



# FEED <sup>THE</sup> FUTURE

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



FEED THE FUTURE  
INNOVATION LAB FOR HORTICULTURE  
ANNUAL REPORT 2018-2019



**USAID**  
FROM THE AMERICAN PEOPLE

HORTICULTURE  
INNOVATION LAB

**UC DAVIS**  
UNIVERSITY OF CALIFORNIA

# HORTICULTURE INNOVATION LAB

# ANNUAL REPORT

# 2018-2019

**SEPT. 27, 2019**

This publication is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the Horticulture Innovation Lab and do not necessarily reflect the views of USAID or the United States Government.

**COVER PHOTO:**

Fresh horticultural products at a market in Rwanda, where a Horticulture Innovation Lab team has been working to reduce postharvest losses.

Horticulture Innovation Lab photo by Brenda Dawson.



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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, Honduras, and Zambia.

## **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
- Heather Kawakami, Financial Analyst
- Archie Jarman, Program Manager
- Angelos Deltsidis, International Postharvest Specialist
- Beatriz Rodriguez Abogado, Executive Assistant
- Brenda Dawson, Communications Coordinator
- Anthony Phan, Project Analyst
- 2018-19 paid and unpaid student staff: Lauren Howe, Michelle Boutell, Corey Rodda, Lisa Artuso, Liza Wood, Marieke Fenton, Kyle Freedman
- Special projects staff: Amrita Mukherjee, Mohamed Rezaul Islam, Débora Rivera, Mamadou Alpha Thiam
- Jim Thompson 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, Global Horticulture Assessment and Horticulture Innovation Lab objectives are met.

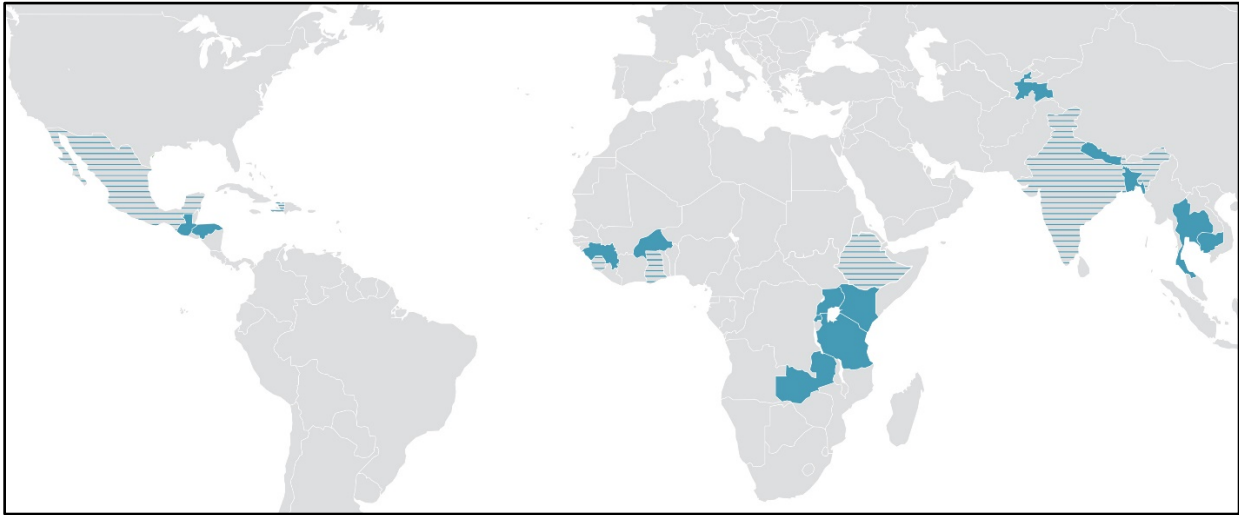
Members of the Horticulture Innovation Lab International Advisory Board:

- Guillermo Alvarado-Downing, GOAL Global, Market Development Initiatives, Chair
- John Edward Bowman, USAID Agreement Officer's Representative
- Cecilia Chi-Ham, HM. Clause
- 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
- Ermias Kebreab, University of California, Davis
- Marco Wopereis, The World Vegetable Center

## LOCATIONS OF 2018 – 2019 PROJECT ACTIVITIES

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, the Horticulture Innovation Lab this year has Trellis Fund projects in Ghana and Ethiopia, and has partners working to scale the DryCard in Mexico, Nigeria, Haiti, India, 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 - World Fish; WinRock; Bangladesh Agricultural University; The Patuakhali Science and Technology University

Burkina Faso - USAID/Burkina Faso; USAID/Sahel Regional Office; Environmental Institute for Agricultural Research/Burkina Faso; ACIDI-VOCA; Agribusiness Associates

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;

Ethiopia (Trellis only) - Send a Cow Ethiopia

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; ACIDI-VOCA, Cultivating New Frontiers in Agriculture

Haiti (DryCard only) - Fondation Haïtienne de Développement Agricole Durable

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

India - Telangana State Agricultural University; Vivia Foundation

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, Kenya; Finlays, Kenya; Sunripe, Kenya; Frigoken, Ltd., Kenya; Moi University; Development in Gardening, Kenya; Mirror of Hope

Mexico (DryCard only) - CGIAR/CIMMYT, EarthEmpower

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, Inc.; R&D Innovative Solution

Nigeria (DryCard only) - TSM Alpha Ventures

Rwanda – Ministry of Agriculture and Natural Resources; University of Rwanda; National Agriculture Export Development Board; Rwanda Agriculture Board; the Postharvest Education Foundation; Agrifood

Business Consulting; SYBASH, Ltd.; Sustaining Rwanda Youth Organization; National Agricultural Export Development Board

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; Agricultural Research Institute Tengeru

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; Ndibwami Integrated Rescue Project; Makerere University

Zambia – University of Zambia, Center for International Cooperation in Agronomic Research for Development; Hantambo Women’s Group

Sierra Leone (Drycard only): Desert Water

Ethiopia (Trellis only): Send a Cow Ethiopia

## ACRONYMS

ABA: Agribusiness Associates

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: 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: Consortium of International Agricultural Research Centers

CIMMYT: International Maize and Wheat Improvement Center

CIRAD: Center for International Cooperation in Agronomic Research for Development

CMS: Cold room Monitoring System

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

DiG: Development in Gardening



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  
NAED: National Agricultural Export Development Board  
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, Cambodia  
SIIL: Sustainable Intensification Innovation Lab  
SNV: Dutch Volunteers Foundation

SRYO: Sustaining Rwanda Youth Organization  
SUA: Sokoine University of Agriculture  
TARI: Agricultural Research Institute Tengeru  
TAWA: Feed the Future Tajikistan Agriculture and Water Activity  
TAU: Tajikistan Agrarian University  
TEWDI: Teso Women Development Initiatives  
UBB: University of Battambang  
UC: University of California  
UNZA: University of Zambia  
USAC: University of San Carlos  
USAID: United States Agency for International Development  
USDA: United States Department of Agriculture  
WFP: World Food Programme  
ZARDI: Zonal Agricultural Research and Development Institute  
ZECC: Zero Energy Cool Chamber

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# I. EXECUTIVE SUMMARY

The Horticulture Innovations Lab’s global research network advances fruit and vegetable innovations, empowering smallholder farmers to earn more income while better nourishing their communities. In this final year of the Horticulture Innovation Lab’s second five-year contract, our global network delivered on their project objectives and the management entity successfully captured and disseminated their results.

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, Thailand and Cambodia. During the year, 12,000 individuals received short-term training and 80 students received support for long-term training. Our projects have also enhanced their engagement of youth, supporting youth development as entrepreneurs. University curricula were improved in Honduras, Tajikistan, Rwanda, Zambia, Kenya and Tanzania. Over 5000 farmers and 250 organizations applied improved practices or technologies developed by Horticulture Innovation Lab projects, and projects scaled approximately 25 technologies. Our two Regional Centers and our Horticulture Center in Guinea are positioned to continue to serve as hubs to showcase and adapt horticulture best practices and technologies, and many of our project’s accomplishments will be sustainable into the future because of the strong capacity building that was achieved in local horticulture organizations through project activities. We are proud of the accomplishments of our extensive network of researchers to advance knowledge of how to use horticulture to increase income generation and reduce malnutrition in emerging economies.

Capturing and disseminating our global program’s many accomplishments was a significant focus in 2019. This included enhancing our website (<http://horticulture.ucdavis.edu>) as a source of horticulture information for development practitioners and small farms around the world, offering a Horticulture for Development Professionals webinar series to share information and lessons learned from program activities, and hosting the Colorful Harvest Conference in Washington, DC to engage with thought leaders in horticulture for development. Through these efforts we hope to have stimulated further interest and investment in horticulture for development and equipped practitioners with information to kick-start any future horticulture activities.

# 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.

## SUCCESSSES AND CHALLENGES IN FY2019

In the final year of the Horticulture Innovation Lab's second 5-year contract the lab successfully captured and disseminated research results from 24 different projects. In the field, both best practices and new technologies were scaled at the farmer level and institutionally. Partner universities now have higher education curriculums in Tanzania, Guatemala, Honduras, Tajikistan, Rwanda, and Thailand. In Uganda, a training to government officials of farmer-led irrigation strategies resulted in a resolution to expand funding for small-scale irrigation. Further, in the field, new practices such as indigenous vegetable cultivation and marketing occurred, net houses to control pests were erected, and new integrated horticulture-livestock systems managed, among many other innovative technologies deployed. This resulted in an increase of \$1,937,843 for farmers in 2019.

The management entity leveraged these findings to bring horticulture for development to the international stage by hosting the *Colorful Harvest Conference* in Washington, DC. This conference represented a nexus of thought leaders within horticulture for an outcome-driven conversation to advance global goals in nutrition, economic security, and resilience. This conference also brought together young leaders from around the world to discuss issues such as agribusiness, youth empowerment, and university capacity building. To advance the capacity of horticulture researchers and agriculture professionals the Horticulture Innovation Lab also hosted a 9-part web series that spanned postharvest curriculum, gender-sensitive programming, and extension models; 140 individuals from 4 different continents joined over the 9-week course. The *Empowering Women in Honduras* project strengthened the overall capacity of the USAID research system by hosting a two-day "Gender Across the Innovation Labs" workshop that brought together research innovation lab professionals to better understand how to advance gender awareness in program management.

In recognition for this work, the Horticulture Innovation Lab showcased the *Building Safe Vegetable Value Chains* in Cambodia in the Washington Post to demonstrate the importance of US research in building capacity abroad. The lab created 10 videos to highlight research results and draw attention to local entity participation and success. Finally, the management entity received the results of a contracted independent evaluator that praised the lab's interdisciplinary approach and dedication to cross cutting themes of gender awareness, capacity building, and nutrition-sensitive agriculture.

Challenges - The greatest challenge the Management Entity faced in FY2019 was unstable budget forecasts from USAID. Uncertainty and changes in expected funding strained research and activities. Since the Lab shut-down this year late funding caused increased stress on projects and some shut down early since they were not able to operate without funds, and then not able to spend out the funds by close out once they finally arrived.

# III. KEY ACCOMPLISHMENTS

## FY2019 PERFORMANCE

The Horticulture Innovation Lab has granted all funds for Phase II to develop knowledge on key information gaps across the horticulture value chain. During this final year of Phase II, projects maintained a strong focus on research dissemination through trainings.

- **Short-term trainees:** Approximately 12,000 producers, government officials, private sector individuals, and trainees from the civil sector received short-term training.

- **Long-term trainees:** Approximately 80 undergraduate and graduate students were supported by our projects to either earn a graduate or undergraduate degree or participate in a long-term internship.
- **Integration into local universities** – Many of the Horticulture Innovation Lab projects have been successful with integrating research outputs and activities into local, in-country university curricula. Zamorano University’s master’s in Sustainable Tropical Agriculture will advance the work of the *Empowering Women through Horticulture in Honduras* project through student research. An apricot producer handbook for production and postharvest management will be distributed to students of the Tajik Agriculture University in the *Improving practices for dried apricots in Tajikistan* project. The University of Rwanda, in collaboration with the *Reducing postharvest losses in Rwanda* project, established a fruit and vegetable collection center, a sensory lab, and a processing kitchen at its Postharvest Training and Services Center. At the University of Zambia and the University of Eldoret, Kenya, students are continuing research on African indigenous vegetables and their nutritional content for the *Improving nutrition with African indigenous vegetables in Kenya and Zambia* project.
- **Increased production:** In Guatemala, under the *Promoting drip irrigation and climate resilience - MasRiego* project, drip irrigation was installed on over 400,000m<sup>2</sup> of land, benefiting 292 producers in FY2019. These producers’ revenue increased by approximately \$850 per farmer, post-intervention.
- **Government outreach:** The *Developing small-scale irrigation solutions in Uganda* project conducted extension work with agriculture and agricultural engineering government department officials utilizing the technologies developed by the project team. As a result, the trainings motivated the National Agricultural Advisory Services of southeastern Uganda districts to pass a resolution to expand funding for small-scale irrigation.
- **Gender considerations:** In FY2019, over half of the short-term training recipients were women, and over 65% of the full-time employment positions created by Horticulture Innovation Lab projects were women. The *Empowering Women through Horticulture in Honduras* project, led by Pennsylvania State University, conducted a profoundly effective summative session with the Horticulture Innovation Lab principal investigators at the Innovation Lab’s Annual Meeting on gender and horticulture.
- **Adoption of improved technologies:** Close to 5000 farmers applied technologies or practices developed by Horticulture Innovation Lab projects in FY2019, impacting over 500 hectares of smallholder horticulture production. Further, over 250 organizations applied improved technologies and practices.
- **New technology development:** Advancing beyond field-testing, our projects scaled approximately 20 technologies or practices in FY2019.



# 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. Closing the final year 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, hunger and malnutrition. Horticulture development offers the opportunity to 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 youth. Horticulture research is crucial to enabling 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 - continued as the management entity of the Horticulture Innovation Lab. We maintained strong relationships with university and organizational entities worldwide during both Phase I and Phase II. In addition, the partners' faculty expertise and diversity of crops addressed by their research, teaching and outreach made 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 focused 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 was 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.

**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 life cycle 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 four 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, Youth-led Horticulture Services and Training Center, with USAID/Guinea, and a \$300,000 Mission Service project in Tajikistan to improve apricot drying practices in the Khatlon Province of southern Tajikistan.

Efforts to effectively disseminate research results increased in FY2018-19 as the Horticulture Innovation Lab completed its final year of Phase II. This dissemination occurred through the Regional Centers, other training and service centers (established in Cambodia, Guinea, Rwanda, Burkina Faso, Tanzania), and in collaboration with in-country universities such as Royal University of Agriculture, Cambodia, Sokoine University of Agriculture, Tanzania, and Patuakhali Science and Technology University, Bangladesh, amongst many others.

## **REGIONAL CENTERS**

The Regional Centers at Zamorano in Honduras and at Kasetsart University in Thailand have firmly established themselves as information hubs for their regions (Southeast Asia and Central America). For example, the Regional Center at Kasetsart has now been integrated into the efforts of a Thai institution dedicated to expanding the science capacity of high school students along with the University of Agriculture and Forestry, Nepal, and the creation of a specialized mango production and postharvest learning center. The Regional Center at Zamorano not only is integrated into the curricula of its host university, the Center conducts capacity building trainings for extensionists from various government ministries in Central America. The 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 that are clearly valuable to stakeholders and this value will help promote the sustainability of the Centers after the close-out of the Horticulture Innovation Lab.

In this final year, the management entity focused on building 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 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, Tuskegee University, USA, Zamorano, Honduras, Asociación de Mujeres Intibucanas Renovadas, Honduras

**Achievements:** As a result of the project's farmer field school, the team presented research at the Seeds of Change Conference (CGIAR) at the University of Canberra, Australia; the Latin American Studies Association annual meeting in Boston; and the Rural Sociological Society annual meeting. Our presentations have covered discussion of the Gender Integrated Farmer Field School, initial analysis of the evaluation of the FFS, and analysis related to market access from the project's household survey. Multiple factsheets in English and Spanish have been produced related to food security, dietary diversity, and nutrition.

**Capacity development:** The team plans on having a graduate-level certificate in Gender and Agriculture approved and implemented in the fall of 2020. A series of online modules are in the final stages that will be available globally through Penn State extension, one of which will highlight the outreach experiences from this project. The first year's cohort of the Master's in Sustainable Tropical Agriculture at Zamorano is continuing the work of the project through their research. The student's data is being collected this quarter and partners with the local NGO, Asociación de Mujeres Intibucanas Renovadas (AMIR), while investigating women's participation in agriculture. Through the project, we have supported multiple graduate students at both partner universities. The in-country PI, Arie Sanders, has successfully completed his Ph.D. in Rural Sociology and International Agriculture and Development. Dr. Sanders is now the Assistant Dean for the new Master's program at Zamorano. Two in-country researchers that the project has partnered with, Hazel Velasco and Alfredo Reyes, will begin their graduate studies at Penn State this fall. AMIR has also been able to leverage funds to continue implementing the gender-integrated Farmer Field School. They have hired two graduates from Zamorano as facilitators who conducted their internship with the project, spending time doing undergraduate research in Honduras and then participating in an exchange at Penn State.

**Lesson learned:** The team has found that there are many institutional and human capacity development opportunities for gender scholarship. The team sees a need for establishing research networks in gender and agriculture to compare findings and best practices. The project has also found that within US universities, there are opportunities for engaging with the important cross-cutting theme of gender, particularly in the agricultural sciences. The project continues to develop its partnership with in-country universities and NGO's that will broaden the impact of the gender research and elevate the issues of gender inequities to a larger audience.

### Presentations and Publications

A) Publications (2 publications, 1 highlighted)

i) Larson, J., Castellanos, P., & Jensen, L. (March 2019). Gender, Household Food Security and Dietary Diversity in Western Honduras (pp.170-179). Global Food Security, 20, No City Listed. 2211-9124

B) Presentations (10 presentations)

## **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 completed field demonstrations, a technical efficiency analysis of the potato farming system, and developed a mental model of the farmers and their perceptions on soil health, plant nematodes, and potato yield. The project has evaluated different policy scenarios ranging from ignoring nematode control to increasing the use of compost amendments in the potato fields based upon the mental models. The team has shown that increases in soil health nutrient levels with compost increase potato yields for the farmers. Finally, the project has also learned that farmers are likely to adopt the use of more compost to increase soil health, suggesting that this could be a successful and impactful policy to adopt.

**Capacity development:** The project's 3-way partnership with the University of Hawaii, Michigan State University, and the University of San Carlos Guatemala was very fruitful. The principal investigators worked well together and found the project professionally exciting. The team has partnered with Popoyan, a biological pesticide manufacturer, to deliver biological control products for use in field demonstrations. The project collaborated with farmers and potato cooperatives in 4 communities in the Western Highlands of Guatemala. These collaborators recognize the importance of improving soil health to improve potato yield and this makes demonstrations and trainings more effective. This core group is able to organize, model, and inspire other farmers to adopt practices to improve soil health. The team's workshops have allowed farmers to learn about the impact of nematodes on potato yield, how soil health can abate yield loss, and how modification of practices, without addition of inputs, can improve their technical efficiency of production. The project has trained undergraduate students and fostered graduate student learning. One graduate student completed their master's in science degree. The potato cooperative staff have increased their knowledge of soil health and nematodes and have brought this new knowledge to those farmers unable to attend our workshops.

**Lessons Learned:** The smallholder potato farmers want dramatic yield increases. The incremental yield increases that occur with biological control and compost amendments have less impact on the growers and their willingness to adopt innovations. Training and workshops are most successful when scheduled to accommodate the farmers. The area is very male-dominated and the team needed to try more ways to engage females in workshops and trainings.

## **BUILDING POSTHARVEST CAPACITY IN TANZANIA**

**Location:** Morogoro, 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:** In May of 2019, the project team hosted 151 farmers at a daylong training on postharvest handling practices. A chimney solar dryer was successfully installed after making some modifications to the physical space at SUA, and can now be easily replicated as needed. Furthermore, in July 2019, project team members gave multiple presentations at this year's American Society for Horticultural Science (ASHS) Conference in Las Vegas, Nevada. For example, Dr. Ramadhani Majubwa from SUA, presented on packhouse design by detailing the construction of an affordable mini packhouse using shipping containers on the SUA campus. Dr. Majubwa's presentation has generated a lot of interest, including from the Postharvest Education Foundation, who would like to feature the design in their monthly newsletter. In addition, Eleni Pliakoni shared information about the project's collaboration and institutional capacity building efforts through supporting a new curriculum and developing graduate level classes in postharvest management of fresh produce. In total, this project has trained 2009 growers on postharvest handling since May 2018, through the trainers we trained in our 2018 postharvest short course.

**Capacity development:** Dr. Royce Ann Collins of Kansas State University created a Faculty Guide. Topics in this Faculty Guide include managing classrooms, working with adult learners, time management, engaging teaching techniques, and syllabus and course content, to name a few. SUA Horticulture staff plans to adopt these skills into their practice, and the Master's curriculum is in the process of being accepted by SUA. Over four days in May 2019, 151 farmers were trained on postharvest handling techniques in four villages near Iringa, Tanzania. 22 trainers from our two postharvest short courses led these daylong workshops. The workshops covered topics such as harvesting practices/tools/technologies, harvest maturity indices, practices and technologies to reduce mechanical damage, temperature management, sorting and grading, cooling options, storage conditions, packaging technologies and transportation. The success of this training model demonstrates the trainers' dedication and initiative, as well as their ability to apply the skills they learned in 2018 to extend the information to local growers. The breakdown of trainers and farmers over the course of these four days is as follows: May 28 in Mgama: 5 trainers, 41 farmers; May 29 in Mangalali: 5 trainers, 38 farmers; May 30 in Ilula: 6 trainers, 33 farmers; and May 31 in Ruaha Mbuyuni: 6 trainers and 39 farmers. It is our hope that the trainers continue to train and the farmers adopt what they learned in the postharvest workshops into their own practices to produce higher quality product.

**Lessons Learned:** As project leaders, we once again let the trainers take the lead on the farmer trainings, and they were all very successful. We learned that communication among stakeholders is key on any project, and we continued to build on the strong communication skills of our team.

### **Presentations and Publications**

- A) Presentations (5 presentations; 1 webinar; 1 highlighted):
  - i.) Pliakoni, E. (July 2019). Capacity Building on Produce Postharvest Management in Tanzania. Presentation at ASHS Annual Conference, Las Vegas, Nevada United States of America
- B) Publication (2 posters; 2 manuals; 1 curriculum; 1 highlighted):
  - i.) Majubwa, R. O., Msogoya, T. J., Sargent, S., Rivard, C., & Pliakoni, E.. The Container mini packhouse: Affordable demonstration facility for produce sorting, packaging, storage of fresh produce for small/medium scale farmers



## **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 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, The Postharvest Education Foundation, USAID/Burkina Faso, USAID/Sahel Regional Office, Environmental Institute for Agricultural Research/Burkina Faso (INERA), ACDI-VOCA, MIT D-Lab

**Achievements:** One major achievement was the construction of the postharvest center's cold room and Postharvest Training and Services Center. The project team also completed three noteworthy research activities. The first activity was the evaluation of tomato varieties for their adaptability to rainy season production in the Center-North and Eastern regions of Burkina Faso. The second research achievement was that the INERA team worked with Dr. Eric Verploegen of MIT's D-Lab on evaporative cooling research. The results indicate that evaporative cooling can be used to increase the shelf life of fruits and vegetables by providing a more stable temperature and humidity. Third, project team conducted Rapid Market Assessments on onion, cabbage and pepper in July. In total, 30 producers, three collectors, three wholesalers and three retailers were interviewed. The study revealed that incorrect harvesting techniques, poor storage infrastructure, unfair transport systems, and a lack of processing technologies result in excessive postharvest losses

**Capacity development:** Environmental Institute for Agricultural Research/Burkina Faso (INERA) conducted nine trainings for 244 farmers and agronomists in postharvest management, including demonstrations for evaporative cooling. Farmers and extension agents from more than 35 communities were involved in the training and included the participation of USAID VIM Plus and other projects as well as the Regional Directorate of the Agriculture Service. Agribusiness Associates (ABA) conducted two trainings for agribusiness development in which 72 budding entrepreneurs were trained. The Postharvest Innovation Competition was successfully organized. The top 10 participants received workshops on preparing their PowerPoint pitch decks and how to present them. The top six winners were given awards totaling \$10,000, accompanied with business development coaching through a local business development services provider. During and after the competition, ABA hosted 4 coaching events through which 67 people were mentored.

**Lessons Learned:** Evaporative cooling works very efficiently in Burkina Faso and is an important technology for scale-up. However, improper design of evaporative cooling systems can reduce effectiveness drastically. Thus, it is important to convey the design principles of evaporative cooling in an effective manner. For instance, when a Zero Energy Cool Chamber (ZECC) is made with local materials, ideally any deviations do not significantly compromise cooling efficiency.

### **Publications**

- a) Windinkonte, S., Traore, A., Zongo, R., & Koussao, S. (July 2019). Rapid market assessment: Onion, cabbage, and pepper in Burkina Faso.
- b) Koussao, S., Jeanne, N., & Irmean, S. (July 2019). Evaluation of tomato varieties for their adaptability to rainy season production in Centre-North and Eastern regions of Burkina Faso

## **IMPROVING PRACTICES FOR DRIED APRICOTS IN TAJIKISTAN**

**Location:** Southern 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:** In April and May of 2019, the project conducted three workshops for almost 70 growers covering: 1) market standards and business planning; 2) food safety practices; and, 3) drying protocols. The team also trained almost ten extension services personnel, as well as in-country project managers from the Feed the Future TAWA project. Workshops held were part of the Entrepreneurship Readiness Program imparted in four districts (Yovon, Bokhtar, and two in Qubodiyon) to a similar ratio of male to female farmers.

The project conducted pre- and post-workshop surveys to understand the impact of business planning training, which also can be used to understand potential business success, and adoption of good business practices. The project staff provided certificates to each of the farmers that attended the workshops. Materials and learning modules from the workshop have been utilized to develop a Growers Handbook that will be printed and distributed to over 1,000 farmers, extension personnel, and students of TAU in Tajikistan. We found that, on average, male and female farmers increase their business plan knowledge for their apricot business by 581%. For example, in Yovon district, in the pre-workshop survey only two farmers knew about business plan creation, and all 20 farmers reported knowledge on business plan development post-workshop. The proportion of farmers that learned how to create mission statements increased by 470%, while the knowledge of strengths/opportunities and weaknesses/threats increased by 977% and 1295%, respectively. Together, these numbers convey that the Entrepreneurship Readiness Program increased knowledge and potential success rate of apricot business operations in the four districts of southern Tajikistan.

**Capacity development:** Partnerships with stakeholders, growers associations, and university personnel remain essential to the long-term impact of the project. The project trained over 100 farmers and over 10 extension personnel on entrepreneurial, food safety, and drying practices. The project will reach over 1,000 Tajik stakeholders with a printed version of handbook and expect a higher number to be reached through the online version.

**Lessons Learned:** Collaboration with in-country partners are essential to delivery of workshops, material, and data collection.

### **Presentations and Publications**

#### A) Growers' Handbook

- a. Entrepreneurship Readiness: Handbook for Apricot Growers in Tajikistan – URL: [www.purdue.edu/hla/sites/hortbusiness/wp-content/uploads/sites/10/2019/08/TajikHandbookLOWresS1.pdf](http://www.purdue.edu/hla/sites/hortbusiness/wp-content/uploads/sites/10/2019/08/TajikHandbookLOWresS1.pdf)

## II. STRENGTHENED RESILIENCE AMONG PEOPLE AND SYSTEMS

### REDUCING POSTHARVEST LOSSES IN RWANDA

**Location:** Rwanda

**Description:** 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 to provide systems-based solutions.

**Collaborators:** Ministry of Agriculture and Natural Resources; Rwanda, Agribusiness Associates Inc.; the Postharvest Education Foundation; University of Rwanda; Rwandan Agricultural Board, National Agricultural Export Development Board

**Achievements:** In the final year, the project focused on the sustainability of the initiatives and ensuring that the capacity created and the technology adoption work has gained enough momentum to continue scale-up with local partners. Technology adoption initiatives included: working with farmers, cooperatives and private sector entrepreneurs to increase adoption of Zero Energy Cool Chambers (ZECCs), field sheds, cold rooms and crates using a cost-sharing and partnership approach, along with technical assistance and on-field capacity building. The project assisted in the construction of 4 collection centers and 8 cold rooms, and worked with cooperatives to increase adoption of harvesting bags and crates. The Rwandan Agricultural Board worked with small-scale processors and equipped them with small tools. University of Rwanda started a collection center, sensory lab and processing kitchen at its Postharvest Training and Services Center. The project continued to build local capacity in Rwanda via trainings on cold rooms, postharvest practice education, conferences, extension education, and partnering with the University of Rwanda to train students in postharvest management. Postharvest Innovation Competition winners were provided business coaching and mentoring to scale up their business, and are all successfully producing products sold in local markets. Research and assessment efforts included assessment of cold chain, adaptive research for postharvest extension and research on evaporative cooling in partnership with.

**Capacity development:** University of Rwanda worked to develop a Master's in postharvest management with the support of the project. The program has been designed and submitted for approval.

The project partnered with several local cooperatives to disseminate postharvest technologies. Dr. Jate Sathornkish of Kasetsart University conducted training in Rwanda to 60 technicians on CoolBot cold room installation and maintenance. 548 extension agents and lead farmers were trained in various postharvest topics. 391 farmers were reached through on-field extension held in 4 rural areas. 111 experts attended the Postharvest Conference in Kigali and 26 regional horticultural experts attended the 2 day East Africa Horticulture Experts Meeting. 76 students at the University of Rwanda received a short training on postharvest management. Three University of Rwanda students completed a 1 month internship at the Mulindi Center and were trained on temperature management, appropriate packaging containers, maturity indices, packaging, drying and use of recommended doses during application of pesticides. The National Agricultural Export Development Board's (NAED) food science graduate facilitators trained cooperative members on the same topics.

**Lessons Learned:** Technology adoption initiatives with smallholder farmers require initial support to demonstrate value as well as regular and hands-on capacity building. Demand for solar dryers has been low primarily due to low consumer acceptance of dried food.

#### **Presentations and Publications**

- a) Extension Bulletins (10)

## TRELLIS FUND (ROUND 6 & SUMMIT)

**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 institutions.

**Collaborators:** UC Davis, North Carolina State University, University of Hawai‘i at Mānoa, University of Florida, Send a Cow Ethiopia (SACE), University of Cape Coast (UCC; Ghana), Methodist University College Ghana (MUCG), Kumasi Institute of Tropical Agriculture (KITA, Ghana), Tip Top Foods (Ghana), Aythos, Inc. (Nepal), Center for Agricultural Research and Development-Nepal (CARD-Nepal), SYBASH (Rwanda), University of Rwanda, Agricultural Research Institute (TARI) Tengeru (Tanzania), Ndibwami Integrated Rescue Project (NIRP; Uganda), Uganda Rural Information and Communication Technology/ Educational Center (URICT Uganda), Mwino Group (Uganda), Eco-Agric Uganda, Teso Women Development Enterprise (Uganda), Development in Gardening (DiG; Kenya), Sustaining Rwanda Youth Organization (SRYO; Rwanda), and Makerere University (Uganda)

**Achievements:** 31 demonstration plots across nine project sites were developed, showcasing a range of technologies including drip irrigation, biochar, mulching, cold chain and other postharvest technologies. In total, 109 trainings were conducted, reaching nearly 4,000 smallholder farmers and other stakeholders (66% women) along the horticultural value chain. Through collaboration with their graduate student partners, host organizations learned new techniques for adult education, gained technical agricultural information, and increased their monitoring and evaluation capacities. The projects allowed in-country organizations to build working relationships with key players ranging from government to education to the private sector. Furthermore, the Trellis Fund provided a valuable opportunity for cross-cultural exchange and learning through exposure to other cultures both on the part of the host organization and the US graduate students. Another major achievement was the Trellis Fund Summit (March 2019) in Washington DC. Participants came from Bangladesh, Ethiopia, Ghana, Kenya, Mali, Nepal, Rwanda, Tanzania, Uganda and the US, and included 15 org representatives, 11 student alumni, 2 former and 2 current Trellis coordinators. The summit generated reflection and planning for the program’s future.

**Capacity development:** Numerous new partnerships between in-country host organizations, local and international organizations were formed, including with government, education, and private industry. Eco-Agric’s project led them to interactions with the USAID Mission and two seed companies. SACE networked 28 key stakeholders through an all-day workshop as a part of their project on sweet potato leaves for family nutrition, and UCC collaborated with a local company to install drip irrigation. The capacity of local organizations was strengthened during this process. Depending on the training, either US grad students or partner organizations led, assisted with, and participated in the trainings. US graduate students also contributed knowledge and skills through creating training and extension materials.

**Lessons Learned:** Relationship building is at the core of our work. While emails and video conference calls are necessary, face-to-face meetings are key. By bringing together stakeholders from across continents, years of participation, organizational affiliation, age, and part of the horticulture value chain, the Trellis Summit fostered human connections and potential partnerships that can only be achieved through an in-person event. Collaboration and participatory approaches, i.e. gathering and prioritizing input from participants (before, during and after the Summit), are key to envisioning a more inclusive, responsive, and impactful program. Participation is an approach and foundation of a program, not a tool.

### **Presentations and Publications**

A) Presentation (6 presentations; 1 highlighted):

- i.) Howe, L. (July 2019). Building scientific and organizational capacity along the horticulture value chain by engaging international partners and young scientists. Presentation at American Society for Horticultural Science (ASHS) Annual Conference, Las Vegas, NV

B) Publication (3 published; 1 highlighted):

- i.) Adkison, C. & Paul, O.. Postharvest Value Addition of Oranges and Mangoes

## **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 main overall achievements since October have been to develop outreach and informational materials, and training local government officials in how these innovations can be applied. This includes setting up a project website that shares all the major features of the project, including project sites and innovations. The website makes the results available in easy to use form for a wider audience of agricultural practitioners in East Africa. Other informational products include factsheets that explain how to use or implement some of these innovations, and summarize key issues related to aspects such as technology and gender. Another achievement has been training local government officials from the agriculture and agricultural engineering departments on some of the innovations developed in the project. This was presented both in annual review meetings and in a project hosted training. This has translated into a resolution for the National Agricultural Advisory Services South Eastern Uganda Districts to increase funding for small scale irrigation in their zone, which was approved in the annual budget. The project has also trained other farmer groups in nearby districts in some of the project innovations, from their own funding. The team has also and advised district staff on how to use similar water sources in one nearby district and managers from a large international NGO on how to use small water sources for irrigation in Eastern Uganda.

**Capacity development:** The project has trained district agricultural and agricultural engineering staff on how to use the innovations developed in the project to improve small-scale irrigation sites in their districts. The agricultural engineering staff are responsible for developing small-scale irrigation, and the information provided to them will help support their offices to develop farmer-appropriate solutions. The project has already kept in touch with some of these staff who are trying to develop small schemes in various districts. One of the master's students, Tom Ghashali completed his master's degree in Irrigation and Drainage Engineering from Busitema University. The team has also supported a graduate student from University of Valencia to conduct her master's research on gender issues in the irrigation sites. In the field, the project continued training farmer groups in crop and irrigation management, and savings and loans.

**Lessons Learned:** It is will be important to follow up with some of the participants who engaged in the outreach activities to provide support on how to implement some of these innovations and get feedback how they are working in other sites. This can be done through the project's in-country network and website, but because of the cost of travel and staff time, in-person follow ups could be difficult.

### 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

**Achievements:** The major project achievements include; the conclusion of the second nutrition intervention, conducting 1,000 end-line consumer (household dietary diversity) and about 600 producer surveys in Kenya and Zambia, tracking sales data as income revenue, as well as hosting an end of project conference and a larger scientific forum that was open to other researchers and organizations.

**Capacity development:** During this year the project started collaboration with Mirror of Hope, a Kenyan-based NGO, in Kibera slum in Nairobi and developed a sack garden project establishing more than 100 sacks in 2019. This year, the project expanded “train the trainer” courses at Mirror of Hope in Kibera, Nairobi, Kenya. Mirror of Hope included 30 additional women. In Kenya and Zambia, 250 households (in each country) participated in an AIV culinary skills intervention. The infrastructure at the site at University of Zambia (UNZA) has been updated this year with fencing, drip irrigation, and the planting of various fruit trees. Additionally, field lab practicums in UNZA classes in Dept. Plant Science and Food Science and Nutrition used the ShadeBot, CoolBot cold room, the Zero Energy Cool Chamber (ZECC) and other technologies exposing students to postharvest handling and field production of African indigenous vegetables (AIVs). At UNZA, three undergraduate students are continuing their work on Ethiopian Mustard, Spider Plant, and the nutritional values of three AIVs. All are expected to graduate in 2019 using the AIV research projects as part of their course requirements. At University of Eldoret, Kenya, one student is now completing her master’s in entomology of AIVs. At Rutgers University, 3 Ph.D. students continue their dissertation work on AIVs and additional graduate students received mentorship and training.

**Lessons Learned:** AIV value-chain additions, such as collection centers, are essential for farmers getting their product into the formal market. Building strong in-country partnerships strengthen expertise in various disciplines across countries. This increases the impact and ownership of partner contributions. More time is needed between the project closing and expectations for partners to have all of their final reporting documents and data submitted. Due to the need to ensure the dietary household surveys were being conducted over a sufficient time period following the last intervention, the data collection was done in June and July to ensure integrity of the study. A contingency budget should be set aside to cover unexpected activities toward the end of a project due to unexpected increases in prices (national labor policies leading to increased personnel costs) in labor, fuel and transportation.

#### **Presentations and Publications:**

A) Publications (2 publications, 2 highlighted)

i) Simon, J. E., Byrnes, D., Hoffman, D., & Merchant, E. (December 2018). Preventing Micronutrient Deficiencies using African Indigenous Vegetables in Kenya and Zambia(pp.177-181). Sight and Life Magazine, 32(2), NA. NA

ii) Simon, J. E., Byrnes, D., Yuan, B., & Wu, Q. (January 2019). Quantity Assessment of polyphenols, glycoalkaloids and saponins in Solanum scabrum berries of different genetic sources and maturity by HPLC/UV-Vis/MS methods(pp.NA). Journal of the Science of Food and Agriculture, NA(NA), online. doi:doi: 10.1002/jsfa.9579



## **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:** For fiscal year 2019, there were several achievements. The project hosted, in collaboration with the USAID Livestock Systems Innovation Lab, the first annual Cambodian Swine Day, which was an event intended for knowledge sharing and skills transfer across multiple stakeholders. Additionally, the project team presented livestock research data at a Regional Conference in Hanoi, Vietnam and horticulture research data at the annual conference for the American Society for Horticultural Science. Finally, the project completed its research activities and commenced with data analysis and reporting.

**Capacity development:** The has continued to partner with the Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) and the Royal University of Agriculture (RUA) in order to develop their capacity for research and education. However, as a part of this project, the team identified that RUA and CE SAIN hold a key position to do outreach and extension based activities. This has already begun to some degree, but more attention should be focused. Further, although laboratory capacity is increasing, RUA still requires more investment in their research capacity, particularly for laboratory capacity and livestock research.

A total of four students were able to complete their master's research projects. Due to the relatively short timeline of the project, these students are still finalizing their degree programs and will not graduate until next year. Students have also been given the opportunity to present data at regional and international conferences.

**Lessons Learned:** Farmers, particularly in regard to livestock production, have high interest but low capacity. This is particularly true in terms of livestock nutrition. Outreach activities should focus on informing farmers on how to make better decisions for nutrition, and that short-run costs will increase long-term profits. Vegetable value-chain actors conduct several practices that may lead to food contamination. A large focus should be placed on improving vegetable handling practices in Cambodia, in order to ensure their safety. Further research is necessary in order to identify the trade-offs of living mulches for farmers, this includes expanding into further vegetable types and different regions within the country.

### **Presentations and Publications:**

A) Fact Sheet: Farmer Decision Making Tool Fact Sheet

i) Stewart, Z., Vipham, J., Sampson, G., & Yoeu, A.. - Farmer Decision Making Tool

## **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 final phase of the project focused on establishing the necessary linkages to ensure the project activities conducted over the last three years will be sustained in the communities and supported by the local economy. At the close of the project, net-houses are being purchased by farmers, farmers are making their own earthworm compost, and the farmer cooperative is now being effectively led by an elected board of community leaders. Research to support the agricultural innovations developed and introduced by this project will continue to be conducted at the project's in-country partner university, the Royal University of Agriculture.

**Capacity development:** This project supported on-the-job training and mentoring for university faculty and students at the Royal University of Agriculture to develop and carry-out their own research agenda. The Royal University of Agriculture is now a highly regarded research and training institution that is now acquiring its own research funds and implementing its own research agenda. The faculty and students of the Royal University of agriculture now demonstrate their increased capacity to carry out independent research and development projects.

**Lessons Learned:** Building human capacity at in-country research and training institution is the most powerful way to transform the food system and establish support mechanisms for new innovations in developing countries.

## **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; R&D Innovative Solution, Nepal; Fondation Haïtienne de Développement Agricole Durable, Haiti; Vivia Foundation, India; and Desert Water in Sierra Leone

**Achievements:** The DryCard was selected as a finalist in the Elevator Pitch Contest at the 19th World Congress of Food Science and Technology in Mumbai, India in October 2019. Anthony Phan was invited to present a poster at the international Conference on Postharvest Management for improved food security in Hanoi, Vietnam in November 2019 and presented at the Horticulture Innovation Lab Annual Meeting in March 2019 in Washington, DC.

The DryCard distribution network expanded to include R&D Innovative Solution in Nepal, Fondation Haïtienne de Développement Agricole Durable in Haiti, and the Vivia Foundation in South Asia. As of September 2019, a total of 30,000 DryCards have been distributed, of which 23,000 were sold. The Horticulture Innovation Lab purchased 40,000 DryCards from DryCard entrepreneurs to be distributed to local organizations conducting postharvest trainings for farmers.

**Capacity development:** The project set up production with R&D Innovative Solution in Nepal, Desert Water Limited in Sierra Leone, Mwino Group in Uganda, Fondation Haïtienne de Développement Agricole Durable in Haiti, and the Vivia Foundation in South Asia. It also assisted Agrifood Business Consulting and Ofori Agrochemicals with challenges in sourcing proper packaging materials, and assisted Go Organics and Desert Water Limited with ordering more humidity indicator paper from Micro Essential Labs. The project provided training materials for all DryCard entrepreneurs that could be shared with organizations conducting trainings on DryCard. R&D Innovative Solution, Desert Water Limited, Mwino Group, Fondation Haïtienne de Développement Agricole Durable, and the Vivia Foundation were trained to manufacture DryCards according to required specifications. All DryCard entrepreneurs were provided training materials to be able to conduct trainings or provide training resources for local organizations.

**Lessons Learned:** Many are still unaware of the concept of water activity and postharvest losses. It has also been determined that many are unaware that the DryCard is reusable. According the Postharvest Education Foundation, it was identified that additional training and demonstrations are needed. Another lesson learned is that government postal services may pose challenges with receiving and processing packages with DryCard materials.

### **Presentations and Publications**

#### A) Presentations

- a. DryCard for Chain Management. Annual Meeting – 2019
- b. Scaling the DryCard - 2018

#### B) Publications

- a. Howe, L. DryCard Training Facilitator Manual. 2019.
- b. Thompson, J., Reid, M., Felix, L., Donis-Gonzalez, I., Mjawa, B., & Ambuko, J. (October 2017). DryCard™ — A Low-Cost Dryness Indicator for Dried Products (pp.339-344). AIMS Agriculture and Food, 2(4), Springfield, MO, USA.

## IV. REGIONAL CENTERS

### HORTICULTURE INNOVATION LAB REGIONAL CENTER AT ZAMORANO, HONDURAS

**Location:** Honduras

**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 vegetable; and, finally, technical assistance for small and medium-scale farmers.

**Collaborators:** University of California, Davis, University of Wisconsin, Pennsylvania State University, MasRiego Project

**Achievements:** During this year, the Center established several new technologies: hydroponic growing systems; an aromatic and medicinal garden; Zero Energy Cool Chamber (ZECC) utilizing crushed tile; and, traditional and biointensive family garden designs. All of these are technologies are supported by Zamorano students in a learning module created by the Regional Center to train students on effective design of technologies for smallholder farmers. In total, seven research trials were conducted by Zamorano students at the Center. More than 150 Zamorano students participated in the “Learn by Doing” module held at the Regional Center.

Two students completed a professional internship in coordination with the Regional Center. One student from Regional University Center of the West and another from Germany joined Regional Center staff this internship. Close to 400 farmers, students, and government personnel were trained by the Regional Center during this year. During this past year, the Center submitted sixteen proposals for grant and training opportunities.

**Capacity development:** The Regional Center has helped to increase the capacity of public and private institutions, universities, and federal and local partners in production, postharvest and processing technologies. The Center has helped create opportunities for new projects, job creation and linkages to new donors. The Center has also helped build the expertise of the technical and administrative staff and growers within these institutions through the different provided during the year. The Center has created strategic alliances with the University of Florida, Texas Tech University, Ohio State University, Word Renew, CREATIVE, RIKOLTO, SNV, Swiss Contac, Kolping International, Sur en Acción, and the Ministry of Education for Honduras and El Salvador, among others. As a “Train the Trainer” provider, the Center has helped to strengthen the effectiveness of producers located in the municipalities of the dry corridor of Honduras for the production of grains, seeds, vegetables, livestock and the postharvest management of horticulture crops. These trainings have benefited 578 people, 137 of them women and 441 men.

**Lessons Learned:** Strategic alliances established during the development of the Center’s activities play an important role for the sustainability of the Center. Effective identification of the needs of small and medium-holder farmers is key for providing and transferring stakeholder driven technologies. Incorporating the Zamorano students’ ideas is essential for expanding the activities of the Center on campus.

#### **Presentations and Publications**

- A) Thesis/Dissertations (7 supported theses, 1 highlighted)
  - i. Avecillas Ureña , L. (October 2018). Comparative analysis of two zero energy cooling chambers for small-scale horticultural farmers. Zamorano

## **HORTICULTURE INNOVATION LAB REGIONAL CENTER AT KASETSART UNIVERSITY, THAILAND**

**Location:** 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 and Bangladesh and in Cambodia. The activities range from evaluate, adapt, and demonstrate technologies to training programs.

**Collaborators:** Horticulture Innovation Lab at UC Davis; 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:** During this period, the project conducted 5 training for over 100 participants. The trainings were in cooperation with other USAID funded projects and collaboratively the teams addressed the local needs of the smallholder farmers. Additionally, the team conducted training in Rwanda on postharvest handling and the usage of cold storage, specifically the CoolBot cold room. During this training, the Regional Center team introduced the Cold room Monitoring System (CMS) and participants in Rwanda have requested 10 more units. The team trained Rwandan technicians on how to build the units in country and only needs to provide support for coding and troubleshooting. Additionally, this year the project conducted research on utilizing Regional Center technologies for medicinal herb production for smallholder farmers.

**Capacity development:** The project continued its collaboration with the WinRock AIFA project to evaluate the technologies that were granted funding by their project. In this cooperation, the team conducted two successful trainings in Nepal and established strong connections with farmer communities and private companies in Nepal. Additionally, the project has local partners within the communities that will monitor the application of the technologies. The partnership amongst Kasetsart University, Winrock Nepal, the Nepal Agriculture Research Center, and the University of Agriculture and Forestry, Nepal was solidified with the establishment of the National Mango Learning Center at the university. This year the Regional Center supported two students: one student was from Zamorano University, Honduras and another from Royal University of Agriculture, Cambodia. Finally, the Center has been contacted by the Institute for the Promotion of Teaching Science and Technology, Thailand to mentor high school students and already one high school student has received a grant to learn how to build a small-scale, environmentally controlled greenhouse using the Center's cool room design and technologies.

**Lessons Learned:** To make trainings more effective, working with a local partner that has experience working with the target training group is needed to define the problem to ensure suitable technologies are presented. Furthermore, the local partner is also important to monitor the application and usage of the technologies. In the absence of a local partner, most of the training materials and technologies were not apply or wrongly applied.

### **Presentations and Publications**

A) Manual (2 manuals, 1 highlighted)

- i) Sathornkich, J. (2019). Cool Room Monitoring System Building Manual

## **ADVANCING HORTICULTURE TECHNOLOGIES THROUGH DESIGN, EDUCATION AND OUTREACH WITH D-LABS IN HONDURAS AND THAILAND**

**Location:** Honduras, Thailand

**Description:** This project supports satellite D-Labs at the two regional innovation centers. The UC Davis D-Lab continues to assist the Horticulture Innovation Lab in assessing, promoting, and augmenting the portfolio of horticulture technologies. Among other technologies, the project promotes the CoolBot through technology and business development, modeling, and pilot project design. The D-Lab also collaborates, networks, and shares information with the regional innovation centers and other partners.

**Collaborators:** D-Lab, University of California, Davis USA (Lead); Zamorano University, Honduras and Kasetsart University, Thailand.

**Achievements:** The team has created a webpage on the Horticulture Innovations Lab website where instructors can go to learn about the client-focused, project-based courses taught by UC Davis D-Lab, and access downloadable tools to create their own course using the same methodology. D-Lab courses are structured around problem framing deliverables, which guide students through the process of framing and analyzing a problem, then identifying potential solutions. The "toolkit" includes comprehensive manuals about setting up and teaching the courses, as well as downloadable presentations for the key deliverables and analytical tools.

**Capacity development:** In addition to the international partners mentioned in the semi-annual report, the team has strengthened the synergistic connection between D-Lab/Horticulture Innovation Lab and Global Affairs. A project formation workshop was led with the Mandela fellows (young leaders from Africa who are at UC Davis for 6 weeks through a State Department program), who have since contacted us with projects for students to work on in D-Lab classes. The project formation workshop gave the Mandela fellows a structured way to align needs with opportunities, resources, and constraints and create potential project ideas. A workshop is currently being delivered to professors in Uruguay who wish to teach their students hands-on, interdisciplinary, and critical-thinking skills in diverse areas. Collaborations are also ongoing with on-campus partners, specifically Global Affairs and the Institute for Food & Health Innovation, to search for more opportunities to promote the toolkit locally.

**Lessons Learned:** Always identify and involve all relevant stakeholders, including the Horticulture Innovation Lab Communications Director and management team who will ultimately be responsible for the inclusion of the toolkit on the website. Taking the D-Lab courses and leading workshops have been key factors in informing the contents of the toolkit and its development.

### **Publications:**

- A) Toolkit
  - a. Slattery, M. Davis D-Lab Toolkit. 2019



## V. BUY-IN AND ASSOCIATE AWARDS RESEARCH PROJECTS

### 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 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:** During this period, the Barbara Ford Peace Center continued implementation of activities and achieved several noteworthy accomplishments. During the past year, 412,576.62 m<sup>2</sup> of arable land were installed with drip irrigation systems benefiting 292 producers and 15 educational institutions. A total of 1,621 farmers (858 men, 763 women) and 774 students (387 men, 387 women) increased their knowledge and skills through project trainings. 587 farmers and 19 educational centers applied more than one technology and/or improved practice in the management of their crops, in a total of 76.39 hectares. Average revenue increases per producer were US \$861.84 with a total increase of US \$327,497.62. A successful field environmental evaluation was also conducted with farmers, highlighting that 80% of them followed EMMP recommendations.

**Capacity development:** The Barbara Ford Peace Center supported six students from the National University of San Carlos and two from the Mayan Technical Institute to complete their university degrees. Technical assistance, training, and the establishment of demonstration plots were provided to 15 schools. Out of 26 producer organizations supported, 22 adopted specific new technologies and practices and four received technical assistance. Training was also given to 572 producers and technicians by Zamorano on drip irrigation systems, water and soil management, agronomic crop management, marketing, and sustainable watershed management.

**Lessons Learned:** Over the last year, project promotion improved as additional authorities including the Municipal Development Councils (COMUDE) were approached. There was difficulty recovering loans for drip irrigation systems granted through the Junam Q'ab 'RL Cooperative. Establishing improved coordination between the team and cooperative personnel helped correct this. Some producers have expressed interest in applying technologies that are not economically feasible for which additional guidance on alternatives and best practices helped identify appropriate solutions.

#### **Presentations and Publications**

- A. Manuals (13 manuals, 2 highlighted)
  - i) Rivera, D. et al. (2019) Manual - Buenas Practicas Agricultura
  - ii) Rivera, D. et al. (2019) Manual - Operacion y Mantenimineto de Sistemas de Riego por Goteo

## **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); the Patuakhali Science and Technology University (PSTU)

**Achievements:** The UC Davis solar chimney dryer has been scaled up by other organizations (WorldFish, World Food Programme (WFP)). The project developed and successfully tested a higher capacity (40 kg) chimney dryer. The project increased the capacity of a technician who now has been employed by WorldFish for making chimney dryers as well training people on how to build the dryer. The project developed the skill of technicians working with the floating garden beneficiary communities who now possess the knowhow of building the technology and its operation and management. The team increased the awareness in collaborating farming communities about safe food preservation and value addition. The project empowered these same communities to face adverse climatic conditions in case of flooding and how to produce organic vegetables in fish ponds without hampering water quality. Additionally, the project increased the capacity of target communities with technologies and techniques to reduce food wastage and generate value addition by preservation. Finally, the project completed the economic assessment of the technologies.

**Capacity development:** The Patuakhali Science and Technology University (PSTU) has tested the bigger capacity solar chimney dryer for fish drying and also conducted the nutritional analysis of the chimney dried fish. WorldFish (funded by WFP) tested, trained and scaled up the solar chimney dryer for fish and vegetable drying in Bangladesh's coastal belt (Teknaf, Coxsbazar) to support communities who recently suffered due to Rohingya crisis. iDE Global is currently assessing the market opportunities and developing a business model for the CoolBot cold rooms introduced to Bangladesh by the project. Finally, a refresher training was provided to the floating garden community of Agailjhara, Barishal.

**Lessons Learned:** The solar chimney dryer opens up opportunities for safe fish drying in coastal communities. Drying products with high value helps to promote the economic feasibility of this technology. Storing particular products such as chili, eggplant, and melon during festival or flood seasons result in higher economic return. Beneficiaries showed reluctance to repair technologies independently after the end of project support and sometimes have returned to their old practices. Not having technologies linked up with a proper market value chain is a major challenge for sustaining the technologies. Small and marginal beneficiaries often lack the capital and courage to invest in the technologies or failed to use the technologies for revenue generation.

### **Presentations and Publications**

#### **A) Presentations (2 presentations, 1 highlighted)**

- i) Deltisidis, A., Mukherjee, A., Islam, M., Reid, M., & Mitcham, E. (July 2019). Examining Nutrition Impacts and Sustainability of Horticultural Innovations in Southern Bangladesh. Presentation at American Society of Horticultural Sciences Annual Meeting, Las Vegas, NV

## 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, 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; the Agriculture Research Institute of Guinea (IRAG); Centre Régionale de Recherche Agronomique de Foulayah (CRRAF); WinRock Guinea, Cultivating New Frontier in Agriculture (CNFA); ACDI/VOCA

**Achievements:** The project introduced to Guinean farmers and extensionists the DryCard, the Horticulture Innovation Lab's chimney solar dryer, the CoolBot cold room and improved agriculture production practices that encourage organic, sustainable production without the use of chemical inputs. Mulching to protect the ground against erosion, inhibits weeds and retains moisture has been adapted by many small horticulture producers. Trellises for tomato and cucumber production were also introduced by the project and have been adapted by producers which increased their production significantly. For example, Mr. Mamadou Saidou Bah, a young, Guinean tomato producer, utilized the tomato trellises in Mamou and as a result has increased his market value production by at least 60 percent. According to Mr. Bah, "Before, I used the stick method to support my tomato plants individually, since I was introduced to the trellis [referring to the Florida braids trellises introduced by Horticulture Training and Service Center], our plants are healthier and our production has increased and where we used to lose over 30% of the tomatoes in the field before harvest, now with the trellis, we are able to harvest most of the tomatoes ready for the market." Mr. Bah has also trained other farmers in the Mamou area to install the trellises and producers are praising and embracing the new production technology.

**Capacity development:** The Horticulture Training and Service Center in Guinea is based at the Centre Régionale de Recherche Agronomique de Foulayah (CRRAF) research center in Kindia with close collaboration with its personnel. CRRAF field workers and researchers participated and facilitated trainings on the chimney solar dryer construction and guidelines on fruit and vegetable production. The CoolBot cold room was also installed for the first time on the CRRAF site and served as a hands-on training and capacity building opportunity for technical personnel. The Demonstration Center built at CRRAF will remain open for training and demonstrations and will be managed by young agro-entrepreneurs trained by the Horticulture Training and Service Center. The project trained 12 young entrepreneurs (AVENIRs) that are in the process of establishing agribusinesses using new techniques and technologies learned at the Center and will continue to train other interested persons in these technologies. AVENIR and CRRAF personnel participated in a ten day field training at Centre Songhai in Benin as part of the capacity building efforts. The trainings included: composting, integrated production systems, organic production techniques, fish farming, animal husbandry, product transformation, and reinforcement of agribusiness techniques. The Center also trained 75 farmers and AVENIRs in new production and postharvest management technologies that will help increase production and access to markets with fresh produce and new products (dried fruits and vegetables).

**Lessons Learned:** More hands on training and field demonstrations will help farmers discover new technologies. It is essential to have more Demonstration Centers throughout the Zone of Influence where the technologies and improved practices can be introduced and scaled out to farmers' fields.

# VI. HUMAN AND INSTITUTIONAL CAPACITY DEVELOPMENT

## FY2019 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	Refresher training on floating gardens	Producers	6	4	10
Benin	Good agricultural practices	Producers, Government, Civil Society	4	2	6
Burkina Faso	Agribusiness workshop	Government, Private Sector, Civil Society	10	11	21
Burkina Faso	Postharvest technologies	Government, Private Sector, Civil Society	14	4	18
Burkina Faso	Agribusiness	Government, Private Sector, Civil Society	9	12	21
Burkina Faso	Agribusiness	Private Sector, Civil Society	4	9	13
Burkina Faso	Agribusiness	Civil Society	31	20	51
Burkina Faso	Training farmers on tomato postharvest handling	Producers	22	0	22
Burkina Faso	Tomato postharvest handling	Producers, Government	23	6	29
Burkina Faso	ZECC construction	Producers	11	14	25
Burkina Faso	ZECC construction	Producers, Government	24	8	32
Burkina Faso	ZECC construction	Producers, Government	16	15	31
Burkina Faso	Post-harvest management of fruits and vegetables	Producers	9	18	27
Burkina Faso	Post-harvest management of fruits and vegetables	Producers	24	6	30
Burkina Faso	Post-harvest management of fruits and vegetables	Government	25	6	31
Burkina Faso	Agribusiness	Private Sector	5	7	12
Cambodia	Nethouses	Producers	12	9	21
Cambodia	Composting (Earthworm)	Producers, Private Sector	11	6	17

Cambodia	Scaling safe vegetable value chains	Civil Society	8	4	12
Cambodia	Organic horticulture	Producers, Government	12	5	17
Cambodia	Compost training (Earthworm)	Producers	8	2	10
Cambodia	Earthworm Compost Scale Up	Producers, Civil Society	29	21	50
Cambodia	Nethouse Evaluation Workshops	Producers	15	18	33
Cambodia	Composting, Nethouses, safe handling	Producers, Civil Society	15	18	33
Cambodia	Composting, Nethouses, safe handling	Producers, Government, Private Sector, Civil Society	20	15	35
Cambodia	Fertilizers	Producers	5	6	11
Cambodia	Safe vegetable handling	Producers, Government, Private Sector	12	0	12
Cambodia	Record keeping	Producers, Government, Civil Society	30	10	40
Cambodia	Livestock and horticulture	Producers	18	23	41
Cambodia	Livestock and horticulture	Producers, Government, Private Sector, Civil Society	120	59	179
Ghana	Bio char use	Producers, Government, Private Sector, Civil Society	18	2	20
Ghana	Mango alue addition	Producers	46	33	79
Ghana	Utilization of mango waste into compost	Producers	49	18	67
Ghana	Seedling Production Systems	Producers, Civil Society	34	52	86
Ghana	Records Keeping and Economic Analysis	Producers, Civil Society	21	34	55
Ghana	Organic agricultural practices	Producers, Civil Society	28	5	33
Ghana	Organic agricultural practices	Producers, Civil Society	24	12	36
Ghana	Organic agricultural practices	Producers, Civil Society	48	49	97
Guatemala	Soil Health and Technical Efficiency	Producers	37	10	47
Guatemala	Nitrogen Concepts for Agriculture Conservation	Civil Society	154	83	237
Guatemala	Organizational Management	Producers	4	0	4
Guatemala	Integrated pest management	Producers	10	7	17
Guatemala	Integrated pest management	Producers	3	0	3
Guatemala	Integrated pest management	Producers	0	3	3
Guatemala	Integrated pest management	Producers	1	2	3
Guatemala	Integrated pest management	Producers	1	2	3
Guatemala	Integrated pest management	Producers	1	1	2
Guatemala	Community Participation and Leadership	Producers	28	12	40

Guatemala	Community Participation and Leadership	Producers	5	5	10
Guatemala	Community Participation and Leadership	Producers	49	46	95
Guatemala	Good agricultural practices	Producers	1	4	5
Guatemala	Integrated Pest Management	Producers	4	0	4
Guatemala	Good farming practices	Producers	10	5	15
Guatemala	Marketing (Production Costs) Community Participation and Leadership	Producers	11	1	12
Guatemala	Organizational Strengthening	Producers	9	6	15
Guatemala	Drip irrigation system	Producers	8	0	8
Guatemala	Soil Fertilization	Producers	13	9	22
Guatemala	Integrated pest management	Producers	0	3	3
Guatemala	Drip irrigation system and Integrated pest management	Producers	38	9	47
Guatemala	Soil, Water and Drip Irrigation Systems	Producers	2	23	25
Guatemala	Drip Irrigation System and Good Agricultural Practices	Producers	12	2	14
Guatemala	Operation and maintenance of the Drip Irrigation System	Producers	25	5	30
Guatemala	Integrated pest management	Producers	3	4	7
Guatemala	Good farming practices	Civil Society	24	14	38
Guatemala	Good farming practices	Civil Society	33	20	53
Guatemala	Good farming practices	Civil Society	36	25	61
Guatemala	Drip irrigation system	Civil Society	7	10	17
Guatemala	Drip irrigation system	Civil Society	73	86	159
Guatemala	Drip irrigation system	Civil Society	7	8	15
Guatemala	Good Agricultural Practices	Civil Society	23	16	39
Guatemala	Good Agricultural Practices	Civil Society	56	84	140
Guatemala	Good Agricultural Practices	Civil Society	17	32	49
Guatemala	Drip Irrigation	Civil Society	18	21	39
Guatemala	Drip irrigation system	Civil Society	15	4	19
Guatemala	Drip irrigation system	Civil Society	8	9	17
Guatemala	Good agricultural practices	Producers	2	15	17
Guatemala	Drip Irrigation Systems Maintenance	Producers	33	5	38
Guatemala	Drip Irrigation Systems Maintenance	Producers	2	33	35
Guatemala	Drip Irrigation Systems Maintenance	Producers	24	8	32
Guatemala	Integrated Pest Management	Producers	7	5	12
Guatemala	Drip Irrigation Systems	Producers	4	17	21
Guatemala	Drip Irrigation Systems	Producers	21	41	62
Guatemala	Drip Irrigation Systems	Producers	7	6	13
Guatemala	Good agricultural practices	Producers	47	22	69
Guatemala	Integrated pest management	Producers	12	2	14
Guatemala	Drip Irrigation Systems Maintenance, Good Agricultural Practices and Integrated Pest Management	Producers	43	7	50
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	9	15	24
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	34	47	81

Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	40	129	169
Guatemala	Drip Irrigation Systems Maintenance	Producers	17	8	25
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	9	32	41
Guatemala	Soil Fertility and Fertilizers	Producers	5	5	10
Guatemala	Soil Fertility and Fertilizers	Producers	24	2	26
Guatemala	Soil Conservation	Producers	3	21	24
Guatemala	Fertility and Fertilizers	Producers	5	78	83
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	39	22	61
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	6	0	6
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	40	8	48
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	25	26	51
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	24	2	26
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	41	17	58
Guatemala	Good Agricultural Practices and Integrated Pest Management	Producers	15	4	19
Guatemala	Good Agricultural Practices and Integrated Pest Management	Civil Society	23	9	32
Guatemala	Good Agricultural Practices and Integrated Pest Management	Civil Society	36	37	73
Guatemala	Good Agricultural Practices and Integrated Pest Management	Civil Society	11	12	23
Guatemala	Irrigation systems and management of hard and settled water	Civil Society	41	6	47
Guatemala	Irrigation systems and water use	Producers	32	11	43
Guatemala	Irrigation systems and water use	Producers, Government	34	32	66
Guatemala	Soil and water management	Producers	52	17	69
Guatemala	Soil and water management	Producers	49	16	65
Guatemala	Technical advice in the management of the pea crop	Producers	11	36	47
Guatemala	Irrigation systems and water use	Producers	4	35	39
Guatemala	Soil health workshop	Producers	61	9	70
Guatemala	Soil health workshop	Producers	38	10	48
Guinea	Cold chain	Producers, Government	19	12	31
Guinea	Mango Processing	Private Sector	4	5	9
Guinea	Installation of a trellis system for cucumber production	Producers, Civil Society	9	6	15
Guinea	Installation of a trellis system for tomato production	Producers, Government	37	19	56
Guinea	Plant Disease Management	Producers	14	3	17

Guinea	Tomato Processing	Producers	1	4	5
Guinea	Postharvest management	Producers, Government, Private Sector	64	36	100
Guinea	Postharvest management	Producers	31	13	44
Guinea	Postharvest management	Producers	11	17	28
Guinea-Bissau	Good Agricultural Practices and Integrated Pest Management	Producers	82	37	119
Honduras	Gender and research workshop	Government, Private Sector, Civil Society	25	18	43
Honduras	Gender and outreach workshop	Civil Society, Private Sector	11	22	33
Honduras	Climate smart agriculture	Government	13	11	24
Honduras	Good agriculture practices	Producers	61	50	111
Honduras	Good agriculture practices	Producers	59	41	100
Honduras	Soil Fertility and Fertilizers	Producers, Private Sector	37	63	100
Honduras	Good agriculture practices	Government, Private Sector	8	20	28
Honduras	School gardens	Government	6	6	12
Kenya	Marketing Fresh Vegetable	Producers	0	27	27
Kenya	Marketing Fresh Vegetable	Producers	14	4	18
Kenya	Marketing Fresh Vegetable	Producers	2	31	33
Kenya	Marketing Fresh Vegetable	Producers	22	3	25
Kenya	Marketing Fresh Vegetable	Producers	1	19	20
Kenya	Marketing Fresh Vegetable	Producers	6	12	18
Kenya	Marketing Fresh Vegetable	Producers	1	16	17
Kenya	Marketing Fresh Vegetable	Producers	1	19	20
Kenya	Marketing Fresh Vegetable	Producers	0	14	14
Kenya	Marketing Fresh Vegetable	Producers	3	11	14
Kenya	Marketing Fresh Vegetable	Producers	4	15	19
Kenya	Marketing Fresh Vegetable	Producers	0	17	17
Kenya	Marketing Fresh Vegetable	Producers	0	14	14
Kenya	Marketing Fresh Vegetable	Producers	7	12	19
Kenya	Marketing Fresh Vegetable	Producers	0	20	20
Kenya	Harvest and Postharvest Management	Producers	10	14	24
Kenya	Harvest and Postharvest Management	Producers	6	16	22
Kenya	Harvest and Postharvest Management	Producers	7	12	19
Kenya	Harvest and Postharvest Management	Producers	14	12	26
Kenya	Harvest and Postharvest Management	Producers	15	16	31
Kenya	Harvest and Postharvest Management	Producers	11	13	24
Kenya	Harvest and Postharvest Management	Producers	2	16	18
Kenya	Harvest and Postharvest Management	Producers	15	4	19
Kenya	Harvest and Postharvest Management	Producers	3	13	16
Kenya	Harvest and Postharvest Management	Producers	3	5	8
Kenya	Harvest and Postharvest Management	Producers	0	10	10
Kenya	Harvest and Postharvest Management	Producers	22	4	26
Kenya	Harvest and Postharvest Management	Producers	0	18	18



Kenya	Harvest and Postharvest Management	Producers	1	23	24
Kenya	Harvest and Postharvest Management	Producers	0	24	24
Kenya	Harvest and Postharvest Management	Producers	0	18	18
Kenya	Harvest and Postharvest Management	Producers	6	10	16
Kenya	Harvest and Postharvest Management	Producers	1	19	20
Kenya	Harvest and Postharvest Management	Producers	2	18	20
Kenya	Harvest and Postharvest Management	Producers	0	24	24
Kenya	Seed Production and Marketing	Producers	0	18	18
Kenya	Seed Production and Marketing	Producers	4	20	24
Kenya	Seed Production and Marketing	Producers	6	13	19
Kenya	Seed Production and Marketing	Producers	3	11	14
Kenya	Seed Production and Marketing	Producers	2	18	20
Kenya	Seed Production and Marketing	Producers	1	15	16
Kenya	Seed Production and Marketing	Producers	18	5	23
Kenya	Marketing Fresh Vegetables	Producers	1	12	13
Kenya	Marketing Fresh Vegetables	Producers	5	11	16
Kenya	Marketing Fresh Vegetables	Producers	5	11	16
Kenya	Marketing Fresh Vegetables	Producers	0	17	17
Kenya	Marketing Fresh Vegetables	Producers	5	5	10
Kenya	Marketing Fresh Vegetables	Producers	1	24	25
Kenya	Marketing Fresh Vegetables	Producers	3	8	11
Kenya	Marketing Fresh Vegetables	Producers	0	14	14
Kenya	Marketing Fresh Vegetables	Producers	4	5	9
Kenya	Marketing Fresh Vegetables	Producers	8	19	27
Kenya	Marketing Fresh Vegetables	Producers	2	11	13
Kenya	Marketing Fresh Vegetables	Producers	3	16	19
Kenya	AIV Vegetable and Seed Production	Producers, Civil Society	10	5	15
Kenya	AIV Vegetable and Seed Production	Producers, Civil Society	12	4	16
Kenya	Culinary intervention: recipes and culinary skills	Producers	7	13	20
Kenya	Culinary intervention: recipes and culinary skills	Producers	2	19	21
Kenya	Culinary intervention: recipes and culinary skills	Producers	7	8	15
Kenya	Culinary intervention: recipes and culinary skills	Producers	7	8	15
Kenya	Culinary intervention: recipes and culinary skills	Producers	2	22	24
Kenya	Culinary intervention: recipes and culinary skills	Producers	1	9	10
Kenya	Culinary intervention: recipes and culinary skills	Producers	4	11	15
Kenya	Culinary intervention: recipes and culinary skills	Producers	1	15	16
Kenya	Culinary intervention: recipes and culinary skills	Producers	2	18	20

Kenya	Culinary intervention: recipes and culinary skills	Producers	2	21	23
Kenya	Culinary intervention: recipes and culinary skills	Producers	10	9	19
Kenya	Culinary intervention: recipes and culinary skills	Producers	2	13	15
Kenya	Marketing Fresh Vegetables	Producers	20	8	28
Kenya	Marketing Fresh Vegetables	Producers	12	16	28
Kenya	Marketing Fresh Vegetables	Producers	15	14	29
Kenya	Marketing Fresh Vegetables	Producers	2	10	12
Kenya	Marketing Fresh Vegetables	Producers	9	12	21
Kenya	Marketing Fresh Vegetables	Producers	0	10	10
Kenya	Marketing Fresh Vegetables	Producers	9	12	21
Kenya	Marketing Fresh Vegetables	Producers	13	2	15
Kenya	Marketing Fresh Vegetables	Producers	1	13	14
Kenya	Marketing Fresh Vegetables	Producers	3	4	7
Kenya	Marketing Fresh Vegetables	Producers	6	15	21
Kenya	Marketing Fresh Vegetables	Producers	6	9	15
Nepal	Soilless culture for smallholder farmers	Producers, Private Sector, Civil Society	10	13	23
Nepal	Mango production	Private Sector, Civil Society	22	18	40
Nepal	Winter pruning	Producers	43	25	68
Nepal	Summer pruning	Producers	44	42	86
Nepal	Soil and plant health	Producers, Civil Society	15	20	35
Nepal	Soil and plant health	Producers, Civil Society	3	19	22
Nepal	Soil and plant health	Producers, Civil Society	3	34	37
Nepal	Soil and plant health	Producers, Civil Society	7	33	40
Nepal	Crop selection	Producers, Civil Society	8	37	45
Nepal	Integrated pest management	Producers, Civil Society	3	32	35
Nepal	Integrated pest management	Producers, Civil Society	6	31	37
Nepal	Integrated pest management	Producers, Civil Society	10	34	44
Nepal	Agroecosystem analysis	Producers, Civil Society	10	29	39
Nepal	Agroecosystem analysis	Producers, Civil Society	1	20	21
Nepal	Agroecosystem analysis	Producers, Civil Society	1	16	17
Nepal	Soil nutrient management	Producers, Civil Society	2	26	28

Nepal	Integrated pest management	Producers, Civil Society	3	19	22
Nepal	Soil health	Producers, Civil Society	3	14	17
Nepal	Soil health	Producers, Civil Society	3	12	15
Nepal	Integrated Pest Management	Producers, Civil Society	4	26	30
Nepal	Soil health	Producers, Civil Society	4	33	37
Nepal	Soil health	Producers	1	34	35
Nepal	Soil health	Producers, Civil Society	0	25	25
Nepal	Nursery management	Producers, Civil Society	0	22	22
Nepal	Integrated pest management	Producers, Civil Society	2	22	24
Nepal	Integrated pest management	Producers	0	18	18
Nepal	Agroecosystem analysis	Producers	0	16	16
Nepal	Agro-ecosystem analysis	Producers	0	19	19
Nepal	Integrated pest management	Producers	0	15	15
Nepal	Integrated pest management	Producers	0	18	18
Rwanda	Training of Master Trainer for Horeco and PSDAG Beneficiaries	Producers, Government	27	6	33
Rwanda	Training of trainers on best harvesting and postharvest practices	Government	20	11	31
Rwanda	Bootcamp Training for Postharvest Innovation Competition Winners	Private Sector	9	6	15
Rwanda	Coldroom with Coolbot Maintennace and Troubleshooting	Private Sector	47	13	60
Rwanda	Postharvest management	Producers, Government	13	16	29
Rwanda	Small scale processing technology for horticultural products	Private Sector, Civil Society	16	14	30
Rwanda	Small scale processing technology for horticultural products	Private Sector, Civil Society	9	18	27
Rwanda	Postharvest handling for vegetables and fruits	Producers, Civil Society	2	20	22
Rwanda	Conducting Research on Evaporative Cooling Technologies	Producers, Government, Private Sector, Civil Society	7	8	15
Rwanda	Reducing Post-harvest losses of fruits and vegetables	Producers	185	85	270
Rwanda	Postharvest management	Producers, Private Sector	164	71	235
Rwanda	Postharvest management	Producers	137	94	231
Rwanda	Postharvest management	Producers	9	7	16
Rwanda	Postharvest management	Civil Society	42	34	76
Rwanda	Postharvest management	Producers	14	8	22

Rwanda	Training of trainers on postharvest handling	Producers	15	20	35
Rwanda	Training of trainers on postharvest handling	Producers	31	10	41
Rwanda	Postharvest management	Producers	133	99	232
Rwanda	Postharvest management	Civil Society	94	66	160
Rwanda	Postharvest management	Producers, Government	67	54	121
Rwanda	Postharvest handling practices for fruit and vegetable crops	Producers	13	17	30
Rwanda	Training of Master Trainer for Rwanda Youth in Agribusiness	Producers, Private Sector	32	12	44
Rwanda	Reducing Post-harvest losses of fruits and vegetables	Producers	28	12	40
Rwanda	Coldroom with CoolBot installation and maintenance	Producers	50	10	60
Rwanda	Production of Selected Tropical Fruits	Producers, Private Sector	5	17	22
Rwanda	Production of Selected Tropical Fruits	Producers, Private Sector	4	20	24
Rwanda	Good agriculture practices	Producers, Government	18	32	50
Tajikistan	Entrepreneurial Readiness	Producers, Private Sector	33	33	66
Tajikistan	Food safety training	Producers, Private Sector	33	33	66
Tajikistan	Field demonstration of solar dryers	Producers, Private Sector	33	33	66
Tanzania, United Republic of	World Vegetable Producer Internship	Civil Society	2	1	3
Tanzania, United Republic of	Postharvest management	Producers	11	30	41
Tanzania, United Republic of	Postharvest management	Producers	13	25	38
Tanzania, United Republic of	Postharvest management	Producers	26	7	33
Tanzania, United Republic of	Postharvest management	Producers	21	18	39
Tanzania, United Republic of	Postharvest management	Producers, Government, Private Sector, Civil Society	24	25	49
Tanzania, United Republic of	Postharvest management	Producers, Government, Private Sector	25	20	45

Tanzania, United Republic of	Postharvest management	Producers, Government, Private Sector, Civil Society	39	5	44
Tanzania, United Republic of	Postharvest management	Producers, Government, Private Sector	19	17	36
Tanzania, United Republic of	Farmers Field day workshop	Producers, Government	45	41	86
Thailand	Cool room with CoolBot and introduction of postharvest training	Producers, Private Sector	19	16	35
Thailand	Cool room with CoolBot and introduction of postharvest training	Producers	6	14	20
Uganda	Small scale Irrigation Innovations	Producers, Government	20	5	25
Uganda	Tomato Production	Producers	7	20	27
Uganda	Tomato Production	Producers	4	8	12
Uganda	Pipe repair Training	Producers	2	6	8
Uganda	Savings and Loans Association Management	Producers	7	20	27
Uganda	Onion Management and Irrigation Training	Producers	15	7	22
Uganda	Field Material Composting	Producers	4	11	15
Uganda	Input Micro Enterprise Training	Producers, Government	2	1	3
Uganda	Multipurpose moveable irrigation system	Producers	14	16	30
Uganda	Making of pineapple jam	Producers, Government, Private Sector, Civil Society	30	13	43
Uganda	Making of Tomato Sauce	Producers, Government, Private Sector, Civil Society	31	10	41
Uganda	Making of Passion fruit squash	Producers, Government, Private Sector, Civil Society	16	24	40
Uganda	Good agriculture practices	Producers, Government, Private Sector, Civil Society	12	35	47
Uganda	Mango/Orange fruit value addition	Producers, Government, Civil Society	137	63	200
Uganda	Conservation Agriculture for Smallholder Farmers	Producers	0	10	10
Uganda	Postharvest management	Producers	1	21	22
Uganda	Vegetable packhouse operations	Producers, Civil Society	1	12	13
Uganda	Cooling and storage	Producers, Civil Society	1	12	13
Uganda	ZECC construction	Producers	0	9	9

Uganda	Construction of a chimney solar dryer	Producers, Civil Society	2	15	17
Uganda	Agribusiness	Producers	2	16	18
Uganda	Reducing food losses	Producers	3	21	24
Uganda	Good agriculture practices	Producers	3	21	24
Uganda	Leadership training for women	Producers	1	18	19
Uganda	Irrigation	Producers	3	32	35
Uganda	Irrigation	Producers	4	56	60
Uganda	Irrigation	Producers	3	18	21
Uganda	Irrigation	Producers	0	46	46
Uganda	Mushroom production	Producers	5	54	59
Uganda	Vegetable production	Producers	0	10	10
Uganda	Postharvest management	Producers	0	11	11
Uganda	Postharvest management	Producers	3	55	58
Uganda	Postharvest management	Producers	1	30	31
Uganda	Postharvest management	Producers	4	31	35
Uganda	Postharvest management	Producers	2	46	48
Uganda	Solar drier construction and operation	Producers	2	60	62
Uganda	Solar drier construction and operation	Producers	3	45	48
Uganda	Irrigation	Producers	12	45	57
Uganda	Irrigation	Producers	0	51	51
Uganda	Postharvest management	Producers	9	40	49
Uganda	Solar drier construction and operation	Producers	1	26	27
Uganda	Solar drier construction and operation	Producers	0	25	25
Uganda	Mushroom production	Producers	6	42	48
United States	Gender across the Innovation Labs workshop	Government, Civil Society	7	21	28
Zambia	Seed Production and Storage	Producers	1	18	19
Zambia	Seed Production and Storage	Producers	6	6	12
Zambia	Seed Production and Storage	Producers	4	3	7
Zambia	Seed Production and Storage	Producers	12	13	25
Zambia	Nutrition	Producers	5	20	25
Zambia	Nutrition	Producers	0	6	6
Zambia	Nutrition	Producers	4	19	23
Zambia	Nutrition	Producers	0	20	20
Zambia	Nutrition	Producers	3	18	21
Zambia	Nutrition	Producers	0	11	11
Zambia	Nutrition	Producers	9	19	28
Zambia	Nutrition	Producers	8	17	25
Zambia	Nutrition	Producers	7	14	21
Zambia	Nutrition	Producers	3	29	32
Zambia	Nutrition	Producers	21	12	33
Zambia	Nutrition	Producers	8	16	24
Zambia	Postharvest management	Producers, Civil Society	8	13	21
Zambia	Postharvest systems student practical	Civil Society	9	4	13
Zambia	Seed Production and Storage	Producers	0	18	18

## FY2019 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	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	Phany Vouer	Female	University of Battambang	Bachelor's	Agronomy	Oct-18
Cambodia	Heat Heang	Male	University of Battambang	Bachelor's	Agronomy	Nov-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	Put Pon	Male	Royal University of Agriculture	Internship	Agronomy	Mar-19
Cambodia	Seheang Thorn	Male	Royal University of Agriculture	Internship	Agronomy	Mar-19
Cambodia	Phanet Youn	Male	Royal University of Agriculture	Internship	Agronomy	Mar-19
Cambodia	Bunthi Bou	Male	Royal University of Agriculture	Master's	Agronomy	Sep-19
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
Canada	Rupenanda Widange	Male	University of Hawaii	Master's	Agricultural Economics	May-19
Canada	Rupananda Widanage	Male	University of Hawaii at Manoa	Ph.D.	Natural Resource and Environmental Management	Jun-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
Ethiopia	Melese Lendado	Male	Wolaita Sodo University	Master's	Rural Development and Planning	Jul-19
Ghana	Richard Gbal	Male	College of Tropical Agriculture	Other	General Agricultural Science	Jun-20
Ghana	Gilbert Osei	Male	University of Cape Coast	Ph.D.	Irrigation Technology and Management	Jul-21
Greece	Konstantinos Batziakas	Male	Kansas State University	Ph.D.	Horticulture	Dec-19
Guatemala	Rehina Pacheco	Female	Centro de Paz Barbara Ford	Internship	Technical Professional in Natural Resources	Nov-18
Guatemala	Alfredo Mejia	Male	University of San Carlos Guatemala	Bachelor's	Agronomy	Jun-19
Guatemala	Siria Cifuentes	Female	Centro de Paz Barbara Ford	Internship	Agrarian Engineer	Jul-19
Guatemala	Carmen Sapon	Female	Barbara Ford Peace Center	Internship	Agrarian Engineer	Jul-19
Guatemala	Juan Roblero	Female	Centro de Paz Barbara Ford	Internship	Agrarian Engineer	Jul-19
Guatemala	Alvaro Tax	Female	Centro de Paz Barbara Ford	Internship	Agrarian Engineer	Jul-19
Guatemala	Marco Chay	Male	Centro de Paz Barbara Ford	Internship	Agrarian Engineer	Jul-19
Guatemala	Sarita Montejo	Female	Centro de Paz Barbara Ford	Internship	Agrarian Engineer	Jul-19
Guatemala	Cleto Ramos	Male	Centro de Paz Barbara Ford	Internship	Technical Degree in Natural Resources	Oct-19
Guatemala	Agustin Pacheco	Female	Centro de Paz Barbara Ford	Internship	Technical Degree in Natural Resources	Oct-19
Guinea	Macire Camara	Female	Youth-led Horticulture Training and Services Center	Internship	Youth entrepreneurship	Mar-19
Guinea	Namory Traore	Male	Youth-Led Horticulture Training and Services Center	Internship	Youth-led entrepreneurship	Mar-19
Guinea	Fatoumata Bah	Female	Youth-led Horticulture	Internship	Youth-led entrepreneurship	Mar-19



			Training and Services Center			
Guinea	Ibrahima Diallo	Male	Youth-led Horticulture Training and Services Center	Internship	Youth-led Entrepreneurship	Mar-19
Guinea	Kabinet Fofana	Male	Youth-led Horticulture Training and Services Center	Internship	Potato production and postharvest management	Jul-19
Guinea	Francois Kpogomou	Male	Youth-led Horticulture Training and Services Center	Internship	Agribusiness - Product commercialization	Jul-19
Guinea	Aissatou Diallo	Female	Youth-led Horticulture Training and Services Center	Internship	Horticulture fruits and vegetable production and transformation	Jul-19
Guinea	Paula Goumou	Female	Youth-led Horticulture Training and Services Center	Internship	Horticulture field production - Tomatoes)	Jul-19
Kenya	Angeline Mnene	Female	University of Eldoret	Master's	Entomology	May-19
Nepal	Samikshya Shrestha	Female	Aythos Nepal	Bachelor's	Agriculture Science	Jan-19
Nepal	Sameer Barai Magar	Male	Agriculture and Forestry University	Master's	Soil Science	Feb-19
Nepal	Bijay Sapkota	Male	Agriculture and Forestry University	Master's	Agriculture Entomology	Dec-19
Nepal	Kafil Ahamad	Male	Agriculture and Forestry University	Master's	Agriculture Entomology	Dec-19
Nigeria	Ibukun Timothy Ayankojo	Male	University of Florida	Ph.D.	Soil and Water Sciences	Aug-20
Rwanda	Ali Shyaka	Male	University of Rwanda - College of Agriculture	Bachelor's	Crop production	Aug-20
Uganda	Tom Gashali	Male	Busitema University	Master's	Irrigation Engineering and Water Management	Dec-18
Uganda	Robert Mboizi	Male	Kyambogo University	Bachelor's	Agro-Business	Sep-19
United States	William Reichert	Male	Rutgers University	Internship	Plant Biology	Nov-18

United States	Amaleah Mirti	Female	Youth-Led Horticulture Training and Services Center	Internship	Horticulture Innovation, improved production and postharvest management	Nov-18
United States	Dylan Vanderberg	Male	University of Hawaii	Master's	Agricultural Economics	Dec-18
United States	Meredith Stamberger	Female	Youth-Led Horticulture Training and Services Center	Internship	Horticulture Innovation, production and postharvest management	Dec-18
United States	Brooke Stefencik	Female	Youth-Led Horticulture Training and Services Center	Internship	Horticulture Innovation, production and post-harvest management	Dec-18
United States	Bernard Sanders	Male	Rutgers University	Ph.D.	Medicinal Chemistry	Jun-19
United States	Jerry Nkhoma	Male	UNZA	Bachelor's	Plant Science	Aug-19
United States	Jessica Kanter	Female	University of California-Davis	Master's	International Agricultural Development	Sep-19
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	Emily Merchant	Female	Rutgers University	Ph.D.	Plant Biology	May-21
United States	Martin Zorde	Male	Rutgers University	Ph.D.	Plant Biology	May-21
United States	Lara Brindisi	Female	Rutgers University	Ph.D.	Plant Biology	May-21
United States	Nick Reitz	Male	University of California, Davis	Ph.D.	Food Science	May-21
United States	Lauren Howe	Female	University of California, Davis	Master's	International Agriculture Development	Jun-19
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	Jun-20
United States	Michelle Boutell	Female	University of California, Davis	Bachelor's	International Agricultural Development	Jun-20
United States	Liza Wood	Female	University of California, Davis	Ph.D.	Geography	Jun-23

United States	Marieke Fenton	Female	University of California, Davis	Ph.D.	Agricultural Economics	Jun-23
United States	Kyle Freedman	Male	University of California, Davis	Master's	International Agricultural Development	Jun-21
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

FY2019 was the final year of the Horticulture Innovation Lab's second phase. Efforts during this final year concentrated on the dissemination of proven technologies and practices designed, developed, and tested by our projects. Project activities have been translated into manuals, publications, videos, extension bulletins, and other information packages that are accessible on the Horticulture Innovation Lab's website and have been actively promoted to development institutions. A prime product example that the management entity has generated is a nine-part webinar series, the *Horticulture for Development Professional Series*, targeting in-country organizations. This series of webinars focused on professional development for researchers, student and, practitioners interested in the intersections between horticulture and international development. Webinars were regularly attended by ~50 individuals needing to increase their capacity to address the needs of smallholder horticulture farmers. Individuals who attend all nine webinars will receive a certificate, commemorating the new skills that they have gained.

The management entity-led projects have all significantly contributed to the capacity of host-country institutions. For example, the host institution of the Horticulture Training and Service Center in Guinea, Centre Régionale de Recherche Agronomique de Foulayah, will inherit the demonstration center located on its campus after their staff received training on the displayed technologies. Additionally, the DryCard project has three new entrepreneurs that will sell DryCards in Nepal, Haiti, and South Asia and provided training materials for all DryCard entrepreneurs that were then shared with their partner organizations conducting trainings on DryCard and the importance of effective drying and hermetic storage. In FY2019, the Trellis Fund project held the Trellis Fund Summit in Washington DC. Fifteen partner organization representatives from Bangladesh, Ethiopia, Ghana, Kenya, Mali, Nepal, Rwanda, Tanzania, Uganda, participated in three days of capacity building, reflection and planning for the program's future. The *Examining nutrition impacts of horticultural innovations in Bangladesh* project supported the Patuakhali Science and Technology University's (PSTU) research trials evaluating a larger capacity solar chimney dryer that will be used to dry fish and, as another example, the World Food Programme and World Fish have adopted the chimney solar dryer into other project activities in Bangladesh. Finally, students from National University of San Carlos and Mayan Technical Institute in Guatemala received project support to earn university degrees from *Promoting drip irrigation and climate resilience in Guatemala* project.

The Horticulture Innovation Lab's Demonstration Center located on UC Davis' campus is an established learning center for international visitors to the university. Humphrey Fellows, Mandela Washington Fellows, Cochran Fellows, and McCain Memorial Fellows annually visit the Center. These fellows represent future leaders of their respective countries and the lessons learned while visiting the Center have translated into solutions that are disseminated by the fellows to in-country institutions. Furthermore,

departments and entities on the UC Davis campus – Student Farm, Global Affairs, Plant Sciences, the UC Davis D-Lab – have utilized the Center for internal projects or activities.

## PROJECT INSTITUTIONAL DEVELOPMENT

- ***Building postharvest capacity in Tanzania***  
The project team at Kansas State University created a Faculty Guide that Sokoine University of Agriculture’s horticulture staff will adopt. The guide covers critical topics such as classroom management classrooms, developing engaging teaching techniques, instructing adult learners, time management, and designing syllabus and course content.
- ***Horticulture Innovation Lab Regional Center at Zamorano***  
Partnerships have formed with outside universities in which universities send students for internships at the Regional Center to acquire skills and knowledge about appropriate technologies and practices for smallholder farmers. This year, students from the Regional University Center of the West and from a German institute participated.
- ***Empowering Women through Horticulture in Honduras***  
The Asociación de Mujeres Intibucanas Renovadas (AMIR), leveraged project activities to receive funding to continue implementing the gender-integrated Farmer Field School. AMIR employed two Zamorano University graduates who had interned with the project to be facilitators.
- ***Developing farmer-led irrigation solutions in Uganda***  
The project has trained agricultural and agricultural engineering staff from local districts on proper use of the project’s small-scale irrigation technologies located at research sites in their districts. These agricultural engineering district personnel are charged with advancing small-scale irrigation in their respective districts and will incorporate the technologies.
- ***Horticulture Innovation Lab Regional Center at Kasetsart University***  
The Regional Center collaborated with Winrock Nepal, the Nepal Agriculture Research Center, and the University of Agriculture and Forestry, Nepal to develop the National Mango Learning Center hosted by the University of Agriculture and Forestry and dedicated to improving production and postharvest outcomes for mango producers in Nepal.
- ***Improving nutrition with African indigenous vegetables in Kenya and Zambia***  
The project team built the capacity of Mirror of Hope, a Kenyan-based NGO in Nairobi, by starting a sack garden project and a “train the trainer” program. Additionally, the project expanded the demonstration center at the University of Zambia (UNZA) and UNZA’s field lab practicums have used the technologies displayed at the site.
- ***Designing for horticulture development with D-Labs in Honduras and Thailand***  
Mandela fellows at UC Davis received an initial training with an online toolkit containing comprehensive manuals and presentations designed to empower in-country institutions to conduct a course based on the D-Lab methodologies. As a follow-up, the fellows have communicated with the UC Davis D-Lab to work collaboratively to develop stakeholder-driven technologies to improve outcomes for smallholder horticulture farmers. Additionally, university professors in Uruguay are participating in D-Lab toolkit training and will utilize the content and knowledge gained to improve curricula for their students.

# 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, take advantage of information communications technologies opportunities, 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's DryCard had continued success in FY2019. The DryCard was a finalist in the Elevator Pitch Contest at the 19th World Congress of Food Science and Technology in Mumbai, India in October 2019. Additionally, three new entrepreneurs joined the DryCard distribution network: R&D Innovative Solution in Nepal, the Fondation Haïtienne de Développement Agricole Durable in Haiti, and the Vivia Foundation in South Asia. A total of 30,000 DryCards have been distributed, of which 23,000 were sold. To accelerate the dissemination and adoption of the DryCard, the Horticulture Innovation Lab used an expansion approach utilized by the Purdue Improved Crop Storage program. The Innovation Lab purchased DryCards from DryCard entrepreneurs that will then be distributed at no cost to local organizations conducting postharvest trainings for farmers, boosting the entrepreneurs while increasing accessibility to and markets for the DryCard.

The management entity continued its promotion of the CoolBot cold room in several of its sub-awards, the Regional Centers, and in its projects in Bangladesh and Guinea. The Horticulture Training and Service Center in Guinea established a CoolBot cold room utilizing low-cost foam mattresses as insulation in order to determine their viability as a cheaper alternative to expensive polyethylene, aluminum plated, paneling. Early tests have been positive, and the room continues to operate. The CoolBot cold rooms installed in Bangladesh for the *Examining nutrition impacts of horticulture innovations* project are now being assessed by iDE in a market-study for fresh fruits and vegetables.

The Horticulture Innovation Lab at UC Davis' chimney solar dryer was disseminated and adopted in several countries in FY2019, including in the United States at the International Rescue Committee's New Roots Farm in Sacramento, California. In Bangladesh, the World Food Programme will introduce the solar chimney dryer to Rohingya refugees and the dryer was promoted during a Postharvest Losses Innovation Lab conference in Nepal as a solution for controlling mycotoxins in fruits and vegetables. Additionally, the management entity developed a facilitator's training manual that accompanies the chimney solar dryer

construction and use manual. Combined, these documents empower extensionists, NGOs, and government ministries to independently disseminate the technology. Furthermore, the facilitator's manual addresses the importance of drying properly, verifying dryness, and storing dried product in hermetic storage (the "Dry Chain") to confront food losses and aflatoxins.

## PROJECT TECHNOLOGIES IN PHASE 1: UNDER RESEARCH

### *Horticulture Innovation Lab Regional Center at Zamorano*

- **Zero energy cool chamber using broken tile:** Zero energy cool chamber made with tile. This chamber was created by recycling broken tiles disposed during roof repairs to the buildings at Zamorano.

## PROJECT TECHNOLOGIES IN PHASE 2: UNDER FIELD TESTING

### *Trellis round 6*

- **Biochar for horticulture crops (Ghana):** Improving soil fertility using biochar which is incorporated into the soil in Ghana. A graduate student from University of Florida assisted Tip Top Foods for the biochar trials in six crops.

## PROJECT TECHNOLOGIES IN PHASE 3: MADE AVAILABLE FOR TRANSFER

### *Developing farmer-led irrigation solutions in Uganda*

- **Input Micro Dealers:** A system of retailing agro inputs that supplies respected local farmers with small quantities of the most critical chemicals for the common vegetables in their area, which they sell to nearby farmers on a per-knapsack basis. This allows farmers to purchase only what they are going to use, and ensure high quality chemicals are available even in villages, where quality dealers are not available. Training is given to the micro dealers to understand how to use each chemical, and which problems it can be used to solve. A credit guarantee for the chemical distributor's first delivery is offered to the micro dealer, to build trust between them. After the first delivery, additional credit would be the responsibility of the distributor.

### *Improving postharvest practices for tomatoes in Burkina Faso*

- **Zero Energy Cool Chamber and Zeer Pots/Pot-in-Pot:** These simple brick and clay pot structures can help cool fresh produce inexpensively in conditions where evaporative cooling is effective.

### *Building safe vegetable value chains in Cambodia*

- **Nethouses:** Nethouses create a physical barrier to protect crops from pest damage, reduce pesticide usage and boost yield.
- **Packinghouse:** Packinghouse for aggregating products and conducting good postharvest practices to improve quality and reduce postharvest loss and improve market connections.
- **Earthworm compost research and training centers:** Multiple compost centers for testing the methodology and disseminating the research to local users have been established.
- **CoolBot:** CoolBot cold room technology was used to provide effective cooling to reduce postharvest losses and extend shelf life of fresh vegetables.

### *Managing nematodes and soil health in Guatemala*

- **Biological Controls:** The addition of fungi such as biological control agents can help to reduce the population densities of damaging nematodes. *Purpureocillium lilacinus* has been applied as a biological control agent against potato cyst nematode.
- **Compost amendment:** Addition of compost to the soil to improve soil health and increases soil fertility.

### *Investigating integrated vegetable-livestock systems*

- **Feeding Swine Breeding Herd a Mineral and Vitamin Supplement:** Breeding swine are deficient in certain dietary minerals and vitamin for optimum reproduction and milking ability. This is especially true for calcium, phosphorus, sodium, chloride and most B-vitamins. Also, diet levels of zinc, copper, selenium, manganese, iron and iodine are generally too low in feed ingredients to meet reproductive gilt and sow requirements for high reproductive capabilities. It is important that methods to increase weaned pig number are implemented that are cost effective and improve small pig farmer profitability. It has been observed that small pig farmers may or may not routinely supply a mineral and vitamin supplement for breeding swine. If they do provide to reproductive swine, it was observed no routine measured amount was given daily. Also, only a small amount was being provided under the actual recommendation of the supplement manufacturer.
- **Mineral Block Feeding for Cattle:** A method of supplying vitamins and minerals to ruminant animals is through mineral blocks, which are compressed, hard square blocks that cattle “lick” with their tongue to obtain the mineral nutrients.
- **Rice Straw Storage Technique: Tarp Covering:** Rice straw is often collected and stored after rice harvest in December through February each year. The rice straw is piled into stacks which is exposed to rain and environmental conditions. Due to time of year, the amount of rainwater that soaks into the pile can be significant causing routing of forage and decreased nutrient value as feed. Rice straw is often feed in the months of June through October. Farmers currently do not cover rice straw piles and an opportunity to improve or preserve its feed quality needs to be researched.

### *DryCard Franchise Project*

- **DryCard (India and Haiti):** The DryCard is a simple, inexpensive visual tool to test the level of dryness of dried products for smallholder farmers.

### *Trellis Round 6*

- **Organic pesticide formulation (Ghana):** The organic pesticide formulation uses local leaves such as neem leaves, bitter leaves, pawpaw leaves with a combination of bird eye pepper, onion, garlic and ginger.
- **Chimney Solar Dryer (Uganda and Nepal):** A passive solar dryer that maintains efficient drying under variable weather conditions by creating airflow utilizing a chimney covered by a plastic.
- **DryCard (Uganda):** The DryCard is a simple, inexpensive visual tool to test the level of dryness of dried products for smallholder farmers.
- **Zero Energy Cool Chamber (Uganda):** Low-cost cool storage that utilizes evaporative cooling.
- **Seedling production with coco peat as growth medium (Ghana):** This practice involves the production of seedlings from seeds sown in plastic cell trays and the use of coco peat as a growth medium.
- **Good Agricultural Practices Related to Production (peat moss as soil substrate, foliar fertilizer and planting in trays) (Rwanda):** Improved nursery bed for vegetables using peat moss as soil substrate,

foliar fertilizer and planting in trays. Additionally, use of fertilizers that are quickly assimilated by vegetables such as nitrogen phosphorous and potassium.

- **Drip kits (Uganda):** A SIRACO Kit with drip lines is installed using an elevated bucket and drip lines.

## VIII. 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 during the course of Phase II activities.

## 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 are finalizing the process of uploading links to public data repositories and directly to the DDL for close-out activities.

## 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 FY2019 we used our expertise locally as well as internationally. The Horticulture Innovation Lab assisted the International Rescue Committee in engaging their Nepali farmers with the dry chain. Researchers also used USAID’s new scaling assessment platform to do a series of analysis on current technologies, results of which are forthcoming.

## XI. ISSUES

The Horticulture Innovation Lab projects in the final year had a shortened period to operate. The activities concluded earlier than the end of the fiscal year (September 30<sup>th</sup>) due to the management entity’s need to collect and process close-out project reports (financial and research reports). Ultimately, many projects simultaneously conducted critical project activities to achieve objectives and assure sustainability while simultaneously conducted administrative activities to maintain fiscal and reporting compliance, leading to intense final months for project teams. For some projects, the delay in receiving final year funding from USAID and out to projects inhibited their ability to accomplish all their objectives.

# 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
  - 01/01/2015 – 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.