in Cambodia

- **New soil preparation methodology:** This treatment incorporates lime ($CaOH_2$) into soil before planting vegetables in order to decrease pest damage, disease damage, and raise the pH of acidic soils. The soil treatment and preparation methods have been demonstrated to smallholder farmers, and local sources for materials have been identified for use. The scope of the problem is currently being evaluated, and the necessity for conducting additional field testing or developing a launch plan is being evaluated.
- **Nethouses:** Nethouses create a physical barrier to protect crops from pest damage, reduce pesticide usage, and boost yield.

Developing farmer-led irrigation solutions in Uganda

- **Manual pivot piping system:** The main purpose of this technology is to have a minimal pipe length for maximum irrigable area.
- **Micro basins for vegetables:** This system uses very small basins to allow water to concentrate around the crops, reducing runoff and increasing water application efficiency.
- **Micro Furrows:** Micro furrows are very short furrows with flat, level bottoms that run along the contour of a slope, filled one at a time to allow water infiltration. Unlike traditional furrow irrigation, micro-furrows can be set across a moderate slope. Each furrow can be filled by an open pipe from either a pump or a gravity system.

- **Multiple head sprinklers:** This sprinkler set has 4 heads in one location to increase application rates within a small area. This allows farmers to irrigate for a shorter amount of time, and take advantage of soils with high infiltration rates. It can be applied to any sprinkler irrigation system.
- **Paid Operator System for Equipment Management:** This is a method of managing irrigation equipment owned by an irrigation group. The group appoints a set number of operators who are the only people authorized to move, set up, and take down the equipment. Other members are required to schedule their time with the equipment with the operator and pay a small fee each time the operator sets up the equipment at their plot. This done in order to compensate the operator, ensure clear accountability for equipment damages, and improve fairness in scheduling use of the equipment. This is especially helpful for women farmers, who often do not have power to demand equipment when male farmers are using it.
- **Raised, Terraced Canals**: A main canal for feeding water into irrigation furrows is raised above the level of the field to allow more control. The canal is terraced to have a minimal slope in each section of the canal in order to ensure an even distribution of water through discharge points along the canal. Spiles are inserted into the sides of the canal to divert the water to the plot.
- **Tied furrows for water uniformity in furrows:** This technology adds small blockages in furrows to adjust for the slopes that cause poorer uniformity in closed and cutback furrow systems. In sloping furrows, water tends to build up towards the closed furrow end. Making ties in the furrow levels out the water level along the slope.
- **Two tier irrigation group:** This is a system of managing irrigation equipment with a two-tier system of group management. The irrigation group members split up into sub groups, each with five to twenty members. Each subgroup has their own irrigation site, and members divide plots among themselves in this site.
- **Women's irrigation land trust:** A system of land management that helps women obtain land in irrigable areas. A plot of land is rented with a long-term renewable agreement with the landlord, to be used by the land trust. The land trust then allocates plots to members, who are exclusively women. Women make contributions at once or throughout the year, for a set fee or variable cost depending on the plot size (depending on the preferences of members).

Managing nematodes and soil health in Guatemala

- **Biological Control:** The addition of fungi as biological control agents can help reduce the population density of nematodes. *Purpureocillium lilacinus* was applied as a biological control agent against potato cyst nematode.
- **Compost amendment:** Addition of compost to the soil helps to increase the soil health which reduces susceptibility of nematode infestation.

Horticulture Innovation Lab Regional Center at Kasetsart University, Thailand

- **Cold room usage recording system**: A low cost data logging system that can record power consumption, temperature, humidity, door opening status, and display this data real-time on an LED screen.
- **Cold room user warning system:** A low cost user warning system that can send an SMS to specified mobile numbers when a problem occurs with the cold Room.

Trellis Round 6

- **Sweet potato leaves:** In Nepal sweet potato leaves developed for human consumption instead of animal fodder or plant propagation.

VII. ENVIRONMENTAL MANAGEMENT AND MITIGATION PLAN

The Horticulture Innovation Lab has finalized an Environmental Management and Mitigation Plan (EMMP) for all funded projects. The EMMP has been approved by the Agreement Officer's Representative (AOR) and Bureau Environmental Officer (BEO). Projects report on compliance semi-annually through the Horticulture Innovation Lab database. Management Entity will gladly provide EMMP if needed. Projects report on compliance semi-annually through the Horticulture Innovation Lab database. No environmental hazards demanding mitigation have been reported.

IX. OPEN DATA MANAGEMENT PLAN

In August 2015, the Horticulture Innovation Lab submitted our open data management plan to our AOR. The Open Data Management Plan (plan) is tracked in our Piestar database, and available upon request. The first data uploaded to the Development Data Library (DDL) were from the Horticulture Innovation Lab rapid assessment in Guinea. Projects have started the process of uploading links to public data repositories and directly to the DDL at the end of this fiscal year.

X. GOVERNANCE AND MANAGEMENT ENTITY ACTIVITY

The extensive horticulture experience UC Davis and the Management Entity bring to the management of the Horticulture Innovation Lab brings tremendous value to this program and to USAID. Our team uses this expertise to develop strategic plans for promoting the benefits of horticultural crop production and marketing to improve livelihoods in developing countries. With this expertise, we determine research priorities, develop RFPs and manage a portfolio of collaborative research activities. The ability to rely on

a management team with extensive expertise in a particular field to manage the research portfolio is one of the great strengths of the Feed the Future Innovation Labs.

The management entity of the Horticulture Innovation Lab is structured to minimize administrative overhead, ensure flexibility and transparency, and foster collaboration between institutions in the United States and the developing world in building capacity for horticultural research, outreach and implementation.

A unique feature of our management team is that many of our leaders devote only part of their professional time to our program, through "leads", our International Advisory Board, External Reviewers and Technical Committee. For this reason, we have a large scope of expertise and experience, but the total management FTE is comparable to similar programs. Responsibilities of each individual are matched to their interests and experience as much as possible.

In FY2018, we designated members of the ME team to evaluate how we can improve indicators to better capture research project outputs that meet the GFSS goals. This process has involved deeply looking at the impact of research and how to best transform research outcomes into impact; As well as hired as assessing outselves through the Feed the Future framework through a third-party evaluator.

XI. OTHER TOPICS

SCALING

Scaling has become a central component of the Horticulture Innovation Lab's initiatives as Phase II comes to an end in order to ensure that research outputs are thoroughly disseminated and sustainable.

- Several projects have established innovation and technical centers as hubs for training and demonstration of hard technologies.
- The DryCard's entrepreneur start-up model – providing a DryCard kit to make 10,000 DryCards to individuals with promising business plans – has accelerated the scaling of the technology and is an income driver. Furthermore, the DryCard entrepreneurs are now incorporating technologies addressing the entire dry chain – chimney solar dryers, Drying Beads, and Purdue Improved Crop Storage (PICS) bags – into their portfolio.
- The projects *Establishing a horticulture center in Guinea*, *Assessing the feasibility of pest exclusion nets in Kenya,* and *Promoting drip irrigation and climate resilience in Guatemala - MasRiego* sell technologies to farmers, recognizing that scaling the technology without donating the technology can increase farmer engagement toward driving proper implementation.
- As an alternative approach to scaling, the Horticulture Innovation Lab management entity has posted a completed chimney solar dryer building manual and instructional video on its website and farmers have built the units on their own, sending photos of completed units to the team. The management entity is pursuing additional strategies for the chimney solar dryer, such as sending Erin McGuire, Associate Director, and Anthony Phan, Project Analyst, to the Scale Up Conference held at Purdue University in September 2018 for insights on the chimney solar dryer scaling approach.
- Targeting the right scaling actor is key, as exhibited in the *Scaling up drying technologies for seed in Bangladesh* project in which motivated seed companies, rather than individual farmers, were the optimum medium for scaling the technology and ultimately benefiting smallholder farmers.

- Projects have been successful scaling technologies through effective training of methods and practices to smallholder farmers who then produce the hard technology at their farm site. An example of this is with the *Expanding Tomato Grafting for Entrepreneurship in Guatemala and Honduras* in which a women's cooperative trained in effective grafting techniques with tomatoes now sells grafted tomatoes they produce to surrounding farms.

The Horticulture Innovation Lab recognizes that institutional and organizational collaborations are critical for scaling of technologies. Collaborations and communications with institutions involved in horticulture for development are used by the Horticulture Innovation Lab as vital indices of our effectiveness. We believe that these intermediaries, with their in-country presence, are essential conduits for scaling.

COMMUNICATIONS

The Horticulture Innovation Lab maintains an active communications presence via its website, blog, email newsletter, Twitter, Facebook, Flickr and YouTube channels. The program also supplies articles to the Agrilinks website and Feed the Future newsletter, as appropriate. On social media, the program shares its own news while also circulating news of relevance related to international development, horticultural science, university research, agricultural extension, as well as networking with project partners, UC Davis units, and Feed the Future programs.

During 2017-2018, the Horticulture Innovation Lab team rebuilt its website to expand its capacity for delivering information in ways that are highly accessible, clear and attractive. The renovation not only updated the visual design and technology the website is built upon, but also created structures to better highlight research findings, extension materials, and network experts. The new website merged the program's blog with more than 300 "information product" webpages that are categorized by countries, crops, value chain stages, technologies, and other categories.

This year also saw advances in the Horticulture Innovation Lab's use of videos as a communications tool. Each of the program's research projects created a 90-second video to present during the Horticulture Innovation Lab's annual meeting, which continue to be shared on the program's YouTube channel with ongoing plans to embed the videos in future blog posts. The management team also created a three-part video series on the chimney solar dryer, as complementary pieces to its new Chimney Solar Dryer Manual document. These short videos provide not only a way for users to better explore three-dimensional technical specifications and agricultural settings on other continents, but are also another way for new users to find Horticulture Innovation Lab content through YouTube's powerful search engine.

See the Appendix for a complete list of news articles and blog headlines for FY2018.

WEBSITE

The Horticulture Innovation Lab launched a new website in April. In addition to updated project information, blog posts, and news articles, the new website started with more than 300 "information product" webpages based on presentations, reports, manuals, posters, and other extension materials generated by Horticulture Innovation Lab-supported research projects.

The new website provides a structure to further increase the quality, availability, and visibility of these and many more extension materials and information deliverables available from project teams—for use by partners within the network and also external parties to improve outcomes along the horticulture value chain. The website's information is organized by country and by phase in the value chain (seed, production, pest management, postharvest, etc.), as well as crops, technologies, and other categories. The new website is built upon a fast, open-source platform developed by UC Davis programmers after an in-depth customization process. The site allows for team member contributions, merges the program's blog and website, and also better adheres to Feed the Future branding.

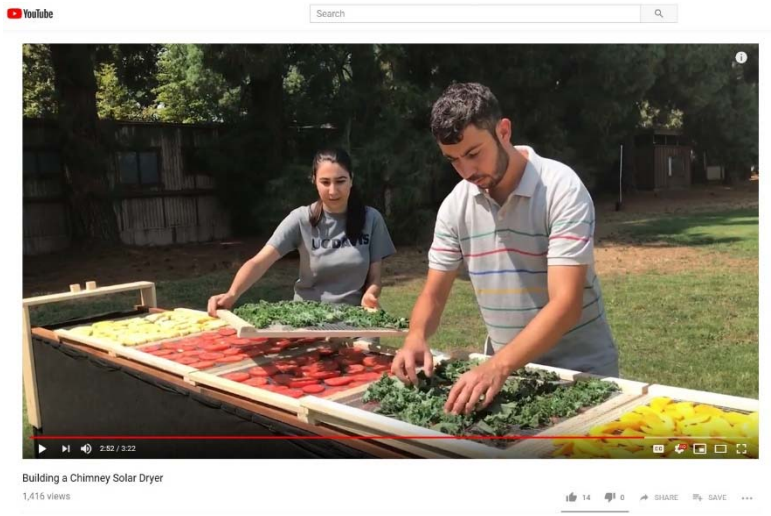
Over the course of the year, the Horticulture Innovation Lab website garnered over 38,600 sessions (an increase over the previous year's 34,000 user-sessions combined from the program's separate website and blog, with a noticeable spike and plateau since the new unified site launched). This year's website sessions were from more than 21,700 users.

The Horticulture Innovation Lab team continues to build out the new website, with more information product webpages, additional profiles of network experts, and new blog articles.

VIDEOS

On the Horticulture Innovation Lab's YouTube channel, analytics report more than 13,000 views of the program's videos over the course of the year. Videos uploaded in the last 12 months with the most views include "Building a Chimney Solar Dryer" which is the first in a three-part series about the chimney solar dryer and "From the Field: Pineapple Postharvest, UC Davis to Uganda" which is a short video about a grad student's Trellis Fund experience.

As part of this year's annual meeting, each research project created a 90-second video highlighting a specific, short story, finding or achievement from their team. This activity resulted in 20 short videos, or one new video for each of the Horticulture Innovation Lab's current research projects. The videos debuted at the annual meeting in lieu of traditional PowerPoint presentations and continue to be shared on YouTube. The videos were created in the wake of a hands-on training for researchers about how to shoot short videos featuring their work, held during last year's annual meeting.



In addition to the project videos, the Horticulture Innovation Lab's management entity also created a three-part video series about how to use the UC Davis-designed chimney solar dryer, as a complement to the Chimney Solar Dryer Manual document. During that time, the program also shared three short videos featuring Trellis Fund student experiences, created as a complement to related blog posts. A short, introductory video called "The Promise of Horticulture" created originally as a YouTube channel trailer was cross-promoted on Facebook, where it garnered more than 1,000 views reported by Facebook alone.

SOCIAL MEDIA

The Horticulture Innovation Lab is active on social media channels, particularly Twitter and Facebook. Both Facebook and Twitter are ways to promote news and information from the program, in addition to sharing news of our partners and circulating news related to horticulture and international development. Twitter in particular allows the program to network with other similar programs, including Feed the Future Innovation Labs, horticultural research organizations, USAID programs, UC Davis programs, partner organizations, partner scientists and other universities. Twitter is also a way to gather news and information on horticultural science news and international development topics in a timely way.

Twitter: As of Oct. 3, 2018, the Horticulture Innovation Lab account (@HortInnovLab) had 3,158 followers, which is an increase of 435 followers in the last 12 months. Employees of the Horticulture Innovation Lab's management entity—in particular Brenda Dawson, Angelos Deltsidis and Erin McGuire—also operate Twitter accounts that circulate information about their work with the Horticulture Innovation Lab.

Live tweeting from the Horticulture Innovation Lab's annual meeting in Rwanda and from the program's participation in World Food Prize events help share and further promote information from the program to a wider audience. The Horticulture Innovation Lab's global network also participated in the #EndHunger social media campaign, with photos shared from the program's research partners in Bangladesh, Guatemala, Rwanda, Ethiopia, Honduras, Guinea, Cambodia and the United States.

Facebook: As of Sept. 30, 2018, the Horticulture Innovation Lab's page had 2,761 fans ("likes"), which is a net increase of 337 likes in the past 12 months (2,424 likes as of Oct. 1, 2017).

Among the page's top Facebook posts over the course of the year were a short video introduction to how the program works, a link to a Feed the Future newsletter article featuring a young entrepreneur in Guinea who works with the Horticulture Innovation Lab, and a link to a blog post featuring director Elizabeth Mitcham's brief appearance discussing fresh produce quality on Good Morning America.

IMPACT EVALUATION

Our global research network advances fruit and vegetable innovations, empowering smallholder farmers to earn more income while better nourishing their communities.

Goal: Through collaborative research, extension, and capacity building, the Horticulture Innovation Lab works to build resilience and end poverty by:

- Creating economic opportunities for smallholder farmers and entrepreneurs
- Improving dietary diversity and nutritional status
- Empowering women, youth, and the most vulnerable
- Facilitating the exchange of innovative ideas and technologies
- Advancing horticultural science, from seed to consumption

Objectives-

- Identify and address key knowledge gaps through research and development of innovative technologies.
- Increase stakeholder access to and adoption of reliable information and technologies to improve the horticulture value chain.
- Build capacity of stakeholders to conduct research and effectively apply and disseminate information and innovative technologies.

To assess the Horticulture Innovation Lab's success against these goals and objects, and the Feed the Future Framework, an Independent Evaluator, Dr. Gregory Sullivan, has been hired to provide insight on program successes and challenges. The evaluation will be used to share out what we have learned in the past seven years - to benefit researchers, practitioners, and students, as well as the farming families that we aim to serve. We are deeply dedicated to learning new, more effective ways for the management entity to award and conduct research projects in emerging economies. See the entire scope of work provided in the appendix.

XII. ISSUES

In the *Improving practices for dried apricots in Tajikistan* project, no visits or trainings occurred in FY2018 by U.S. based researchers. However, the team at Purdue has scheduled a visit early in 2019 to catch up on project activities. The *Improving nutrition with African indigenous vegetables in Kenya and Zambia* needed to find an implementing partner in Zambia. Thankfully, the project was able to find a new collaborator, the Hantambo Women's Group, relatively quickly and maintained activities occurring at the University of Zambia.

XIII. FUTURE DIRECTIONS

In the final year, the Horticulture Innovation Lab will focus on sharing information and new knowledge with development practitioners and the research community. The management entity will draw lessons learned from across all ongoing projects and those implemented in previous years. Distribution of this new knowledge through various outreach methods is critical to our mission to benefit small-scale farmers now and in the future. In addition, the management entity will engage in responsible reflection on how the Horticulture Innovation Lab has been successful in innovating solutions for agriculturists, but also how we can improve processes to better serve the international research community, students, and farming families.

XIV. APPENDICES

APPENDIX A. LIST OF AWARDS IN PHASE II:

Inclusive and sustainable agricultural-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, increasing food availability, generating income from production, creating employment and entrepreneurship opportunities throughout value chains, and spurring growth in rural and urban economies.*

Empowering Women through Horticulture in Honduras

- PI: Janelle Larson, The Pennsylvania State University
- Partner institutions: Zamorano University
- Project duration: 4.5 years
    - 01/01/2015 – 07/31/2019
- Award amount: $1.435 million
- Project goal: To use a rigorous qualitative and quantitative approach to understand how the horticultural value chain can be a mechanism to support gender equity and empowerment for women and other marginalized populations while identifying technologies, institutions and policies that enable the participation of women and other marginalized groups in the horticultural value chain.

Managing nematodes and soil health in Guatemala

- PI: Brent Sipes, University of Hawai‘i at Mānoa
- Partner Institutions: Michigan State University, Universidad de San Carlos de Guatemala
- Project duration: 3 years
    - 10/01/2016 – 07/31/2019
- Award amount: $449,994
- Project goal: With smallholder potato farmers in the Western Highlands of Guatemala transdisciplinary research team will demonstrate and advocate for integrated practices of cover cropping, intercropping, soil amendment, biopesticides, and crop resistance.

Building Postharvest Capacity in Tanzania

- PI: Eleni Pliakoni, Kansas State University
- Partner institutions: University of Florida, Sokoine University
- Project duration: 2 years
    - 05/01/2017 – 07/31/2019
- Award amount: $500,000
- Project goal: To provide students, farmers, traders, marketers, and agriculture extension educators that are working with fresh produce, the tools necessary to improve the quality and shelf life of their products and consequently reduce postharvest losses in Tanzania.

Improving postharvest practices for tomatoes in Burkina Faso (Mission Service Project)

- PI: Gurbinder Singh Gill, Agribusiness Associates
- Partner institutions: USAID/Burkina Faso, USAID/Sahel Regional Office, TBD
- Project duration: 2 years
    - 3/1/2017 – 2/28/2019
- Award amount: $300,358
- Project goal: To improve postharvest handling, storage and marketing of tomatoes in the Research to Improve Handling, Storage, and Marketing of Tomatoes in Burkina Faso for Resilience in the Sahel-Enhanced (RISE) zone of Burkina Faso.

Improving practices for dried apricots in Tajikistan (Mission Service Project)

- PI: Ariana Torres, Purdue University
- Partner institutions: USAID/Tajikistan and TBD
- Project duration: 2 years
    - 02/15/2017 – 04/30/2019
- Award amount: $300,000
- Project goal: Provide evidence base for appropriate postharvest handling, processing, and marketing of dried apricots in the Feed the Future zone of Tajikistan.

Establishing a horticulture center in Guinea (Guinea Mission Buy-In)

- PI: Horticulture Innovation Lab
- Partner Institution: IRAG, Winrock, CNFA, ACDI/VOCA, Peace Corps, Zamorano
- Project duration: 2.5 years
    - 2/1/2017 – 7/31/2019
- Project Amount: $655,000
- Project goal: Establish a training and services center led by youth (AVENIRS) to train local farmers and agribusinesses on horticultural technologies that can be used to improve livelihoods.

Advancing Horticulture Technologies through Design, Education, and Outreach

- PI: Kurt Kornbluth, University of California, Davis
- Partner Institutions: University of California, Davis
- Project duration: 1 year
    - 09/01/2018 - 07/31/2019
- Award amount: $60,000
- Project goal: Based on lessons learned in previous years, this initiative will focus on supporting demonstration centers, developing and disseminating a D-Lab tool kit. The toolkit will be developed from existing D-Lab curriculum on: Project Framing, Feasibility Studies, and Prototyping (Design, Build, Test). D-Lab will compile and produce an easily accessible version of the toolkit to be disseminated widely to partner universities and stakeholders.

Scaling up drying technologies for seed in Bangladesh

- PI: Johan Van Asbrouck, Rhino Research, Thailand
- Partner institutions: University of California, Davis and Professor Jayashakar Telangana State Agricultural University
- Project duration: 2 years

    - 06/01/2015 – 09/30/2017 (Extended to 09/30/2018 with bridge funding of $85,000
- Award amount: $679,660
- Project goal: To scale the drying bead technology that has been adapted into dryers.

Assessing feasibility of scaling up nets for pest-exclusion in Kenya

- PI: Vance Baird, Michigan State University
- Partner institutions: CIRAD, KALRO, Rutgers the State University of New Jersey, A to Z Textile Mills, Center for Large Scale Social Change, LLC
- Project duration: 1 year
    - 08/01/2016 – 07/31/2017 (NCE to 07/31/2018
- Award amount: $196,287
- Project goal: To scale the pest-exclusion net technology by targeting export production in Kenya.

Expanding tomato grafting for entrepreneurship in Guatemala and Honduras

- PI: James Nienhuis, University of Wisconsin-Madison
- Partner institutions: World Vegetable Center, Taiwan; Catholic Relief Services, Guatemala; Zamorano University and Fundación Hondureña de Investigación Agrícola (FHIA), Honduras
- Project duration: 2 years
    - 01/01/2015 – 12/31/2017 (NCE under review to finalize outstanding financial obligations)
- Award amount: $329,520
- Project goal: To test scion and rootstock combinations for resistance to soil-borne diseases and consumer/farmer desirability and transfer these lines and the knowledge to produce them to local farmer groups.

Promoting conservation agriculture for vegetable growers in Nepal and Cambodia

- PI: Manuel Reyes, North Carolina A&T State University
- Partner institutions: Royal University of Agriculture; Agricultural Development Denmark Asia, Cambodia; International Development Enterprises (iDE), Nepal
- Project duration: 2 years
    - 01/01/2015 – 12/31/2016 (NCE to 12/31/2017)
- Award amount: $300,000
- Project goal: To introduce and test conservation agriculture, drip irrigation, and rainwater harvesting for vegetable farmers and understand the climate- and labor-associated gains associated with these technologies.

Cooling in Tanzania

- PI: Horticulture Innovation Lab
- Partner institutions: Horti-Tengeru; World Vegetable Center Arusha
- Project duration: 1 year
- Award amount: $50,000
- Project goal: To improve the postharvest cooling infrastructure at Horti-Tengeru and conduct a postharvest training program.

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.*

Promoting drip irrigation and climate resilience in Guatemala - MasRiego (Guatemala Mission Buy-In)

- PI: Horticulture Innovation Lab
- Partner institutions: Kansas State University, North Carolina A&T, Zamorano University, Barbara Ford Peace Center
- Project duration: 4 years
    - 08/01/2015 – 07/31/2019
- Award amount: $3 million
- Project goal: To promote private sector development in the horticulture value chain and promote household horticultural production and household food security through the increased use of drip irrigation, conservation agriculture and rainwater harvest practices.

Reducing postharvest losses in Rwanda

- PI: Gurbinder Singh Gill, Agribusiness Associates
- Partner Institutions: Ministry of Agriculture and Natural Resources, University of Rwanda, National Agriculture Export Development Board, Rwanda Agriculture Board
- Project duration: 3 years
    - 08/01/2016 – 07/31/2019
- Award amount: $1.7 million
- Project goal: This project is aimed at increasing food security in Rwanda, by understanding and identifying the most efficient ways to reduce postharvest losses.

Trellis Fund

- Partner institutions: University of California, Davis, University of Florida, University of Hawai‘i at Mānoa, North Carolina State University
- Project duration: 5 years
    - 4/01/2014 to 04/30/2019
- Award amount: $444,066 ($4,000 to 15 organizations plus 15 student trips)
- Project goal: To provide small-scale, in-country development organizations access to U.S. graduate student expertise, providing benefits to both the student and the in-country institutions.

Developing farmer-led irrigation solutions in Uganda

- PI: Kate Scow, University of California, Davis
- Partner institutions: Texas A&M, Teso Women Development Initiatives (TEWDI), Amelioration of Agricultural Risks (AMARI), Busitema University, Buginyanya ZARDI (BugiZARDI), Nabuin Zonal Agricultural Research and Development Institute (Nabuin ZARDI), and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Uganda
- Project duration: 2 years
    - 01/01/2105 – 12/31/2016 (NCE to 12/31/2018)
- Award amount: $314,000
- Project goal: To research and develop a suite of tested and affordable small-scale irrigation solutions for Eastern Ugandan vegetable farmers that have been vetted by the farmers for affordability and viability.

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.*

Improving nutrition with African indigenous vegetables in Kenya and Zambia

- PI: James Simon, Rutgers, the State University of New Jersey
- Partner institutions: Purdue University, AMPATH-Moi Family Preservation Initiative in Kenya, Eldoret University, Kenya Agricultural and Livestock Research Organization, University of Zambia, World Vegetable Center Arusha, Focus on Africa.
- Project duration: 4.5 years
    - 01/01/2015 – 07/31/2109
- Award amount: $2.08 million
- Project goal: To determine the nutrition content of AIVs and to assess the impact of increased African indigenous vegetable productions on household-level consumption and dietary diversity.

Examining Nutrition Impacts of Horticulture Innovations in Bangladesh (Sub-award)

- PI: Patrick Webb, Nutrition Innovation Lab, Tufts University
- Partner institutions: Horticulture Innovation Lab, Tufts Nutrition Innovation Lab, WorldFish, Auburn University
- Project duration: 4 years
    - 09/29/2014 – 09/28/2018 (Extension to 04/30/2019)
- Award amount: $895,000
- Project goal: To study the impact of behavior change communication alone or coupled with horticulture and/or aquaculture interventions on household-level nutrition. This is a four-year study with control groups and several interventions.

Investigating integrated vegetable-livestock systems in Cambodia

- PI: Jessie Vipham
- Partner institutions: Kansas State University
- Project duration: 2 ½ years
    - 2/15/2017 – 7/31/2019
- Award amount: $750,000
- Project goal: To understand how integrated animal-horticulture systems are most feasible for smallholders by rigorously addressing - through interdisciplinary research - the potential of these systems with regard to sustainable production capacity, income generation, and gender dimensions. The project will provide useful recommendations for smallholder farmers

Building safe vegetable value chains in Cambodia

- PI: Glenn Young, University of California, Davis
- Partner Institutions: Royal University of Agriculture, IPM Innovation Lab
- Project duration: 3 years
    - 09/01/2016 - 07/31/2019
- Award amount: $450,003
- Project goal: Increase access to the safe vegetable value chain for smallholder farmers (often women) through innovative technologies, relationship building, and cold chain development.

DryCard Franchise Project

- ME project, led by Anthony Phan
- Project goal: The Horticulture Innovation Lab will work with users, researchers, and developers to test the usability and impact of the DryCard. To increase awareness and adoption of the DryCard, the Horticulture Innovation Lab will partner with local organizations and entrepreneurs to manufacture and market the DryCard to their respective region.

Regional Centers: *The centers bring together key regional players to improve livelihoods of smallholder farmers and small businesses in the regions' developing countries, while building capacity at the host institutions.*

Primary goals shared between each of the Regional Centers are:

- *Researching, innovating and disseminating horticultural technologies*
- *Training farmers, horticultural stakeholders, extension agents and researchers*
- *Building capacity among local institutions*
-

Horticulture Innovation Lab Regional Center at the Panamerican Agricultural School, Zamorano, Honduras

- PI: Julio Lopez
- Partner institution: Escuela Agrícola Panamericana, Zamorano
- Project duration: 8 years
    - 01/01/2015 – 07/31/2019
- Award amount: $406,353

Horticulture Innovation Lab Regional Center at Kasetsart University, Thailand

- PI: Poonpipope Kasemsap
- Partner institution: Kasetsart University
- Project duration: 8 years
- Award amount: $324,500
    - 01/01/2015 – 07/31/2019

Horticulture Innovation Lab Regional Center at AgriSmart in Zambia

- PI: Emil Van Wyk
- Partner institution: AgriSmart Zambia
- Project duration: 2 years
- Award amount: $137,500
- Project goal: To showcase technologies and innovations that improve horticulture in their respective regions.

Designing for horticulture development with D-Labs in Honduras and Thailand

- PI: Kurt Kornbluth, University of California, Davis
- Partner Institutions: Zamorano University, Kasetsart University
- Project duration: 1 year
- Award amount: $50,000

- Project goal: Supporting the satellite D-Labs at the two regional innovation centers, the objective is to provide technical and curriculum support to improve implementation of the D-Lab courses and modules.

APPENDIX B. BLOG POSTS AND EXTERNAL NEWS ARTICLES

These are timely articles that appeared on websites or media outlets that are not controlled by the Horticulture Innovation Lab. Listed chronologically with Date: Outlet "Headline".

- October 10, 2017: UC Davis Dateline "Horticulture Innovation Lab hosts World Food Day event"
- October 31, 2017: Feed the Future Newsletter "Guinea's Innovators Plant the Seeds for Success"
- November 13, 2017: Chronica Horticulturae "The UC Davis Chimney Dryer and DryCard – tools for implementing the dry chain"
- November 16, 2017: Agrilinks "7 ways that gender matters in Western Honduras"
- November 27, 2017: Growing Produce "Apricot Research Aids Asian Export Market"
- November 28, 2017: Agrilinks "Building Capacity in Gender and Irrigation Design With Young Engineers in Uganda"
- December 19, 2017: Western Fruit Grower "Central Asia Linchpin: Apricot research aids Tajikistan"
- January 25, 2018: UF IFAS News "UF Students win grants for projects that aid farmers in developing countries"
- January 29, 2018: Zamorano News "Promoviendo la equidad de gémero por medio de la metodologia de escuelas de campo"
- February 2, 2018: National Agricultural Export Development Board "Horticultural post-harvest losses can be reduced"
- February 10, 2018: URICT Uganda "Official Announcement of Trellis Fund Projects"
- February 12, 2018: UC Davis Department of Land, Air and Water Resources "Soils Graduate Student Selected for Trellis Fund Project in Nepal"
- February 13, 2018: The Alligator "Nine UF graduate students will work in developing countries this summer"
- February 28, 2018: Foreign Policy Interrupted "FPI's 2018 Winter Fellows"
- March 7, 2018: UC Davis Dateline "LAURELS: Athletics' Video Director Wins National Award, Elizabeth Mitcham of the Horticulture Innovation Lab named as Foreign Policy Interrupted Fellow"
- April 16, 2018: UC Davis CA&ES Outlook "Digging Deep: Master's student works with Ugandans to illuminate gender roles and improve farming practices"

- April 18, 2018: UC Davis BFTV News “PhD candidate in Marco Lab selected to work in Uganda”
- May 2, 2018: Agrilinks “Calling all Innovators in Rwanda: Postharvest Innovation Competition Heats up”
- May 3, 2018: Agrilinks “Calling all Innovators in Rwanda: Postharvest Innovation Competition Heats Up”
- May 4, 2018: IGIHE “Ikoranabuhanga rya DryCard rifasha kumenya umusaruro wumye neza ryagejejwe mu Rwanda” (Kinyarwanda language)
- May 14, 2018: Grow: Wisconsin’s Magazine for Life Sciences “Ancient Method Helps Feed Present-Day Communities”
- May 15, 2018: UC Davis Dateline “The Download: Staff pride, Food Innovation, New Arrivals” (Chimney solar dryer video)
- May 15, 2018: UC Davis News “UC Davis Innovators Honored for Contributions in Agriculture, Pathology”
- May 16, 2018: Sacramento Business Journal “UC Davis Chancellor’s Innovation Awards honor food safety, diagnostic technology”
- May 16, 2018: Woodland Daily Democrat “UC Davis innovators honored for contributions to agriculture and pathology”
- May 23, 2018: UC Davis Feature “UC Davis DryCard Invention Wins Chancellor’s Innovators Award to Reduce Food Loss Globally”
- May 25, 2018: ABC News “Trying out 3 popular same-day grocery delivery services”
- May 25, 2018: Yahoo News “Trying out 3 popular same-day grocery delivery services”
- May 28, 2018: Good Morning America “Grocery Wars”
- June 1, 2018: Davis Enterprise “UCD innovators honored for contributions in ag, pathology”
- August 27, 2018: Penn State News “Farmer Field School addresses food insecurity, gender inequality in Honduras”
- September 1, 2018: FoodTank “35 Food Policy Leaders Convene in New York City”
- September 28, 2018: Imperial Valley News “Food Policy Leaders Convene in New York City”

Additionally, these blog posts were published on the Horticulture Innovation Lab website, listed chronologically by headline:

- Sharing postharvest knowledge, from classroom to mango farm
- Ugandan president commends students for irrigation innovations
- Drying beads help Bangladesh farmers access better seed

- Young entrepreneurs help Guinea's farmers access postharvest innovation
- UC Davis and Uganda students consider gender in irrigation design
- Video: UC Davis student connects with Ugandan farmers over pineapple postharvest practices
- New projects in Africa and Asia to help fruit and vegetable farmers, with a little help from U.S. university students
- Accomplishments from our global network in 2017
- UC Davis expert judges fresh produce quality on ABC News
- Rwanda Postharvest Competition begins
- DryCard team honored as 'Innovators of the Year'
- Internships: Join team helping farmers in Guinea
- Rwanda Postharvest Week incubates visionary postharvest solutions

APPENDIX C. MANAGEMENT ENTITY M&E FRAMEWORK

MISSION

Our global research network advances fruit and vegetable innovations, empowering smallholder farmers to earn more income while better nourishing their communities.

GOALS

Through collaborative research, extension, and capacity building, the Horticulture Innovation Lab works to build resilience and end poverty by:

- Advancing horticultural science, from seed to consumption
- Creating economic opportunities for smallholder farmers and entrepreneurs
- Improving dietary diversity and nutritional status
- Empowering women, youth, and the most vulnerable
- Facilitating the exchange of innovative ideas and technologies

OBJECTIVES

Identify and address key knowledge gaps through research and development of innovative technologies.

Increase stakeholder access to and adoption of reliable information and technologies to improve the horticulture value chain.

Build capacity of stakeholders to conduct research and effectively apply and disseminate information and innovative technologies.

INDICATORS OBJECTIVE 1

Objective: Identify and address key knowledge gaps through research and development of innovative technologies.

Indicators:

Project areas to track for each indicator	Key knowledge gaps[1] identified	Number of products demonstrating new knowledge[2]	Number Phase I technologies[3] addressing key knowledge gaps	Number of Phase II technologies[4] addressing key knowledge gaps	Number of Phase III technologies[5] addressing key knowledge gaps
Nutrition					
Pest management					
Postharvest					

Production					
Irrigation					
Value addition					
Gender/vulnerable communities					

Collection method: Piestar and in-house records

Definitions: Key knowledge gaps- gaps in horticultural knowledge as defined through GFSS (White papers, RFPs); And Horticulture Innovation Lab Network expertise (IAB, ME, PIs, Expert Reviewers)

Products demonstrating new knowledge- Published papers, white papers

Phase 1 Technologies- Technologies that are under research as a result of U.S. Government assistance: count new technologies or management practices under research in the current reporting year.

Phase 2 Technologies- Technologies that are under field testing as a result of USG assistance: "under field testing" means that research has moved from focused development to broader testing under conditions intended to resemble those that the potential users of the new technology will encounter. Testing might be done in the actual facilities or fields of potential users, or it might be in a facility set up to duplicate those conditions.

Phase 3 Technologies- Technologies made available for transfer as a result of USG assistance. This phase counts technologies that are now able to be transferred to an end user. It does not count the number of technologies actually transferred by public or private entities, including implementing partners. Completing a research activity does not in itself constitute having made a technology available for transfer. Conditions may need to be met before a technology can move into the public domain, and this Phase captures technologies that have met these conditions.

Technologies- defined as hard and soft technologies FTF EG.3.2-7; Disaggregate by phases as defined in FTF Indicator Handbook Definition Sheet

INDICATORS OBJECTIVE 2

Objective: Increase stakeholder access to and adoption of reliable information and technologies to improve the horticulture value chain.

Number of information products[1] created

Total promotion of information products from newsletters, blogs, emails, meetings, conferences, webinars, and social media

Total peripheral network[2]

Number of thought leadership engagements[3]

Collection method: In house records

Types of intermediaries[4] aware of and using Horticulture Innovation Lab products

Number of intermediaries aware of and using Horticulture Innovation Lab products

Collection method: representative survey conducted by Horticulture Innovation Lab GSR survey annually.

Definitions: Information products- items ready for intermediary or farmer consumption e.g. manuals, factsheets, videos, etc.

Peripheral network- number of social media followers, number on listserv, page views

Thought leadership engagements- number of events spoken at; what/type of event; number of speaking invites; number of ME-led projects (short-course); clips including op-eds, responses and press releases; co-authorship; number of white papers (including those demonstrating new knowledge in Objective 1)

Intermediaries- the Horticulture Innovation Lab management entity's stakeholders, such as NGOs, universities, and other institutions that serve as middle men between the management entity and farmers. Examples: Other development actors, research universities, extension services, in-country corporations, US-based/Western corporations, missions, local NGOs, regional centers, US government scientists, USAID, other awardees, project leads, policymakers, US government consultants

INDICATORS OBJECTIVE 3

Objective: Build capacity of stakeholders to conduct research and effectively apply and disseminate information and innovative technologies.

Indicators:

Number of leveraged funds[1]

Number of leveraged activities[2]

Number of students trained FTF: EG.3.2-2

Collection method: Piestar

In-country project personnel demonstrate expanded capacity for future activities[3]

Collection Method: Short survey given to in-country and US-based PIs. Could have university PIs give in-country PIs survey and start a listserv of in-country PIs. Close out survey and once a year.

Technologies adopted:

Number of hectares that adopted technology FTF EG.3.2-18

Number of individuals that adopted technology FTF EG.3.2-17

Region that technologies are adopted

Collection method: Piestar (FTF indicators)

Definitions:

Leveraged funds- external funds that result from Horticulture Innovation lab management entity funds/projects

Leveraged activities- external activities that result from Horticulture Innovation lab management entity funds/projects

Examples: if student became a professor, new partnerships, technology improvements/leveraged, postharvest course beyond scope

In-country project personnel demonstrate expanded capacity, or increased resources, skills, and ability to:

Conduct research

Effectively use information and innovative technologies

Disseminate information and innovative technologies

Self-reflection questions:

"Do you feel able to disseminate technology after this project?"

"Do you feel more confident in adopting this technology, best practice, or performing this research?"

Do you feel confident in educating others on this technology or information?

"Do you have plans to continue related activities? Course, etc."

How many trainees are you thinking of training?

Sustainability questions:

Lessons learned. And have the in-country PIs fill out certain aspects of annual reporting that US-based PIs usually do (like lessons learned.)

Are any project activities continuing? (after the project ends)

Are people continuing to be taught this research approach, information or technology?

Are local groups (cooperatives) continuing project activities or continuing to use technology?

We already collect FTF indicators around number of trainings, particularly for students (GSRs) and research institutions.

APPENDIX D. REQUEST FOR PROPOSALS FOR HORTICULTURE INNOVATION LAB EVALUATOR

About the Horticulture Innovation Lab

Feed the Future Innovation Labs. The Horticulture Innovation Lab is one of 24 Innovation Labs led by U.S. universities with funding from the United States Agency for International Development (USAID), as part of the U.S. government's global hunger and food security initiative called Feed the Future. Of the 24 Feed the Future Innovation Labs, the Horticulture Innovation Lab is one of 10 programs that specifically focus on collaborative research (previously called CRSPs) and share the following characteristics:

Coordinated, multi-disciplinary research programs that are collaboratively developed and cooperatively implemented, with shared responsibilities between U.S. and host country institutions and scientists. Our goals are to support economic growth and to reduce poverty through the generation of knowledge and technologies important to the development of agriculture and natural resources of developing and transition countries, while also contributing to the improvement of agriculture in the United States.

Long-term activities carried out largely in developing countries. Research proposals are selected competitively and are subject to review by USAID.

Development of the human and institutional capabilities of research organizations in the countries where our activities are located. Research projects are a vehicle for this capacity development, as are graduate degree programs, research assistantships, and workshops. The institutional relationships established between our programs and host country institutions are intended to be enduring and to transcend the life of the program.

Horticulture Innovation Lab**.** The Horticulture Innovation Lab builds international partnerships for fruit and vegetable research to improve livelihoods in developing countries. Now in its second phase, the program began in 2009 when USAID selected the University of California, Davis, to lead a 5-year program (then called the Horticulture Collaborative Research Support Program, or Horticulture CRSP). The program team and its projects help 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 focused on ensuring gender equity, improving information access, targeting innovative technologies and increasing research capacity.

The Horticulture Innovation Lab projects span the value chain of fruit and vegetable production, from seed systems to postharvest processing. Individual projects are generally led by U.S. university researchers, with collaborating partners in developing countries. In its first phase, from 2009-2014, the Horticulture Innovation Lab funded 61 projects in more than 30 countries. As a result of the Horticulture Innovation Lab's activities, 39,027 individuals (56% women) received short-term training, and 14,492 farmers (65% women) applied new technologies or management practices on their farms between 2009 and 2015. Between Africa, Asia, and Latin America, 11,864 hectares are now under improved management practices or managed with improved technologies, as a result of our work. In the second phase, from 2014 – 2019, the Horticulture Innovation Lab has funded 21 projects and 3 additional projects were funded by other USAID entities. These projects are on track to realize similar feed the future target numbers as Phase I and work in Africa, Asia, and Central America.

THE HORTICULTURE INNOVATION LAB IS COMMITTED TO:

CAPACITY BUILDING:

Our projects employ participatory approaches to develop research projects, targeted trainings and information dissemination methods to build the capacity of actors along the value chain and improve horticultural research and production in the developing world. For faculty and students, capacity building is embedded within the collaborative research program between U.S. universities and developing country institutions. Horticulture Innovation Lab project research generally takes place in the focus country. This

ensures that involved students are engaged in research that is relevant to their home country, and improves their opportunities for finding employment locally in their field of interest as a result of their Horticulture Innovation Lab research experience. Faculty mentors learn research methods and mentoring skills.

Long-term training takes place through supporting graduate degrees in the U.S., at home institutions, and at third party institutions in the developing world.

Short-term training is embedded in the research projects, offered through our regional centers, and incorporated in the activities of the information management and dissemination activities of the Management Entity. Short-term training is geared towards a variety of stakeholders engaged in horticultural crop production, handling and marketing, including seed producers, farmers of small and medium-sized plots, traders, and marketers, as well as researchers and extension educators.

SHARING INFORMATION:

We work to understand, package, and disseminate technical and best-practices information for horticultural production and marketing. This effort includes summarizing research findings from projects into usable fact sheets, and developing and circulating clear, concise methodologies for enhanced information dissemination. We partner with other leading organizations including the Global Horticulture Initiative and the International Society for Horticultural Science to increase our collective reach in this effort. We seek to better understand how farmers obtain information and the role that intermediaries and their associated information channels play. We support trainings and initiatives to improve intermediaries' ability to connect farmers with up-to-date, reliable horticultural research. This effort includes looking at the appropriate use of Information and Communications Technologies (ICT) and how such tools can expand information access and use while helping us better understand target audiences and their evolving needs. Across all projects, we work with our collaborators to help them package and deliver their project research findings in a way that enables more people to benefit.

EMPOWERING WOMEN AND THE MOST VULNERABLE:

Our research and interventions are aimed at empowering women and other vulnerable people (the elderly, people with diseases, indigenous peoples, people living in conflict) who work in horticulture value chains, but often as unpaid labor. The Horticulture Innovation Lab seeks to understand how women and members of vulnerable groups can benefit from the production of fruits and vegetables, either as a source of income generation or to complement a healthy and diverse diet. We conduct baseline studies within all of our projects to target this question and design technologies and interventions that specifically target these groups. Our project teams are trained on empowerment and responsive project planning, and all projects are assessed on their impact on the empowerment of women and the most vulnerable. In addition, we work with projects to ensure that they are gender sensitive, women's participation is encouraged, and women and vulnerable people benefit from the research.

INNOVATION AND SCALING:

We promote the development and dissemination of technologies to stimulate and facilitate horticultural development worldwide. Specifically, we focus on technologies that reduce on-farm costs, minimize postharvest losses, improve labor efficiency, empower women, take advantage of ICT opportunities, and

use limited natural resources more sustainably. Technologies and innovations come in a variety of forms. We support advances in "hard' and "soft" technologies to increase the productivity and profitability of horticultural systems. We work closely with USAID in-country missions, our Regional Centers and local and regional partners to scale technologies or techniques developed by our collaborators.

RESEARCH ACROSS THE HORTICULTURAL VALUE CHAIN:

We support research that tackles knowledge gaps along the value chain, by generating baseline information and identifying barriers to adoption for important horticultural products and technologies. We encourage adaptive research on innovative technologies that enable farmers to have greater access to markets.

NUTRITION-SENSITIVE HORTICULTURE:

We support research that improves understanding and availability of nutritious crops from production to consumption. Nutrition is a cornerstone of poverty reduction. We work with all projects throughout their lifecycle to ensure that they are nutrition sensitive and seek to identify the possible nutrition-related impacts that their research or innovations will have on human nutrition at the household, community, local and/or regional levels.

REGIONAL CENTERS

Projects are encouraged to interact with our Regional Centers to learn about technologies promoted by the Horticulture Innovation Lab that might benefit their work, and to engage with the Centers if appropriate. The Centers have strategic objectives:

- Increase farmer knowledge of improved horticultural practices.
- Increase the number of regionally specific horticultural technologies.
- Increase local adoption of horticultural technologies by smallholder farmers.
- Improve the research and management capacity of the host institutions.
- Increase investments in and the number of entrepreneurs working with horticultural technologies.

The Centers meet these objectives by integrating with new and existing Horticulture Innovation Lab research projects, synchronizing with new and existing USAID/BFS funded value-chain projects and Mission-led horticulture projects, building strategic relationships with partners, conducting research, and building local management, research, and horticulture capacity. Each Center focuses on innovation and technology; working in parallel with each Horticulture Innovation Lab funded research project to test and modify new technologies, host workshops and activities and serve as a regional resource for project PIs. To learn more, visit: http://horticulture.ucdavis.edu/main/centers.html.

HORTICULTURE INNOVATION LAB AND FEED THE FUTURE

The Horticulture Innovation Lab's goals associated with battling malnutrition, improving gender equity, and providing income to smallholder farmers aligns well with the U.S. Government's Feed the Future Initiative. Feed the Future pursues two paths: (1) addressing the root causes of hunger that limit the potential of millions of people; and (2) establishing a lasting foundation for change by aligning USAID resources with country-owned processes and sustained, multi-stakeholder partnerships. Through USAID leadership in this initiative, we advance global stability and prosperity by improving the most basic of human conditions – the need that families and individuals have for a reliable source of quality food and sufficient resources to access and purchase it.

Horticulture Innovation Lab projects and initiatives focus on three key Feed the Future objectives:

1. Inclusive agriculture growth

2. Increased resiliency

3. Improved nutrition, particularly for women and children

The Horticulture Innovation Lab focuses on bottlenecks in production-to-consumption of horticultural value chains. The program emphasizes research where horticulture can complement and diversify staple crops, extend cropping and marketing seasons, impact the entire horticulture value chain, and increase the production and consumption of nutritious horticultural products. The Horticulture Innovation Lab has supported research projects on seed systems, sustainable production of horticultural crops, postharvest practices, food safety, market access and linkages, nutrition, gender, and enabling environments. Find a list of Horticulture Innovation Lab projects at http://horticulture.ucdavis.edu/main/projects.htm.

Feed the Future and other U.S. government priorities – including global health and climate change – allow us to confront the growing challenges of global poverty, disease, water scarcity, climate change and depleting natural resources. By addressing these complex challenges and promoting our values, we protect our own security and lay the foundation for a more peaceful and prosperous future for all. More information on Feed the Future can be found at http://www.feedthefuture.gov.

SCOPE OF WORK

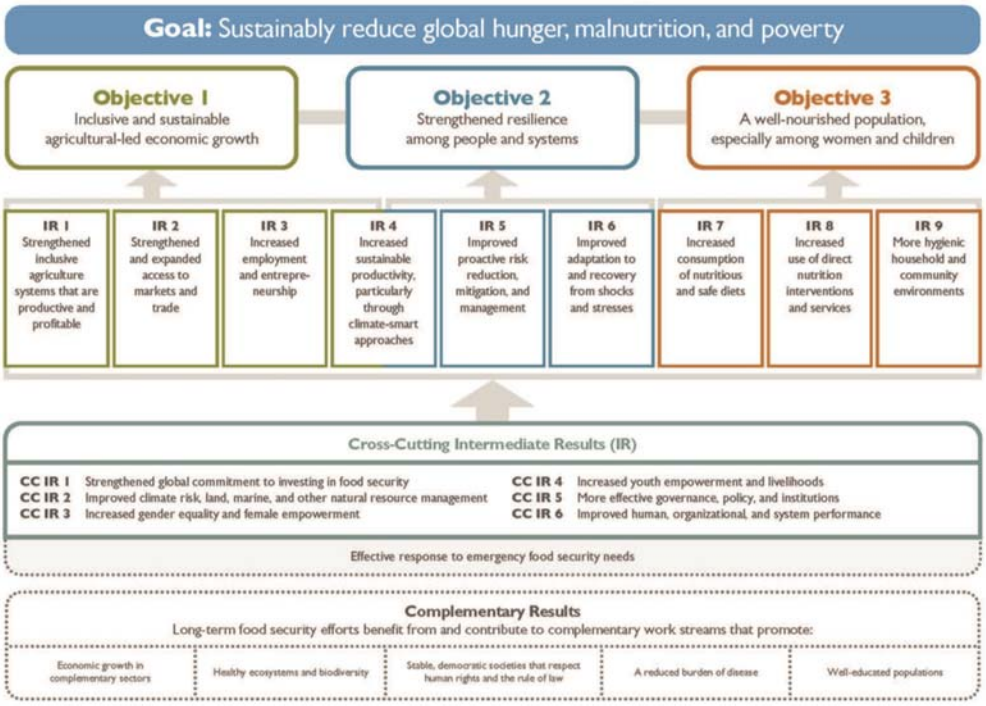
Under general supervision by the Associate Director, the independent evaluator will be required to work with internal monitoring and evaluation staff to evaluate the Horticulture Innovation Lab's impact. The Horticulture Innovation Lab works under the Feed the Future Evaluation framework and has a Management Entity set of objectives and indicators. The evaluator will be responsible for proposing an evaluation plan that answers to both of these frameworks.

The first framework directly speaks to the Feed the Future Framework. All of the projects funded under the Horticulture Innovation Lab attempt to answer key knowledge gaps to better achieve inclusive agriculture growth, increased resilience, and nutrition sensitive agriculture. The evaluation should provide deep understanding and case studies around flagship projects, such as Improving Nutrition with African indigenous vegetables, that speak to these high-level objectives.

This will include conducting and evaluating surveys, and/or interviews with project collaborators, potentially at project site locations globally. The Horticulture Innovation Lab has collected detailed qualitative and quantitative data on past and current projects and a desk review and potential follow-up should be included in the proposal.

Further, data on 11 Feed the Future Indicators have been collected over 7 years, which include number of graduate students trained, number of farmers trained, etc. These are an important part of the Horticulture Innovation Lab global impact; however, we are also interested in more deeply understanding the impact of specific projects, through the Feed the Future Framework lens. Along with specific case studies, this may include return on investment (ROI) figures, leveraged activities, and interesting value-adds from projects or results, among others. The evaluator is expected to review our portfolio of projects on our website and propose a potential approach to evaluating impact. Final scope of work and selection of specific projects for deep dive will be developed in collaboration with the Horticulture Innovation Lab.

Feed the Future Framework:



While all of our projects have immediate impacts in each country, the Horticulture Innovation Lab is also interested in better understanding how well the Management Entity operates to identify key information gaps, how well the research funded addressed that gap, and the ability of the Horticulture Innovation Lab to move key results to important stakeholders for utilization or adoption. These activities are the specific value add of the Horticulture Innovation Lab to the Feed the Future Initiative and are represented in the following forthcoming framework:

GOALS-

Through collaborative research, extension, and capacity building, the Horticulture Innovation Lab works to build resilience and end poverty by:

- Advancing horticultural science, from seed to consumption
- Creating economic opportunities for smallholder farmers and entrepreneurs
- Improving dietary diversity and nutritional status
- Empowering women, youth, and the most vulnerable
- Facilitating the exchange of innovative ideas and technologies

Management Entity Draft Objectives

- Identify key knowledge gaps and conduct research in the horticultural sector.
- Improve access to and adoption of reliable horticultural information by relevant stakeholders.
- Increase the development and adoption of technologies that advance the horticultural value chain.
- Build capacity of stakeholders to conduct research and effectively apply and disseminate information and innovative technology.

Example Indicators for Draft Objectives

Objective 1- Identify key knowledge gaps and conduct research in the horticultural sector.

Funded projects seek to answer research questions that relate to key knowledge gaps

Projects provide answers to research questions and/or point out additional critical areas of research

For more information regarding this forthcoming framework, please contact Erin McGuire ejmcguire@udavis.edu

Beyond awarded projects, the Horticulture Innovation Lab addresses key horticulture development challenges itself, by building and disseminating appropriate technologies. This technology development and scaling will be included in the evaluation scope of work, in addition to new information/technologies generated by our granted projects (this activity is referred to as scaling assessments below).

To successfully complete this impact assessment, the evaluator is expected to collect and organize data and conduct activities that will provide deeper learning within the Feed the Future framework and Management Entity objectives. This should include:

Three case studies of major projects that speak to the Feed the Future Framework, supported by existing indicator data.

Impact assessments of three major projects, which could include an ROI, post-survey, or other method of demonstrating impact.

Information value chain report that addresses Management Entity objectives (separate from Feed the Future Framework)

Two scaling assessments of Management Entity appropriate technologies

Recommendations report which identifies solutions to better address the information value chain.

The evaluator will analyze program data using the designed methodologies to summarize key findings, lessons learned, current or potential outcomes and impacts, and recommendations to improve projects and research.

Timeline: Submission of proposal is due by January 15, 2018, with work complete by July 1, 2018

Requirements

Minimum Qualifications

- Graduate degree in a relevant field of study, such as international agricultural development, agricultural sciences, agricultural economics, or related degree
- Five years of relevant experience in evaluation in the field of international development
- Demonstrable evaluation experience (prior reports/case studies)
- Previous agricultural research experience
- Strong interpersonal skills and organizational skills to multi-task and prioritize multiple streams of work
- Quantitative and qualitative data analysis skills

Preferred Qualifications

- Experience with Feed the Future programs

Physical Demands

- Work at a computer terminal for an extended period of time
- Ability to travel to developing countries

Questions

- What is your experience conducting surveys or interviews in developing countries?
- What is your experience designing monitoring and evaluation frameworks and methodologies?
- What is your experience assessing program or project impacts?
- What data analysis skills do you have, both qualitative and quantitative?

Proposal Format

Please include the following in your application:

- Cover letter
- CV
- Proposed plan of work to evaluate Horticulture Innovation Lab through the Feed the Future Framework and Management Entity objectives.
- Three references
- Examples of prior works, including reports and case studies
- Budget

Proposal Preparation and Submission Instructions

- Funding restrictions and cost share
- Proposals are not to exceed $75,000. Deliverable must be completed by July 1, 2018.
- Proposal format and submission
- Proposals should be submitted via the Horticulture Innovation Lab database at https://proposals.piestar.com/opportunities/horticulture (new link must be added)
- Proposals should be formatted as 8.5" x 11" pages, single-spaced, 1 inch margins on all sides, Times New Roman, font size 12. Proposals not submitted in the correct format will not be reviewed.

Point of contact for questions: Erin McGuire, ejmcguire@ucdavis.edu

YOUNG ENTREPRENEURS IN GUINEA HELP FARMERS ACCESS INNOVATION

Golden rings of pineapple have already started to dry around the edges, fragrant as they soak up the sun's heat beneath a sheen of clear plastic — on the way to becoming dried fruit.

Fatoumata Cissoko knows this routine of drying pineapple slices well. At 29, she runs a small dried fruit business in West Africa and has already spent three years trying out different drying methods on her parents' farm in Guinea. She is confident of the entrepreneurial opportunities that are found after harvest — when fruit can be processed, dried, stored and sold later at favorable market prices — and she is working to expand her knowledge and share it with more farmers.

"The best thing about agriculture is being able to harvest the fruit of your work," Cissoko said. "Farmers are happy when I bring them new things, like the possibility of drying their fruits and vegetables that they cannot sell. And that is a great satisfaction for me."

She is part of a small team that has started a new Horticulture Training and Services Center as a way to boost rural entrepreneurship and agricultural prosperity. This effort is part of the long recovery from the Ebola outbreak. The burgeoning center is housed on a campus of Guinea's national agricultural research institute, *Institut de Recherche Agronomique de Guinée*. For this new center, the institute is partnering with the Feed the Future Innovation Lab for Horticulture, led by researchers at the University of California, Davis.

Cissoko is one of several young entrepreneurs who are working to turn the center into a hub for rural innovation who were trained to extend rural innovation in Guinea with Winrock International and Cultivating New Frontiers in Agriculture.

Together with her colleagues, Cissoko is helping to build a center that will reflect the needs of the rural farming community in the Kindia district and surrounding region. Eventually, the center will offer training to farmers and demonstrate how new technologies work.

Above, pineapple slices dry in a chimney solar dryer. At left, Fatoumata Cissoko works to prepare compost for a demonstration garden at the new Horticulture Training and Services Center on the IRAG campus in Kindia, Guinea. (Horticulture Innovation Lab photos)

To efficiently dry pineapple slices — as well as other fruits and vegetables — the team has built a chimney solar dryer from wood and plastic tarps, designed by UC Davis researchers.

To test whether the food is dry enough to store safely without mold growth, the team is manufacturing DryCards, a low-cost tool that indicates levels of dryness by changing color. It's convenient for farmers, who can seal a reusable DryCard with a sample of their dried product in an airtight container to test for dryness before storage.

The team is also demonstrating other horticultural technologies, including drip irrigation and plastic mulch. Researchers at the center are identifying which tools and agricultural services are marketable in the region, with sensitivity to the needs of French-speaking Africa. By bolstering young entrepreneurs like Cissoko with business training and access to new innovations, the center is not only advancing rural farmers, but also enabling successful youth entry into agriculture. Supporting the advancement of this new generation is critical during a time when unemployment is growing across Africa, particularly among youth.

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TARGETING SOIL HEALTH TO REDUCE NEMATODES ON GUATEMALAN FARMS

In Guatemala, potato farmers are losing their spuds to a microscopic menace – potato cyst nematodes.

In the Western Highlands, nematodes have been blamed for cutting crop yields in half over the past 20 years. Small-scale farmers are responsible for 75 percent of Guatemala's potato production, digging ditches in steep cliffs to plant the tubers by hand. They save smaller potatoes for their family and sell larger, more valuable potatoes at markets.

The nematodes tunnel into the roots of potato plants to feed, where they grow into fat, circular-shaped cysts. Their presence reduces the quantity and size of potatoes, robbing farmers of income and nutrition. Pesticides to eradicate nematodes are neither readily available nor culturally sanctioned in the region.

Researchers supported by the Feed the Future Innovation Lab for Horticulture have been working with smallholder farmers near Huehuetenango and San Marcos to rid crops of this tack-sized pest, which thrive in degraded soils. Improving soil health creates a complex soil food chain where the nematodes are suppressed and beneficial organisms prosper.

Plant pathologist Brent Sipes leads an international project team of collaborators from the University of Hawai`i at Mānoa, the Universidad de San Carlos de Guatemala and Michigan State University. The team used a research method called Fuzzy Cognitive Mapping to gather data about how farmers perceive the nematode problem. Research has shown that promoting best intervention practices without understanding their socio-cultural relationships reduces adoption rates of new technologies.

"Cognitive mapping helps us understand how the community is thinking, to tailor our workshops and teaching so that we can target misconceptions and linkages that they do not see," Sipes said.

Potato cyst nematodes thrive in depleted soil and are blamed for major reductions in potato yield in Guatemala's Western Highlands. After analyzing farmer perceptions, researchers recommend they use chicken litter compost and biopesticides to reduce this pest pressure among potatoes. (Horticulture Innovation Lab photo by Erin McGuire/UC Davis)

One finding was that that many farmers were distrustful of certified potato seeds which they blamed for attracting nematodes to their crops.

"If we go in and say that they should use certified potatoes and they have anecdotal evidence that suggests certified potatoes are to blame for the problem, they might be polite to us, but likely won't trust our interventions," Sipes said.

Through the mapping, the team identified two effective interventions to recommend to farmers: incorporating composted chicken litter into their soil and applying *Trichoderma* and *Purpureocillium lilacinum*. These fungi attack nematode eggs and are a biopesticide treatment sold by Popoyán, a Guatemalan company.

In one community where farmers believed chicken litter attracts nematodes, the researchers instead encouraged them to mix composted horse litter into their soil.

From the cognitive mapping, researchers also learned that farmers relied on cooperatives to learn new farming practices. Thus the team is sharing their techniques with two prominent potato cooperatives, so these strategies can be shared more widely and long after the project has ended.

Sipes reflected that soil in the region is so depleted that it may take years to restore its health.

"In the long term, I hope that we have an impact in teaching farmers about the incorporation of more organic matter and soil health," he said. "I hope that by knowing that they have a nematode problem, they make better choices."

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ENGAGING START-UPS TO REDUCE POSTHARVEST LOSSES IN RWANDA

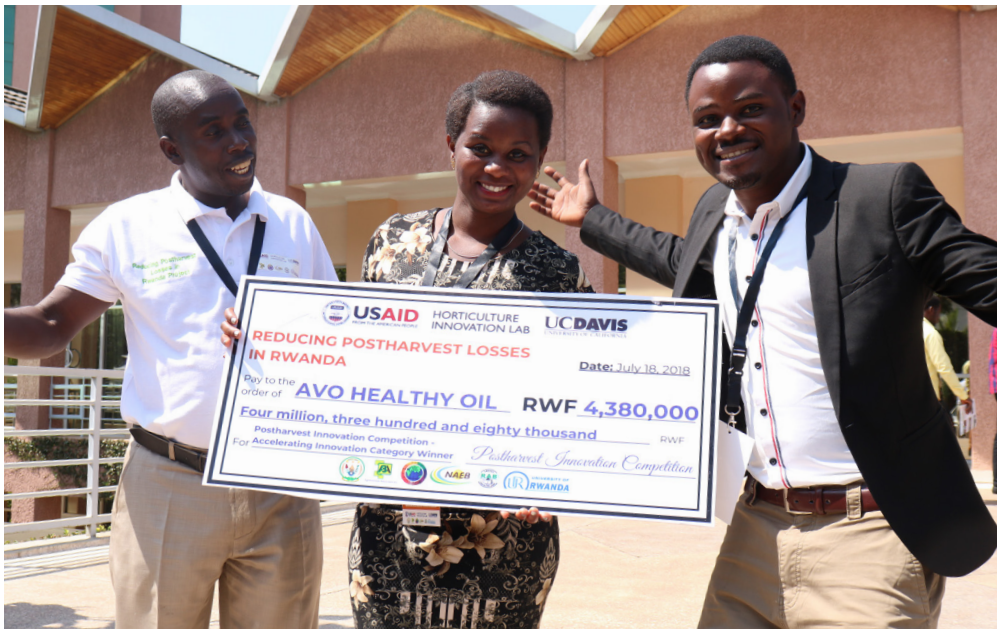
With nearly half of all fruits and vegetables wasted before they can be eaten, reducing losses of fresh produce after harvest requires systematic change. Simple interventions related to postharvest handling can have an impact, but no single isolated intervention will prove effective at mitigating this issue.

An international team supported by the Feed the Future Innovation Lab for Horticulture is taking a systems approach to reducing postharvest losses in Rwanda, beginning by understanding the problem, laying the groundwork for improvements, and perhaps most importantly engaging entrepreneurs and industry in leading the way for lasting solutions.

Led by Agribusiness Associates with guidance from Rwanda's Ministry of Agriculture and Animal Resources, the team has analyzed the problem of postharvest losses in Rwandan horticulture across four different value chains: green chili peppers for export; tomatoes for regional domestic markets; sweet potatoes for local markets; and green bananas for local markets. Published this year, the reports combine a value chain analysis with a commodity systems assessment methodology to evaluate postharvest losses.

The team also established three Postharvest Training and Services Centers, each hosted by a key organization in Rwanda's horticulture industry. One center is located at the University of Rwanda in Busugo, another center is hosted by the Rwanda Agriculture Board in Rubona, and a third is part of the National Agricultural Export Development Board at Mulindi. Each of the centers is equipped with postharvest technologies and run by knowledgeable partners who can share improved postharvest practices with nearby farmers and agricultural businesses.

With postharvest tools now available, the team launched the Rwanda Postharvest Innovation Competition to provide postharvest entrepreneurs with seed funding and skills to start profitable businesses that reduce postharvest losses.



Niyidukunda Mugeni Euphrosine, one of 13 Postharvest Innovation Competition winners, will use award money to purchase processing equipment for her avocado oil extracting company. She also makes soaps and avocado flour. (Horticulture Innovation Lab photo by Rashmi Ekka/Agribusiness Associates)

The competition culminated in the first-ever "Rwanda Postharvest Week," in Kigali, which included a conference attended by 100 people, a two-day postharvest training for agronomists and farming cooperative leaders, and a graduation workshop for 33 new postharvest trainers after a year-long e-learning course — in addition to the announcement of the competition winners.

Competition participants ranged from innovators with a prototype, to businesses that have already introduced a product to the market and are ready to accelerate growth. Over the course of two months, participants attended an agribusiness development training, polished a persuasive "pitch deck" slideshow, and submitted financial projections for their enterprise.

Innovations were judged based on their economic opportunity, value to customers, place in the value chain and financial sustainability. The competition's winning projects ran the gamut from a cold storage service provider to the makers of a traditional chili sauce, tree tomato jam and pumpkin oil.

Winners of the competition were 13 burgeoning enterprises that received a cumulative total of $50,000 (44,054,000 Rwandan francs) in seed funding for their postharvest technologies and start-up businesses.

Through the competition, entrepreneurs learned how to combine their business savvy to extend innovative solutions in the postharvest sector, creating value in crops that might otherwise be lost or wasted. By engaging entrepreneurs, this Horticulture Innovation Lab team is seeding sustainable change in Rwanda's horticulture industry.

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