



FEED ^{THE} FUTURE

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



FEED THE FUTURE INNOVATION LAB FOR
COLLABORATIVE RESEARCH ON HORTICULTURE
ANNUAL REPORT 2015-2016



USAID
FROM THE AMERICAN PEOPLE

HORTICULTURE
INNOVATION LAB

UC DAVIS
UNIVERSITY OF CALIFORNIA

HORTICULTURE INNOVATION LAB

ANNUAL REPORT

2015-2016

OCTOBER 31, 2016

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COVER PHOTO:

Pointed gourd in a field in Bangladesh, during a postharvest training. Horticulture Innovation Lab photo by Britta Hansen.



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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 \$18.7 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 \$3.5 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
- Mark Bell, Leader of Communications and Information Transfer
- Heather Kawakami and Sara Saberi, Accounting and Fiscal Analysts
- Britta Lilley Hansen, Program Officer
- Angelos Deltsidis, International Postharvest Specialist
- Diana Puccetti, Office Management and Event Planning
- Brenda Dawson, Communications Coordinator
- 2015-16 paid and unpaid student staff: Elyssa Lewis, Emily Baker, Emily Webster, Liz Hohenberger, Anthony Phan, Elise Brockett, Jamey Smith, Owen Cortner, Mariah Cosand, and Julia Jordan
- Special projects staff: Amrita Mukherjee, Aquaculture-Horticulture for Nutrition project and Meagan Terry, MásRiego project

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:

- Detlef Virchow, Global Horticulture Initiative, Chair
- Robert Paull, University of Hawai‘i at Mānoa, Partner Representative
- Walter Bowen, University of Florida, Partner Representative
- L. George Wilson, North Carolina State University, Partner Representative
- Julio López Montes, Zamorano Pan-American Agricultural School, Regional Center Director
- Poon Kasemsap, Kasetsart University, Regional Center Director
- Emil van Wyk, AgriSmart, Regional Center Director
- Idah Sithole-Niang, University of Zimbabwe
- Bob Nanes, Massachusetts Institute of Technology, D-Lab
- Marco Wopereis, The World Vegetable Center
- Josette Lewis, University of California, Davis
- Guillermo Alvarado-Downing, GOAL Global, Market Development Initiatives
- Erik Kueneman, Global Agriculture Consultant

LOCATION OF 2015 – 2016 PROJECT ACTIVITIES

The Horticulture Innovation Lab currently works in Bangladesh, Guatemala, Honduras, Kenya, Nepal, Tanzania, Thailand, Uganda and Zambia. During the period captured by this report, we have also obligated funds to Trellis and USAID Mission service projects to be implemented in the next reporting period, located in Burkina Faso, Cambodia, Ghana, Nepal, Tajikistan, Uganda.



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; University of California, Davis; University of Florida; University of Hawai'i at Mānoa; University of Wisconsin-Madison

Bangladesh - World Fish

Burkina Faso - USAID/Burkina Faso, USAID/Sahel Regional Office

Cambodia - Agricultural Development Denmark Asia, Royal University of Agriculture (RUA), Green Shoots Foundation, Community-based Integrated Development Organization

Ghana (Trellis only) – Council for Scientific and Industrial Research, Crops Research Institute

Guatemala - Catholic Relief Services; Universidad Rafael Landívar, Zamorano University, The Barbara Ford Peace Center (CPBF); Universidad de San Carlos de Guatemala

Guinea – USAID Mission, Winrock

Honduras - Panamerican Agricultural School, Zamorano University; Fundación Hondureña de Investigación Agrícola

India - Professor Jayashakar Telangana State Agricultural University

Kenya – Academic Model Providing Access to Healthcare (AMPATH) 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

Nepal – Center for Agriculture Research and Development-Nepal; International Development Enterprise (iDE); Himalayan Pearl Enterprise

Rwanda – Ministry of Agriculture and Natural Resources, University of Rwanda, National Agriculture Export Development Board, Rwanda Agriculture Board

Taiwan – The World Vegetable Center

Tajikistan – USAID/Tajikistan

Tanzania – AVRDC – The World Vegetable Center; Horti-Tengeru

Thailand – Kasetsart University; Rhino Research

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

Zambia – AgriSmart; University of Zambia

ACRONYOMS

ADDA: Agricultural Development Denmark Asia

AIARD: Association for International Agriculture and Rural Development

AIV: African Indigenous Vegetable

AMPATH: Academic Model Providing Access to Healthcare

ANR: Agriculture and Natural Resources

AOR: Agreement Officer's Representative

ASHS: American Society for Horticultural Science

AVRDC: The World Vegetable Center

BEO: Bureau Environmental Officer

BMP: Best Management Practices

CA: Conservation Agriculture

CA&ES: College of Agricultural and Environmental Sciences

CGIAR: Consultative Group on International Agricultural Research

CIRAD: Agricultural Research for Development

CPBF: The Barbara Ford Peace building Center

CRSP: Collaborative Research Support Program

DAI: Development Alternatives Incorporated

DDL: Development Data Library

EFN: Eco-Friendly Net

EMMP: Environmental Management and Mitigation Plan

FTFMS: Feed The Future Monitoring System

GRIT: Gender Research and Integrated Training

HORTI-Tengeru: Horticultural Research and Training Institute

HVC: Horticultural value chain

IAB: International Advisory Board

iDE: International Development Enterprise

IDIN: International Development Innovation Network

INTECAP: Technical Institute for Productivity and Training

IPM: Integrated Pest Management

IRB: Institutional Review Board

KALRO: Kenyan Agriculture and Livestock Research Organization

LWSST: labor, water and soil saving technologies

MELP: monitoring, evaluation, and learning plan

MOU: Memorandum of understanding

MSP: Mission Service Project

NCA&T: North Carolina Agricultural & Technical State University

NGO: Non-Governmental Organization

NRDC: Natural Resource Development College

PI: Principal Investigator

PTSC: Postharvest Training and Service Center

SIIL: Sustainable Intensification Innovation Lab

QA: Quality assurance

RFP: Requests for Proposal

RISE: Resilience in the Sahel-Enhanced

RUA: Royal University of Agriculture

SANREM: Sustainable Agriculture and Natural Resources Management

SIIL: Sustainable Intensification Innovation Lab

TEWDI: Teso Women Development Initiatives

UC: University of California

UNZA: University of Zambia

USAID: U.S. Agency for International Development

VCA: Value Chain Analysis

WagN: Women in Agriculture Network Project

WHIP: Western Highlands Integrated Programs

YPARD: Young Professionals for Agricultural Development

ZECC: Zero Energy Cool Chamber

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I. EXECUTIVE SUMMARY

The Horticulture Innovation Lab management entity at the University of California, Davis manages a portfolio of nine projects, three Regional Centers and two Buy-Ins during FY2016. Our program was active in Africa (Guinea, Kenya, Rwanda, Tanzania, Uganda, Zambia), Southeast Asia (Bangladesh, Cambodia, Nepal, Thailand) and Central America (Guatemala and Honduras), with a Trellis Project in Ghana. Projects underway focus on making the case for horticulture for nutrition, understanding gender constraints in horticulture systems, identifying and promoting adoption of appropriate postharvest technologies to reduce produce losses, conservation agriculture for vegetable production, introducing grafted tomato seedlings, testing irrigation solutions for small-scale farms, and introduction of drip irrigation. We are also working to scale two technologies, drying beads and insect barrier nets, with some early success with scaling of drying beads in Bangladesh. Recently awarded projects will focus on nematode control in Guatemala and production of safe vegetables in Cambodia.

Our program collaborated with several other Innovation Labs during the past year. We have a joint project with the Nutrition Innovation Lab funded by USAID Bangladesh, and also collaborate with the Sustainable Intensification Innovation Lab (Cambodia), Integrated Pest Management Innovation Lab (Cambodia and Nepal), and the Small Scale Irrigation Innovation Lab (Uganda). The Horticulture Innovation Lab also collaborates extensively with the World Vegetable Center through many of our research projects. The World Vegetable Center is a key partner providing improved germplasm of African indigenous vegetables, tomatoes, and expertise in vegetable seedling grafting. We also collaborated with the World Vegetable Center, Tanzania to improve the postharvest infrastructure at HORTI-Tengeru.

The Horticulture Innovation Lab has also actively collaborated with USAID Missions, even more than usual during the past year with our Mission Service Projects RFP. Missions were encouraged to submit ideas for small research projects that would benefit their value chain projects. Two projects were selected and we worked collaboratively with the Missions in Burkina Faso and Tajikistan to develop the RFPs. In addition, we were pleased to launch our new Buy-In project from USAID Guatemala, MasRiego, which developed out of our report, Advancing Horticulture in Central America, an assessment of constraints to horticulture sector growth in Central America, funded by the USAID Bureau for Latin America and the Caribbean. This assessment highlighted the need for irrigation solutions for smallholder farmers.

Our Regional Centers in Thailand and Honduras have increased their regional impact and have leveraged their funds from the Horticulture Innovation Lab. For example, the Center at Kasetsart University was awarded a leading role in a large USAID Regional Development mission for Asia project led by Winrock. Kasetsart University will manage approximately \$500K to scale a number of technologies relevant for smallholder farmers in Southeast Asia, including at least one technology developed by the Horticulture Innovation Lab. The Regional Center at Zamorano is part of a large Government of Honduras led program to improve the current extension system in that country. Our third regional center is under development in Zambia and will launch in February 2017.

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 FY2016

Successes. The Horticulture Innovation Lab successfully launched “MásRiego”, a \$3.5 million buy-in award from USAID/Guatemala. The project represents a collaboration with the Western Highlands Integrated Programs, Centro de Paz Bárbara Ford, Panamerican Agricultural School Zamorano, Kansas State University, and North Carolina Agricultural & Technical State University. Objectives of the four year initiative include increasing knowledge of conservation agriculture practices to 9,000 farmers, increasing business capacity by local youth, and converting 100 hectares of land in the departments of Quiché, Quetzaltenango and Totonicapán in drip irrigation and improved water management practices, as well as resiliency to climate change.

On World Food Day 2015, The Horticulture Innovation Lab held the official grand opening of its UC Davis demonstration center. More than 100 people attended the event, with speakers including Congressman Ami Bera and Helene Dillard, Dean of the College of Agricultural and Environmental Sciences. The center will be used to test new varieties and technologies and to increase awareness of important fruits and vegetables in Africa, Southeast Asia, and Central America.

Challenges. The slow start of project has been a reoccurring challenge as the Horticulture Innovation Lab has worked to award research funds in a sound, competitive manner. The management entity has addressed over optimistic timelines with more realistic projections based on past experience.

DESCRIPTION OF EXPECTED FY2017 ACTIVITIES

The Horticulture Innovation Lab will solicit for project proposals in several areas this year. We will make awards focused on postharvest, integrated pest management, food safety, and integrated animal-horticulture systems. Projects in Tajikistan and Burkina Faso will also be awarded to serve value chain development of horticulture crops identified as important by the USAID country mission. Also, Trellis Projects return in FY2017 with nine students traveling to Cambodia, Ghana, Kenya, Nepal, and Uganda.

See Appendix C for full list of expected FY2017 Awards

III. KEY ACCOMPLISHMENTS

FY2016 PERFORMANCE

The Horticulture Innovation Lab began the second phase by funding major research projects focused on nutrition and gender equity, as well as the scaling of technologies and techniques found to be successful in previously funded research. During the past year, we also funded a major postharvest project in Rwanda that will investigate constraints in four value chains that lead to postharvest losses and test interventions to reduce these losses. During the past two years we have seen promising results emerge from these projects and project teams actively engaged with nearly 800 farmers, development practitioners, and others who benefited directly from U.S. government assistance.

- **Increased income:** From data of 60 farmers in Cambodia, it is evident that farmers can earn income from small 100 m² commercial vegetable home garden plots. If sustainably intensified, earnings went as high as \$500 per year per 100 m².
- **Better nutrition:** Findings indicate that amaranth, an African indigenous vegetable, is reliable as a rich source of magnesium and calcium.
- **Applied research:** 473 farmers applied improved technologies or management practices with US Government assistance. Half of these farmers using new practices are women.
- **Increased conservation:** Farmers in Cambodia are increasing the amount of their land under conservation agriculture for vegetable production.
- **Adoption of improved technologies:** Three large seed companies in Bangladesh have adopted drying bead technology for drying their vegetable seeds.
- **Lesson learned:** Time and money saved by having access to irrigation and growing more crops can lead women to adopt other forms of income generating activities and enterprises.
- **Long term trainees:** Our program trained 3 postdoctoral associates and 31 students, including 10 Bachelor, 15 Masters and 7 PhDs. Fifty percent of the students were female.
- **Short term trainees:** Horticulture Innovation Lab researchers also provided short-term training to 954 individuals
- **New technology:** Research included field testing or scaling of 130 new technologies (including seed varieties) and also increased dry storage for seeds by 9,201 cubic meters.

IV. RESEARCH PROGRAM OVERVIEW AND STRUCTURE

SUMMARY

For the past seven years, a collaborative team lead by UC Davis, has managed the Horticulture Innovation Lab (formerly Horticulture CRSP), with the mission of building international partnerships for fruit and vegetable research to improve livelihoods in developing countries. Currently in entering Year 3 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 HORTICULTURAL RESEARCH

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

TECHNICAL LEADERSHIP

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

OBJECTIVES/PILLARS IN PHASE II

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

Horticultural value chain research. We support research projects along the entire horticultural value chain. In the upcoming year, we will work on special projects of interest to the USAID Mission Value Chain projects.

Innovation and scaling. We work with our projects and the Regional Centers on the dissemination and scaling of innovative horticultural technologies. In addition, we have funded one project specifically focused on scaling technologies from Phase I projects and are conducting research on the business case to scale two other technologies (research to be funded in FY2016).

Capacity building. We build the capacity of researchers, institutions, students, and other actors in the horticultural sector worldwide. Capacity building is integrated into all Horticulture Innovation Lab activities. We have funded our Trellis program for one round during this period.

Nutrition sensitive horticulture. All of our research projects are nutrition sensitive and we will fund one project on nutrition by the end of this year. At the end of Phase II, we aim to be a thought leader in nutrition and horticulture.

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 will issue six types of Requests for Proposals (RFPs) during Phase II, each with a different scope and focus. All RFPs will aim to be competitive, and applications will be evaluated by a combination of management entity and external reviewers. In cases where a call for proposals does not result in adequate candidates the management entity will seek exceptional candidates and work with stakeholders to develop the best proposal. Most proposals must be collaborations between a U.S. university researcher 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 spin-off and scaling-up projects for scaling of Phase I technologies and to address new research needs identified in Phase I. We also have expanded our project portfolio to include three opportunistic technology projects, a nutrition project with the Nutrition Innovation Lab led by Tufts University, a \$3.5 million mission-buy in with USAID/Guatemala to implement and evaluate new irrigation systems, and finally, ongoing support on value chain analysis and postharvest work with USAID/Guinea.

In FY2017, we will fund two Mission service projects, one in Tajikistan focusing on postharvest practices for dried apricots, and another in Burkino Faso focusing on best practices and marketing of tomatoes (both at \$300,000 over two years). Additionally, we will fund four focus projects on postharvest, integrated pest management, food safety, and integrated animal-horticulture systems, at the beginning of year three (four 2.5-year projects, \$375,000-\$450,000 each). The Horticulture Innovation Lab has designated nine Trellis projects that will be implemented in FY2017.

REGIONAL CENTERS

The Regional Centers at Zamorano University in Honduras and at Kasetsart University in Thailand were originally envisioned to be test sites for Horticulture Innovation Lab and local technologies and while still valuable partners to the management entity, the Regional Centers have become hubs of information and research responsive to their own communities' needs. The Regional Center at Zamorano is now considered in most agriculture and health request for proposals sent out by the USAID mission and is aiding in an effort to re-build the national extension service with the Honduran government. The Regional Center at Kasetsart University was recently awarded \$500,000 to collaborate with Winrock on the "Feed the Future Asia Innovative Farmers Activity", a four year USAID project to address targets food security,

poverty reduction, and improved nutrition. In early 2017 a new Regional Center in Zambia will hold a launch event to kick of their new partnerships and activities.

In the coming years the management entity will focus on continuing to build the capacity and sustainability of these successful initiatives.

V. RESEARCH PROJECT REPORTS

A. MAJOR PROJECTS

EMPOWERING WOMEN THROUGH HORTICULTURE IN HONDURAS

- 1) **Location:** Intibuca, Honduras
- 2) **Principal Investigator:** Janelle Larson, The Pennsylvania State University
- 3) **Description:** Women in Agriculture Network Project (WAgN) in Honduras seeks to understand how the horticultural value chain can be a mechanism to support equity and empowerment for women, those who are landless or land-poor and other marginalized populations. Project will identify technologies, institutions and policies that facilitate small-scale farmers producing horticultural products to improve their household nutrition and enter the local, regional and international horticultural markets, as well as other opportunities in the horticultural value chain for entrepreneurs and wage laborers. To achieve this, the project will carry out a gendered analysis of the horticultural value chain in Honduras, including access to inputs, production, packaging and processing. We shall also identify barriers women and others face in access to credit, technical assistance, use of technologies, and access to markets. As it is becoming vertically integrated, the structure of the market that producers face will be analyzed to determine how women and other small farmers can best negotiate price and risk mitigation. To complement this value chain analysis, we shall identify policies and regulations as well as cultural norms that limit the participation of women in the horticultural value chain. Using these findings, we shall partner with local NGOs, microfinance intuitions and women's organizations to develop and deliver appropriate training, technologies and financial tools to producers, NGOs, private enterprises, and research institutes.
- 4) **Collaborators:**
 - Tuskegee University, USA
 - Zamorano, Honduras
- 5) **Achievements:**

Objective 1: Increase the nutritional status and income for poor households in the Feed the Future target region through increased women participation in the horticultural value chain.

- **Focus Groups:** In the first nine months, the project conducted 10 focus groups with six producer organizations in the Western Highlands. In November of 2015, an additional three focus groups with two organizations were held. Two tools of social analysis were used in these focus groups: social domain analysis to understand participants' perception of themselves and their relationships with other actors, and causal dynamics, to understand participants' perception of barriers to participation in various levels of the HVC. Findings from this analysis informed development of the questionnaire used in the household surveys later in the year.

- **Network analysis of the potato value chain in Intibucá:** A focus group was conducted with officers from three producer organizations and one micro-finance organization in Intibucá in March. A net-mapping exercise was done to identify key actors in the potato value chain, the exchanges among them, and their power relationships. Discussions showed that women are most active in selecting, washing and packaging processes while men are responsible for production.
- **Key informant interviews – constraints in credit markets for women:** A review of the literature as well as key informant interviews in the first year of the project had indicated that many small producers in the zone are credit constrained. A Penn State faculty member, Dr. Anouk Patel-Campillo, spent two weeks in June conducting key informant interviews with institutions that provide credit or other financial services in the region to identify specific constraints for women. A total of eight interviews were conducted. Dr. Patel-Campillo has since left The Pennsylvania State University and taken a faculty position at the London School of Economics. This work will be helpful in informing future fieldwork, analysis of our survey data, and the development of programming.
- **Household surveys:** A key achievement of this program year was initiation of household surveys. This entailed developing a sampling framework, writing the questionnaire, obtaining Institutional Review Board (IRB) clearance and deploying the survey.
- **Six enumerators (four women and two men) were hired** and trained in early August. They, along with research associates Alfredo Reyes and Hazel Velasco, pretested the survey in Intibucá and started the household surveys in late August. As of 30 September, 450 individuals in 240 households have been interviewed in the departments of Ocotepeque and Copán.

Objective 2: Identify and disseminate appropriate technologies for women's greater participation in the horticultural value chain.

- **Preliminary field assessment:** A Pennsylvania State University graduate student in plant pathology with a dual-title in International Agriculture and Development visited Zamorano in March 2016 to identify existing resources and needs for production manuals for the planned Farmer Field Schools. She learned about the current research and outreach being conducted through the Horticulture Innovation Lab Regional Center at Zamorano, as well as the challenges growers in Honduras face in terms of losses due to insects and diseases. Using this information, she will help draft production manuals for onion, tomato, pepper, carrot and lettuce production. She identified needs in pest identification and management and will suggest technologies and practices to address these issues.

Objective 3: Build capacity in local agricultural institutions and NGOs as well as international universities and research institutes in gender sensitive value chain analysis and sustainable intensification.

- **Undergraduate internships:** The WAgN-Honduras grant funded undergraduate research projects of four students of the department of Agribusiness at Zamorano. The students did their fieldwork from January until March in the department of Intibucá in western Honduras (8 weeks), followed by a visit to Penn State University in April to analyze and present their data to the project team (4 weeks). Two research projects had as a goal to analyze the institutional capacity of two local women's organizations. Both organizations have been promoting the integration of indigenous women in economic activities/value chains such as the production of coffee and horticulture crops. The other two research projects studied the participation and role of women in two horticulture value chains (carrots and tomatoes). Both

value chains are managed by small farmers' organizations in the region and mainly dominated by men. The findings obtained from the research projects have been used by the students for their undergraduate theses. The information will also be used as input for future publications by the project personnel.

Capacity building: The project funded four Zamorano interns that conducted research and analysis on institutional capacity and tomato and carrot value chains from a gender perspective. The students spent eight weeks in the fields and then eight weeks at Pennsylvania University.

- 6) **Lessons Learned:** Producer organizations play a critical role as intermediaries between producers and the market, including input suppliers, financiers, and retailers. They also sometimes implement community development projects designed by national and international NGOs. However, these organizations are dominated by men and rarely consider the needs of women associates or community members in the design and implementation of their programs. This reinforces traditional gender roles and power inequities both in the household and the community. Gender sensitization program for these organizations will be key in later years of the project

7) **Presentations and Publications:**

- Presentations:
 - Castellanos, Paige, Elisabeth Garner, Leif Jensen, and Janelle Larson. "Las practicas del proyecto interdisciplinario 'Red de Mujeres en Agricultura: En Honduras.'" Primer Congreso Latinoamericano de Investigación y Educación Superior Interdisciplinaria. Montevideo, Uruguay, September 2016.
 - Jensen, Leif, Carolyn Sachs, Janelle Larson. 2016. "Gender and Horticulture: Deeper Consideration and Next Steps." Presented at the Horticulture Innovation Lab annual meeting, Siem Reap, Cambodia, March 2016.
 - Larson, Janelle, Leif Jensen, Arie Sanders. 2016. "Women in Agriculture Networks: Honduras." Lightning Talk presentation at the Horticulture Innovation Lab annual meeting, Siem Reap, Cambodia, March 2016.
- Working Papers:
 - Reyes, Alfredo and Hazel Velasco. 2016. "Focus Group Report."
 - Reyes, Alfredo, Hazel Velasco y Arie Sanders. 2016. "Análisis de Red Social de la Cadena de Papa en Intibucá, Honduras."

IMPROVING NUTRITION WITH AFRICAN INDIGENOUS VEGETABLES (AIV) IN KENYA AND ZAMBIA

- 1) **Location:** Eastern province, Zambia; Western and Rift Valley Regions, Kenya
- 2) **Principal Investigator:** James Simon, Rutgers, the State University of New Jersey
- 3) **Description:** The goal of this program is to improve the production of, and increase access and consumption of AIVs in communities in Kenya and Zambia as an effort to improve nutrition, income and health outcomes of people at risk for malnutrition.
- 4) **Collaborators:**
 - Rutgers University, USA
 - Purdue University, USA
 - AgriSmart, Zambia
 - Moi University, Kenya
 - University of Eldoret, Kenya
 - World Vegetable Center, Tanzania.

5) **Achievements:**

Objective 1: Identifying key determinants linking horticulture with improved nutrition: Evaluate whether the intervention program has increased access to and consumption of AIVs among producers and consumers within select communities of Kenya and Zambia.

- **Analyzed economic surveys in Zambia:** Surveys on AIV producers and intermediaries that were completed in Zambia have been analyzed, data quality control checked and final reports as planned are now being prepared from these two baseline surveys. In Zambia which consisted of 75 intermediaries and 300 producers surveyed: 50 in Lusaka (central Zambia), and in the Eastern province with 50 in Chipata, 75 in Lundazi, 75 in Petauke, and 50 in Katete, Zambia. These baseline results will inform our strategies moving forward.
- **Analyzed economic surveys in Kenya:** Surveys on AIV producers and intermediaries that were completed in Kenya have now been analyzed, data quality controlled checked from 82 intermediaries and 301 producers from Western and Rift Valley regions, respectively, in Kenya. Results of these surveys to contribute to our future plans for production intervention strategies.

Objective 2: Linking horticulture with improved nutrition through AIVs: Promote and expand availability of AIVs at the local level and improve market access for producers of AIVs.

- **Final survey completed:** Following the two pilot surveys on consumption (50 surveys conducted in both Zambia and Kenya) on the dietary diversity and AIV consumption by households which were conducted in Y1Q4 in both Zambia and Kenya, the results and questions faced by the enumerators led to subsequent revisions for both the Kenyan and Zambian surveys, to improve clarity, minimize/eliminate redundancy and further strengthen the questionnaires. The consumer surveys were revised, agreed upon by all project partners,

submitted for institutional review and, as with all our surveys, received IRB approval for the updated and final survey version.

- **Surveys have commenced:** With the IRB approval of the final survey, surveys have commenced in both Zambia and Kenya and are expected to reach our target of 500 households by Y2Q4.
- **Draft extension guides:** Developed drafts of extension guides on seed production for amaranth, spider plant, and African eggplant to be used as part of production intervention.
- **New varieties being tested:** Two new varieties of nightshade (Ex- Hai, BG-16), two new varieties of amaranth (Ex-Zim, AC 38) and two new varieties of spider plant (PS,ML-SG-29) under are now undergoing distinctive, uniformity and stability (DUS) tests in collaboration with Kenya Plant Health Inspectorate Services (KEPHIS) to be certified as varieties to be made available commercially in Kenya. This work is led by Kenyan Agriculture and Livestock Research Organization (KALRO) and is being done to properly introduce new and improved AIVs through national screening and evaluations. Such an accomplishment can significantly facilitate increased access to these AIVs and improved germplasm.

Objective 3. Verify best management practices (BMP) for and measure production of high quality AIVs while building capacity of smallholder farmers and improving access to AIVs

- **Establishment of demonstration site in Turbo, Kenya.** An approximately 0.5ha plot was fence-enclosed and equipped with drip irrigation, raised beds, a vermicomposting unit for production of soil amendments, and an affordable solar dryer was built. Soil was sampled and analyzed by Nuts4Crops in Nairobi, Kenya.
- **Protocols established:** Revised the field protocols created in Y1 for establishing, conducting and implementing the AIV variety trials and other field work to allow for direct comparison between agroecological zones across the lines provided by World Vegetable Center and Rutgers University. Created and implemented a protocol for monitoring common insect pests found on AIV cultivars.
- **Establishment of demonstration site in Lusaka, Zambia.** An approximately 0.2 ha plot, previously fence enclosed, has had its irrigation system rehabilitated and expanded, raised beds constructed and soil tested. This site is serving to conduct limited variety trials of lines from World Vegetable Center and Rutgers University AIVs for horticultural performance and nutritional content as well as for trials to test agronomic practices. Results will be used as part of recommendations implemented in production intervention activities.
- **Variety and nutrition testing:** A separate variety trial was conducted and completed by the World Vegetable Center with amaranth, spider plant, and nightshade, horticultural traits have been recorded, plant samples were freeze-dried and shipped to Rutgers University where nutritional and phytochemical analysis is underway.

Objective 4: Evaluate the nutritional composition of fresh and processed AIVs

- **Nutritional analysis conducted:** Nutritional analysis for nightshade, amaranth, and spider plant samples from the World Vegetable Center, Tanzania, have been completed for quantifying content of provitamin A (based upon beta-carotene), vitamin E (based upon toopherols), total phenols, total antioxidants, and elemental micronutrients. Methods to quantify anti-nutritives specific to nightshade have been validated and will be expanded to include incoming samples from each partnering country.

- **Nutritional analysis conducted:** Analysis of moringa samples from Zambia were conducted. Samples of amaranth, spider plant, nightshade, and Ethiopian mustard have been shipped from Kenya and nutritional analysis has commenced. A key goal is to identify those AIVs which data indicates could be classified as nutrient rich. The requisite nutritional data to achieve this goal this is being collected now based upon the field work being conducted in this project.
- **Results submitted:** Results of multiple amaranth trials on horticultural and elemental micronutrient content have been analyzed and submitted in manuscript form to the *Journal of American Society of Horticultural Science*. Findings indicate that amaranth (independent of specific germplasm/population evaluated) is reliable as a rich source of Mg and Ca, but variable for Fe, and not a rich source for Zn.
- **Draft extension materials:** Draft guidelines for farmers are being prepared for the production of AIVs. These guides will contain recommendations for farmers in each location based on reliability to deliver key nutrients in addition to standard horticultural productivity.

6) Lessons Learned

One of the primary lessons learned this year is the need to perform pilot surveys and data analysis. The feedback that was provided from our in-country partners on the ground, and from the initial data analysis allowed the project team to create more meaningful and useful survey instruments, especially for the household surveys. Additionally, nutritional analysis of different varieties across multiple trials was shown to be a necessary screening activity to characterize for nutrition content, as per findings submitted in Byrnes et al. manuscript.

Another lesson has come from successful collaboration around nutrition; by expanding on the primary activities of this Horticulture Innovation Lab project, new funding opportunities have been successfully applied for.

7) Presentations and Publications

- Presentations
 - 2016. Hoffman, D. Seminar delivered at University of Sao Paulo Brazil 4/16 “Interdisciplinary Research in Nutrition and Development”
 - 2016. Hoffman, D. “Poor growth and metabolic consequences”. Presented a seminar at Moi University, Eldoret Kenya, 10/16.
 - 2016. Simon, J.E. “Improving Income and Nutrition of Smallholder Farmers in Eastern Africa using a Market Driven Approach to Enhance Value Chain Production of African Indigenous Vegetables”. Presented a seminar on the AIV nutrition project at the annual Horticultural Innovation Lab, March 13, 2016, Siem Reap, Cambodia
 - 2016. Simon, J.E. “Using Agricultural Development for Social Economic Justice: Using Horticulture as a Vehicle for Income Generation and Nutritional Improvement: Case studies from Sub-Sahara Africa”. Presented an invited lecture to Princeton University, STEP seminar.
 - 2016. Simon, J.E. “Value of Medicinal Plants-What is the Evidence?” Invited presentation at the Royal Academy of Cambodia, March 18, 2016, Phnom Penh, Cambodia
 - 2016. Simon, J.E. “Horticulture for Social Justice: Using Horticulture as a Vehicle for Income Generation and Nutritional Improvement in Sub-Sahara Africa” University of Minneapolis, Kermit Olson Memorial Lecture, February 13, 2016.

- 2016. Bowman, J. Improving Income and Nutrition of Smallholder Farmers in Eastern Africa Using African Indigenous Vegetables. Presentation given at the Multi-sectoral nutrition strategy, global learning and evidence exchange, June 21-23, 2016, Bangkok, Thailand. Presentation content co-prepared by J. Simon, S. Weller, D. Byrnes and D. Hoffman.
- 2016. Simon, J.E. “Improving Income and Nutrition of Smallholder Farmers in Eastern Africa using a Market Driven Approach to Enhance Value Chain Production of African Indigenous Vegetables”. Presented invited seminar at the SEAVEG 2016 World Vegetable Center hosted symposium and the USAID Horticulture Review and Strategy Meeting, Putrajaya, Malaysia, September 08, 2016. Presentation content co-prepared by Simon, J.E., S. Weller, R. Govindasamy, D. Byrnes, and D. Hoffman.
- 2016. Gohole, L.S., S.A. Omasaja, J.S. Yaninek. Composition and abundance of insect pests of African indigenous vegetables in western Kenya. Oral Presentation, ICE 2016 XXV International Congress of Entomology, Orlando, Florida, USA, September 25-30, 2016.
- Publications
 - 2016. Ayua, E., V. Mugalavai, J. Simon, S. Weller, P. Obura and N. Nyabinda. Comparison of a Mixed Modes Solar Dryer to a Direct Mode Solar Dryer for African Indigenous Vegetable and Chili Processing. *J. Food Processing and Preservation* (in press).
 - 2016. Ayua, E., V. Mugalavai, J.E. Simon, S. Weller, P. Obura and N. Nyabinda. Ascorbic acid content in leaves of Nightshade (*Solanum* spp.) and spider plant (*Cleome gynandra*) varieties grown under different fertilizer regimes in western Kenya. *African J. of Biotech* 15(7):199-206.
- Submitted
 - 2016. Hoffman, D, T. Cacciola, P.L. Barrios and J.E. Simon. “State of Childhood Nutrition in Kenya and Zambia”. *Journal of Nutrition, Population, and Health* (submitted). This paper reviews the current nutritional state of children in both Kenya and Zambia and was prepared to contribute to our base-line understanding of their nutritional state.
 - 2016. Byrnes, D., F. Dinnsa, S. Weller and J.E Simon. “Elemental Micronutrient Content and Horticultural Performance of Various Vegetable Amaranth Genotypes”. *Journal of American Society of Horticultural Science* (submitted). The main findings are that amaranth can be selected for elemental micronutrient content at high-source levels for three of the most commonly deficient: Fe, Ca, and Mg.
 - 2016. Silvia Ajaa Omasaja – Occurrence and abundance of insect pests of different African indigenous vegetables under different variety and fertilizer treatments and different seasons. Masters thesis, University of Eldoret, 2016 (submitted now pending final approval)

EVALUATING POSTHARVEST LOSSES AND EFFECTIVE INTERVENTIONS IN RWANDA

- 1) **Location:** Kigali, Mulindi and Rubrizi, Rwanda
- 2) **Principal Investigator:** Gurbinder Singh Gill, Agribusiness Associates

- 3) **Description:** This project is aimed at increasing food security in Rwanda, by understanding and identifying the most efficient ways to reduce postharvest losses. The three main objectives of this project are
- Gain understanding of postharvest losses, constraints and opportunities in the six identified horticultural crop value chains;
 - Determine the benefits of introducing postharvest practices and technologies through various institutions; and
 - Build entrepreneurial capacity in stakeholders across the value chain.

Under the first objective, we will test three different assessment methodologies for postharvest losses. The selected methodology will include qualitative and quantitative analyses and will be complemented with environmental analysis to provide an additional lens into postharvest losses. We will make recommendations on how to reduce postharvest losses and test these recommendations through experiments at three sites where we will set up Postharvest Training and Service Centers (Objective 2). The intervention plan will be vetted by an Industry Council, so that the project is market-led. The intervention plan will also be reviewed by the Steering Committee, which will ensure that the most up-to-date postharvest technology and tools are used and all local stakeholders are involved in the decision making process. The project will train graduate students in postharvest education, research and extension practices. Through this approach, we will not only build postharvest capacity in Rwandese agronomists, but also have research on what is the best way to replicate the Postharvest Training and Service Centers as we are testing these centers across three diverse stakeholders (University – University of Rwanda, Government – Ministry of Agriculture and Animal Resources, private trade - National Agriculture Export Board). Under the third objective, the project will work with farmers and small horticultural business owners to develop their agri-businesses and entrepreneurial capabilities through adopting a strategic business approach and will convene a postharvest/agri-business competition. Overall, our 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.

4) **Collaborators:**

- Duke University, USA
- The Postharvest Education Foundation, USA
- University of Rwanda, Rwanda
- Ministry of Agriculture and Animal Resources, Rwanda
- National Agriculture Export Board, Rwanda

- 5) **Achievements:** *Note: This project began 8/1/2016.* The initial meeting of the Steering Committee took place in August 2016. The project is currently conducting its first set of postharvest loss assessments on tomatoes and bananas using three methodologies – commodity systems assessment methodology, value chain analysis and environmental life cycle assessment, and setting up MOUs with the University of Rwanda, Ministry of Agriculture and Animal Resources, and the National Agriculture Export Board.

B. SCALING-UP AND SPIN-OFF PROJECTS

SCALING UP DRYING TECHNOLOGIES FOR SEED IN BANGLADESH

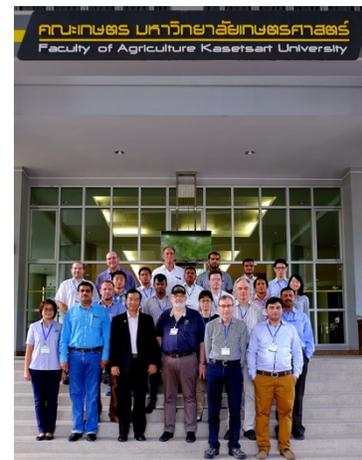
- 1) **Location:** Bangkok and Phichit, Thailand; Dhaka, Bangladesh
- 2) **Principal Investigator:** Johan Van Asbrouck, Rhino Research
- 3) **Description:** The goal of this project is to create the foundation for spontaneous diffusion and large-scale adoption of advanced drying technologies in Bangladeshi agriculture. Drying in the hot, humid climate of Bangladesh, as with much of South and South East Asia, poses a significant challenge to seed production and agricultural processing. Traditional sun drying and dry room/cold storage methods lead to a rapid deterioration of the quality of agricultural outputs and especially seeds, resulting in large postharvest losses and susceptibility to mold, fungal and insect infestations. Bangladeshi seed companies estimate that they lose 5-10% or more of their seeds due to poor drying, worth tens of millions of dollars in horticultural seeds alone. The high cost and unreliable quality of improved, high-yielding, stress-tolerant seed varieties are major factors that cause less than half of Bangladeshi farmers buy commercial horticultural seeds; an even lower share buy commercial cereal seeds. In addition, insufficient drying of agricultural products leads to rapid deterioration after harvest and often development of aflatoxins within the products.

This project addresses the challenges of drying seeds and commodities in hot, humid climates by scaling up the Dry Chain concept for horticultural seeds and commodities that was conceived and developed through the prior Seed Systems project funded by the Horticulture Innovation Lab. It will do so by promoting the commercial adoption of Drying Beads technology in Bangladesh for both seeds and processed food products. The theory of change is that by getting the major Bangladeshi seed production and agricultural processing companies to adopt this technology, it will diffuse through commercial channels throughout those two sectors, and eventually to smallholder farmers. Indeed, several of the target companies have already approached Rhino Research/Centor Thai about manufacturing drying containers and becoming exclusive dealers for Drying Beads technology in Bangladesh. If efforts under this project to develop a viable business model to provide drying services to smallholder farmers are successful, diffusion to smallholder farmers will be much more rapid.

- 4) **Collaborators:**
 - University of California, Davis, USA
 - Professor Jayashakar Telangana State Agricultural University, India
- 5) **Achievements:** The specific aim of the project is to demonstrate the effectiveness of drying beads technology in decreasing seed and processed product losses and improving product quality and longevity, i.e. the business case for Dry Chain technology. Following are the brief details of achievements made in accordance to the project objectives:
 - **Memorandums of understanding (MOUs):** In order to achieve our goal, MOUs had been signed with various Bangladeshi organizations that include viz. Lal Teer Seed Ltd, Getco Agro Vision, Metal Seed Ltd and Development Alternatives Incorporate (DAI). Under the signed MOUs, they were offered complete hands on training on the use of modern drying

technologies and their key quality control people have been fully trained. As a result, they have completely adopted the drying beads technology and are getting excellent results at their localities. Many other organizations including government research agencies, seed and food processing companies are showing keen interests to join the project by next year.

- **Trainings:** Bangladesh has diverse agro and food processing industries. The spontaneous diffusion of drying beads technology into these industries was only possible by training their key quality control people which are now training their staff working under their supervision.
 - **1st Training**, November 27, 2015 at Kasetsart University, Bangkok, Thailand. The topic of the training module was ‘Seed Longevity, Drying and Storage’ and the contents of the module were ranging from basics to the medium level of understandings. It was an intensive training that focused on learning of the basic rules of safe seed drying and storage. All the participants showed keen interest in theoretical leanings and practical demonstrations.
 - **2nd Training**, February 27 to March 03, 2016 at Rhino Research Technologies, Phichit, Thailand **and 3rd Training**, May 15-20, 2016 at Rhino Research Technologies, Phichit, Thailand. Both above mentioned training programs focused on the practical part of the project implementation. Participants learned about the seed moisture calculation, relationship between relative humidity and seed moisture contents, use of various desiccants, comparison of drying beads with other desiccants and many others.
 - **4th Training**, September 19-22, 2016 at Hotel Dhaka Garden Inn, Banani, Dhaka, Bangladesh. This training included the whole year wrap up and was organized in Dhaka, Bangladesh. Co-PI of the project (Dr. Keshavulu) also joined the event and trained participants. Besides our core organizations, two other major seed companies, one NGO and the Seed Association of Bangladesh also joined this event. The training was highly successful; participants shared their experiences and results of using drying beads technology. They have started drying the seeds commercially by using drying beads and getting excellent response. Top management of various companies met with us and showed their interest in adopting the drying beads technology.



- **Annual Meeting of the Project** Sep 24, 2016 at Hotel Dhaka Garden Inn, Banani, Dhaka, Bangladesh. Annual meeting of the project was a highly successful event, more than 45 persons from public, private and NGO sectors attended the meeting and appreciated the efforts of USAID, Horticulture Innovation Lab UC-Davis and Rhino Research for introducing this technology in Bangladesh. Efforts are being made by many professionals to introduce Drying Beads technology in the undergraduate and postgraduate academic courses.



- 6) **Lessons Learned:** We have received an overwhelming response from all sectors of the agro-industry including academia. We have trained many professionals in drying and storage of seeds at the company level, but we believe that our efforts will be more flourishing when this technology will be at the doorstep of the farming community. Now we have learned that we'll have to work out the possibilities to make this happening. In this context we're working with DAI, who leads the Value Chain Project in Bangladesh funded by USAID Bangladesh, to provide this technology to the farmers through agro dealers. Another important issue is regarding the import of our drying products in Bangladesh that charges huge taxes. We have started working on this through various agencies such as Bangladesh seed association to convince the government to reduce the taxes.
- 7) **Presentations and Publications:** Learning material of each training including presentations and relevant research publications has been provided to the participants in the form of hard and soft copies and we have found this method more convenient and fruitful for supporting the training participants.

ASSESSING FEASIBILITY OF SCALING UP NETS FOR PEST-EXCLUSION IN KENYA

- 1) **Location:** Kirinyaga County, Uasin Gishu County, Kajiado County, Migori County, Nakuru County, Embu county. Kenya
- 2) **Principal Investigator:** Vance Baird, Michigan State University
- 3) **Description:** This project will conduct a 1-year pilot study examining the commercial feasibility of scaling-up the use of AgroNets, also known as Eco-Friendly Nets (EFNs), for sustainable production of fresh market vegetables in Kenya. Very promising research results show that netting technology leads to increased yields with a higher percentage of marketable produce, while simultaneously significantly reducing the use of synthetic insecticides or eliminating their application altogether. As such, their use has generated significant interest among growers, particularly smallholder farmers, grower associations and netting manufacturers. The use of such EFNs/AgroNets with French/green bean and tomato and other high value vegetable crops is of particular interest as this technology precludes or minimizes the need for insecticides for crop protection – enhancing exporter compliance with strict EU requirements relative to pesticide minimum residue levels. Some growers are now using and promoting EFNs/ AgroNets, yet questions remain that need to be addressed to better determine the probability of success for their broader and long-term adoption. Until now, the focus has been on research relative to technology application and refinement, while noting its limitations. Key concerns to be resolved when seeking to determine scaling potential are: (1) the return on investment (ROI) in relationship to the crops grown (e.g., French bean, tomato and/or cabbage) and the demographic of the potential adopters (e.g., largescale and smallholder farmers); (2) barriers to sustained adoption of the technology by the target audience, including (a) broad awareness of the technology’s potential impact as well as availability, and (b) grower access to innovative low-interest loans or savings schemes that provide the investment capital needed to purchase the technology; and (3) the long-term commitment and investment by the prime partnering manufacturer to provide the EFNs/AgroNets and in addressing future design improvements (wear and tear, bulk roll dimensions, support frames, etc.). In addition, secondary issues that may be addressed include (i) the optimum physical design and engineering of support structures such as tunnels and nethouse kits; (ii) the range of specialty crops that can be profitably grown under the nets; and (iii) the cost-effectiveness of combining proven biological control agents/biopesticides with net technology.
- 4) **Collaborators:**
 - Center for Large Scale Social Change, LLC, USA
 - A to Z Textiles, Ltd., Tanzania
 - International Centre of Insect Physiology and Ecology, Kenya
 - Real-IPM, Kenya
 - Finlays, Kenya
 - Sunripe, Kenya
 - Frigoken, Ltd., Kenya

- 5) **Achievements:** *Note: This project began 8/1/2016.* The project has begun incorporating results from a previous Horticulture Innovation Lab study to determine the return on investment and barrier to adoption of the net technology for a range of crops and production scales in Kenya.

- 6) **Capacity Building:** The results of this one-year study will determine the appropriateness for, and the probability of success in, the scale-up of the AgroNet technology. The results will provide answers to questions about grower gross margins and ROI, existing and necessary financial environments, business plans and marketing requirements, likelihood of broad adoption of the technology, net/kit design and production capabilities of commercial manufacturers, appropriate crops or crop mixes, and applications under which the AgroNet technology can be most profitable.

DEVELOPING SMALL-SCALE IRRIGATION SOLUTIONS IN UGANDA

- 1) **Location:** Mbale and Jinja District, Uganda
- 2) **Principal Investigator:** Kate Scow, University of California, Davis
- 3) **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.

The main approach of the project is to work with farmers in sites where smallholders are already utilizing a water source for irrigation using varying local technologies. Rather than developing completely new schemes, we are working to make farmers' existing efforts more efficient and effective. We will establish small technology development plots in each site that targets key challenges faced by farmers in those areas. These technology development plots will be designed by the project team in collaboration with farmers, and managed by a committee of farmers already elected at each site. We will collect data on technical and social parameters to evaluate each innovation for net benefits to farmers and to the schemes as a whole.

The project approach is to tap the existing knowledge farmers have, to engage them in the research and development process as active participants rather than beneficiaries. This is designed to improve applicability of the technologies developed and reduce the cost of innovation both for the farmers and for the project.

Secondary activities include trainings with farmers and other stakeholders, advisory support to organizations implementing water management with farmers, hosting student field practical experiences and internships, and other emerging activities related to horticultural water management.

The overall goal is to provide the evidence of which approaches work in various conditions, with an emphasis on womans' empowerment through dry-season horticulture. We also hope to develop designs and tools for how these approaches can be implemented. This will support other stakeholders to develop projects with the both the technical knowledge and human resources built in the project. In addition, the outputs we develop will help district level staff to make meaningful proposals for small scale irrigation and water management in the future.

- 4) **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

5) Achievements:

Objective 1: Develop and implement innovations in small-scale irrigation and soil-water management

- **Identify Innovation Sites:** Six innovation sites were selected to represent differing agroecological and social conditions.
- **Develop host committees:** One host committee was elected by farmers participating in irrigation at each site to work with the project to develop and innovate on irrigation technologies and management strategies.
- **Develop recommendations for small scale irrigation improvements and technologies.** The project has identified and coded major irrigation challenges faced by smallholders; and has documented irrigation approaches and design features which are important to better serving smallholders' farming systems.
 - i. Develop small scale irrigation innovations with research and management plans
 1. The project has designed 5 technological innovations, targeting challenges raised at each site.
 2. Each committee has drafted innovations in how to govern the use of the new systems, with a set of rules and regulations regarding how the new systems will be used.
 - ii. Conduct research trials to compare irrigation innovations at each innovation site
 1. Research plots have been established on 4 of the 6 sites, each having 6 replicate plots in the new systems and 6 using the prior irrigation technologies.
 2. Detailed plot data has been collected from each plot, including soil, landscape, climate, and farmers' characteristics.
 3. One full season has been completed at two sites and two other sites are currently in their first season of data collection. Data collected include farmers' operations, inputs, harvest, crop development, weather, irrigation amount, labor, costs, and income.
 - iii. Conduct community education, outreach, and promotional activities at each site
 1. Conducted trainings with farmers at 5 sites on:
 - a. Pest management (1)
 - b. Irrigation system management (4)
 - c. Savings and Loans (1)

Objective 2: Evaluate agronomic, economic, market, nutrition, and gender implications of innovations

- **Develop evaluation criteria to evaluate performance of the innovations:** A set of criteria were developed from focus groups with farmers engaging in different types of irrigation. The project has expanded upon farmers' criteria to develop a more comprehensive set of evaluation criteria.
- **Collect evaluation data:** A data collection plan has been developed to monitor status and changes in the main criteria over the course of the project
 - Data is being collected on four of six sites
 - Innovation Evaluation meetings held with communities and women focus groups

- **Conduct cost-benefit analyses of irrigation innovations:** Data is currently being collected to analyze the cost / benefit and water profitability of different irrigation technologies and approaches.
- **Develop a Practitioner's Toolkit:** Ten session guides for establishing participatory irrigation sites have been developed and tested.

Objective 3: Develop protocols for integrating women into small-scale irrigation design and planning

- **Develop operating agreements in collaboration with host committees:** Operating agreements with committees have been developed for all project sites. Rules and regulations governing the irrigation systems installed by the project have been developed by committees at each site.
- **Document problem-solution trees regarding irrigation access:** Irrigation criteria have been mapped from focus groups with farmers at the six sites. Potential solutions are being identified and tested to integrate into problem/solution trees.
- **Conduct focus groups after each season with women members:** 10 Focus groups conducted with women farmers after planning and review meetings
- **Document key areas that improved women's access, empowerment in planning and implementation:** 16 issues that restrict or improve empowerment in irrigation identified during focus groups with women farmers. Key challenges in implementation related to women involvement identified.

Objective 4: Strengthen capacity among farmers and local agricultural support organizations

- **Build farmer capacity through educational sessions:** 90 Farmers in five sites trained in irrigation system operations
- **Build capacity among agricultural support organizations within the region:** Trained and built capacity among two local NGOs and one international NGO in irrigation system design and operations. Built awareness of one district local government of irrigation system design and operations.
- **Train undergraduate and graduate students:** 11 Undergraduates trained in water harvesting, irrigation system design, surveying/plotting, horticulture, weather data collection, pressurized irrigation system installations, and other topics through five internships, and six field practical experiences.

6) Lessons Learned

- Women have particular issues that may be overlooked when focusing on technical aspects. E.g. children safety around reservoirs. Their increased income being taken by husbands, need for rented plots to be paid in increments.
- Governance needs to be established at start of project but also be flexible to adapt to unexpected challenges. E.g. written 'rules and regulations' to guide use of new irrigation systems. Need to build these around users' existing experiences of what works and does not in irrigation and other collective action in their area.

- Opportunities for women to improve irrigation can lead to new opportunities. Time and funds saved by having access to irrigation and growing more crops can lead to adopt other forms of incomes and enterprises.
- In some locations, irrigation strategies must anticipate periods of too much rain as well as drought conditions. Irrigable locations in the landscape may pose new disease issues farmers are unfamiliar with.
- Committees of farmers are critical to sustainability of the irrigation systems. Many unique local challenges emerge which cannot be easily solved without creative local ownership. Regular committee meetings called by the project must provide an environment of constructive criticism that emphasizes the role of women in decision making for adaptive management to occur. Farmers otherwise easily allow status quo to dominate rather than risk being the member of the community to raise conflict related to challenges in the irrigation system.

EXPANDING TOMATO GRAFTING FOR ENTREPRENEURSHIP IN GUATEMALA AND HONDURAS

- 1) **Location:** Siguatepeque, Guatemala and Francisco Morazan, Honduras, Honduras
- 2) **Principal Investigator:** James Nienhuis, University of Wisconsin-Madison
- 3) **Description:** Tomato grafting technology represents a proven technology that is being increasingly adapted world-wide in both temperate and tropical countries to reduce risk of soil borne pathogens and provide more sustainable production. In many tropical countries, tomato production is not simply reduced, but often a complete loss due to soil borne pathogens, impacting the livelihood, stability and nutrition of families in rural areas. The most limiting soil borne pathogen in the tropics is *Ralstonia solanacearum* (Bacterial wilt). Grafting produces a physical hybrid plant – the rootstock is chosen for its genetic ability to resist soil borne disease, and the scion is chosen based on fruit quality for commercialization. The technology is relatively simple, but can have a huge impact in providing more sustainable production to small-scale growers. Grafting represents added value to the producer and creates a unique opportunity for entrepreneurial women’s groups to specialize, as do many new small greenhouse-based businesses in the US, in the production and sale of grafted tomato seedlings. Grafting is a scalable technology that can provide a unique value-added horticultural product. Through a prior Horticulture Innovation Lab project, we identified and commercially produced fruit and seed of World Vegetable Center cultivars that combine resistance to begomoviruses with fruit quality and postharvest characteristics necessary for successful commercialization. We propose on-farm field trials with women’s group to validate this technology and identify the optimal rootstock/scions combinations. We also propose regional training in grafting technology, seed storage and small business management in cooperation with the Horticulture Innovation Lab Regional Center at Zamorano.
- 4) **Collaborators:**
 - University of Wisconsin, USA
 - The Ohio State University, USA
 - Catholic Relief Services, Guatemala
 - Zamorano, Honduras
 - World Vegetable Center, Taiwan.
- 5) **Achievements:**
 - **Training:** Hands-on workshop on grafted vegetables with 27 participants from Guatemala, Nicaragua (at their own expense) and Honduras. Presenters included the worldwide experts, Matt Kleinhenz of the Ohio State University and Willie Chen of the World Vegetable Center, Taiwan ROC
 - **Student Capacity Building:** Erick Gutierrez from Honduras arrived to UW-Madison in May of 2015 to begin his M.S. degree in Plant Breeding and Genetics. He has successfully completed his first year as a graduate student, and completed both required classes and field experiments. Ms. Paulina Quesada from Costa Rica began her graduate studies at University

of Wisconsin. Her thesis will focus on grafting rootstock germplasm. Her work is critical to this project; nevertheless, she is funded through an internal Univ. of Wisconsin grant. Ms. Katherine Duran of the Instituto Tecnológico de Costa Rica completed and defended her thesis on grafted tomatoes (at no cost to our project).

- **Field Trials:** Completed and analyzed data from field experiments using grafted tomatoes. Tomato grafts were successfully produced in:
 - Instituto Tecnológico de Costa Rica (in collaboration with, but not paid by grant)
 - Totonicapan, Guatemala in cooperation with Catholic Relief Services
 - Zamorano, Honduras in cooperation with Horticulture Innovation Lab.
 - Madison, Wisconsin, this is a check location without soil pathogens, but which allowed us to test if grafting affected size, color, flavor, etc. of tomato fruit from scions.
 - **Results:** Two tomato rootstocks and three scions were tested in various combinations. Scions 1004 and 1010 showed the greatest increase in yield when grafted. Even self-grafted plants showed yield increases of about 40%, but when these scions were grafted onto Armada or BB rootstocks, yields increased 85 to 100% and was especially increased with the Armada rootstock.
- 6) **Lessons Learned:** Many more options for rootstock genetics exist, but we are really only able to test three with resistance to *Ralstonia* as our focus. Hopefully our new grant proposal to expand testing of rootstocks will be funded by Council of Agriculture of Taiwan, ROC.

PROMOTING CONSERVATION AGRICULTURE FOR VEGETABLE GROWERS IN NEPAL AND CAMBODIA

- 1) **Location:** Puok Soutniko, Prasat Bakong District, Cambodia; Banke, Surkhet, Lalitpur and Dadeldhura, Nepal
- 2) **Principal Investigator:** Manuel Reyes, North Carolina A&T State University
- 3) **Description:** Horticulture crop production is susceptible to yield losses due to water deficiency. In regions of Cambodia and Nepal, water is scarce for extended periods, negatively affecting food security. We have been addressing this problem through labor, water and soil saving technologies (LWSST) of storing water through rainwater harvesting and by efficient water use through drip irrigation and CA production systems. In a previous Horticulture Innovation Lab and Sustainable Agriculture and Natural Resources Management (SANREM) project, we conducted experiments comparing vegetables grown with drip irrigation and conservation agriculture systems versus traditional ways farmers grow vegetables in Cambodia. Our women partners liked drip irrigation and CA because labor in watering, tilling and weeding were reduced; vegetable yields and quality increased; they earned income; and their households could eat nutritious vegetables. LWSST can boost food security and climate change resiliency, since soil erosion can be controlled, land productivity and farmers' income can be enhanced, drought can be shortened, water quality can be improved, flooding can be minimized and biodiversity bolstered. We hypothesize that for LWSST to be scaled-up, we need to: a) provide incentives to smallholders, and b) research and identify pathways for smallholders to market vegetables. We will serve marginalized smallholders who can farm only small, income-generating vegetable gardens of no more than 200 m² and whose families likely suffer from chronic malnutrition. They have little training in science-based vegetable production and postharvest handling and packaging; very limited access to good seeds; and have very little capital to risk in new ways to produce vegetables. We will provide these trainings and also capital as incentives for them to shift from traditional to LWSST of drip irrigation, conservation agriculture and rainwater harvesting. They also have very limited market access. Hence, we will research and identify pathways for smallholders to market vegetables.

4) Collaborators

- Agricultural Development Denmark Asia (ADDA), Cambodia
- Royal University of Agriculture (RUA), Cambodia
- International Development Enterprise (iDE), Nepal

5) Achievements

Objective 1: To provide incentives for adoption of LWSST

CAMBODIA:

- **Increase in land size for Conservation Agriculture.** At the beginning of this project we recommended land size of 100 m² for commercial vegetable home gardens. We measured the land area of 60 farmers practicing CA. The plot sizes now range from 100 to 350 m², with the average plot size now increasing to 179 m², a 79% increase. We are observing a trend of increasing land under CA per farmer.

- **Increase income.** Total gross annual income for 60 farmers was \$26,164 from a total area of 10,720 m². Income per farmer averaged \$436 per farmer for an average area of 179 m². From an annual income of \$75 per 100 m², at the beginning of the project, income increased to \$244 per 100 m² with highest at \$522 per 100 m². Income per farmer ranged from a low \$54 per year to a high \$1565 with four having income greater than \$1000.
- **Conservation Agriculture Retention.** Last year, we reported that most women commercial vegetable home gardeners in Siem Reap who were involved in the first and second phase of this project through funding by the SANREM and Horticulture Innovation Labs (45 of them) are still producing vegetables by applying CA and drip irrigation technologies. With some farmers (those in the program longer), less incentives were provided so we could see if the farmers will continue with the program. Many are continuing and several increased the land area under CA. However, about nine gave up for the following reasons: flooding of land, health problems, children requested them to stop, and land converted to residential use.
- **Business by cooperative to sell seedlings.** We built a seedling nursery that a cooperative will inherit. As incentive only, farmers who practice CA can access these seedlings. Seedling nursery was useful. Farmers relayed they will be willing to buy healthy seedlings if cooperative guarantees seedlings that they need. Hence, for this year, the cooperative through the project will build two additional seedling nurseries for back up so seedlings are available when farmers need them. Cooperative will ask farmers what seedlings they will need and produce them. This will be a business that the cooperative will manage.
- **Cooperative is intact and functioning.** Last year, team worked with one ADDA organized cooperative. The cooperative has been maturing. Tanks and drip systems were purchased for 2016 dry season starting November 2015. The cooperative agreed to collect payments for tanks. However, not all farmers opted to do drip due to extreme drought.
- **Refresher training essential.** We conducted a refresher CA training as farmers tend to forget CA's advantages and importance and slowly reverts to past practices. Our observation is a number of farmers need these reminders to seal their involvement in CA.
- **A new incentive, tool for transplanting.** In 2015, the team designed and fabricated a simple planting tool with two hole sizes. Testing with six farmers was positive. It reduced labor in planting of seedlings, farmers observed that since seedling's roots were not disturbed, the vegetables grew faster, the bed is less disturbed, and women farmer's planting posture was improved due to less bending during digging.
- **Another new incentive, intensification of vegetable production.** Seven farmers practiced intercropping and were able to re-lay crop because there was no need for tillage. They had a main crop with a longer growing season (eggplant, bitter gourd, sponge gourd, wax gourd, or tomato) and another crop with a shorter growing season like Chinese kale, Chinese cabbage, morning glory, and spinach. The short duration crops were grown along the alleys. In one year they can grow with this cropping system nine kinds of vegetables.

NEPAL:

- **Field trials began for tomatoes, cauliflower and bitter gourd:** Six women farmers (with landholding less than 200m²) from each of four districts (total of 24 women

farmers) were selected for the field trials/demonstration. For 12 months, 3 successive crops (tomato, bitter-gourd and again tomato) were planted in Banke and Dadeldhura districts; whereas cauliflower, bitter-gourd and tomato were planted in Surkhet district. In Lalitpur, tomatoes were planted twice inside plastic tunnels. These crops were researched under two treatments. The treatments were: T1 - CA practices plus drip (with live mulching, CAD) and T2 - Traditional tillage and manual irrigation practice (without mulching and manually irrigated, TPM) and analyzed as paired.

- **Infrastructure and tools developed:**

- Hole maker. Twenty-nine hole-makers were made and provided to the trial farmers and farmer's groups in 4 districts. It has become a handy tool for farmers, reducing the amount of time required for land preparation because of CA (no tillage).
- Animal Built Pond. Animal built ponds were completed in Banke and Surkhet for water storage to irrigate commercial vegetable home gardens.
- Water Harvest Tank. A water harvesting tank was installed in Surkhet and Dadeldhura. The water harvesting tank collects water for both drinking and irrigation purposes. About 10 households were benefitted from the water harvesting tank constructed in each district.

Objective 2: To identify and implement local markets and pathways to sell vegetables for continued adoption of LWSST

CAMBODIA:

- **Income by cooperative.** Cooperative opened a bank account and deposited \$1,233 income from buying and selling of vegetables produced in CA by cooperative members for five months (April to August, 2016).
- **Market slogan.** Beng Mealea Vegetables: Grown Right, Handled Right, Community Right. Developed flyer and distributed these to neighborhoods in Siem Reap.
- **Harvesting.** Tools and training on appropriate materials for harvesting (shape knife, scissor and clipper and use of basket or plastic crate during harvest and transportation); and best time to harvest (in the morning or evening time with lower temperatures), bringing product to the shade quickly.
- **Coolbot.** A new storage technology to keep product fresh and of high value for long periods. It is successfully being used by the cooperative to store vegetables for door to door selling.
- **Tuktukbot:** Before the Tuktukbot, the team sold vegetables for three months to the local market, making it very difficult to compete and profit was low. Then we started selling door to door in neighborhoods via the Tuktukbot in March 2016 and more and more people are purchasing veggies directly with profit margin increased.
- **Nepal marketing.** An interaction meeting with the market planning committee, farmers, traders and agro-vets was organized in each district. The major objectives of this interaction meeting was to know the current marketing channel of vegetables, time of vegetable collection, postharvest handling, grading and proper storage of vegetables and some administrative issues of the market planning committee.

6) Lessons Learned

- **Vegetable yield increase in CA.** We have results in Cambodia, Honduras, Guatemala, and Ethiopia showing yield increases for vegetable production under CA. From this report, now we have results from Nepal and a researcher managed study at the Royal University of Agriculture, Cambodia, that vegetable yields increase due to CA. We are getting more and more confident in scaling up this technology, which we are doing in the MasRiego project in Guatemala; and which we will also do in Battambang, Cambodia (through funding from the Sustainable Intensification Innovation Lab) and in Ethiopia (through funding from the Sustainable Intensification Innovation Lab). We are also testing this technology in Tanzania and Ghana. Funding for the tests in Africa is through the Innovation Lab for Small Scale Irrigation. The rest were funded by the Horticulture Innovation Lab.
- **Women farmers can earn profit from small area commercial vegetable home gardens.** From data of 60 farmers in Cambodia, it is evident that farmers can earn income from small 100 m² commercial vegetable home garden plots. If sustainably intensified, earnings went as high as \$500 per year per 100 m². In 2011, 41% of the Cambodian population lived on less than \$2.00 a day (<https://www.adb.org/sites/default/files/institutional-document/151706/cambodia-country-poverty-analysis-2014.pdf>), a women farmer can earn \$900 on 200 m². This does not require a whole day's work. In addition, the family will have nutritious healthy vegetables to eat.
- **Cooperative can earn selling vegetables to replace middle person.** Project made a business plan, and it is apparent that the cooperative can pay Coolbot and Tuktukbot if farmers will all sell vegetables to the farmer owned cooperative. The cooperative already has deposited funds in a bank. Interesting are stories that middle persons are offering higher prices to farmers now, because the buying price of the cooperative was relatively higher than the previous buying price of the middle persons.
- **Evidence that CA can decrease pest and diseases.** Results from Nepal study showed that pest and diseases can decrease with CA plus drip, compared with conventional farmers' practice; except for white grubs where the population was higher in CA with drip. However, the yield was higher in CA plus drip compared with farmer's practice.
- **Ready to expand to commercial home gardens.** The women already have gained mastery in CA for vegetable production. They are ready to expand to a nutritious, a 'diverse little of everything' commercial *home garden* farming system and not only commercial vegetable home gardens. Most already have some form of it but innovation labs can add science to what they are doing. I am proposing adding fruits, fish, chicken and ducks for eggs and meat, cattle and goats for meat and milk, pigs, frogs, and pasture. We started it in two of the farms at the Horticulture Innovation Lab site as an incentive to adopt CA and drip technology. Fish has been added and are thriving in two of the farms. Also a SIIL funded rice-horticulture farming system will start experimentation on pasture production after rice for livestock feed, mulch for vegetables, and improvement of soil quality on rice fields. Integrating livestock to horticulture will provide more income and nutrition to women in Siem Reap; and needed manure fertilizer for adding to mulch in commercial vegetable home gardens.

7) Presentation and Publications

- Presentations
 - Reyes, M.R., L. Sah, and S. Poudal. 2016. Integrated Pest Management and Conservation Agriculture in Commercial Vegetable Home Gardens. Oral presentation at the International Congress of Entomology, Orlando, Florida, September 25-30, 2016.

- Edralin, D. and M.R. Reyes. 2016. Sustainably Intensified Vegetable Production System. Oral presentation at the ASABE 2016 Annual International Meeting, Orlando, FL, July 17-20, 2016.
- Edralin, D., M.R. Reyes, and G. Sigua. 2016. Short term improvement in Soil Quality in Conservation Agriculture with Commercial Household Vegetable Farmers in Cambodia. Oral presentation at the ASABE 2016 Annual International Meeting, Orlando, FL, July 17-20, 2016.
- Reyes, M. R. 2016. Conservation Agriculture, Drip Irrigation and Rainwater Harvesting for Vegetable Production. Presented at the annual horticulture innovation lab meeting, March 14, 2016, Siem Reap, Cambodia.
- Reyes, M.R. 2015. Global Application of Drip Irrigation and Conservation Agriculture for Commercial Vegetable Home Gardens. Invited seminar speaker in the Food Agriculture Organization of the United Nations, Rome, Italy, December 8, 2015
- Edralin, D., G.C. Sigua, and M. Reyes. 2015. Soil carbon and soil respiration in conservation agriculture with vegetables in Siem Reap, Cambodia. Poster presentation at the 2015 American Society of Agronomy, Crop Science Society of America, Soil Science Society of America International Annual Meeting, Minneapolis, MN, November 15 to 18, 2015.
- Publications
 - Edralin, D.I., G. A Sigua, and M. Reyes. 2016. Dynamics of Soil Carbon, Nitrogen and Soil Respiration in Farmer's Field with Conservation Agriculture, Siem Reap, Cambodia. International Journal of Plant and Soil Science, 11 (1):1-13.

SPECIAL INITIATIVES

COLD STORAGE AND POSTHARVEST TRAINING TANZANIA

- 1) **Location:** Arusha Region, Tanzania
- 2) **Principal Investigator:** Horticulture Innovation Lab Management entity
- 3) **Description:** The Horticulture Innovation Lab renovated an existing cold room at HORTI-Tengeru in Arusha, Tanzania by installing a new air conditioner and a CoolBot device. The cold room is already being used to demonstrate the effects of lower storage temperatures to students who are taking classes at the Horticulture Research and Training Institute in Tengeru (HORTI-Tengeru). It is also used to store production from the nearby student garden that is being taken care of by students and faculty. In addition, we worked with HORTI-Tengeru to design a charcoal cooler and packing area at their location. This unit is being constructed with funds from the World Vegetable Center. Also, in July 2016, in collaboration with the World Vegetable Center, the Horticulture Innovation Lab organized a week-long training with three UC Davis faculty in collaboration with local instructors giving lectures on postharvest handling of fruits and vegetables.
- 4) **Collaborators:**
 - The World Vegetable Center, Eastern and Southern Africa, Arusha, Tanzania
 - Horticultural Research and Training Institute (HORTI)-Tengeru, Tanzania
- 5) **Achievements:** Renovation of an old unused cold room on the premises of HORTI Tengeru and installation of a CoolBot controller and A/C unit. Organization of the week-long training tailored for industry leaders, trainers, and teachers using the Postharvest Training and Service Center (PTSC) set up at the World Vegetable Center, Arusha by Lisa Kitinoja and Diane Barrett in an earlier Horticulture Innovation Lab project. The training was comprised of four days devoted to postharvest biology and technology for fresh products – fruits, vegetables, and flowers, while the final day was focused on drying. A feature of the course that proved to be very successful was the inclusion of practical exercises that were carried out at the PTSC. Each participant was provided with a basic postharvest kit, including jaw calipers, a tool for measuring fruit diameter, a refractometer, a digital thermometer, pH paper, relative humidity paper, chlorine test strips, a 5 kg scale, and a USB flash drive loaded with useful documents, including PDFs of all the lectures, and a PDF of the small-scale postharvest manual in English as well as in Swahili.
- 6) **Capacity Building:** The training in Arusha was given to 40 Tanzanian industry leaders, trainers, and teachers who in turn will train their colleagues, employees and farmers using the postharvest tool kit they were given
- 7) **Lessons Learned:** Finding an inverter A/C unit in Tanzania was hard. Buying supplies for trainings is time consuming, requiring visiting many stores, and many items were either too expensive or unavailable.

BANGLADESH AQUACULTURE HORTICULTURE FOR NUTRITION COLLABORATIVE RESEARCH PROGRAM

- 1) **Location:** Dhaka, Bangladesh
- 2) **Principal Investigator:** Patrick Webb, Nutrition Innovation Lab, Tufts University
- 3) **Project Description:** Communities located in 9 unions are being utilized in Bangladesh to test three innovative technologies for improving horticulture and aquaculture productivity and value chains (3 unions per technology), to include 126 producers. The households include producers who are not part of current or past USAID programs. Additionally, there will be many consumers of aquaculture and horticulture products in these locations who are not direct beneficiaries. Following the implementation of the first panel survey (Year 2, December 2015), the Horticulture Innovation Lab has installed the three technologies; floating gardens for use on fish ponds to grow vegetables, improved solar drying technology (UC Davis Chimney Dryer) for fish and horticultural crops, and CoolBot controlled cool rooms for storage of fish and horticultural crops.
- 4) **Collaborators**
 - World Fish Bangladesh
 - Bangladesh Agriculture University (BAU)
 - Patuakhali University of Technology (PUT)
- 5) **Achievements:** Installation of all three technologies in the already chosen locations. More specifically, the Horticulture Innovation Lab installed 3 CoolBot controlled cool rooms, 3 UC Davis Chimney dryers and 36 floating gardens. Our collaboration with the two universities has been ongoing. BAU has been working on the UC Davis Chimney Dryer, is testing drying different types of fruits and vegetables and how the slice size and shape affect the quality of the dried product. Also, PUT has been testing the effect on plant growth and productivity of different growing medium compositions as well as innovative designs for the floating gardens in order to increase the productivity while reducing the cost for the farmers.
- 6) **Capacity Building:** We are working together with one faculty and two students from Bangladesh Agricultural University and one faculty and one student from Patuakhali University on testing two horticultural technologies. The collaboration is already helping the faculty members and students learn more about these technologies and about conducting rigorous research. During our visits at BAU the Horticulture Innovation Lab team built a UC Davis chimney dryer with a number of students and professors, teaching the basics concept of solar drying.

- 7) **Lessons Learned:** Progress is slow in Bangladesh. Finding reputable companies to work with is also hard and the long rainy season hinders the completion of construction projects due to flooding of the sites. Also, securing electricity connection is a challenge.

- 8) **Presentations and Publications:** The solar drying technology will be presented at the poster session of the 6th SCI World Conference 2017 in Goraj, Vadodara, Gujarat, India by our Bangladeshi staff (Amrita Mukherjee and Rezaul Islam) (abstract accepted and travel fund grants for both). Also, International Postharvest Specialist Angelos Deltsidis will be giving an oral presentation and presenting a poster at the International Symposia on Tropical and Temperate Horticulture in November 2016.

REGIONAL CENTERS

KASETSART UNIVERSITY

- 1) **Location:** Thailand: Serves Bangladesh, Cambodia, Nepal
- 2) **Principal Investigator:** Poonpipope Kasemsap, Kasetsart University
- 3) **Description:** Horticulture Innovation Lab Regional Center at Kasetsart University in Thailand has worked on several activities with various partners to disseminate horticulture technologies to Feed the Future countries in Asia, including Nepal, Bangladesh, and Cambodia. The activities ranged from evaluate, adapt, and demonstrate technologies to training programs.
- 4) **Collaborators**
 - 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
- 5) **Achievements**
 - **Technology training:** The center offered short term technology trainings where they transferred knowledge and technologies to 36 individuals (29 men 7 women). They also provided the pest exclusion net training for Feed the Future (FTF) projects, Winrock International. The training was done in the center at the Kampang Saen Campus and we trained 11 farmers from three Feed the Future countries.
 - **Continued technology testing:** A continuing project is to develop a cold room usage monitoring system; this system will record the use of electricity and behavior of the farmers using the cold room and record automatically for improving the usage efficiency in very cheap price and easy to use.

Last year, we successfully introduced a low cost cold room and CoolBot system to a farmer community in Siem Reap, Cambodia. This year we installed the electric power meter and temperature and humidity sensor to the cold room. We also trained the local researcher and farmers how to monitor the power consumption, temperature, and relative humidity in the cold room. We also trained the framers on basic cold storage methods for different species. Farmers already started using the cold room to store their vegetables and changed the way they sell them in bigger lot for better price. We also taught RUA lecturers and students how to insulate a cold room properly, and how to check the leak of the room.
 - **Infrastructure expansion:** We expanded space for the center on the Bangkhen campus. This center is located in the Department of Horticulture, so visitors can visit easily. The expansion includes an exhibition area with roof and two sets of solar watering systems for students in the Department of Horticulture to practice. The horticulture lecturers and students also use the technologies for their study and research. We also maintain center technologies on the Kampang Saen Campus and provide labor and upkeep for the demonstration fields and infrastructure.

- **Institutional development:** The Center has had success in making new connections and collaborations with personnel and researchers of fruit tree in Nepal. The topic is about the mango practice, pest control and off season production. We have an opportunity to introduce the improvement of mango production and postharvest to Nepal team next year.

ZAMORANO UNIVERSITY

- 1) **Location:** Honduras: Serves Guatemala and Honduras
- 2) **Principal Investigator:** Julio Lopez, Zamorano
- 3) **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 technical people, promoters and farmers.
 - Space for ideas, proposals and improvements of the production of fruits and vegetables such as: Physical space for training, short courses, forum and scientific congress.
 - The development of study plans and didactic materials for different sectors.
 - Postharvest investigation technologies, integrated pest management, climate change mitigation technologies, efficient and sustainable production systems for fruits and vegetable.
 - Technical assistance for farmer projects.

The Regional Center promotes agricultural production for small and medium producers through the use of low cost technologies, training and capacitation programs, and opportunities for the diversification of the family income and the food nutritional safety.

- 4) **Collaborators:**
 - University of California, Davis, USA
- 5) **Achievements:**
 - **Establishment of crops:** We have established various field crops to provide food for the families and products to supermarkets. Current crops, managed by students and employees, include: sweet potato, cassava, Jamaica flower, lettuce, chia, herbs and legumes. In addition to the establishment of bio-intensive plot with crops such as tomatoes, peppers, watermelons, cucumbers and others, including lettuce production under hydroponic systems, vertical and horizontal agriculture. The Regional Center has various production structures such as mesh house, and macro mobile and static tunnels. Using these technologies there is production of high value crops such as bell peppers and jalapeño pepper, eggplant, onion and tomatoes.
 - **Establishment of new technologies:**
 - Zero-energy cooling chamber (POT and POT, African refrigerator)
 - Rainwater harvesting roof
 - Macro tunnel of 500 m²
 - Coolbot™
 - Production systems vertical and horizontal
 - Large Zero Energy Cool Chamber (ZECC)
 - Aquaponic System
 - Micro tunnels

- **Integrated Crop Management and Climate Change Module for Students:** The module is part of the Regional Center and to date 800 students have passed through this module and participated in the establishment and adjustment of production and postharvest technologies located at the regional center.
- **Institutional Development:** The Horticulture Innovation Lab Regional Center provides support to:
 - Project Hope- University of Wisconsin: Expanding tomato grafting for entrepreneurship in Honduras and Guatemala
 - Project MásRiego in Guatemala
 - Project Kolping in Honduras
 - Project SNV - PROMESSA CAFCA
 - Project MINED school farm in El Salvador
 - Training and Capacitation Unit-Honduras
 - Students in the MIC-CC Module

6) **Presentations and Publications:**

- Student Research
 - Validation of protected structures for the production of tomato and pepper in communities located in the dry corridor of Honduras.
 - Using the technologies Cold Store and activator lactoperoxidase system for preserving milk.

REGIONAL CENTER IN ZAMBIA

- 1) **Location:** Zambia: Serves Eastern Africa
- 2) **Principal Investigator:** Emil Van Wyk, AgriSmart
- 3) **Description:** The purpose of the Regional Center in Zambia will be to connect horticultural researchers, extension workers, farmers, NGOs and relevant private sector partners within their respective regions. The center will serve as a regional repository for horticultural technologies and knowledge, provide training programs, facilitate the evaluation and adaptation of horticultural technologies, and develop mechanisms for sharing ideas within and across borders. The center will work with national agriculture research and extension system, agricultural universities, NGO's and the private sector to provide ongoing training for the local horticultural industry and for trainers both at the centers and across the regions. The center will draw on local experts who have received technical training through advanced degree programs or train the trainer courses. The center provides testing grounds for horticultural technologies and physical facilities for workshops and training sessions.
- 4) **Collaborators:**
 - Rutgers the State University of New Jersey, USA
 - University of Zambia (UNZA), Zambia
- 5) **Achievements:**

Objective 1: Improve sustainability and local capacity at the lead institution and partners.

- **Field testing:** Variety trials were conducted to evaluate the growth behavior, performance and nutrient content analysis for first harvest (Lusaka site). Technologies applied at the trial plot included pest management, disease management, safe use of chemicals and drip irrigation system.
- **Institutional Development:** Apart from UNZA, new partners are coming on board. Partners like Natural Resource Development College (NRDC), a government institution, is the proposed site for hosting the center . And for the private sector, Kalahari Natural Oils, LTD, a company specialized in extracting oil from Moringa seeds and who also conducts training in postharvest handling, has shown great interest in partnering with the Regional Center once established. Meanwhile, Kalahari will continue partnering through the Mitengo women's group.
- **Capacity Building:** One female student is receiving support as a postgraduate student at UNZA.

Objective 2: Increase technical capacity and knowledge of improved horticultural practices of trainers and community leaders.

- **Capacity Building:** A training was conducted to demonstrate how fresh vegetables can be dried using the solar dryer. In attendance were six women and five men with Yatsani Co-operative in New Kasama, Lusaka. Also, a producer group i.e., Mitengo, Waterfall and Yatsani of New Kasama, received short term trainings in postharvest handling, business enterprise development and record keeping. In attendance were 87 women and 20 men.

6) **Lessons Learned**

- Establishment of the Regional Center in Lusaka was delayed because of failure for UNZA to provide an alternative site to set up the center.
- Because of not having the site or technologies (Coolbot, shadebot and solar dryer), this has resulted in not conducting hands on trainings especially for Lusaka farmers and other partners, including extension workers and other government workers.
- Natural Resource Development College (NRDC) has been fully engaged in the provision of land at the institution so that the center can kick start.

VI. ASSOCIATE AWARD RESEARCH PROJECT REPORTS

MÁSRIEGO

USAID Guatemala, AID-EPP-A-00-09-00004

- 1) **Project Description:** The horticulture sector and the Horticulture Innovation Lab’s work present a unique opportunity to accelerate the scale-up of simple and readily available low-pressure drip irrigation systems and novel conservation agriculture (CA) practices to dramatically improve smallholder vegetable production, and increase the benefits to and participation of women. This project, *MásRiego*, uses innovative irrigation technology, combined with CA and rainwater harvesting, to increase vegetable production for commercial production while decreasing the labor requirement per unit of food grown. The focus is on small-scale horticultural production in Feed the Future communities.

The goal is to promote private sector development in the horticulture sector and promote small-scale commercial horticultural production through the increased use of drip irrigation, CA and rainwater harvesting practices. Through the increased use of these practices, we expect to increase household horticultural production and increase incomes. Our specific objectives are to (1) facilitate improved water management in horticulture (i.e. drip irrigation, CA and rainwater harvesting) in the Feed the Future zone of influence and (2) develop the capacity of MásRiego actors, implementers and beneficiaries, and USAID implementing partners and their technicians in implementing climate change resiliency strategies.

MásRiego supports the Mission’s Feed the Future objectives in the following ways:

- Accelerate engagement with the private sector with innovative finance options for agricultural inputs, business models and toolkits to serve Feed the Future objectives;
- Scale up low-pressure drip irrigation technologies;
- Disseminate knowledge and scale up application of CA practices for household vegetable production and rainwater harvesting, especially for the benefit of women;
- Increase household income and vegetable consumption of surplus leading to nutritional gains among families;
- Study effects of relevant CA versus plastic mulch and compare them with standard agriculture practices considering different scales of production and agro-ecological conditions, according to farmer-identified needs for development of practical extension messages.

In direct coordination with existing Feed the Future efforts in Guatemala this ‘Buy-In Award’ will directly work in a complementary manner with existing contractors to improve the implementation of

drip irrigation and CA practices including water resource development, soil conservation, and rainwater harvesting. Drawing on the existing Horticulture Innovation Lab sub-award project expertise, an immediate effort will be undertaken in the Western Highlands region of Guatemala to assist in the expansion of existing Feed the Future activities.

2) **Collaborators:**

- The Barbara Ford Peace building Center (CPBF)
- Universidad Rafael Landivar (URL) in Guatemala
- Zamorano
- Kansas State University (KSU)
- North Carolina Agricultural & Technical State University (NCA&T)

3) **Achievements:**

- **Project Launch:** MásRiego held an inauguration event in Santa Cruz de Quiche to formally introduce the project to WHIP partners and local collaborators. Sixty five participants attended, including USAID Mission staff, extensionists and technicians, and program staff from the CPBF. The event marked the official launch of the partnership between project partners, and the beginning of collaborations with other Feed the Future initiatives.
- **Diagnostic Study & Baseline Data:** This community diagnostic study is under way, identifying primary and secondary sources to inform the project of communities that will be best suited for drip irrigation adoption. A consultant will be hired to identify various financial methods for farmers to finance their drip systems. As groups, associations and farmers are identified and trained by MásRiego staff, baseline data will be compiled. The identification of 1,200 potential beneficiaries should be complete by October 28, 2016 and by November 15, 2016 800 producers will be identified that are strongly interested in participating in MásRiego training and installing drip irrigation on their land. By December 16, 2016 a complete diagnostic study report will be delivered by the Technical Institute for Productivity and Training (INTECAP) with needs and challenges categorized for each Feed the Future community where project implementation will occur.
- **Community trainings and credit and financing:** Municipality-level action plans are currently being developed in all 12 of the Feed the Future municipalities. Trainings and demonstration plot plans are currently in progress in key municipalities, which include Sacapulas and Uspantan. An expert in credit and financing for smallholder farmers will be hired by mid-November 2016, as part of CPBF staff.
- **Engaging Youth Business:** Plans are in development for the youth cooperative to assemble 10 drip irrigation kits to be installed in key communities in Sacapulas and Uspantan. Curriculum is being developed for trainings by KSU in cooperation with Zamorano and CPBF.

- **Capacity Building:** As of September 30, 2016 the entire team has received three days of training in CA by Kansas State University researchers, Dr. Manny Reyes and soil scientist Ruth McDaniel. The main points of CA in tandem with more efficient irrigation (i.e. drip) were stressed, with both theory in the classroom and practical hands-on activities in the drip irrigation demonstration garden at CPBF.

VII. HUMAN AND INSTITUTIONAL CAPACITY DEVELOPMENT

FY2016 SHORT TERM TRAINING

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	Training on pest exclusion nets by Regional Center at Kasetart University	Producers	3	1	4
Bangladesh	Training on use of drying beads for seed drying and storage	Producers, private sector, civil society personnel	292	76	368
Cambodia	Train farmers in Siem Reap about cool room maintenance, cold storage, postharvest handling and pest exclusion nets	Farmers	13	3	16
Cambodia	Visit CoolBot coldroom	iDE Personnel	3	0	3
Cambodia	Training on how conservation agriculture in commercial vegetable home garden is a technology for resilience to climate change	Cambodian climate change and Cambodian Harvest USAID	8	8	16
Cambodia	Conservation agriculture for commercial vegetable home garden technology	Phramma Kesa organization in Battambang province	0	1	1
Cambodia	Introduction to CoolBot coldroom for possible application to cooperative in their village	Farmers	2	4	6

Cambodia	Training on conservation agriculture for commercial vegetable home gardens and also the packing house to learn about how CA improves soil quality and also see a packing house designed for a village cooperative.	Students from the Royal University of Agriculture	23	20	43
Cambodia	Training on conservation agriculture production system for commercial vegetable home gardens. Students also talked with several farmers adopting this technology.	Students from the Royal University of Agriculture	10	9	19
Cambodia	Introduce students to conservation agriculture and how a packing house works	Students from the Western International School	n/a	n/a	57
Nepal	Production training using conservation agriculture and drip irrigation for commercial vegetable home gardens	Producers	23	77	100
Nepal	Pest management training	Producers	16	81	97
Nepal	Postharvest training	Producers	19	78	97
Nepal	Soil management training	Producers	13	31	44
Nepal	Kitchen garden training	Producers	12	72	84
Nepal	Interaction cum field visit	Producers	45	33	78
Nepal	Animal built pond training	Producers	36	17	53
Nepal	Exposure visit to IPM Learning center, Banke	N/A	2	17	19
Nepal	Train local stakeholders on mango production, postharvest, and introduce Horticulture Innovation Lab technologies	NGOs, extension	13	3	16

Honduras & USA	Internship for students from Zamorano University to conduct gender-related research with 12 week visit to Penn State	Undergraduate students from Zamorano University	2	2	4
Honduras	Workshop on vegetable grafting, based on hands-on, field-based training in grafting technology. In addition visited farms, markets and agro-industries involved in commercialization of vegetables.	Researchers, extension agents and farmers from Guatemala, Honduras and Nicaragua (the Nicaraguans participated at their own expense), and students and faculty of Zamorano University	7	11	18
Honduras	II Biological Course Control Specialized, Weed Management and IPM.	N/A	3	15	18
Honduras	Workshop on Extension Methods and Coach Coaches.	N/A	6	20	26
Honduras	Fourth International Course on Post Harvest Vegetables, Fruits and basic grains	Researchers, extension	5	25	30
Honduras	Workshop on Grafted Vegetables.	N/A	15	12	27
Honduras	Financial micro prisma Workshop	N/A	3	12	15
Honduras	Technical Field Schools	producers	10	30	40
Honduras	Promoters field schools	N/A	8	32	40
Honduras	Soil week in Honduras	N/A	74	320	394
Honduras	First Forum on Sustainable Production of Vegetables	Extension, researchers	10	61	71
Honduras	Workshop avocado crops management	extension	5	15	20
Honduras	Workshop for teachers from agricultural extension program	teachers	5	37	42
Honduras	CAFCA PROMESSA workshop managers	N/A	10	70	80
Guatemala	Training for the promotion of human rights and inclusion of the LGBT community	NGO partners and MásRiego project staff	39	25	64
Guatemala	Training on the principles of CA	CPBF new staff (technicians and youth promoters)	8	8	16

Guatemala	Training on drip irrigation and garden installation	youth in CPBF network	17	5	22
Uganda	Field practical training on pump operations and maintenance; sprinkler irrigation operation; land leveling using oxen; rainwater reservoir construction; furrow irrigation and drainage; and horticultural production	Farmers; Women's cooperatives/groups	31	51	85 (3 ID N/A)
Tanzania	Training of trainers on postharvest handling of fruits and vegetables	Educators, industry professionals, & government employees	25	15	40
Tanzania	Trained B.Sc. students from Sokoine University to assist with data collection	Undergraduate students	1	2	3
Kenya	Competency with AgroNet technology	Small-holder farmers/growers	15	15	30
Kenya	Training of enumerators for consumption survey data collection	Enumerators	9	7	16
Zambia	Basic improved cultural practices in vegetable production	Farmers/producers	16	67	83

FY2016 LONG-TERM TRAINING

Name	Sex	University	Degree	Major	Graduation Date (month/year)	Home Country
Erick Gutierrez Benites	M	Univ. of Wisconsin-Madison	M.S.	Plant Breeding and Genetics	September 2017	Honduras
Paulina Quesada	F	Univ. of Wisconsin-Madison	M.S.	Plant Breeding and Genetics	September 2018	Costa Rica
Anjeline Mnene	F	University of Eldoret	MS	Plant Protection	TBD	Kenya
Silvia Ajaa Omasaja	F	University of Eldoret	MS	Plant Protection	2016	Kenya
Bernard Somers	M	Rutgers University	PhD student	Medicinal Chemistry	TBD	USA
David Byrnes	M	Rutgers University	Ph.D.	Plant Biology – plant breeding for improved nutrition	TBD	USA
Inonge Siziya	F	University of Zambia (UNZA)	M.S.	Plant Science-horticulture & nutrition	TBD	Zambia
Arianne Vasitalis	F	Rutgers University	Ph.D.	Plant Biology-natural Products and nutrition	TBD	USA
Bo Yuan	M	Rutgers University	M.S.	Medicinal Chemistry	TBD	USA (China)
Brittany Graf	F	Rutgers University	Post-doc	Economics		USA
Suren Arumugam	M	Rutgers University	Post-doc	Economics-econometrics		India
Thomas Cacciola	M	Rutgers University	Undergraduate	International Studies	TBD	USA
Walkyria Marte	F	Rutgers University	Undergraduate	Nutrition Science	TBD	USA
Paige Castellanos	F	PSU	Post-doc	Rural Sociology and International Agriculture & Development (dual-title)	Aug 2016	USA
Elisabeth Garner	F	PSU	Ph.D.	Rural Sociology and Women's	Aug 2017	USA

				Studies (dual-title)		
Arie Sanders	M	EAP/PSU	Ph.D.	Rural Sociology and International Agriculture & Development (dual-title)	Aug 2018	Honduras (Netherlands)
Pisey Sar	F	Royal University of Agriculture, Cambodia	B.S.	Agronomy	December 2015	Cambodia
Siv Ee Tong	F	Royal University of Agriculture, Cambodia	B.S.	Agronomy	December 2015	Cambodia
Vihul Moeurn	M	Royal University of Agriculture, Cambodia	B.S.	Agronomy	December 2015	Cambodia
Elyssa Lewis	F	University of California, Davis	M.S.	International Agricultural Development & Agriculture and Resource Economics	June 2017	USA (South Africa)
Liz Hohenberger	F	University of California, Davis	M.S.	International Agricultural Development	December 2016	USA
Anthony Phan	M	University of California, Davis	B.S.	Chemistry	TBD	USA
Elise Brockett	F	University of California, Davis	B.S.	International Agricultural Development	TBD	USA
Owen Cortner	M	University of California, Davis	M.S.	International Agricultural Development	June 2016	USA
Mariah Cosand	F	University of California, Davis	M.S.	International Agricultural Development	TBD	USA

James Smith	M	University of California, Davis	M.S.	International Agricultural Development	TBD	USA
Emily Webster	F	University of California, Davis	M.S.	International Agricultural Development & Horticulture and Agronomy	June 2017	USA
Julia Jordan	F	University of California, Davis	M.S.	International Agricultural Development	December 2017	USA
Shamila Sekandi	F	Busitema University	BSc	Agric. Mechanization & Irrigation Eng.	June 2017	Uganda
Goden Nuwamanya	M	Busitema University	BSc	Agric. Mechanization & Irrigation Eng.	June 2017	Uganda
Raymond Asangai	M	Busitema University	BSc	Agric. Mechanization & Irrigation Eng.	June 2017	Uganda
Cylus Tumushabe	M	Busitema University	BSc	Agric. Mechanization & Irrigation Eng.	June 2017	Uganda
Bush Omeson	M	Busitema University	BSc	Agric. Mechanization & Irrigation Eng.	June 2017	Uganda
Andrew Ebic	M	Busitema University	MSc	Irrigation and Drainage Eng.	June 2017	Uganda
Yoronimo Oketcho	M	Busitema University	MSc	Irrigation and Drainage Eng.	June 2017	Uganda

INSTITUTIONAL DEVELOPMENT

The Horticulture Innovation Lab held the official grand opening of its UC Davis based Demonstration Center to coincide with World Food Day 2015. More than 100 people attended the event, with speakers including Congressman Ami Bera (CA-7) and Helene Dillard, dean of the College of Agricultural and Environmental Sciences. Since the opening, the demonstration center has seen visits from UC Davis Humphrey Fellows from Rwanda and Pakistan, Mandela Washington Fellows from across Africa, representatives from Washington State University, Texas A&M University, Digital Green, among other organizations and universities. Three main research projects have been conducted at the center. A UC Davis graduate student completed research looking at nutrient retention of dried mango and tomato under different drying methods. The research assistant compared nutrient levels after drying using a typical

solar dryer and drying with zeolite drying beads. These data are currently being analyzed. Second, temperature and humidity data has been collected for the zero energy cool chamber (ZECC) showing an average temperature difference of 5°C between the ZECC and ambient temperatures. The third research initiative at the center was to test blanching of tomato segments before solar drying. The application of high heat to the product before the moderate heat of solar drying resulted in a faster drying product as well as less discoloration of the final dried tomato. All three of these research studies involved undergraduate and graduate students, the program officer, as well as the Horticulture Innovation Lab's International Postharvest Specialist and our Leader of Technology and Innovation.

All three Horticulture Innovation Lab Regional Centers have seen institutional growth and changes over the last year. The Regional Center at Kasetsart University was awarded a leading role in a large USAID RDMA project led by Winrock. Kasetsart University will manage approximately \$500,000 to scale a number of technologies relevant for smallholder farmers in Southeast Asia. The Regional Center at Zamorano is part of a large Government of Honduras led program to improve the current extension system. The center has also held its fifth postharvest short course, the first annual congress for family agriculture, and the first annual innovation workshop for agriculture technology. The Regional Center in Zambia, while yet to be officially launched, has been able to secure partnerships with the Ministry of Agriculture and the University of Zambia.

D-Lab at UC Davis is a good example of institutional development with partner universities. The Horticulture Innovation Lab provides funds to the UC Davis D-Lab and to the regional centers in Thailand and Honduras to jointly design curriculum and to implement a design and development (D-Lab) course at each university.

PROJECT INSTITUTIONAL DEVELOPMENT

- ***Improving Nutrition with African Indigenous Vegetables***
Description: Due to the current work being conducted in concert with AMPATH, Rutgers University submitted and received the following supplement grant: 2016-2017 Rutgers Busch Biomedical Pilot Grant to assess African-Indigenous Vegetables ability to Improve Micronutrient Status in Children.
- ***Scaling and Commercialization of Drying Technologies for Improved Horticultural Seed and Processing Quality***
Description: The project trained people from the government and private sector who are now training other people, especially the farming communities. This is directly and indirectly improving the human and institutional capacities at various levels.
- ***Expanding tomato grafting for entrepreneurship in Guatemala and Honduras***
Description: Project partners have developed a good working relationship with both the Catholic Relief Services in Guatemala as well as the Horticulture Innovation Lab Regional Center director and staff at Zamorano, Honduras. They also have a working relationship with both the University of Nacaional Agraria, Managua, Nicaragua and the Instituto Tecnologico de Costa Rica, San Carlos, Costa Rica.
- ***Developing small-scale irrigation solutions in Uganda***
Description: Project is working with staff and students at Busitema University on integrating our project into their teaching curriculum. The project has hosted numerous field practicals and internships by undergraduate students. We have had several meetings with faculty at Busitema regarding opportunities for building curriculum around irrigation engineering and also for field trips to our project sites.

Three NGOs have participated as project partners (Teso Women Development Initiatives, Amari Uganda) or offered an overview of irrigation systems (Action Aid) as part of the project. This has built experience of local experts in the social and technical considerations of developing or improving small scale irrigation systems.

- ***Cold Storage and Postharvest Training in Tanzania***

Description: Project renovated an old unused cold room on the premises of HORTI Tengeru and installed a CoolBot controller and A/C unit. Updating to newer technology allowed for the organization of a week-long training tailored for industry leaders, trainers, and teachers using the Postharvest Training and Service Center (PTSC) set up at the World Vegetable Center. The training was comprised of four days devoted to postharvest biology and technology for fresh products – fruits, vegetables, and flowers, while the final day was focused on drying. Facilities are being used to train students now and the trainees are expected to use their tool kits to train others.

VIII. 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 believes that specific technologies and innovations have the ability to solve problems and challenges 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 has been developing a technology currently called DryCard. The DryCard is an inexpensive gauge, less than 20 cents each, that can be used by farmers and traders to check the moisture content of dried foods before they are stored. The DryCard is a wallet sized card, with a printed color reference scale combined with a strip of relative humidity indicator paper inside a protective plastic sleeve. When the visual scale and relative humidity indicator paper are combined into an easy to carry, read, and reuse card, farmers and traders can easily check the moisture levels in their stored products. The goal is to preserve the quality and reduce the danger of aflatoxin contamination in dried produce (vegetables, fruit, grains, pulses, and seeds). The DryCard is in the first phase of technology development. The Horticulture Innovation Lab is currently testing and modifying the design based on user feedback.

The Regional Centers continue to conduct research and trainings on the UC Davis Chimney Dryer. For example, in Thailand our partners at D-Lab have made some modifications to the dryer that they continue to collect promising data. At the Demonstration Center at UC Davis the management entity has built two dryers, one for moringa leaves and the other for student research.

A preliminary experiment for solar blanching using the UC Davis Chimney Dryer was performed at the Demonstration Center at UC Davis. Solar blanching could be an option for reducing browning/blackening of some types of produce. The preliminary results are very promising but there will be future experiments to determine how to optimize the use of the chimney dryer for blanching. In the developing world, blanching is very rarely done since it is quite an expensive and sophisticated method. The proposed solar blanching can be a very inexpensive approach to provide some level of blanching and improved product quality.

PROJECT TECHNOLOGIES

TECHNOLOGIES TRANSFERRED

- ***Improving nutrition with African indigenous vegetables***
Description: From the World Vegetable Center, seven amaranth, five spider plant, eight African nightshade, nine cowpea, three moringa, and eight Ethiopian mustard lines have been transferred to AgriSmart in Zambia, KALRO, and Moi University/AMPATH in Kenya. An additional amaranth line has been transferred from Rutgers University. All lines are being evaluated for horticultural and nutritional performance across these varying agroecological zones; results will be used to inform recommendations for production interventions. Samples from trials conducted thus far have been transferred to Rutgers University where nutritional analysis is being performed to test across lines, location, and method of preservation.
- ***Developing small-scale irrigation solutions in Uganda***
Description: Six irrigation technologies and user-agreements being piloted and adapted with user input and management.

TECHNOLOGIES SCALED

- ***Scaling up drying technologies for seed in Bangladesh***
Description: Drying beads, DryBox and DryStore technologies have been introduced to seed companies and processors in Bangladesh and company personnel have received several trainings. Several companies have adopted the technology and are now using it and sharing their success with other seed companies. More companies are interested in testing the technology.

TECHNOLOGIES READY TO SCALE

- ***Scaling up drying technologies for seed in Bangladesh***
Description: QualiDry and FlexiDry, the newest drying technology utilizing drying beads for large-scale drying.
- ***Expanding tomato grafting for entrepreneurship in Guatemala and Honduras***
Description: Tomato grafting technology and germplasm.
- ***Promoting Conservation Agriculture for vegetable growers in Nepal and Cambodia***
Description: Conservation agriculture (CA) for commercial vegetable home gardens, drip irrigation and CA for commercial vegetable home gardens, animal built embankments for building rainwater harvesting ponds, tuktukbot, coolbot, evaporative cooler, hole digger for vegetable seedling transplanting.

IX. ENVIRONMENTAL MANAGEMENT AND MITIGATION PLAN

The Horticulture Innovation Lab is in the process of developing an Environmental Management and Mitigation Plan (EMMP) for all projects. The team has created a first draft of the EMMP, which will soon go out to the Agreement Officer's Representative (AOR) and Bureau Environmental Officer (BEO) for feedback. At the same time the draft EMMP will go out to PIs for them to populate with FY2017 activities. Once feedback from all groups has been incorporated, a finalized EMMP will go out to the BEO for final approval. The final step will be to fully roll out and report on the EMMP.

X. OPEN DATA MANAGEMENT PLAN

In August 2015, the Horticulture Innovation Lab submitted our open data management plan to our AOR. We have not received feedback on that plan, but are proceeding with it. The Open Data Management Plan (plan) is included as an appendix to this report. The first data uploaded to the Development Data Library (DDL) was from the Horticulture Innovation Lab rapid assessment in Guinea (see FY2014 Annual Report). None of the Phase II projects have completed their award period and thus no other data has been uploaded to the DDL. There are several new projects that are being developed and their research will be added to plan.

XI. GOVERNANCE AND MANAGEMENT ENTITY ACTIVITY

The extensive horticulture experience UC Davis and the management entity bring to the management of the Horticulture Innovation Lab is of 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 develop RFPs and lead the evaluation of proposed 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. For this reason, we have a large management team, 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. During FY2015 and FY2016, we worked hard as a team to learn from projects that we funded in Phase I and sought to incorporate the lessons we learned into the new research projects.

Late in FY2016 our Associate Director, Amanda Crump, accepted a position at the Western Integrated Pest Management Center. The position remained unfilled for six months during the recruitment process, which put a significant burden on the management entity. Through this time the Horticulture Innovation Lab was able to successfully move several RFPs, award three projects, and maintain good relationships with and management of current principal investigators. In September 2017 a new Associate Director, Erin McGuire was hired.

XII. OTHER TOPICS

COMMUNICATIONS

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

During 2015-2016, the Horticulture Innovation Lab's email newsletter and blog gained momentum as these outlets (which started slowly the previous year) became regular outlets for the program's news and updates.

Discussions about renovating the program's website have continued, with an eye toward better sharing deliverables and research findings from the Horticulture Innovation Lab's completed projects, in a way that is highly accessible to end users.



The management entity is also beginning discussions of how to tell success stories in a more impactful way, through a combination of enhanced evaluations and multimedia storytelling. A trial photo essay, [“Vegetables from Field to Market: Following Cambodian farmers and their postharvest practices”](#) saw excellent engagement through social media channels and among domestic audiences.

SOCIAL MEDIA

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

Twitter: As of Sept. 30, 2016, the Horticulture Innovation Lab account @HortInnovLab had **2,200 followers**, which is an increase of 680 followers since July 2015. Employees of the Horticulture Innovation Lab’s management entity—in particular Brenda Dawson, Britta Hansen, and Angelos Deltisidis—also operate Twitter accounts that circulate information about their work with the Horticulture Innovation Lab.

Facebook: As of Sept. 30, 2016 the Horticulture Innovation Lab page had **1,862 fans**, which is an increase of nearly 800 fans over the last 12 months (it had 1,065 fans on Oct. 1, 2015). The program shares highlights of its news, upcoming events, and funding opportunities on Facebook.

NEWSLETTER, BLOG AND WEBSITE

The Horticulture Innovation Lab’s **email newsletter** is flexibly scheduled, generally once every other month, with 7 editions sent in the last 12 months. The newsletter email list grew by **420 new subscribers** this year (since Sept. 20, 2015), and the most recent newsletter was sent to an email list of 2,469 subscribers. Each email is text-only with one or two briefly summarized articles, followed by headlines and links for other articles on topics of program news and future opportunities. The email is formatted simply and highly accessible, with a majority of links going to the Horticulture Innovation Lab’s blog.

The Horticulture Innovation Lab’s **blog** serves as a functional backbone for its email newsletter, as well as a place to host news and timely information from the program. About 1 in 4 user-sessions on the blog started from a click in the program’s email newsletter. For the year, the blog had about **10,500 user-sessions**, with almost 7,500 users. Because the blog was still a new tool during the previous year, year-to-year growth has been significant (with pageviews up about 200%, with about 17,000 pageviews this year).

The Horticulture Innovation Lab’s **website** also saw gains in users, with about **22,000 user-sessions** (up by about 27% from the previous year) and about 14,000 users (up about 20%). Renovating and redesigning the website is currently being planned by the Horticulture Innovation Lab. Communications coordinator Brenda Dawson led a discussion about goals and priorities for website renovation at the 2016 annual meeting.

TOP STORIES AND CONTENT HIGHLIGHTS

Between blog articles, earned media, and social media there were a small number of stories that made up the major highlights of the Horticulture Innovation Lab's communications achievements this year.

- **CoolBot story:** An article initially written for the Feed the Future newsletter in February 2016 summarizing the Horticulture Innovation Lab's private partnership and upstream work to support scaling of the CoolBot, gained momentum over several months through cross-posting across a number of different websites. The original article eventually spawned a Spanish translation, an original article in the California Farm Bureau's newspaper, an original article in a Cambodian newspaper, and a student-produced video for a UC Davis video contest, among other publicity.
- **UC Davis demonstration center:** The grand opening of a physical location on the UC Davis campus was an entry point for greater engagement with campus and town media in Davis, California. Not only did events at the outdoor center garner attention around the campus, but also raised the program's local profile with communications via photo opportunities.
- **MásRiego project:** A press release announcing this new project, funded by a buy-in award from USAID/Guatemala, was well circulated via interested University of California outlets and has yielded media interest in learning more about the MásRiego project as it progresses.
- **Grant opportunities:** When they happen, requests for proposals and other funding opportunities drive clicks to our website and articles, spiking traffic.
- **Multimedia photo essay trial:** After seeing photo essay examples from USAID, the Horticulture Innovation Lab tried a photo essay on the website Exposure.co based on postharvest practices with vegetables in Cambodia. A link to the post on Facebook garnered remarkably high engagement, and the link was well shared via Twitter and via other university communicators.

See Appendix D for a list of FY2016 blogs, news articles and more information on major highlights.

IMPACT EVALUATION

The Horticulture Innovation Lab is committed to our mission to improve the lives of small-scale farmers in the zones of influence through horticulture. We have identified six pillars to accomplish this work -

1. Horticulture value chain research
2. Innovation and scaling
3. Capacity building
4. Nutrition sensitive horticulture
5. Empowering women and the most vulnerable
6. Sharing information

These strategies must be analyzed and lessons learned and best practices compiled. In order to gather these data our monitoring, evaluation, and learning plan (MEL) includes:

- Monitor project progress to facilitate management and oversight by Horticulture Innovation Lab. While we have always formally acquired information for each project bi-annually we will in addition be implementing a more informal strategy to check-in more often to determine the needs of the project.
- Evaluate completion of project goals and progress towards Horticulture Innovation Lab themes. Once each year and at the end of the project, PIs will submit complete reports that include their progress towards indicators, deliverables, and objectives as well as supply additional project information.
- Assess the impact and sustainability of the projects both at the time of project completion and at intervals after the project has ended. In addition to project monitoring, a final evaluation of each project will be budgeted for and scheduled for a period of 1 to 2 years after the project ends to assess the components of the project that have scaled or were sustainable. The evaluation is both quantitative and qualitative.
- Provide feedback to the Horticulture Innovation Lab management entity that will guide future funding decisions.

One of the most important aspects of the MEL is to share out what we have learned in the past seven years - to benefit researchers, practitioners, and students, as well as the farming families that we aim to serve. We also are deeply dedicated to learning new, more effective ways for the management entity to award and conduct research projects in the developing country.

In order to best compile the wealth of knowledge the management entity and our projects have uncovered and engage in responsible reflection, we will hire a third party to evaluate the effectiveness of the management entity and our partners. We have solicited advice on methodology and on how to communicate lessons learned from our International Advisory Board. We expect this evaluation will include a mixture of quantitative and qualitative data, use Feed the Future indicators collected, and provide engaging case studies through pictures and video.

GENDER

In 2015-2016, the Horticulture Innovation Lab's research and interventions were aimed at empowering women and vulnerable people who often work in horticulture value chains.

The Horticulture Innovation Lab seeks to understand how women and members of vulnerable groups can benefit from the production of fruits and vegetables, either as income generating crops or as crops that complement a healthy and diverse diet. We have sought to design technologies and interventions that specifically target these groups, and to make trainings and research projects equitable. Our project teams have been trained on empowerment and responsive project planning, and all projects are assessed on their impact on the empowerment of women and the most vulnerable. In addition, the management entity has worked with funded projects to ensure that projects are gender sensitive, women's participation is encouraged, and women and vulnerable people benefit from the research.

Internally, at the 2015 annual meeting in Siem Reap, researchers in the gender equity project led a second workshop for all Horticulture Innovation Lab project leaders on 'Gender and Horticulture: Deeper Consideration and Next Steps.' At the end of this workshop, each research team discussed how they were dealing with issues of gender within their projects and solicited feedback on how to address specific challenges.

For instance, the project team improving nutrition through indigenous vegetables in Kenya, Zambia, and Tanzania seek to address gender inequality through the value chain. The team developing small-scale irrigation solutions in Uganda works closely with smallholder women farmers who are often excluded from irrigation and marketing developments. The team expanding tomato grafting for entrepreneurship in Honduras and Guatemala conducts field trials with women's groups to validate the technology and identify the optimal rootstock-scion combinations. The team promoting irrigation practices for smallholders in Cambodia and Nepal empowers women through labor saving technologies and increased horticulture production.

Some of the lessons we have learned through these projects this year:

- Women have particular issues that may be overlooked when focusing on technical aspects of implementing new irrigation techniques, e.g. children's safety around reservoirs. Or if their incomes increase with more productivity, the new income may be taken by husbands, when instead that money needs to be used for rented plots which are to be paid in increments.
- Women farmers can earn profit from small-area commercial vegetable home gardens. From data of 60 farmers in Cambodia, it is evident that farmers can earn from small 100 square meter commercial vegetable home garden plots. If sustainably intensified, earnings went as high as \$500 per year per 100 m². In 2011, 41 percent of the Cambodian population lives on less than \$2.00; a women farmer can earn \$900 on 200 m². This does not require a whole day's work. In addition, the family will have nutritious, healthful vegetables to eat.

In addition to including gender empowerment as a crosscutting theme in all projects, the Horticulture Innovation Lab solicited and funded a major gender equity project (\$1.5 million, five years) on empowering women through horticulture in Honduras. This project adopts a gendered economy perspective — one that is attuned to normative, cultural, economic and political forces that shape gender inequalities in access to and control over resources — in its application of a value chain analysis of the horticultural sector in western Honduras. It employs a rigorous qualitative and quantitative data gathering initiative that seeks to understand how the horticultural value chain can be a mechanism to support equity and empowerment for women and other marginalized populations.

Building on Pennsylvania State’s experience with this project, the Gender, Agriculture, Environment and Energy Initiative was granted funding for a two-year post-doctoral training program for researchers in the CGIAR system. The Gender Research and Integrated Training (GRIT) workshop brought 15 post-doctoral social science researchers from across the CGIAR system to Penn State in June to learn how to effectively integrate gender into their research programs.

NUTRITION

The Horticulture Innovation Lab supports research that improves understanding of nutritious crops from production to consumption and enhances their availability. Nutrition is uniquely important in poverty reduction. Improving on-farm crop diversity through horticulture increases the likelihood that a family will diversify their diet. Lack of diversity in the diet (low dietary diversity) is strongly associated with deficiencies of essential micronutrients such as vitamin A, folate (vitamin B9) iron, and zinc. Micronutrient deficiencies that start during childhood have long-term health and nutrition consequences that affect children’s cognitive and physical development, and their overall well-being.

Rutgers University leads a \$2 million five-year project focused on improving dietary diversity through enhanced access to African indigenous vegetables in Kenya and Zambia. Once considered “famine foods,” these indigenous vegetables such as amaranth, African nightshade and spider plant have increased in popularity — but meeting market demands and understanding the specific nutritional attributes of these vegetables still presents several research, production and marketing challenges. This project will work to understand the specific nutrient profiles of these vegetables, to improve the value chain and will monitor how changes to vegetable production and marketing affect household consumption of these nutritious vegetables. This project will track community’s production, sales and consumption of African indigenous vegetables (AIVs) in Kenya and Zambia. Selected communities will be trained in improved production practices, they will be supported and linked to markets where AIVs are a valued commodity. They will be trained to prepare and consume these nutritious vegetables.

All of our research projects use a nutrition sensitive approach, and seek to understand the roles of nutrition within their projects. Beyond this major nutrition project, the Horticulture Innovation Lab will fund projects that have the potential to make positive impacts in nutrition. All of our projects will be reviewed to consider their nutrition-related impacts, both positive and negative. Improvements in local and regional horticulture could help address two key components of food insecurity: inadequate access to and availability of micronutrient-rich fruits and vegetables. High-value horticulture improves access through income generation all along the value chain and by making nutritious foods more available in the home and in local and regional markets. The most successful horticulture interventions also address the third component of food insecurity: food use through behavior change communication, nutrition counseling, and other approaches.

The Horticulture Innovation Lab is committed to

- Furthering the understanding of these linkages
- Identifying best practices that can be used to improve nutrition through agricultural interventions
- Analyzing all of our projects with nutrition sensitive lens

- A nutrition sensitive research portfolio whereby all projects incorporate nutrition benchmarks and check-ins throughout the project lifecycle. Projects with an explicit nutrition objective, benefit or research focus will measure nutritional outcomes and results to show impact. Nutrition related activities (completed)
- Conducted two seminars for the Program in International Community Nutrition at UC Davis.
- Worked with all project PIs to include nutrition sensitive practices into their projects.

XIII. ISSUES

We have continued to experience slow on-boarding of projects. While we had a particular challenge this year with the transition of our Associate Director, our rigorous RFP process and financial requirements have caused projects to take 6 months to 1 year to develop and award. We continue to evaluate and critique past processes while thinking creatively for new systems and tactics for quicker project onboarding.

XIV. FUTURE DIRECTIONS

The Horticulture Innovation Lab will solicit for project proposals in several areas this year. We will make awards focused on postharvest, integrated pest management, food safety, and integrated animal-horticulture systems. Projects in Tajikistan and Burkina Faso will also be awarded to serve value chain development of horticulture crops identified as important by the USAID country mission. Also, Trellis Projects return in FY2017 with nine students traveling to Cambodia, Ghana, Kenya, Nepal, and Uganda.

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

XV. APPENDICES

- A. FY2016 list of awards** given to U.S. partners (university, USDA, private sector, etc.) to include project name, dates and funding (current year and total) for each partner.

Partner: Michigan State University

- Project Name: Assessing feasibility of scaling up nets for pest-exclusion in Kenya
- Project duration: 1 year, 08/01/2016 – 07/31/2017
- Award amount: \$200,000

Partner: Agribusiness Associates

- Project name: Evaluating postharvest losses and effective interventions in Rwanda
- Project duration: 3 years, 08/01/2016 – 07/31/2019
- Award amount: up to \$1.5 million (\$500,000 per year)

Project name: MásRiego

- Project Duration: 4 years, 08/01/2015 – 07/31/2019
- Partner: North Carolina Agricultural and Technological State University
 - Award Amount: 204,000 over 3 years, (\$68,000 per year)
- Partner: Kansas State University (MasRiego)
 - Award Amount: 385,078 over 3 years (Year 1: \$107,000; Years 2&3: \$138,000)
- Partner: Barbara Ford Peace Center (MasRiego)
 - Award Amount: 1,700,000 over 3 years (Year 1: \$655,000, Year 2: \$670,000, Year 3: \$397,000)

HOW ONE FARMER'S INVENTION IS REDUCING FOOD WASTE

In many developing countries, more than half of all fruits and vegetables are never eaten, but instead are damaged or spoiled after harvest. These post-harvest losses can mean that farmers need to sell their fresh produce immediately at whatever price they can get, before they lose the crops that represent investments of labor, water, and agricultural inputs. Improving how fruits and vegetables are handled after harvest can significantly prolong freshness — and cooling is key.

“The three most important aspects of postharvest handling are: temperature, temperature, temperature,” said Michael Reid, postharvest specialist with the Horticulture Innovation Lab. “In the developing world in particular, affordable cooling technology is mostly absent.”

Cooling can be an expensive challenge — even for American farmers.

As a farmer in upstate New York, Ron Khosla knew this problem too well and could not afford to buy a walk-in cooler for his small farm. So he invented a solution: an electrical device called a CoolBot that tricks an air conditioner into getting colder, turning a well-insulated room into a cold room for less than it costs to buy a refrigeration unit.

“I was hoping for a cheap, do-it-yourself solution that I could maintain, but mostly I just needed to keep my leafy greens and strawberries cold,” Khosla said. He later started a small business to sell the CoolBot called Store It Cold, LLC.

Khosla's CoolBot invention caught the eye of postharvest researchers, including Reid who in 2010 first partnered with agricultural scientists from Uganda, Honduras, and India to test this new device in their climates and with local materials.

Since that first project, the Horticulture Innovation Lab has tested CoolBots for cold storage in Tanzania, Zambia, Uganda, Thailand, Cambodia, Bangladesh, India and



Above, a CoolBot connects to an air conditioner to further lower the thermostat without freezing over so that a well-insulated room can cool fresh produce effectively.

At left, Amrita Mukherjee checks the temperature of potatoes stored in a CoolBot-equipped room in Bangladesh. (Horticulture Innovation Lab photos by Britta Hansen, above, and Amanda Crump, left)

Honduras. Reid has also tested options for solar-powered CoolBots.

One Horticulture Innovation Lab partner — Jane Ambuko of the University of Nairobi — received a grant to pilot this technology among horticultural farmers for the Kenya Feed the Future Innovation Engine.

“I see the CoolBot making a whole lot of difference,” Ambuko said during a TEDxNairobi speech. “But for it to make that desired difference we have to make it cost-effective and affordable for the smallholder farmers.”

In the wake of these successes, Feed the Future Partnering for Innovation also chose to invest in scaling up the CoolBot among

exporters and agricultural associations in Honduras.

And Khosla's small business has been growing. In early 2016, it had grown to employ six people and had sold more than 27,500 CoolBots in 51 countries.

“I'm thrilled and so grateful to be a part of helping lots of people. Working with USAID has gotten us known in other countries, and I'm looking forward to the day when we have enough in-roads in India and Africa where we can work directly with farmers there,” Khosla said. “People didn't believe the CoolBots worked at first. But now we get the most amazing letters from people whose business has doubled or quadrupled. Good postharvest care makes such a difference. Once they try it, then they see.”



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STUDENTS HELP STUDENTS LEARN STATE-OF-THE-ART SCIENCE

In a classroom in Ghana, graduate student Dev Paudel from the University of Florida bent over computers with students and research assistants as they learned the basics of R, a free, open-source programming language for statistical analysis that he had installed on the computers earlier that week. As participants in this Kayaba Management Foundation training, the class members would next analyze the results of a needs survey of more than 300 farmers and vegetable vendors from nearby communities. Their goal?

“If we can use state-of-the-art statistical tools (including R) in Ghana, we can generate research findings that would be accepted by both policy makers and the international investor community,” said Hussein Yunus Alhassan, CEO of the Kayaba Management Foundation and chief instructor at Tamale Polytechnic. His new foundation is laying the groundwork for locally led research that supports the horticulture sector in northern Ghana, markets for horticulture value chains, and women’s empowerment.

As a doctoral graduate student, Paudel uses statistical analysis software frequently. His previous experience as a horticulture development officer in Nepal was an early step in his international development career.

Paudel’s work in Ghana — including his first trip to Africa — is supported by the Trellis Fund, an innovative program that pairs U.S. graduate students with organizations engaged with local farmers in developing countries. 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 Horticulture Innovation Lab’s two main goals for the Trellis Fund are complementary: strengthen smaller organizations with the horticultural expertise that a graduate student can offer,



From left, Dev Paudel walks Shiraz Ibn Haliq and Issahaku Fauzia through a computer exercise to learn about open-source statistical analysis with the Kayaba Management Foundation in Ghana. (Horticulture Innovation Lab photo by Hussein Yunus Alhassan)

and provide experience to the graduate student that could expand their career horizons toward international development. The connections with smaller organizations and young professionals also strengthen the Horticulture Innovation Lab’s network for future projects.

“Trellis promotes horticultural science to organizations that are often smaller than we might otherwise work with. They become part of our Horticulture Innovation Lab family, and many become good partners for us in the future,” said Elizabeth Mitcham, director of the Horticulture Innovation Lab.

The first 47 completed Trellis projects included 7,400 farmer participants, 219 demonstration plots and 238 training meetings. Those projects involved 47 students from five U.S. universities, who served as consultants for projects spanning

15 Feed the Future focus countries in Africa, Asia and Central America.

Though their 6-month Trellis Fund project is officially complete, Paudel, Alhassan and the Kayaba Management Foundation team continued to work together remotely with the goal of publishing a journal article based on their robust analysis of farmer needs from the survey.

“Working with students and research assistants is great because they are really open to new ideas and grasp things very easily,” Paudel said. “This was a challenging course for some of them, particularly those who did not have training in basic programming skills. However, they are practicing their skills with the survey analysis now. I believe this training will be advantageous to the students as they leap into their new careers.”



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Training participants prepared a variety of fruits and vegetables on trays for the chimney solar dryer they built as part of the postharvest short course. (Horticulture Innovation Lab photo by Michael Reid)

SUPPORTING POSTHARVEST IN TANZANIA'S HORTICULTURE SECTOR

In Tanzania horticulture is one of three value chains that Feed the Future activities focus on for greatest impact. Horticultural crops are particularly sensitive to poor postharvest practices, with estimates that half of fruits and vegetables grown in many sub-Saharan Africa countries are lost during postharvest phases.

To enable Feed the Future partners—including educators, industry professionals, and government employees—to better support horticultural development, the Horticulture Innovation Lab led a project to increase training infrastructure and provide training-of-trainers for improved postharvest practices of fruits and vegetables.

At the Horticultural Research and Training Institute in Tengeru (HORTI Tengeru), Horticulture Innovation Lab team members designed a field packing shed and charcoal cooler, which were later built and installed by partners at the World Vegetable Center. The site had an insulated room, which the Horticulture Innovation Lab converted into a working cold room, with the addition of a CoolBot and air conditioner. These postharvest facilities now allow for packing, cooling and storage of crops harvested from HORTI Tengeru's acres of field trials, for improved sales at a market nearby.

In July, the Horticulture Innovation Lab provided a five-day course in postharvest handling of horticultural crops to more than 40 professionals from all over Tanzania, including university professors, technical trainers, industry leaders, and government representatives.

The course was led by Michael Reid and Angelos Deltsidis of the Horticulture Innovation Lab, with Marita Cantwell of the UC Davis Postharvest Technology Center, and Ngoni Nenguwo of the World Vegetable Center. The course was hosted at the Postharvest Training and Services Center on the World Vegetable Center campus in Arusha. Juma Shekidele of HORTI Tengeru also provided assistance in organizing the course.

Each day the course started with lectures covering postharvest principles and practices for crops with commercial potential in Tanzania, including eggplants, tomatoes, bananas, mango, papaya, citrus, avocado, leafy greens, green beans, cherimoya, onions, cut flowers, cucumber, potatoes and carrots.

Hands-on activities were also part of the course. Participants conducted exercises to

examine maturity, produce quality, cooling, packaging, and water loss. Each participant also received a postharvest toolkit and learned how to use the tools with different fruits and vegetables through the exercises.

The course included a module on solar drying, in which attendees constructed and tested the UC Davis-designed chimney solar dryer. The dryer proved its effectiveness in demonstrations; despite heavily overcast conditions, products dried rapidly.

The class also took a couple of short field trips, visiting the local wholesale market, an export packing operation and HORTI Tengeru to see the postharvest facilities and horticultural field trials.

After the course's conclusion, evaluations included many positive comments from participants. Weeks later participants also reported incorporating the chimney solar dryer and other demonstrations into farmer field days in other parts of Tanzania.

"I will use and teach this course to my farmers who produces tomatoes and onion," reported one participant. Many commented that the course should be offered repeatedly in the future.



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C. Expected FY2017 list of awards

i. University of Florida Postharvest Capacity Building Project in Tanzania

- Principal Investigator: Steve Sargent
- Partner Institutions: Kansas State University, Sokoine University, Tanzania
- Project Duration: TBD
- Award Amount: TBD
- Project Goal: To enhance postharvest infrastructure for student training and postharvest curriculum at Sokoine University, Tanzania.

ii. Integrating soil practices for managing nematode pests in Guatemala

- Principal Investigator: 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: \$450,00
- 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.

iii. Building and Scaling of Safe Vegetable Value Chains in Cambodia

- Principal Investigator: Glenn Young, University of California, Davis
- Partner Institutions: Royal University of Agriculture
- Project duration: 3 years
 - 10/01/2016 - 07/31/2019
- Award amount: \$479,00
- Project goal: Increase access to the safe vegetable value chain for smallholder farmers (often women) through innovative technologies, relationship building, and cold chain development

iv. Integrated animal-horticulture systems research project

- Partner institutions: To be determined
- Project duration: Up to 3 years
- 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

v. *FY2017 USAID Mission Service Projects*

In an effort to create greater synergies between the horticulture portfolios of country-based USAID Missions and the applied research sponsored by the Horticulture Innovation Lab, the Horticulture Innovation Lab solicited research needs from a number of USAID Missions to address a persistent challenge related to horticulture facing their development projects. These horticultural challenges could be anywhere along the value chain from seeds to markets, including questions related to policy, production, nutrition, gender, markets and/or postharvest handling. All submissions were reviewed by the Management entity on the basis of projected impact and feasibility of success within a 2-year timeframe. Concept notes by USAID/Burkina Faso and USAID/Tajikistan were chosen, and our office collaborated with each of them to create and draft an RFP that would meet their research needs.

- Mission Service Project: Research to Improve Handling, Storage, and Marketing of Tomatoes in Burkina Faso for Resilience in the Sahel-Enhanced (RISE)
- Mission Service Project: Research on Appropriate Postharvest Handling, Processing, and Marketing of Dried Apricots in Tajikistan

vi. *FY2017 Trellis Projects*

The Horticulture Innovation Lab's Trellis Fund provides small-scale, in-country development organizations access to U.S. graduate student expertise, providing benefit to both the student and the in-country institutions. Trellis Fund projects address a variety of horticultural development topics, including irrigation, fertilization, other aspects of production, pest management, postharvest practices, nutrition, or marketing issues in relation to fruits, vegetables and high-value horticultural crops. This year, the 4th round of projects were completed and we recruited proposal from organizations in Feed the Future countries for Round 5. Acting on lessons learned from the previous round, the review process for projects was more rigorous than before, and this year we will be funding nine projects in Cambodia, Ghana, Kenya, Nepal, and Uganda. At this time, we are in the process of recruiting students from our partner universities to work on these new projects, which are eligible to begin January 2017. We will also be hosting a class this year, training students on subjects that will be directly relevant to working on these project, such as how to design extension material and run a workshop, as well as incorporate gender into project design and implementation.

D. News Articles and Blogs

i. *Horticulture Innovation Lab blog posts*: These blog posts were written by the Horticulture Innovation Lab and primarily circulated as part of its email newsletter. These can be found at <http://blog.horticulture.ucdavis.edu>. Listed by Headline: Date published.

- Call for Trellis Fund project proposals: 11/4/2015
- Scholarship opportunity: Guatemalan to study at North Carolina A&T: 12/9/2015
- Thailand: Visiting Kasetsart University: 12/11/2015
- Moving forward from the First International PHL Congress: 12/15/2015
- New report on horticulture in Guinea, after Ebola: 12/16/2015
- Meet Angelos Deltsidis, international postharvest specialist: 12/16/2015
- Newsletter: New report from Guinea, opportunities, updates: 12/17/2015
- How one farmer's invention is reducing food waste around the world: 2/10/2016
- Building a solar dryer at Bangladesh Agricultural University: 2/11/2016
- Newsletter: New RFP for pest management: 2/12/2016
- Nienhuis honored by Costa Rican university: 3/3/2016
- Students help students learn state-of-the-art science: 4/7/2016
- CoolBots making news in Cambodia: 4/8/2016
- In memoriam: Norman Looney: 4/12/2016
- Moving beyond the computer screen at our annual meeting: 4/14/2016
- Crump moves on, seeking new associate director: 4/14/2016
- Directors of regional horticulture centers gather in Thailand: 4/18/2016
- Following vegetables from field to market in Cambodia: 4/19/2016
- Symposium on Horticultural Science: Highlights from Cambodia's premier agricultural university: 4/20/2016
- Looking back at the Horticulture Innovation Lab's 2016 annual meeting: 4/21/2016
- Chicago Council highlights market-driven horticulture projects in Zambia: 4/21/2016
- Newsletter: Changes, Cambodia highlights, and more news: 4/25/2016
- Huffington Post on hidden hunger and Cambodian farmers: 4/26/2016
- Simon gives memorial lecture at University of Minnesota: 5/12/2016
- Thanks from Uganda: Why the Trellis Fund matters: 5/17/2016
- UC Davis students selected as 'Future Leaders': 5/18/2016

- Video: From seeds to grafted seedlings for farmers in Guatemala, Honduras: 6/7/2016
- What's growing at the Horticulture Innovation Lab Demonstration Center at UC Davis: 6/20/2016
- New funding for market-driven research on apricots, tomatoes: 7/11/2016
- Newsletter: Funding for tomatoes, apricots, postharvest, and more: 7/13/2016
- MásRiego project starts in Guatemala: 8/3/2016
- Horticulture takes the stage at World Food Prize: 8/5/2016
- Seeking insights into integrated animal-horticulture systems: 8/8/2016
- Newsletter: New grant RFP, horticulture on world stage: 8/9/2016
- 5 elements to better work with resource-poor farmers: A.S.K. M.E.: 8/23/2016
- Training postharvest partners in Tanzania's horticulture sector: 9/1/2016
- Feed the Future week: How can we #endhunger?: 9/13/2016
- Welcome to Erin McGuire, new associate director: 9/15/2016
- Grad students: Apply for international ag experience with Trellis Fund: 9/19/2016
- Nine new Trellis Fund projects awarded: 9/19/2016
- Events launch irrigation project in Guatemala: 9/19/2016
- Newsletter: Trellis awards, student opportunities, more: 9/20/2016

- *List of news articles and blog posts on external websites and media outlets:* These are timely articles that appeared on websites or media outlets that are not controlled by the Horticulture Innovation Lab. Listed chronologically by Year-Month-Date Outlet- Headline.
- 2015-October-08 CA&ES Currents- Grand opening of Horticulture Innovation Lab Demonstration Center
- 2015-October-12 UC Newsroom- From 'Healthy Soils' talk to a garden's grand opening
- 2015-October-13 Dateline- 'Healthy Soils' talk, plus a garden's grand opening
- 2015-October-13 UC Food Blog- How will you celebrate World Food Day?
- 2015-October-14 Arboretum Blog- Join us at the new Horticulture Innovation Lab Demonstration Center
- 2015-October-2016 UC News- Taking aim at the global food crisis- From A to Z
- **2015-October-19 Davis Enterprise- On World Food Day, UCD looks to the future**
- 2015-October-19 UC Newsroom- UC celebrates Food Day with bounty of events
- 2015-November-03 FSN Network Newsletter- Trellis RFP

- 2015-November-04 Woodland Daily Democrat- UC Davis hits record \$758M in research funds
- 2015-November-05 Trellis in Peanut & Mycotoxin Innovation Lab blog
- 2015-November-07 Trellis on AABS Agribusiness Consortium blog
- 2015-November-12 CA&ES Currents- Deans Message: Innovations for the developing world
- 2015-November-17 Horticulture Innovation Lab page on TEWDI-Uganda website
- 2015-November-17 IDIN blog- Trellis grant
- 2015-November-17 Terra Viva- Trellis funding opportunity
- 2015-November-18 Global Plant Council- Trellis featured
- 2015-November-19 YPARD- New Trellis RFP: Funding opportunities
- 2016-January-28 Feed the Future newsletter- How US Farmers Invention Reduces Food Waste in Developing Countries
- 2016-February-09 UC Davis News- UC Davis to Host Young African Leaders Program
- 2016-February-16- IPM in the South- Funding for Nematode Control in Latin America
- 2016-February-16- Northeastern IPM Center website- Currently Open Grant Opportunities
- 2016-February-17 North Central IPM blog - Funding for Nematode Control in Latin America
- 2016-February-18 AIARD Newsletter- Amanda Crump award, Penn State project in Honduras
- 2016-February-22 MorningAgClips- Invention reduce global food waste
- 2016-March-01 Western IPM newsletter- Nematode RFP
- **2016-March-17 Chicago Council on Global Affairs - From Seed to Sale_ Connecting
Zambian Farmers to Urban Markets**
- 2016-March-18 NTV- Jane Ambuko on Food Friday segment with CoolBot
- 2016-March-30 UC Food Blog- How one farmer's invention is reducing postharvest losses around the world
- 2016-March-30 UC ANR News- How one farmer's invention is reducing postharvest losses around the world
- 2016-March-30 University of California News- How one farmer's invention is reducing postharvest losses around the world
- **2016-April-05 Khmer Times- Helping Farmers Keep Their Cool**
- **2016-April-06 UC ANR- El invento de un granjero ayuda a reducir las perdidas
poscosecha en el mundo**
- 2016-April-21 Huffington Post- Tackling Global Hunger With Cambodian Vegetables

- 2016-May-18 AgAlert- UC Researcher develops inexpensive cooler for farms
- 2016-June-22 UC Davis CA&ES- Green thumbs need apply
- 2016-June-23 Arboretum- Pitch-and-Plant contest with the Horticulture Innovation Lab
- 2016-June-28 Dateline- Pitch & Plant Contest
- 2016-July-20 UC Fruit & Nut Research and Information Center- Apricot and tomato grant opportunities
- 2016-July-27 Agrilinks- Funding for Research Proposals on Tomatoes, Dried Apricots
- 2016-July-28 Plant Sciences newsletter- Exposure photo essay and RFPs
- 2016-July-28 Plant Sciences newsletter- Exposure photo essay and RFPs
- **2016-July-29 UC Davis News- Bringing More Irrigation and Climate-Smart Farming to Guatemala**
- 2016-August-01 UC Newsroom- Bringing more irrigation and climate-smart farming to Guatemala
- 2016-August-04 CAES News- More Irrigation and Climate-Smart Farming for Guatemala
- 2016-August-09 Dateline- Cambodian Conservation, Obama Shoutout and More
- 2016-August-10 Feed the Future - Research opportunities
- 2016-August-11 CAES Highlights- More irrigation and climate-smart farming for Guatemala
- 2016-August-21 Davis Enterprise- Team brings more irrigation, climate-smart farming to Guatemala
- 2016-September-02 UCANR- More irrigation for climate smart farming food security Guatemala
- 2016-September-13 Dateline- LAURELS: Mitcham elected ASHS VP brief
- 2016-September-14 Feed the Future blog- Investing in Research for Sustainable Solutions

E. Data Management plan

Data Management Plan

Feed the Future Innovation Lab for Collaborative Research on Horticulture

University of California, Davis

Submitted by Amanda Crump, former associate director, to John Bowman, AOR on August 31, 2015.

Approved on _____ by _____.

Modified on _____ by _____.

The datasets outlined in this plan represent data that will be collected in Horticulture Innovation Lab projects that are funded from 2015 to 2019. This plan will be modified as new projects are awarded and on an annual basis, based on new discoveries or research directions. Modifications will be submitted to and approved by the Horticulture Innovation Lab AOR. Modifications and approvals will be recorded by date above.

Data collected by the management entity

The Horticulture Innovation Lab management entity collects monitoring and evaluation data on each project it awards and other activities that the entity engages with. Monitoring data include annual progress updates that show project progress according to each project's monitoring and evaluation matrix. Annual progress is distributed via the Horticulture Innovation Lab's annual report. These are made publicly available in the USAID development clearinghouse.

All Horticulture Innovation Lab projects are evaluated upon completion. This evaluation includes a desk study of each project's fulfillment of their objectives, the project's deliverables, the project's publications, and other items submitted annually to the management entity. If appropriate or possible, an external reviewer interviews the project team (domestically and abroad) one to two years after project completion to look for project scale-up or sustainability. These qualitative data are collected by the reviewer and release of the qualitative data is prohibited by the UC Davis internal review board. Human subjects data involve confidentiality and these data cannot be released in order to protect the identity of the individuals surveyed to conform to the different institutional review boards. Reports on the findings of the evaluations are made available to the project teams, the Horticulture Innovation Lab team, the AOR, and others as appropriate.

Additionally, the management entity collects data that aid in our reporting requirements to USAID (i.e. number of university partners, number of technologies scaled, amount of money awarded). These data will be submitted to the DDL by the management entity every October. These data will consist of raw, datasets saved in a Microsoft Excel format. These data will be collected alongside the Feed The Future Monitoring System (FTFMS) data. These datasets reflect the numbers that are entered into FTFMS.

Data collected by every project

In the first year of each project cycle, the project lead is required to identify a set of indicators. These indicators are set as a goal and used to monitor project progress. These indicators consist of FTFMS indicators and Horticulture Innovation Lab custom indicators. The custom indicators will be reported by the management entity as described in the previous paragraph.

Indicator numbers are sent to the management entity every September where they are cleaned and aggregated. Every October, the FTFMS indicators are entered into the FTFMS. The management entity will upload the aggregated dataset into the FTFMS and the DDL at that time.

Data collected by individual projects

The following pages outline the data collected by each of the Horticulture Innovation Lab projects. This is limited to data collected using Horticulture Innovation Lab money and limited to the projects that the Horticulture Innovation Lab awards. This does not include projects that the Horticulture Innovation Lab participates in (i.e. the nutrition work in Bangladesh led by the Nutrition Innovation Lab) since those project leads have submitted their own data management plan and we have contributed to it as appropriate.

Regional Center at Kasetsart

Dataset #1: Performance data on the technologies tested at the center

- Description: These data consist of field level data on technology performance in the location where it is installed.
- Data Privacy & Use Restrictions: These data are specific to location but otherwise no restriction on use.
- Pre-submission data processing: Data will be cleaned for quality and accuracy prior to analysis. Data will be annotated as necessary. This is the dataset which will be uploaded. Data will be submitted in English.
- Final Data Deliverable: Excel readable file
- Timeline: Upon completion of analysis and after training and reporting has been completed. If a faculty member chooses to publish using these data, these data will be embargoed until publishing.
- Data repository & post-award curation: Submitted to the USAID development data library (DDL)
- Responsible Party: Kasetsart University
- Target Submission Date: September 2019
- Associated Costs: There is a cost with translating data from Thai to English.

Regional Center at Zamorano

Dataset #1: Performance data on the technologies tested at the center

- Description: These data consist of field level data on technology performance in the location where it is installed.
- Data Privacy & Use Restrictions: These data are specific to location but otherwise no restriction on use.
- Pre-submission data processing: Data will be cleaned for quality and accuracy prior to analysis. This is the dataset which will be uploaded. Data will be submitted in English.
- Final Data Deliverable: Excel readable file
- Timeline: Upon completion of analysis and after training and reporting has been completed. If a faculty member chooses to publish using these data, these data will be embargoed until publishing.
- Data repository & post-award curation: Submitted to the USAID development data library (DDL)
- Responsible Party: Kasetsart University
- Target Submission Date: September 2019
- Associated Costs: There is a cost with translating data from Spanish to English.

Irrigation technologies project in Uganda

Dataset #1: Performance of different irrigation technologies in Eastern Uganda

- Description: Data, including biophysical and social data, will be collected and analyzed from July 1, 2015 through the end of the project. Part of this includes publically accessible and published data, other data we are generating and thus are original and primary data. The primary data will be collected from a questionnaire and/or data template administered by key personnel and staff trained in Uganda, and will be entered into electronic spreadsheets. Biophysical analyses data procured using a variety of analytical instruments will be stored locally in computer software systems, QCed and verified and then transferred into EXCEL spreadsheets as appropriate. All data will be kept and collected on hard drives with password protection.
- Biophysical data: crop / seed choice, yield, sales price, labor input, chemical use, irrigation technology type, irrigation water use, soil quality data, climatic and weather data, and all other info relevant on inputs and practices in small scale irrigation & farming systems
- Social data: Focus group and individual questionnaires on: Irrigation management, land access, technology use, agronomic inputs, financial status, empowerment (voice, independence, self-esteem),
- Data Privacy & Use Restrictions: Data are collected by farmers and project staff, assistants, and volunteers / interns. Farmers' identifying data are restricted.
- Pre-submission data processing: Data will be cross checked for consistency, reviewed with enumerators to rectify causes of inconsistency or lack of clarity, and developing into accessible format for analyses.
- Final Data Deliverable: Standard word and excel files after data processing
- Timeline: Embargo until publication
- Data repository & post-award curation: Data will be uploaded to the USAID DDL after publication.
- Responsible Party: University of California, Davis
- Target Submission Date: 2018
- Associated Costs: Negligible.

Grafting of tomatoes project in Guatemala and Honduras

Dataset #1: Performance of rootstock/scion combinations in Central American conditions.

- Description: Data on rootstock/scion combinations under different climatic conditions.
- Data Privacy & Use Restrictions: None.
- Pre-submission data processing: Typical data processing prior to publication.
- Final Data Deliverable: Excel file
- Timeline: Data are collected from 2015 to 2017
- Data repository & post-award curation: USAID DDL
- Responsible Party: University of Wisconsin-Madison
- Target Submission Date: 2018
- Associated Costs: Negligible

Nutrition research project in Zambia and Kenya

The proposed project includes secondary data and primary data. These data will be collected and analyzed from March 01, 2016 through the end of the project. Part of this includes publically accessible and published data, other data we are generating and thus are original and primary data and other will include human subjects data. The data will be collected using a variety of approaches. The primary data will be collected from a questionnaire and/or data template administered by the PIs and student / postdoctoral researchers associated with this project as well as key personnel and staff trained in source country, and will be entered into electronic spreadsheets. The data from the computer-based tasks will consist of tab-delimited output from the programs running the tasks. Chemical analyses data procured using a variety of analytical instruments will be obtained from computer software systems, QCed and verified and then transferred into EXCEL spreadsheets as appropriate. All data will be kept and collected on hard drives with password protection.

Institutional Review Board (IRB)

To conduct the surveys and collect the data, approval for human subjects research will be obtained through the Rutgers Institutional Review Board (<https://orra.rutgers.edu/artsci>). As detailed in the human subjects section of the proposal, and because of confidentiality issues, each subject will be assigned an arbitrary code. One file that contains the correspondence between subject names and codes will be kept in an encrypted, password-controlled file accessible only to the PI and authorized research team members. Any personal information (name, date of birth, etc.) if collected will be removed from raw data prior to data analysis.

Elements of Data management plan

The data management plan contains a framework that links characteristics of the data, and their relationship to existing data. Data collected will be screened, verified for accuracy and reliability (we term this QC) and that data will be used for papers, posters, and scientific presentations. All data presented will be archived, stored and shared. In addition to the scientific quantifiable data, this project will also be collecting a photographic collection of plants highlighting phenotypic, anatomical traits and other features. This data will be archived and photos of plants, plant part will be uploaded and shared for public use. Data highlighting individual people will be collected as will field photos of smallholder farms, the steps along the value chain, including the range of markets and other outlets where the produce is sold and/or trade. Data with individual identifiers will be removed.

Dataset #1: Market availability of African Indigenous Vegetables (AIVs)

- Description: market prices, volume, availability of AIVs in the market collected quarterly
- Data Privacy & Use Restrictions: None.
- Pre-submission data processing: Normal processing prior to publication
- Final Data Deliverable: Excel file
- Timeline: Dataset will be released upon publication.
- Data repository & post-award curation: Rutgers University, see <http://soar.libraries.rutgers.edu/> and that data uploaded into the SOAR site to be shared with USAID DDL
- Responsible Party: Rutgers University
- Target Submission Date: 2020
- Associated Costs: Est. additional costs at \$5,000 for quality assurance (QA) and storage of data with costs associated with personnel assigned to provide oversight, back-up and convert data into sharing format as agreed upon that may not be how data is collected, checked, and stored by research group. Costs are in some ways negligible if we do not include costs of data verification, data conversion and transformation, data uploading and storage and oversight, yet each of these tasks will be required to be borne by research group.

Dataset #2: Household AIV purchase and consumption

- Description: Dietary Diversity and Household purchase and consumption surveys of African Indigenous Vegetables and Horticultural Product
- Data Privacy & Use Restrictions: Restricted; adhering to IRB policies and confidentiality of human subjects.
- Pre-submission data processing: Data will be aggregated, and de-identified before analyzing, then QCed and re-verified for accuracy and completeness, then converted into spreadsheet used for analyses, and then rechecked to ensure private issues are met before presenting in meetings and included into technical reports and research papers and before submission.
- Final Data Deliverable: Aggregated data compiled and checked (quality control), and available when data can be assured non-traceable to individuals and families. Data made available and ready for submission into research journals to be delivered
- Timeline: Dataset of aggregated data- not raw data, which is prohibited, to be shared to release upon publication.
- Data repository & post-award curation: Rutgers University, see <http://soar.libraries.rutgers.edu/> and that data uploaded into the SOAR site to be shared with USAID DDL
- Responsible Party: Rutgers University
- Target Submission Date: 2020
- Associated Costs: We are expecting > 400 surveys that need to be de-identified and aggregated, stored, archived, checked to ensure confidentiality is maintained and more, initial cost estimates are at \$100/individual survey collected and analyzed from source country, to transfer, and more).

Dataset #3: Production of, and Nutrition Content of AIVs

- Description: Agricultural yields under different production systems, and nutritional content/composition of AIVs.
- Data Privacy & Use Restrictions: None.
- Pre-submission data processing: Normal processing prior to publication

- Final Data Deliverable: Excel file
- Timeline: Dataset will be released upon publication and following QCed of data
- Data repository & post-award curation: USAID DDL
- Responsible Party: Rutgers University
- Target Submission Date: 2020
- Associated Costs: We are expecting > 20,000 analyses surveys that need to be QCed/verified, aggregated, analyzed merged for publications, clarity, stored, archived, initial cost estimates are at \$10,000/year).

Gender equity research project in Honduras

Dataset #1: Participatory focus group data regarding barriers to participation in the horticultural value chain for various actors.

- Description: interview notes and quantitative data from focus group discussions
- Data Privacy & Use Restrictions: Restricted; adhering to IRB policies regarding confidentiality of human subjects
- Pre-submission data processing: Data will be aggregated and all personal identifiers removed.
- Final Data Deliverable: Excel file with approximately 60 observations.
- Timeline: Collection and cleaning – summer/fall 2015; analysis – 2016; publication – 2017; submission to USAID -- 2018
- Data repository & post-award curation: USAID DDL; Penn State University
- Responsible Party: Penn State University
- Target Submission Date: 2018
- Associated Costs: Est. additional costs at \$1,000 for quality assurance (QA) and storage of data with costs associated with personnel assigned to provide oversight, back-up and convert data into sharing format as agreed upon that may not be how data are collected, checked, and stored by research group. Costs are in some ways negligible if we do not include costs of data verification, data conversion and transformation, data uploading and storage and oversight, yet each of these tasks will be required to be borne by research group.

Dataset #2: Household surveys of agricultural producers in the western highlands of Honduras.

- Description: Production of horticultural crops, women's empowerment and dietary diversity.
- Data Privacy & Use Restrictions: Restricted; adhering to IRB policies regarding confidentiality of human subjects
- Pre-submission data processing: Data will be cleaned, aggregated and all personal identifiers removed.
- Final Data Deliverable: SAS/Excel file with 300-350 observations
- Timeline: Collection and cleaning – 2016; analysis – 2016-17; publication – 2018-19; submission to USAID -- 2020
- Data repository & post-award curation: USAID DDL; Penn State University
- Responsible Party: Penn State University
- Target Submission Date: 2020
- Associated Costs: Est. additional costs at \$10,000 for data aggregation, quality assurance (QA) and storage of data with costs associated with personnel assigned to provide oversight, back-up and convert data into sharing format as agreed upon that may not be how data are collected, checked, and stored by research group.

Conservation agriculture and drip irrigation project in Cambodia and Nepal

Cambodia:

Dataset #1: Data on vegetable yield, cost of production, income, labor, and water use in Siem Reap, Cambodia

- Description of data: Vegetable yield by each farmer we incentivized adoption of drip irrigation with conservation agriculture technologies, Production cost by each farmer, Income by each farmer
 - Ten farmers will be randomly sampled and we will monitor:
 - Water use by drip irrigation
 - Labor from drip
 - Labor from weeding
 - Labor from seeding
 - Labor from mulching
- Data Privacy & Use Restrictions: No names of farmers, we expect up to 100 participating farmers
- Pre-submission data processing: Data will be processed as is appropriate for publication
- Final Data Deliverable: Website from the iFarmCA App (<http://www.conservationagricultureandagroforestry.org/ifarmca/index.php/search>). Raw data (no quality control) accessible as it is being collected in field.
- Timeline: Upon publication, approximately 2018
- Data repository & post-award curation: Dataset will be uploaded to the USAID Development Data Library (DDL) after publication.
- Responsible Party: North Carolina A&T State University
- Target Submission Date: 2018
- Associated Costs: Negligible

Dataset #2: Data on number of farmers who practiced conservation agriculture and drip irrigation because of incentives

- Description: Number of farmers who tried Conservation Agriculture and number of farmers who continued CA, Number of farmers who tried drip irrigation and number of farmers who continued with drip irrigation.
- Data Privacy & Use Restrictions: No names of farmers, we expect up to 100 participating farmers
- Pre-submission data processing: Data will be processed as is appropriate for publication
- Final Data Deliverable: Website from the iFarmCA App (<http://www.conservationagricultureandagroforestry.org/ifarmca/index.php/search>)
- Timeline: Upon publication, approximately 2018
- Data repository & post-award curation: Dataset will be uploaded to the USAID Development Data Library (DDL) after publication.
- Responsible Party: North Carolina A&T State University
- Target Submission Date: 2018
- Associated Costs: Negligible

Nepal:

Dataset #3: Data on vegetable yield, cost of production, income, labor, and water use in Lalitpur, Banke, Surkhet and Dadeldhura.

- Results of experiment with 24 women commercial vegetable home gardeners, six in each site. Each farmer is a replication managing three treatments and they are:
 - Conventional Tillage System with Drip Irrigation
 - Conventional Tillage System with Integrated Pest Management Technology and Drip Irrigation
 - Conservation Agriculture System with Integrated Pest Management and Drip Irrigation
- Description of data for each treatment:
 - Vegetable yield by each farmer
 - Production cost by each farmer
 - Income by each farmer
 - Water use by drip irrigation
 - Labor from drip
 - Labor from weeding
 - Labor from seeding
 - Labor from mulching
- Data Privacy & Use Restrictions: No names of farmers, we expect up to 100 participating farmers
- Pre-submission data processing: Data will be processed as is appropriate for publication
- Final Data Deliverable: Website from the iFarmCA App
(<http://www.conservationagricultureandagroforestry.org/ifarmca/index.php/search>)
- Timeline: Upon publication, approximately 2018
- Data repository & post-award curation: Dataset will be uploaded to the USAID Development Data Library (DDL) after publication.
- Responsible Party: North Carolina A&T State University
- Target Submission Date: 2018
- Associated Costs: Negligible